IDENTIFICATION OF RECHARGESITES USING GIS TO CONTROL SALTWATER INTRUSION IN TUTICORIN DISTRICT, INDIA

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Abstract

Groundwater Quality in many areas of Tuticorin District is affected due to saltwater intrusion. To control saltwater intrusion, artificial recharge of groundwater is essential. An attempt is made in this study to delineate suitable sites for artificial recharge. The various thematic Maps such as Geology, Geomorphology, Landuse, Slope, Drainage Density, Soil, Distance from Sea, Groundwater Level and Groundwater Qualityare reclassified and then Overlaid using Weighted Arithmetic Method. The result of the study depicted that 29% of the area is not suitable for recharge, 52% of the area is moderately suitable and 19% of the area is highly suitable.Proper planning of recharge wells in the highly suitable areas will provide a way to control saltwater intrusion.

Keywords: groundwater, recharge sites, GIS, saltwater intrusion, artificial recharge

Introduction

Water is essential for the survival of all living thingsin the earth.The demand for water increases as the population increases. In order to meet the demand of Tuticorin District, more wells are operated to pump the groundwater. Over extraction leads to the deterioration of water quality due to saltwater movement. (Kalpana and Velkennedy,2018) determined artificial groundwater adequancy in vaniyar sub basin, Tamilnadu to increase groundwaterlevel by surface runoff. Artificial Recharge is the effective technique to restore the water quality.(Raviraj et.al.,2017) used geology, geomorphology, soil, rainfall, drainage density and lineament map to identify therecharge Zones.(Senanayakeet.al., 2016) concluded that utilising GIS to delineate recharge areas is an effective methodology in the aspect of time, labour and cost. (Sasikkumar et.al.,2017)emphasized that the groundwater recharge map is important inthe planning and management of groundwater sources.(Salwa Farouk Elbeih, 2014) highlighted that integrated Remote Sensing data and GIS are very useful in identifying therecharge sites.(Karthick and Lakshumanan,2018) identified groundwater recharge sites and suitable recharge structures using Geospatial technology.(H Sin – Fu – Yeh et.al., 2016) assessed the groundwater recharge characteristics considering five factors such as lithology, landuse, lineament, drainage and slope for the Hulian watershed, Taiwan using GIS.(Anbazhagan et.al., 2005) planned the recharge area in thAyyar basin, Tamilnadu based on availability of runoff, priority areas, aquifer properties and groundwater table level.(Jialiang Cai et.al., 2015) recommended rearrangement in pumping pattern in Berlin, Germany to control saltwater intrusion.(Yousef Ali et.al., 2015)delineated groundwater potential Zones in Deep Midland Aquifers along Bharahapuzha, Kerala using Geophysical methods.(Muthukrishnanet.al., 2013) found that weighted overlay and Boolean logic model areuseful in identifying artificial recharge area in the Cauvery basin, Tamilnadu.The main objective of thestudyis to identify therecharge sites in Tuticorin, India using GIS to control saltwater intrusion considering

Geology, Geomorphology, Landuse, Slope, Drainage Density, Soil, Distance from Sea, Groundwater Level and Groundwater Quality.

Studyarea

The studyarea is Tuticorin District is as shown in Fig 1.located between 8°19' to 9°22'latitude and 77°40'to 78°23' longitude. The district having 8 Taluks. Agriculture is the main Occupation. Industrial Growth also rapidly developed. Hence extraction of water increases which in turn causes saltwater intrusion.

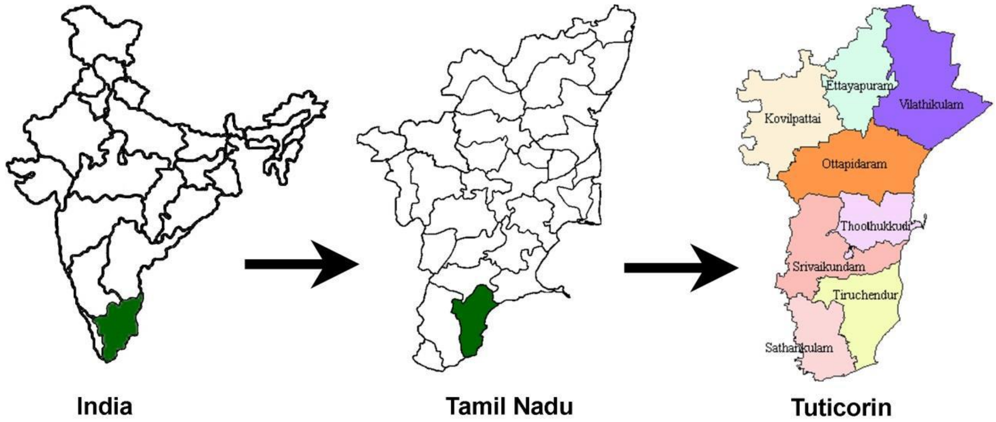

Fig 1. Location of Studyarea

Methodology

The methodology is presented in the Fig 2.

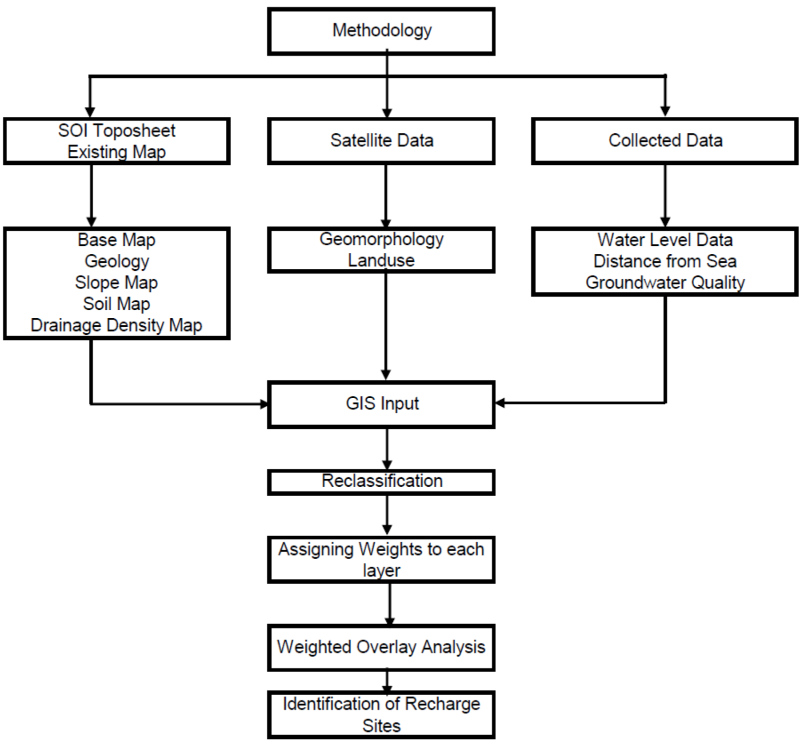

Fig 2. Methodology

Geology

Gneisses is Predominantly found in the area followed by limestone and Sand.Kankar, Basalt, Quartizites, Alluvium are also present in the Tuticorin area. (Vijay Prabhu and Venkateshwaran, 2015) considered alluvium formations overlaid by basalt are suitable for recharge.Hence Basalt and Alluvium are reclassified as highly suitable. Kankar, Quartizites, Gneisses are reclassified as Moderately Suitable. Limestone and Sand are reclassified as Not Suitable for recharge since the water quality changes. Fig 3 shows the geology and reclassified geology map. Based on geology, it is found that 21% of area is highly suitable for recharge, 59% of area is moderately suitable and 20% of area is not suitable for recharge.

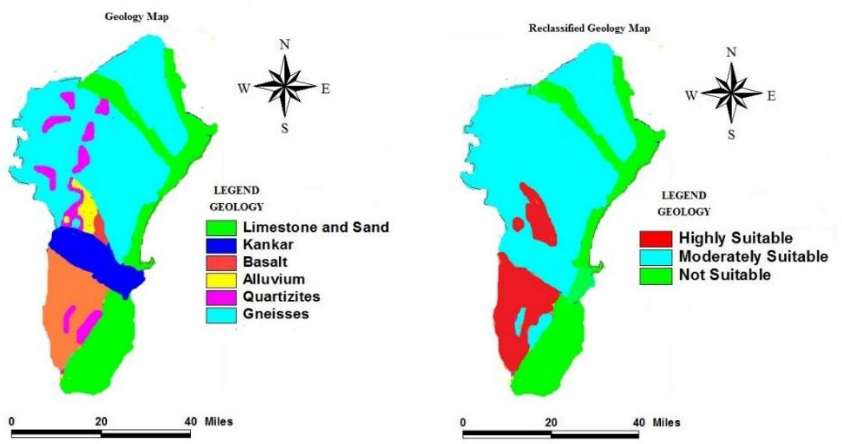

Fig 3. Geology and Reclassified Geology Map

Geomorphology

The whole area is classified into five types namely hilly areas, flood plain areas, Pediments, Beaches and low lyingareas based on geomorphology. Pediments occupy most of the area. Low lying and Flood Plain areasare reclassified as Highly Suitable. Pediments and Beaches are reclassified as Moderately Suitable. Hill is reclassified as Not Suitable. Fig 4 Shows the geomorphology and reclassified geomorphology map.Based on geomorphology, it is found that 21% of area is highly suitable for recharge, 72% of area is moderately suitable and 7% of area is not suitable for recharge.

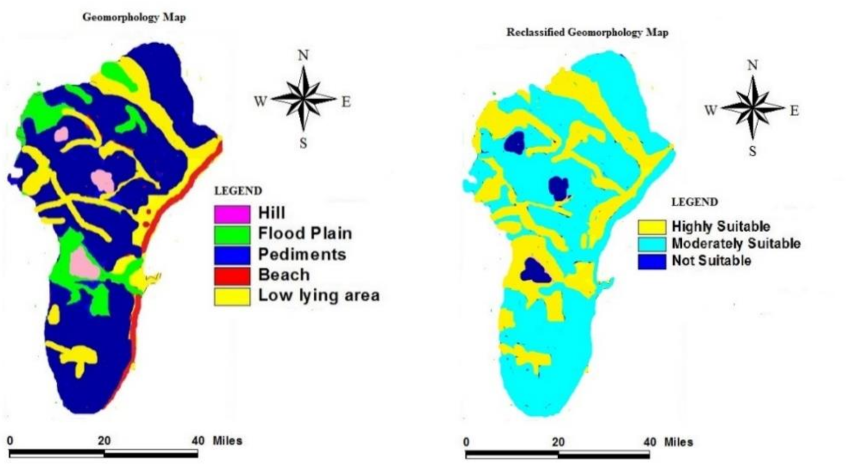

Fig 4. Geomorphology and Reclassified Geomorphology Map

Landuse

Agriculture is the main occupation in the studyarea. Agriculture and Wasteland are reclassified as Highly Suitable Sites. Forest and Waterbodies are reclassified as Moderately Suitable Sites. Built up areas and Salt pan are reclassified as Not Suitable Sites. Fig 5 Shows the Landuse and Reclassified Landuse Map.Based on Landuse, it is found that 61% of area is highly suitable for recharge, 23% of area is moderately suitable and 16% of area is not suitable for recharge.

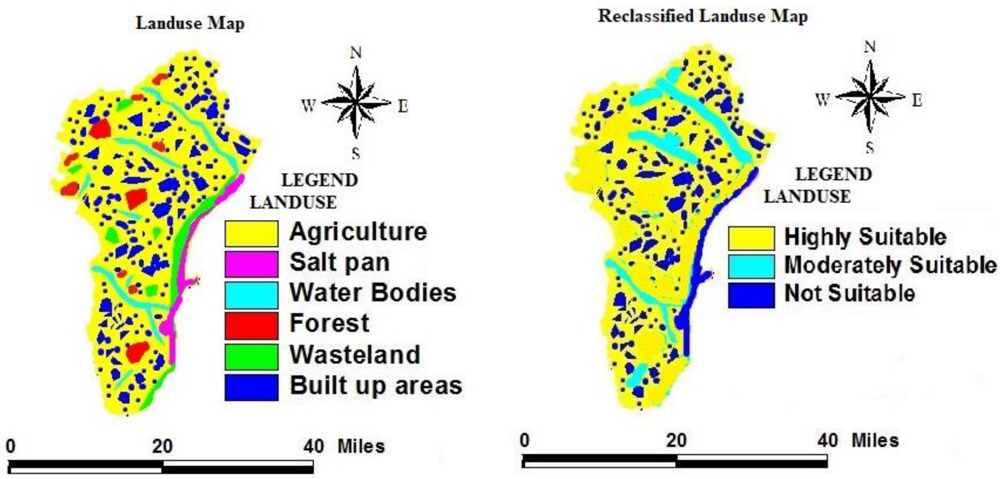

Fig 5. Landuse and Reclassified Landuse Map

Slope

The slope of the studyarea varies from 0 to 30%. The area having the slope 0 to 10%are reclassified as Highly Suitable. The area having 10 to 20% are reclassified as Moderately Suitable. The area having 20 to 30% are reclassified as Not Suitable. Fig 6 shows the slope and reclassified Slope map.Based on Slope, it is found that 31% of area is highly suitable for recharge, 37% of area is moderately suitable and 32% of area is not suitable for recharge.

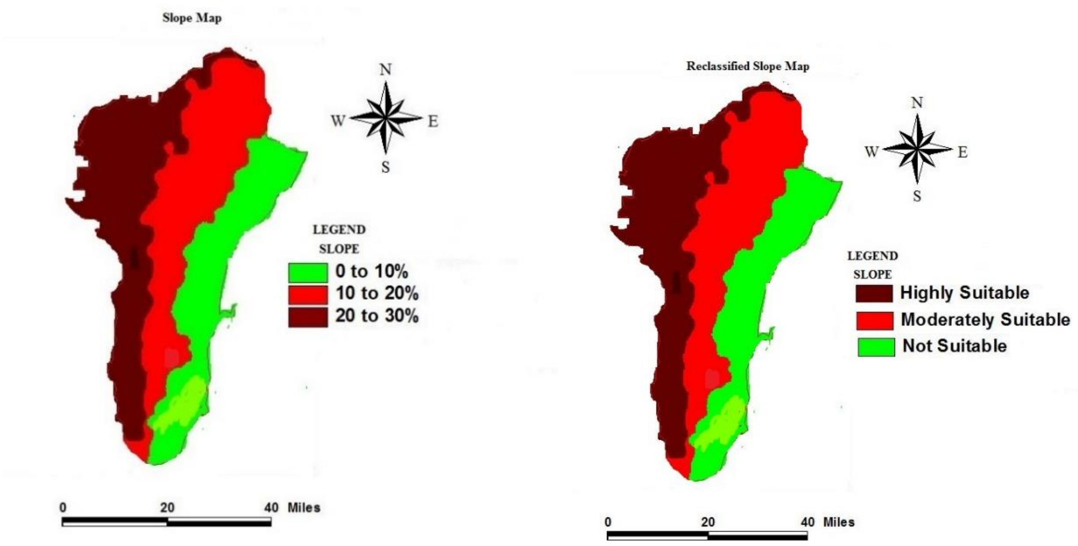

Fig 6. Slope and Reclassified Slope Map

Drainage Density

Drainage Density is inversely proportional to the recharge site. The drainage density between 0 to .25 are reclassified as Highly Suitable. The drainage density between 0.25 to .5 are reclassified as Moderately Suitable.The drainage density between 0.5 to .75 are reclassified as Highly Suitable. Fig 7 Shows the Drainage Density and Reclassified Drainage Density Map. Based on Drainage Density, it is found that 3% of area is highly suitable for recharge, 80% of area is moderately suitable and 17% of area is not suitable for recharge.

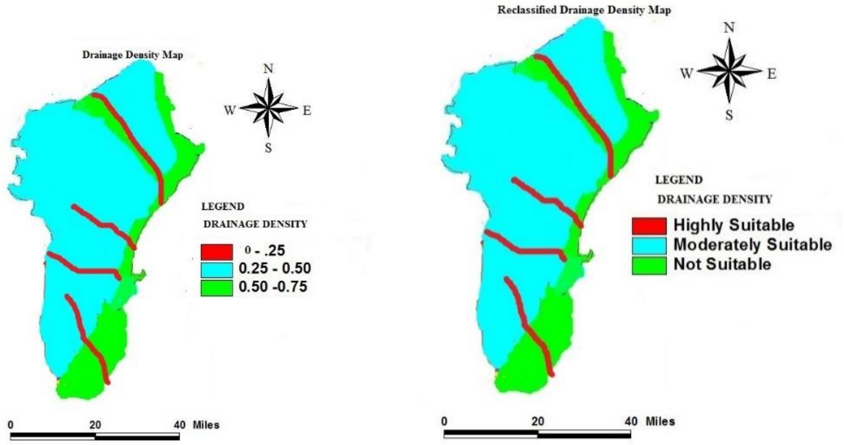

Fig 7. Drainage Density and Reclassified Drainage Density Map

Soil

The soils present in the region are Sandy Loam, Sandy Clay, Loamy Sand, Clay, Sandy Clay Loam and Sand. Sandy clay is reclassified as Highly Suitable. Sandy Loam, Clay and Loamy Sand are reclassified as Moderately Suitable.Sandy clay Loam and Sand are reclassified as NotSuitable. Fig 8 shows the soil and reclassified soil map.Based on Soil, it is found that 27% of area is highly suitable for recharge, 57% of area is moderately suitable and 16% of area is not suitable for recharge.

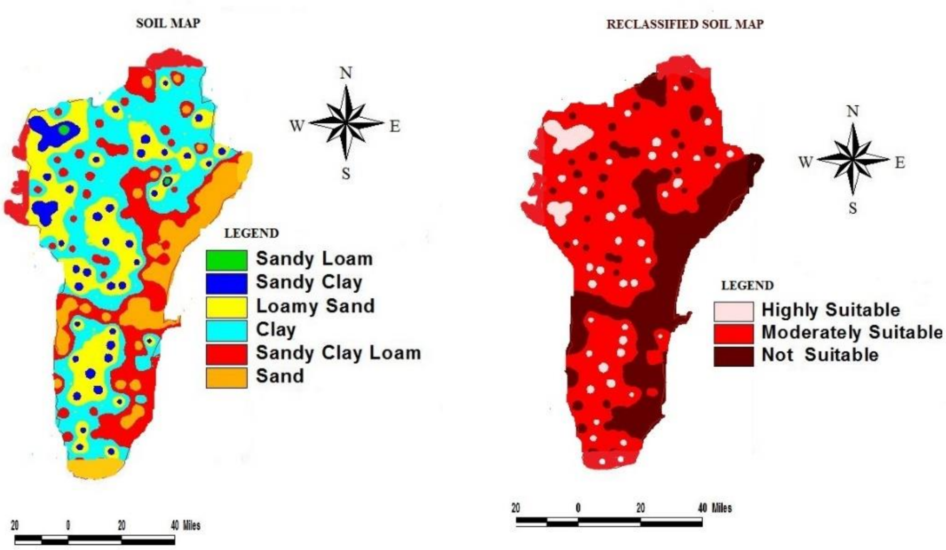

Fig 8. Soil and Reclassified Soil Map

Distance from Sea

Distance from sea also considered in identifying recharge sites. The saltwater and freshwater interface occurs between 10 to 20 m. Hence if the distance from sea is between 0 to 10 m then it is reclassified as Not Suitable.If the distance from sea is between 10 to 40 m then it is reclassified as Moderately Suitable.If the distance from sea is above 40 m then it is reclassified as Highly Suitable. Fig 9 shows the distance from sea and reclassified distance from sea map.Based on Distance from Sea, it is found that 32% of area is highly suitable for recharge, 28% of area is moderately suitable and 40% of area is not suitable for recharge.

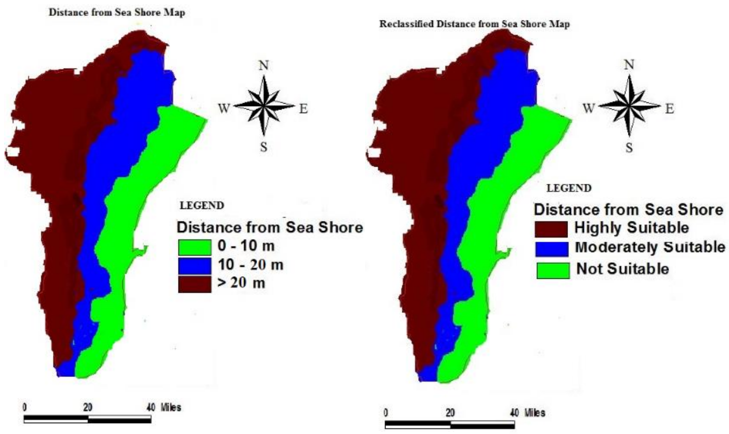

Fig 9.Distance from Sea and Reclassified Distance from Sea Map

Groundwater Level

The groundwater level is measured in the observation wells. (Selvam et.al.,2014) used groundwater level for finding the recharge area.In order to control saltwater intrusion, increase the hydraulic head of the wells.Hence if the water level is between 0 to 5 m then it is reclassified as Not Suitable.If the water level is between 5 to 20 m then it is reclassified as Moderately Suitable.If the water level is above 20 m then it is reclassified as Highly Suitable. Fig 10 shows the Groundwater Level and Reclassified Groundwater Level Map.Based on Groundwater Level, it is found that 29% of area is highly suitable for recharge, 36% of area is moderately suitable and 35% of area is not suitable for recharge

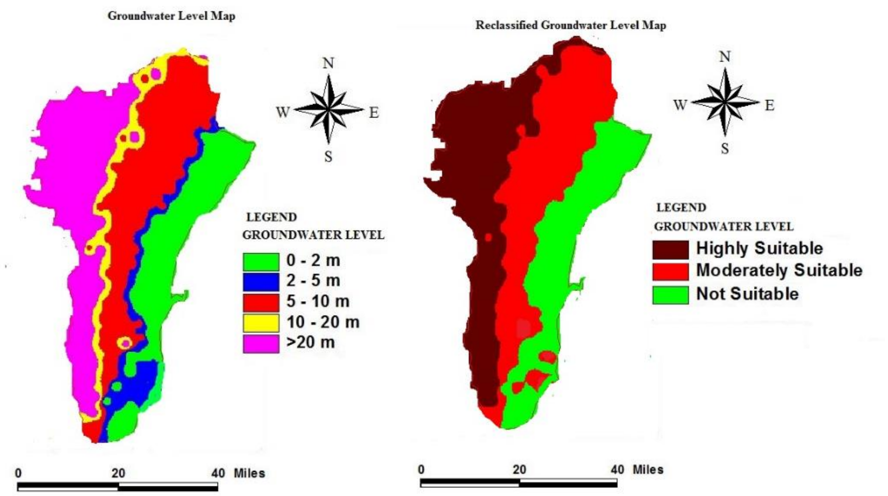

Fig 10 Groundwater Level and Reclassified Groundwater Level

Groundwater Quality

The groundwater quality which is unfit for drinking and very poor are reclassified as Highly Suitable.The groundwater quality which is poor are reclassified as ModeratelySuitable.The groundwater quality which is Good and Excellent are reclassified as Not Suitable. Fig 11 shows Groundwater Quality and Reclassified Groundwater Quality.Based on Groundwater Quality, it is found that 25% of area is highly suitable for recharge, 47% of area is moderately suitable and 28% of area is not suitable for recharge

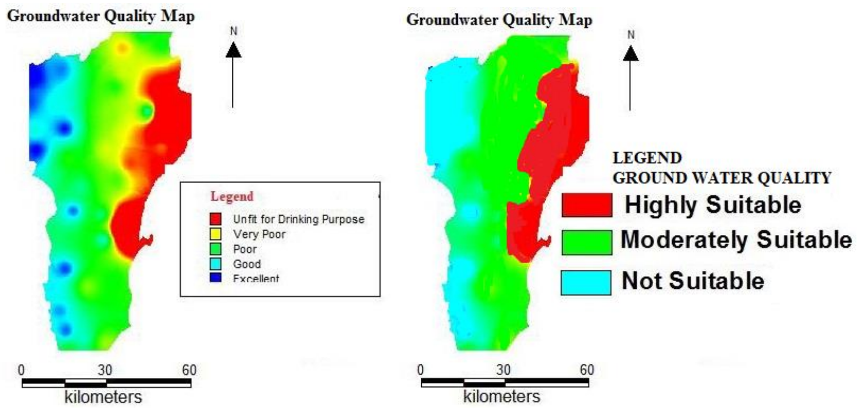

Fig 11 Groundwater Quality and Reclassified Groundwater Quality

Groundwater Recharge sites

All the thematic maps such asGeology, Geomorphology, Landuse, Slope, Drainage Density, Soil, Distance from Sea, Groundwater Level and Groundwater Quality are reclassified and overlaid using the weightage provided in the Table 1 to identify recharge sites, Fig 12 shows the sites suitable for Recharge. The weightageare assumed based on previous studies(Sharma M.P and AnukaranKujur, 2012;Karthick and Lakshumanan, 2018). It is found that that 29% of the area is not suitable for recharge, 52% of the area is moderately suitable and 19% of the area is highly suitable.

Table 1 Rank and Weightage used

S.No	Factor	Classes	Rank	Proposed Relative weight	Weightage Factor
1.	Land Use	Agriculture	1	4	21
		Saltpan	3		
		Waterbodies	1		
		Forest	2		
		Wasteland	2		
		Built up	3		
2.	Geology	Gneisses	1	4	21
		Limestone	3		
		Quartizites	2		
		Kankar	2		
		Alluvium	1		

		Basalt	1		
3.	Geomorphology	Beach	2	2	11
		pediments	2		
		Hill	3		
		Flood plain	1		
		Delta	2		
		Low lying	1		
4.	Slope	0 to 10%	1	2.5	13
		10 to 20%	2		
		20 to 30%	3		
5.	Drainage	0 – 0.25	3	1.5	8
		0.25 – 0.50	2		
		0.50 – 0.75	1		
6.	Soil	Sandy clay	1	1.5	8
		Clay	2		
		Sandy Clay	3		
		Sandy	2		
		Sand	3		
		Loamy	2		
7.	Distance from	0 – 10 m	3	1	5
		10 – 40 m	1		
		>40 m	2		
8.	Groundwater	0 – 2 m	3	1	5
		2 – 5 m	3		
		5 – 10 m	2		
		10 -20	1		
		>20m	1		
9.	Groundwater	Excellent	1	1.5	8
		Good	1		
		Poor	2		
		Very Poor	2		
		Unfit	3		

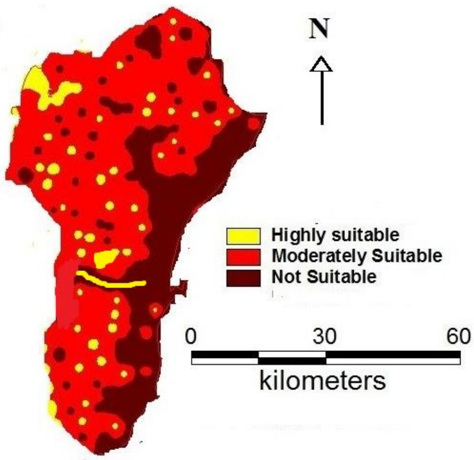

Fig 12 Sites Selection for Recharge

Conclusion

GIS is an effective tool in identifying the sitessuitable for rechargeusing various thematic Maps such as Geology, Geomorphology, Landuse, Slope, Drainage Density, Soil, Distance from Sea, Groundwater Level and Groundwater Quality.The result of the study depicted that 29% of the area is not suitable for recharge, 52% of the area is moderately suitable and 19% of the area is highly suitable. Proper planning of recharge wells in the highly suitable areas will provide a way to control saltwater intrusion.

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