International Journal of Advanced Research in Management and Social Sciences

ISSN: 2278-6236

Impact Factor: 7.624

RAINFALL AND GROUND WATER POTENTIAL ZONES USING GIS TECHNIQUES AND REMOTE SENSING IN AGNIYAR RIVER BASIN IN TAMILNADU

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CONFLICT OF INTEREST: NONE

ABSTRACT

Agniyar river basin has an area of 4663.15 Sq. km spread over in four Districts namely Pudukkottai, Thanjavur, Tiruchirappalli and Dindigul. There are 18 non-recording rain gauge stations in and around the basin. The various agencies maintaining these rain gauge stations, and the number of rain gauge stations maintained by each agency**.** Considering the distribution of rain gauge stations and the availability of data, 12 rain gauge stations having long-term records in and around the basin are considered for the detailed analysis. The details of the rain gauge stations such as, their location, geographical co-ordinates and the study period are analyzed For the purpose of rainfall analysis; month is taken as a time

step. Thiessen polygon map for the rain gauge stations have been prepared to study the distribution pattern of rainfall over the basin area. Groundwater has become the only source for agricultural, domestic and industrial needs in the area of study. The area selected lies in a hot and humid climate with an ephemeral river draining major portion of the study area. But the demand for water has increased many times due to increased agricultural, domestic and industrial needs in this region. The present groundwater resources and natural recharge of groundwater do not come up with the demand. The study aims to analysis and find out the existing hydrological conditions by identifying the groundwater potential zones in the study area using Remote Sensing (RS), Geographical Information System (GIS) techniques.

Key words: rainfall, groundwater, GIS, potential zones, Thiessen polygon map.

1. INTRODUCTION

The present study is aimed at establishing information on the groundwater potential zone in Agniyar river basin, Tamil Nadu, The total geographical area of Agniyar basin is 4663.15 Sq.km. (It falls in the Survey of India degree sheets 58‘J’, 58 ‘N’ and 58’O’’ on 1:250,000 scale). The thematic maps such as geology, geomorphology, soil hydrological group, land use / land cover and drainage map were prepared for the study area using Land sat 8 images. The Digital Elevation Model (DEM) has been generated from the Shuttle Radar Topography Mission

(SRTM) data with 30 m resolution and contour lines from toposheets and obtained the slope (%) of the study area. The information about groundwater potential zones of the study area were developed by overlaying all the thematic maps in terms of weighted overlay methods using the effective analysis tool in Arc GIS 10.3. Ranking has been given for each individual parameter of each thematic map and weights were assigned according to the influence over such as soil -12%, geomorphology - 35%,geology – 20%, land use / land cover - 8%, slope - 2%, lineament - 8% and drainage - 15% and the resulting maps presents the groundwater potential zones in terms of Good, Moderate and Poor respectively. The result shows the groundwater potential zones in the study area and found to be helpful in better planning and management of groundwater resources.

1.1 Monsoon and non-Monsoon Periods

Agniyar river basin lies within the tropical monsoon zone. Based on the hydro meteorological features of the basin, year is divided into 1) Monsoon period spanning from June to December and 2) Non-monsoon period spanning from January to May. The monsoon period is further sub-divided into Southwest monsoon period spanning from June to September (4 months) and Northeast monsoon period spanning from October to December (3 months). Similarly, the non-monsoon period is further sub-divided into winter period spanning from January to February (2 months) and summer period

spanning from March to May (3 months). As the monsoon period brings heavy rainfall, it improves the recharging of groundwater as well as storage of surface water. Hence, the monsoon period is hydrologically significant for water resources analysis. But in the case of non-monsoon period, the rainfall is insignificant**.**

1.2 FREQUENCY ANALYSIS

The range of annual rainfall and their frequency have been analyzed and furnished From the table it is noticed that rainfall exceeding 1000 mm occurred in more than 70% of the study period in Adirampattinam Rainfall in the range 900-1000 mm occurred in more than 17% of the study period in Alagudi, Aranthangi, Iluppur, Keeranur, Pudukkottai, Thirumayam and Manaparai. 600 to 800 mm rainfall occurred in more than 30% of the study period in Keeranur, Kurungulam, Pattukkottai and Pudukkottai. Rainfall less than 200 mm occurred in Kurungulam and Perungalur. The annual rainfall frequency distrubution are analyzed. The monthly and season wise rainfall for 18 rain gauge stations are given. Probable rainfall for 25%, 50%, 75%, 90% dependabilities and the average for southwest, northeast, winter, summer and annual rainfall for all the sub basins have been analyzed. The season wise rainfall contour maps are presented.

1.3 OBJECTIVES

- To analysis and findout the existing hydrological condition by identifiying the groundwater potential zones in the study area using Remote Sensing and Geographical Information System.
- To find the rainfall changes in Agniyar river basin

2. METHODOLOGY

Agniyar basin is one of the major river basins of Tamil Nadu. It is a cone shaped or triangular basin located almost in the middle and eastern side of Tamil Nadu. It falls in the Survey of India Toposheets of 58 /J, 58 / N and 58 / O in the latitude from 9° 55'00" to 10° 45'00" and longitude from 78° 15'00" to 79° 30' 00". Agniyar basin is embedded in between Cauvery basin in the north and northeastern side and Pambar Kottakkaraiyar basin in the south. In the southeastern side it is bordered by the Palk Strait and Palk Bay. Hence it has a small coastal stretch in the southeastern side Administrative boundary wise, it spreads in parts of Pudukkottai, Thanjavur and Tiruchirappalli districts and with a small extent in Sivagangai and Dindigul district. The second stage involved preparation of digital elevation model (DEM) by interpolating SRTM data with 30 m resolution and from SOI toposheet (1:25,000) contour lines. DEM is used to prepare slope (%), flow accumulation and stream order. In the third stage, digital image processing of the geo-referenced satellite data is done for creation of different thematic layers using supervised classification technique. All the details from the collected data then summed to create the buffer map for agriculture area and settlement area. It is then followed by creation of other important data which is used to determine the groundwater potential at the later stage like land use / land cover map, geological, lineament map, geo-morphological map and hydro-geo-morphological. In the fourth stage all above themes are further processed and analyzed in overlay and ranking is given to evaluate suitable groundwater potential zone. All the

thematic layers will overlay by using GIS to find the final integrated output of groundwater potential zones in the present study, geomorphology, slope, drainage density, Land use / land cover, geology and lineament density are considered for the identification of groundwater potential.

3. DEPTH OF RAINFALL

The occurrence of groundwater depends on geological and physiographical setting as well as on climatic conditions. Further, the degree of structural deformation and weathering of the geological formation, control the distribution of groundwater both in vertical and lateral directions. Groundwater occurs in the crystalline rocks of Gneiss and Granites normally under unconfined conditions in weathered and fissured zones and under semi-confined conditions in the fractured, faulted and sheared zones. The pore spaces developed in weathered zones act as shallow granular aquifers and form potential water bearing zones. The water table is shallow in canal and tank irrigated regions and the same is deeper in other areas. In alluvial formation and tertiary formation, the ground water occurs under water table or semi-confined conditions. These formations are highly porous, permeable and develop into potential water bearing zones. In coastal sand, groundwater occurs under water table conditions. These formations are highly porous, permeable and developed into potential water bearing zones. The quality of water is poor due to the depletion of water level below Mean Sea Level and occurrence of marine formations and calcareous formations. The groundwater occurrence is based on geological evaluation and observation wells. An inventory of about 51

observation wells spread over the entire basin has been studied. The list of 51 observation wells considered for the study is studied. The water table or water level is one of the important phenomena in hydro geological evaluation of an area The water level change in the aquifer environment mainly depends on the recharge and discharge of groundwater. The depth of the water level has been measured 51 locations in the study area. The groundwater levels during July-2013 and January-2014 seasons have been furnished and contour maps have been prepared for the water levels. In the July - 2013, the depth of the water table ranges from 2.93 mts to 54.50 mts. Shallow water table found in southern part of study area (0-5 mts) and deeper water table occurring in the northern part of the study area (Above 20 mts) and during January - 2014, the depth of the water table ranges from 1.25 mts to 52.25 mts. The water table is deeper in the northeastern parts of the study areas from 10- 20 mts and shallow water table occurring in rest of the study area (0-5 mts).

3.1 GEOMORPHOLOGY

Geomorphologic study plays an important role in the assessment of water resources both surface and groundwater. The geomorphic landforms are merged with related components like soil, lithology, structure, lineament and other hydrological parameters for hydrogeomorphological study. Geologically this basin is occupied by both sedimentary and hard rock. The eastern part of the basin is covered by sedimentary formations with marine landforms whereas the western part is covered by hard rock terrain, which shows denudation landforms. Remote sensing satellite data based

observation and understanding of terrain conditions favours detailed geomorphological study was carried out in the Agniyar basin and the landforms have been analyzed based on the interpretation of image characteristics like tone, texture, shape, pattern and associated features etc., The qualitative assessment was made for aiming groundwater potential available with each geomorphic unit. There are three major landforms identified in the basin. There are, Denudational Landform, Fluvial Landform Coastal Landform.

3.2 GEOLOGY

Geology is one of the major factors which play an important role in the distribution and occurrence of groundwater. A detailed field investigation of the study area reveals an interesting is a gentle undulating terrain with distorted hill ranges occupying the west and central portion. The quartzite and charnockite forms many of the hill ranges while gneisses and sedimentary rocks occupy the plain. The basin area is traversed by crystalline rocks of Archaean and Proterozoic age and Sedimentary rocks of Miocene and Quaternary sediments. Geology is one of the major factors which plays an important role in the distribution and occurrence of groundwater. A detailed field investigation of the study area reveals an interesting is a gentle undulating terrain with distorted hill ranges occupying the west and central portion. The quartzite and charnockite forms many of the hill ranges while

gneisses and sedimentary rocks occupy the plain.

3.3 Land use / Land cover (LU / LC)

Land use / land cover mapping is one of the important applications of remote sensing. Land use plays a vital role in the development of groundwater resources. It controls many hydrgeological processes in the water cycle viz., infiltration, evapotranspiration, surface runoff etc., surface cover provides roughness to the surface, reduce discharge thereby increases the infiltration. In the forest areas, infiltration will be more and runoff will be less whereas in urban areas rate of infiltration may be less. Remote sensing provides excellent information with regard to spatial distribution of vegetation type and land use in less time and low cost in comparison to conventional data. Due to anthropogenic activities the land surface has been modified enormously in the recent years. The surface covered by vegetation like forests and agriculture traps and holds the water in root of plants whereas the built-up and rocky land use affects the recharge of groundwater by increasing runoff during the rain, so it is necessary to study what kind of features are covered the study area's land surface. The Land sat 8 satellite image has been used for the study to find out the land use and land cover of Agniyar river basin. The supervised classification method has been used with level - I classification. The result of the study found the study area covered by sixteen different classes such as agricultural land, forest, built-up, water body, waste land and others. The weight assigned depending on water logging and

runoff properties of LU/LC. Land use / Land cover map of the study area.

3.4 SOIL

Soil is the one of the main factor which decides the amount of groundwater, the study of soil helps to find out the types and as its properties. The movement of groundwater and infiltration of surface water into ground is based on the porosity and permeability of soil. Therefore the study of soil is important to determine the amount of groundwater of any areas. The base data for the soil classification of present study has been obtained from National Bureau of Soil Survey and Land Use Planning, Bangalore. The result of soil classification found that, the study area has three types of major soils such as Alf sols, Vertisols and Entisols .The movement and infiltration of water in these three types of soil is not same so based on its property the weight ages have been fixed.

3.5 Lineament and Lineament Density

Lineaments are straight linear elements seen at the Earth's surface as a significant “lines of landscape” (Hobbs 1904). These are primarily a reflection of discontinuities on the Earth’s surface caused by geological or geomorphic processes (Clark and Wilson 1994). Geological features that causes to lineaments include faults, shear zones, fractures, dykes and veins as well as bedding planes and stratigraphic contacts. Geomorphic features, which appear as lineaments on the maps, aerial photographs and satellite images include streams, linear valleys and ridgelines. Lineament density of an area has direct influence on groundwater prospectivness of that area. In present study area with very high lineament density

having good groundwater potential where as area with very low lineament density having poor groundwater potential.

3.6 Drainage and Drainage Density Map

Drainage basin is a natural unit draining runoff water to a common point. This map consists of water bodies, rivers, tributaries, perennial and ephemeral streams, ponds. The study area is fourth order basin joining the rivers, tributaries based on topography. Drainage network helps in delineation of watersheds. Drainage density and type of drainage gives information related to runoff, infiltration relief and permeability. Dendritic drainage shows homogenous rocks, the trellis, rectangular and parallel drainage patterns indicate structural and lithological controls. The coarse drainage texture indicates highly porous and permeable rock formations, whereas fine drainage texture is more common in less pervious formations. Drainage density (in terms of km/km^2) indicates closeness of spacing of channel as well as the nature of surface material, thus providing a quantitative measure of average length of stream channel for whole basin. It has been observed from drainage density measurement made over a wide range of geologic and climatic type that a low drainage density is more likely to occur in region and highly resistant of highly permeable subsoil material under dense vegetative cover and where relief is low. The important drainage systems are Agniyar, Ambuliyar and South Vellar rivers. The river drains an area of 1056 Sq. km with in this study area. The surface reservoirs are located on this river. The drainage pattern of the area is mostly controlled by the

structural features. Among the different drainage pattern and released features recognized in this basin is of Dendritic to Sub Dendritic nature.

3.7 Slope

The slope angle is considered as an important input as it has considerable influence in the study area for the identification of Groundwater potential zones. Slope controls the rate of infiltration and runoff of surface water, the flat surface areas can hold and drain the water inside of the ground, which can increase the groundwater recharge significantly whereas the steep slopes increase the runoff and decrease the infiltration of surface water into ground. The slope of the study area has been calculated in degrees based on the DEM model which was based on the SRTM data. The slope of the study area was classified into three classes and each class weight age has been marked, such as less than 5 degree plain area, slope zone 5 -15º, 15 -25º, and 25-35º and above 45º and weight ages of 3, 2 and 1 was respectively assigned to them based on their groundwater prospects. In this case, higher weight age was given to gentle slopes and gradually lesser and lesser weight ages were assigned steeper and steeper slopes because runoff is directly proportional to slope.

3. 8 GROUNDWATER POTENTIAL ZONING

All the thematic maps were changed into grid (raster format) and superimposed by weighted overlay method (rank and weight age wise thematic maps). From the analysis the groundwater potential zones in-terms of

good, moderate and poor zones with the area of 602.48 Sq.km, 353.27 Sq.km and 44.25 Sq.km respectively were obtained.

4. CONCLUSION

The study revealed that the usefulness of spatial data for assessment of groundwater for the study area and also demarcated the groundwater potential zones of Agniyar river basin. From the analysis the weight ages in the GIS layer was generated, for identifying the groundwater potential zones, different ranks and weight ages of the thematic data sets was given and integrated using overlay functions of GIS analysis. The groundwater potential zones have been Indofood for the entire Agniyar river basin and it has been divided into three categories as good, moderate and poor zones. The study of identification of groundwater potential zone in Agniyar river basin shows that, vast area has been covered by moderate potential zone and low potential zones are found in west, southwest and central part. High potential zones have covered very least areas of middle, south and south western parts of study area as 44.25 Sq.km.The study also recommends the use of Geographical Information System (GIS) technology with Remote Senting (RS) data for the advanced study of groundwater, which can reduce the cost, time, human power with higher accuracy

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FIGURES

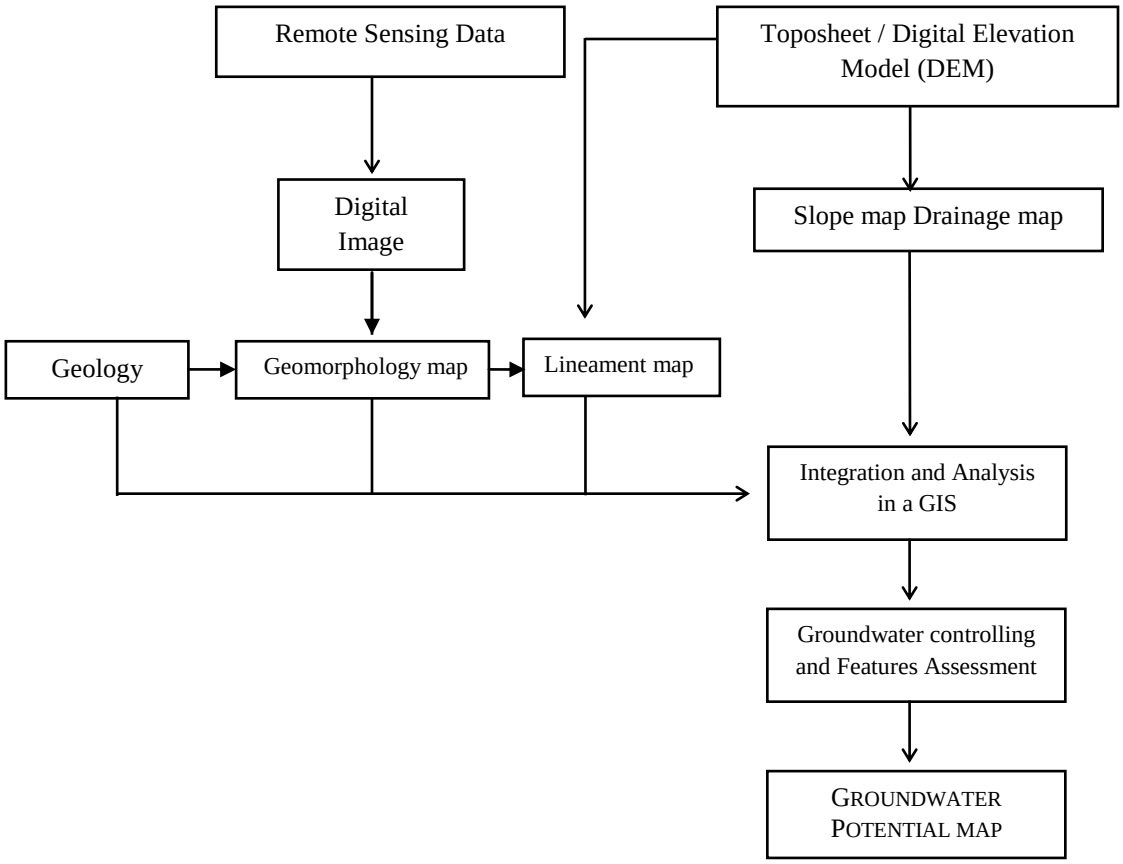

Figure 2 Flow chart for the groundwater potential zones using GIS technique

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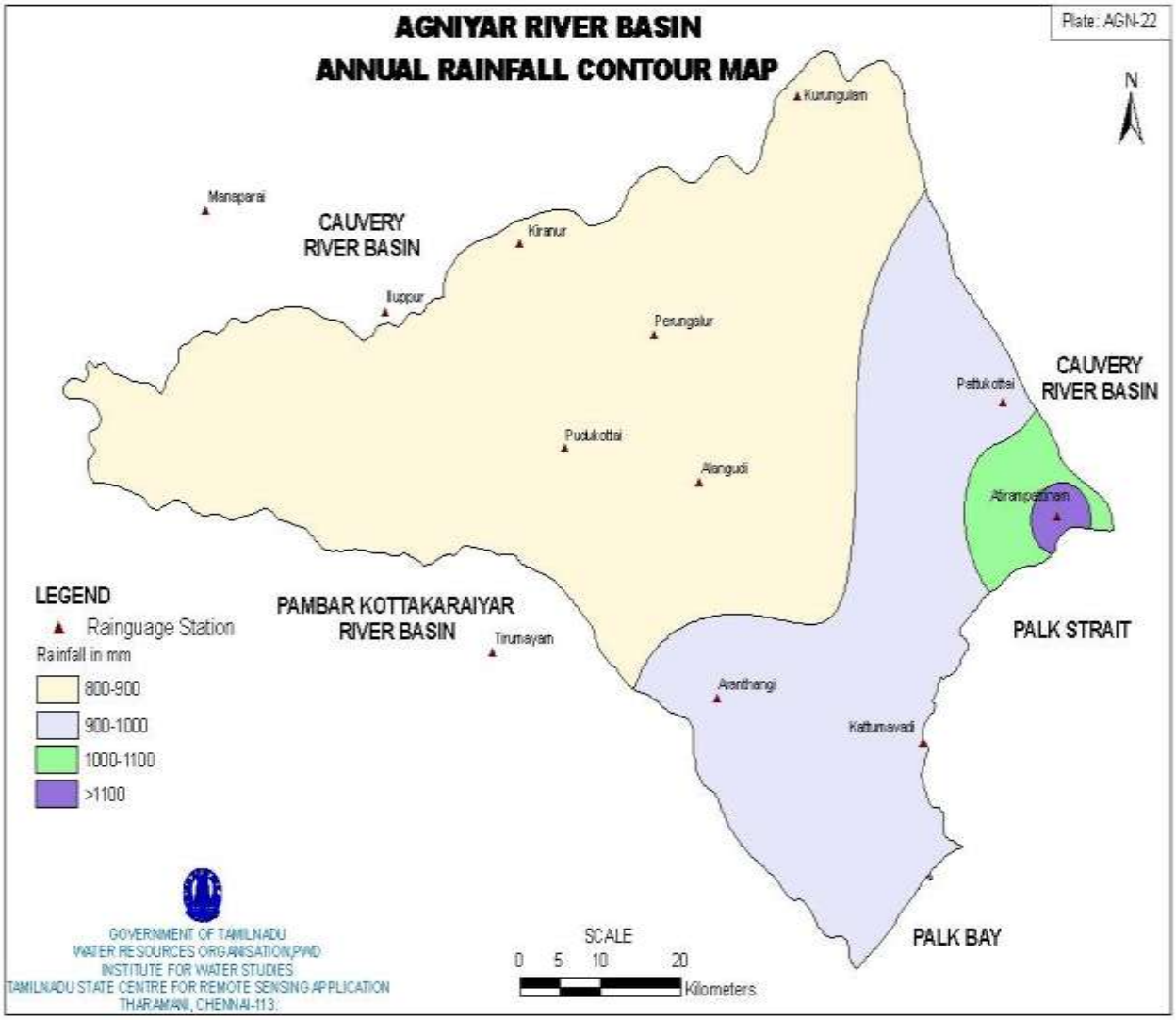

Figure 3. Annual rainfall of Agniyar river basin

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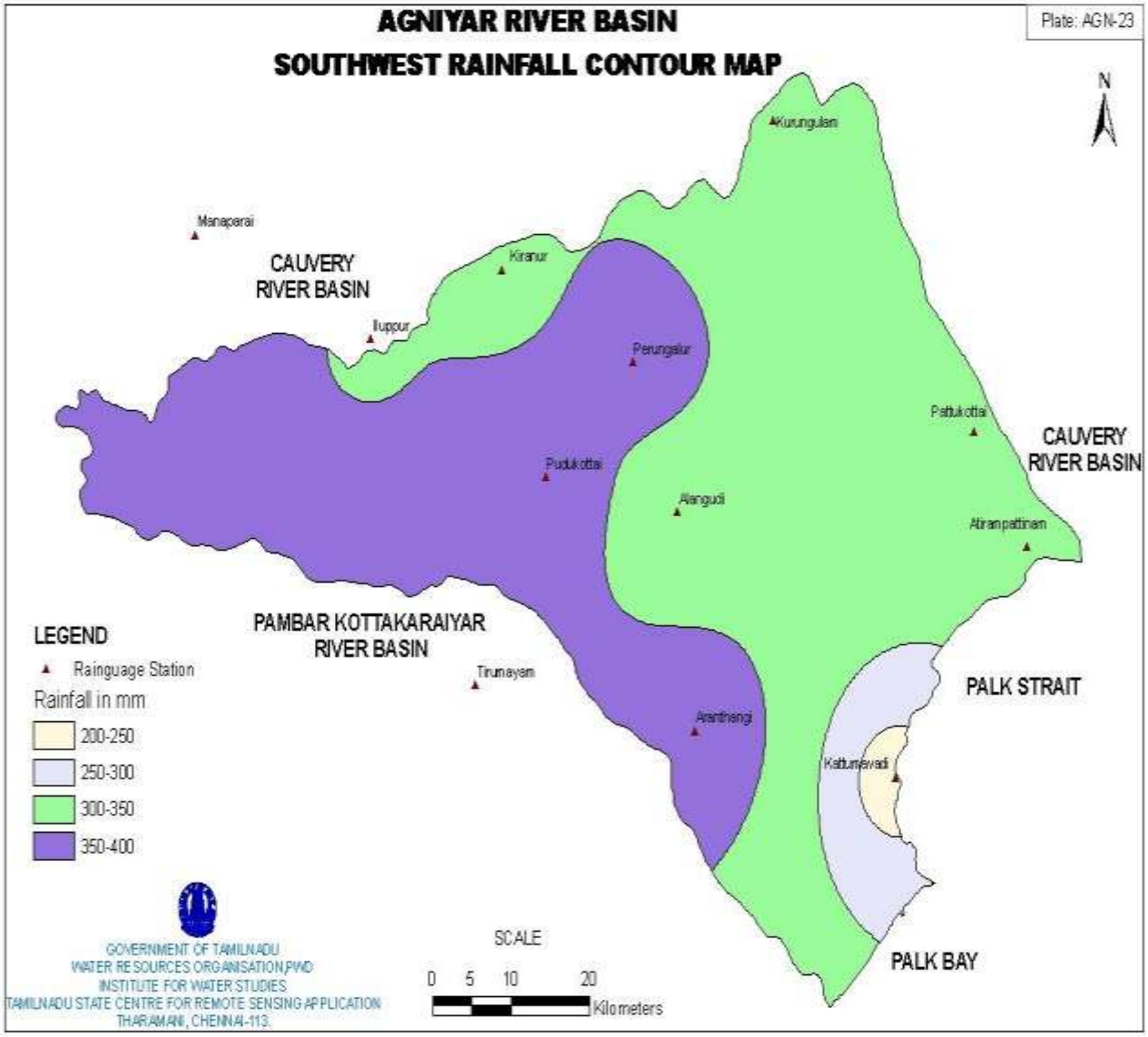

Figure 3 (a) Southwest rainfall of Agniyar river basin

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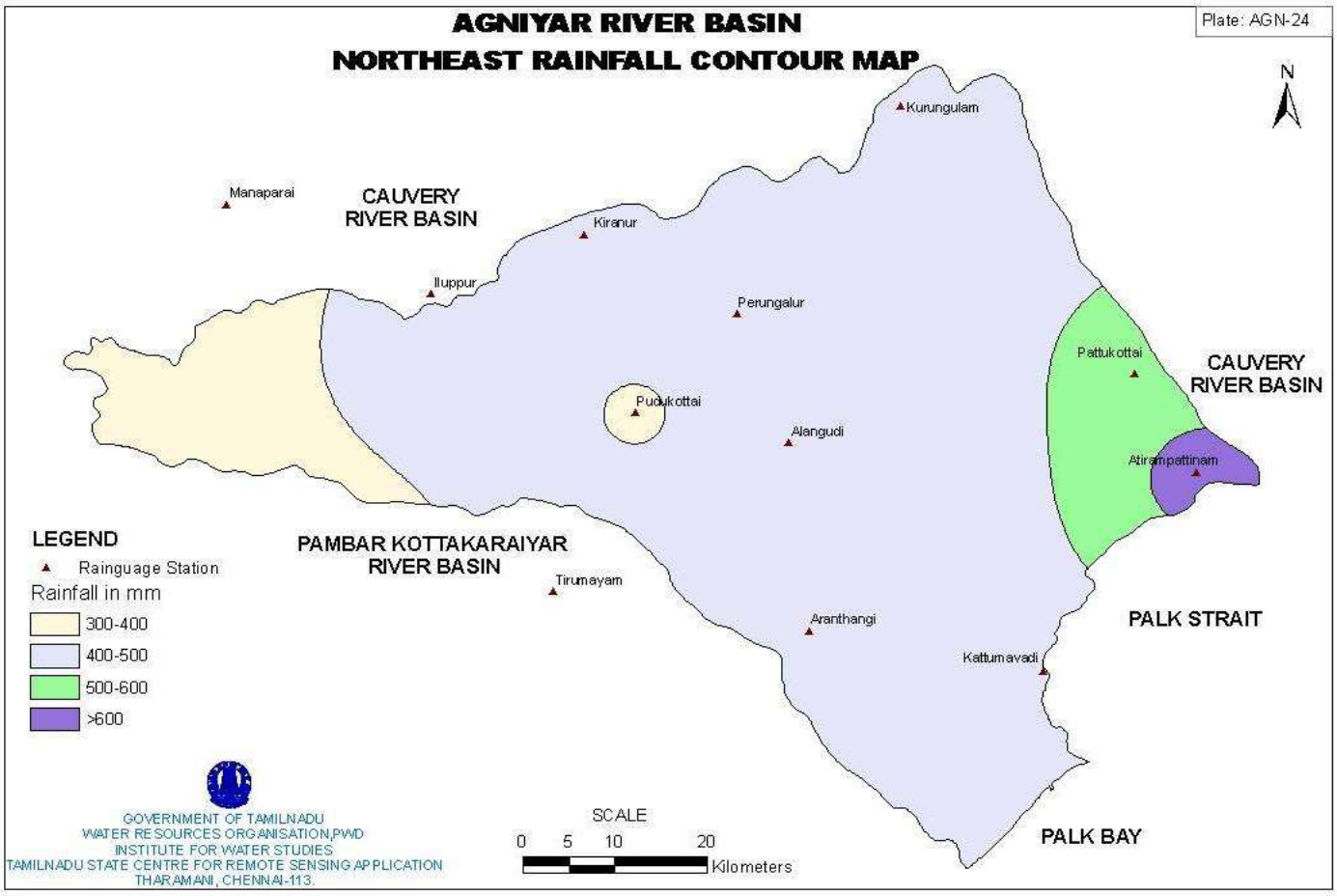

Figure 3 (b) Northeast rainfall of Agniyar river basin

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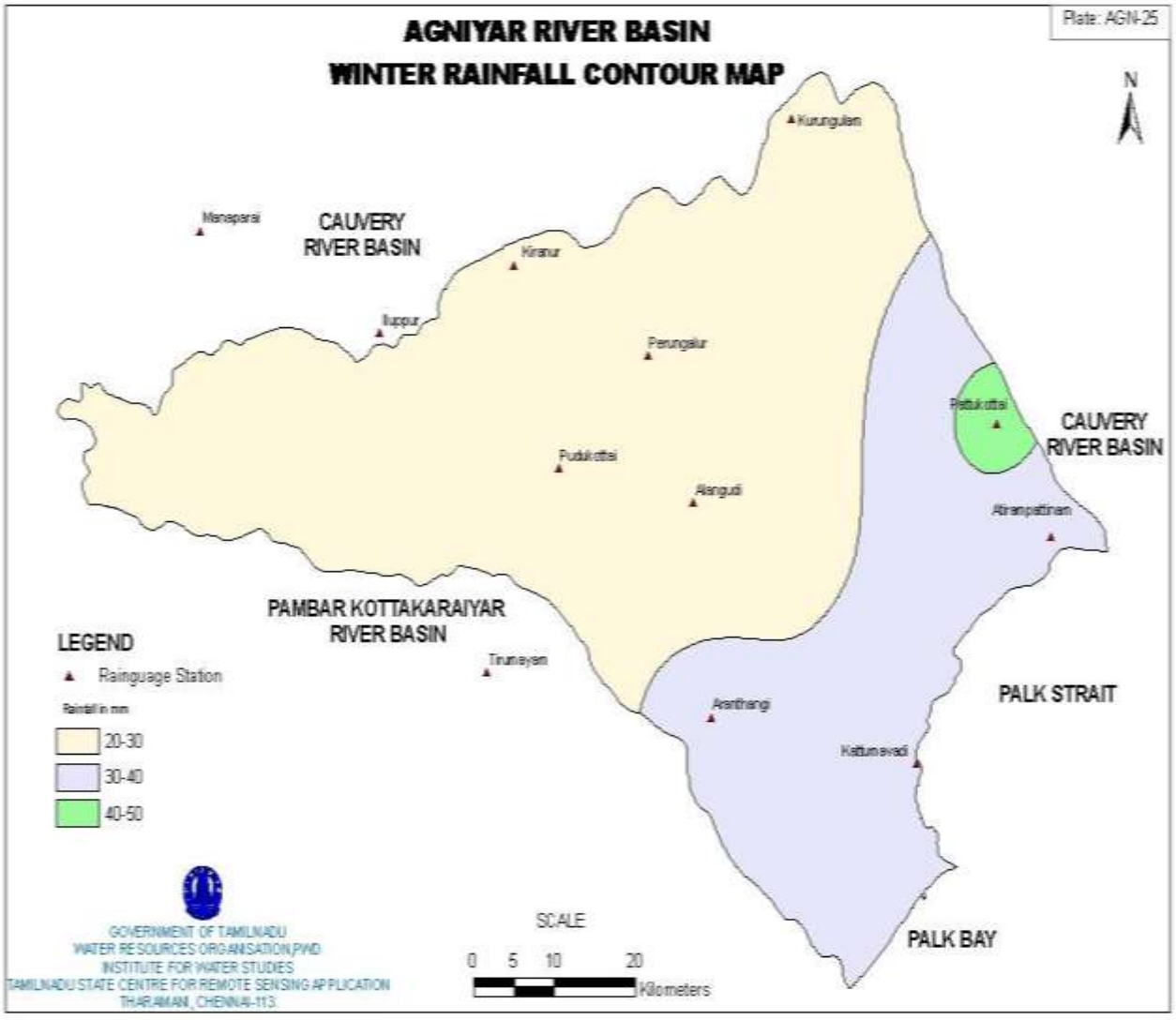

Figure 3 (c) Winter rainfall of Agniyar river basin

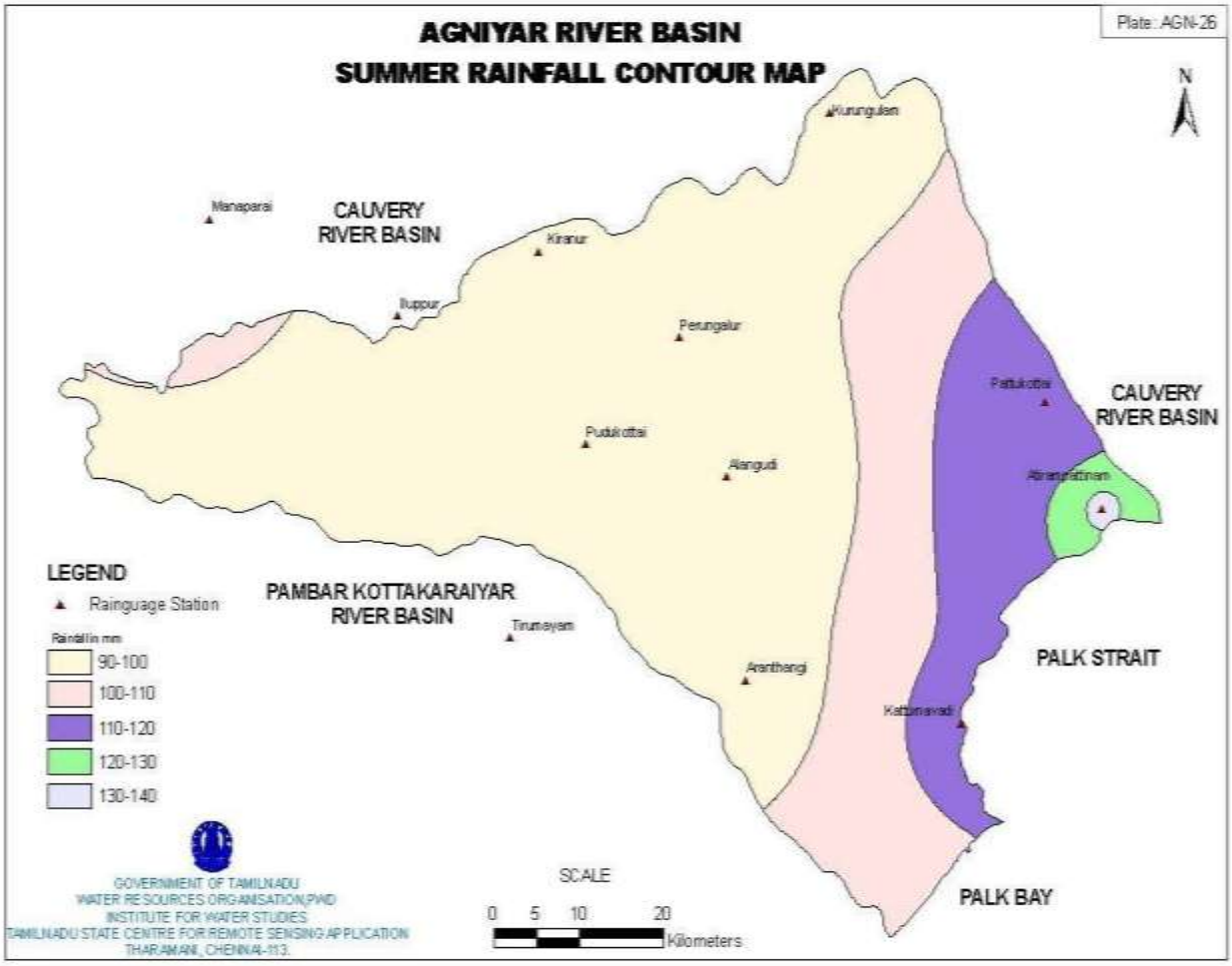

Figure 3 (d) summer rainfall of Agniyar river basin

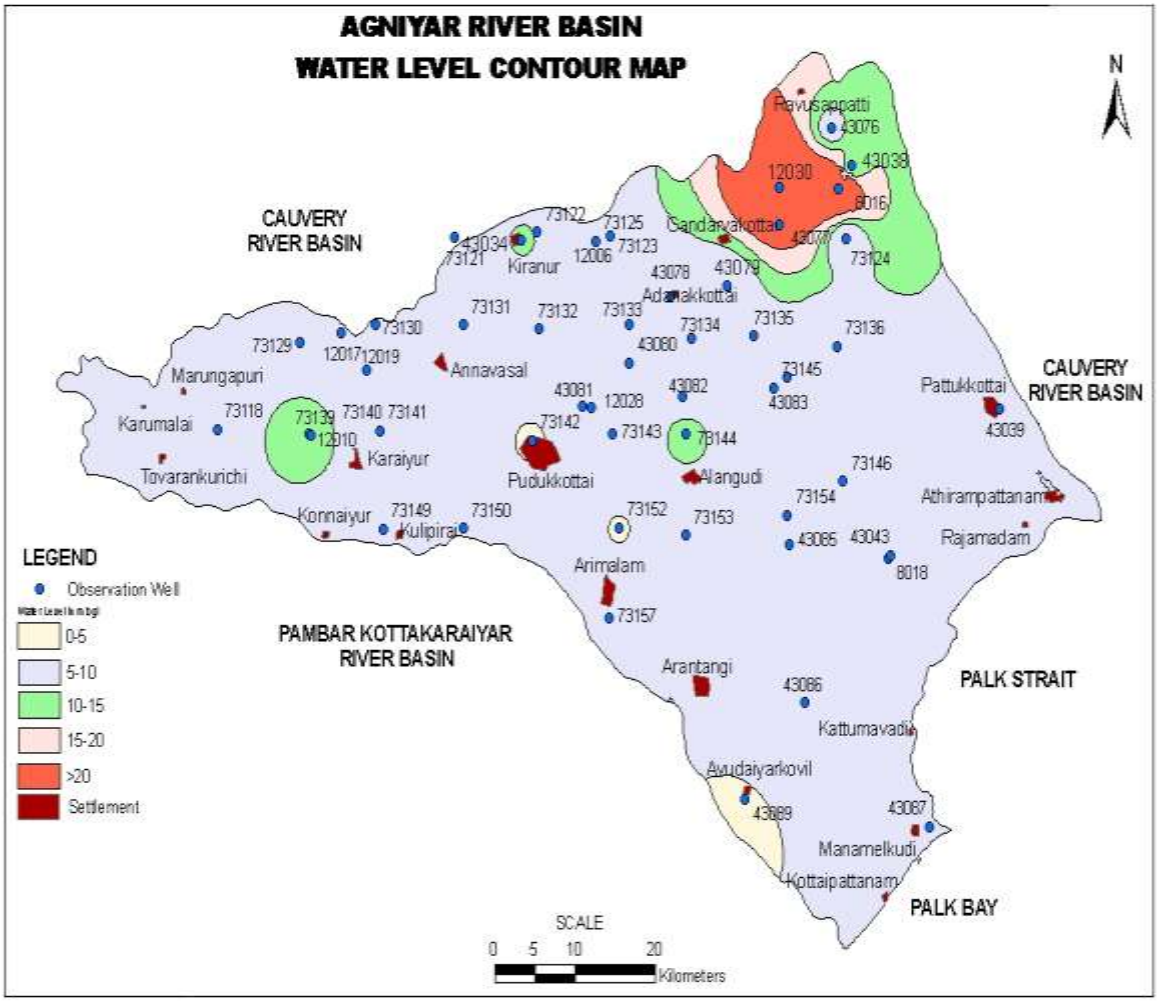

Figure 3 (e) Groundwater table (July-2013)

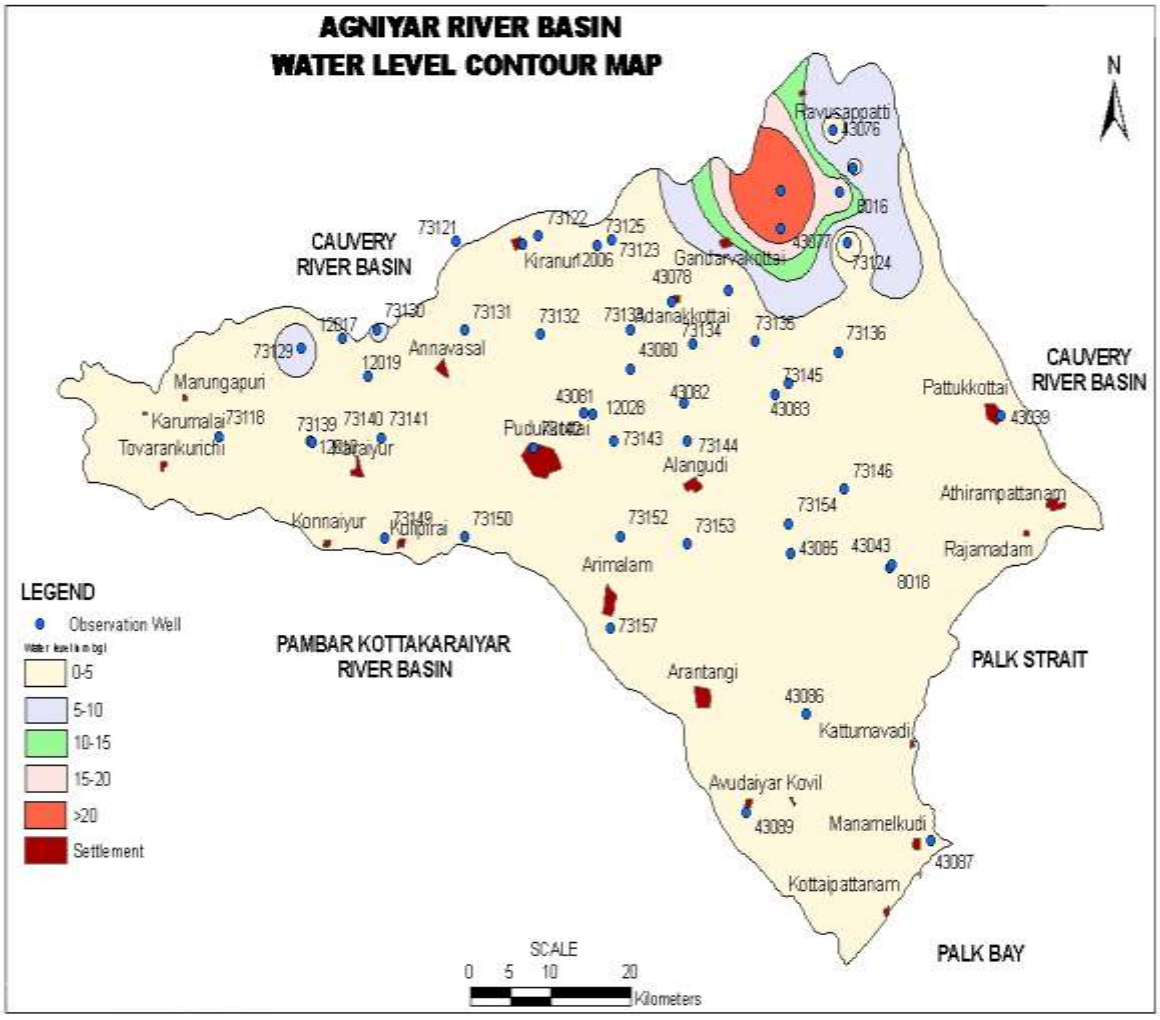

Figure 3 (f) Groundwater table (January-2014)

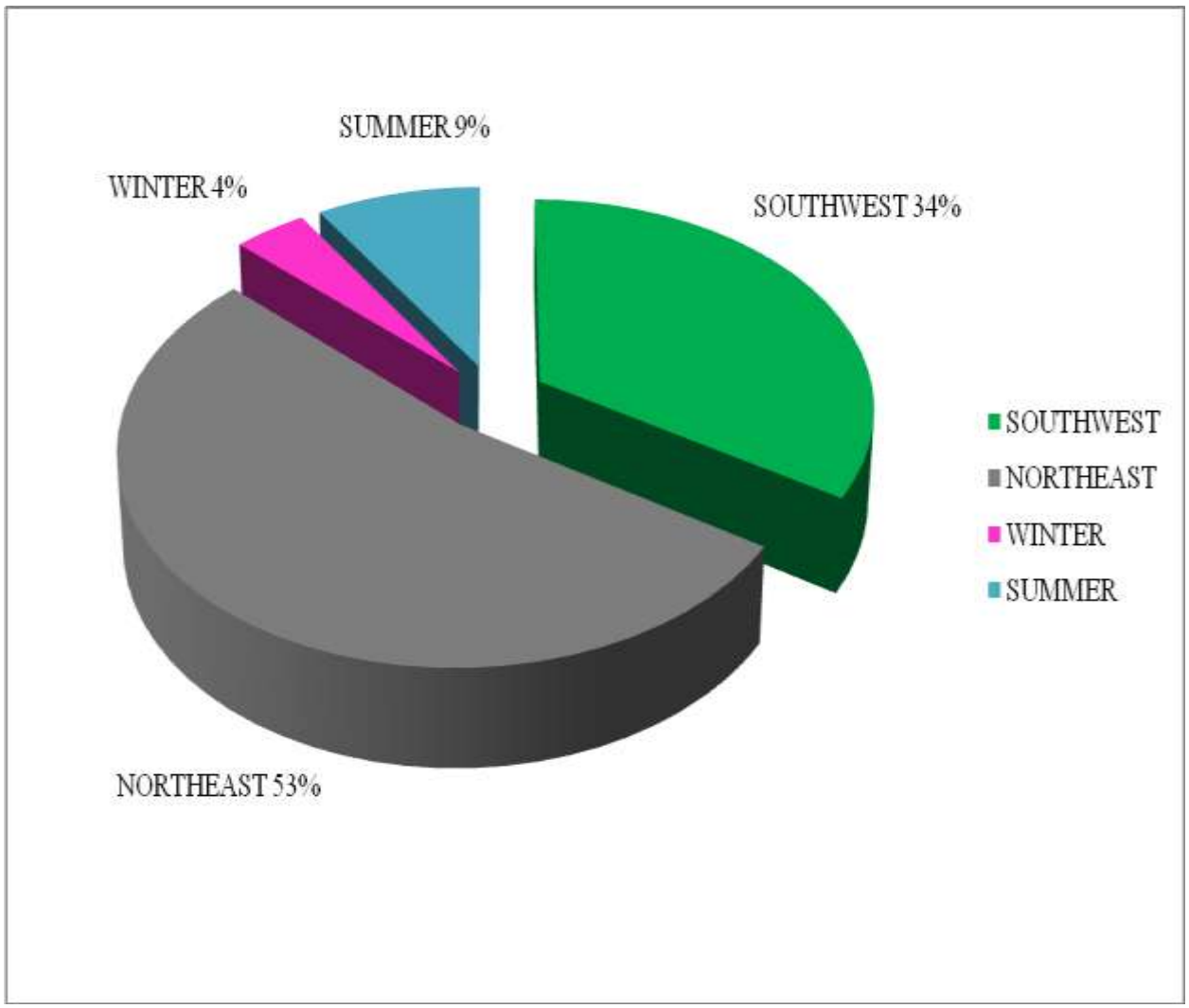

Figure 3 (g) Seasonal rainfall distributions in Agniyar river basin

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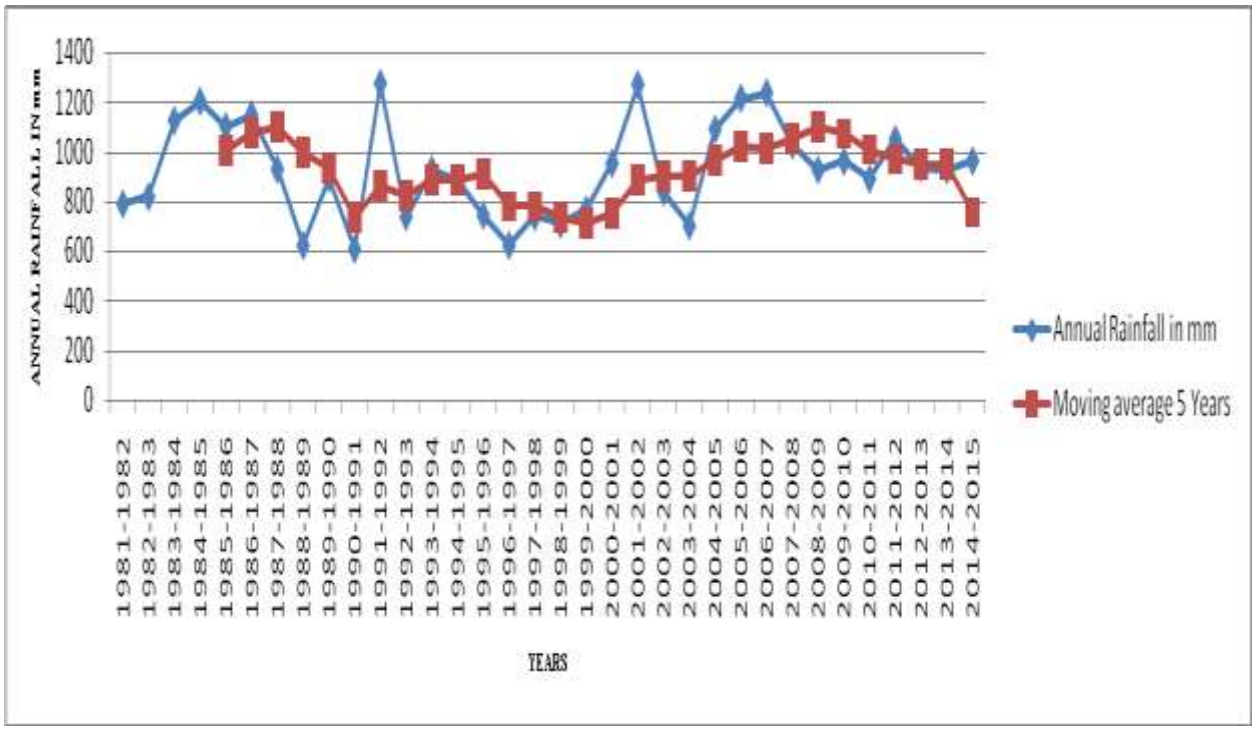

Figure 3 (h) Annual rainfalls in Agniyar sub basin

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Sl. No	Sub Basin	Raingauge Stations	Raingauge Stations Area	Sub basin Area in Sq.km	Weight in %	Annual average weighted rainfall for the sub basin in mm
1	Agniyar	Adiramapattinam	167.12	2057.85	0.083	926.5
		Alangudi	230.81		0.111	
		Iluppur	6.35		0.004	
		Kattumavadi	0.24		0.000	
		Keeranur	190.98		0.095	
		Kurungulam	416.76		0.208	
		Pattukkottai	497.52		0.247	
		Perungalur	455.15		0.224	
		Pudukkottai	92.92		0.042	
2	Ambuliyar	Adiramapattinam	7.28	717.87	0.015	903.7
		Alangudi	296.36		0.417	
		Aranthangi	171.23		0.234	
		Kattumavadi	220.57		0.302	
		Pattukkottai	13.72		0.015	
		Pudukkottai	8.71		0.017	
3	South Vellar	Alangudi	47.24	1887.43	0.020	905.2
		Aranthangi	312.92		0.162	
		Iluppur	508.35		0.268	
		Kattumavadi	334.74		0.176	
		Keeranur	3.65		0.004	
		Pudukkottai	307.32		0.164	

		Thirumayam	122.25		0.067	
		Manaparai	250.96		0.132	
		Total Area	**4663.15**	**4663.15**		

Table 3 (a) Influencing raingauge stations of each sub basin

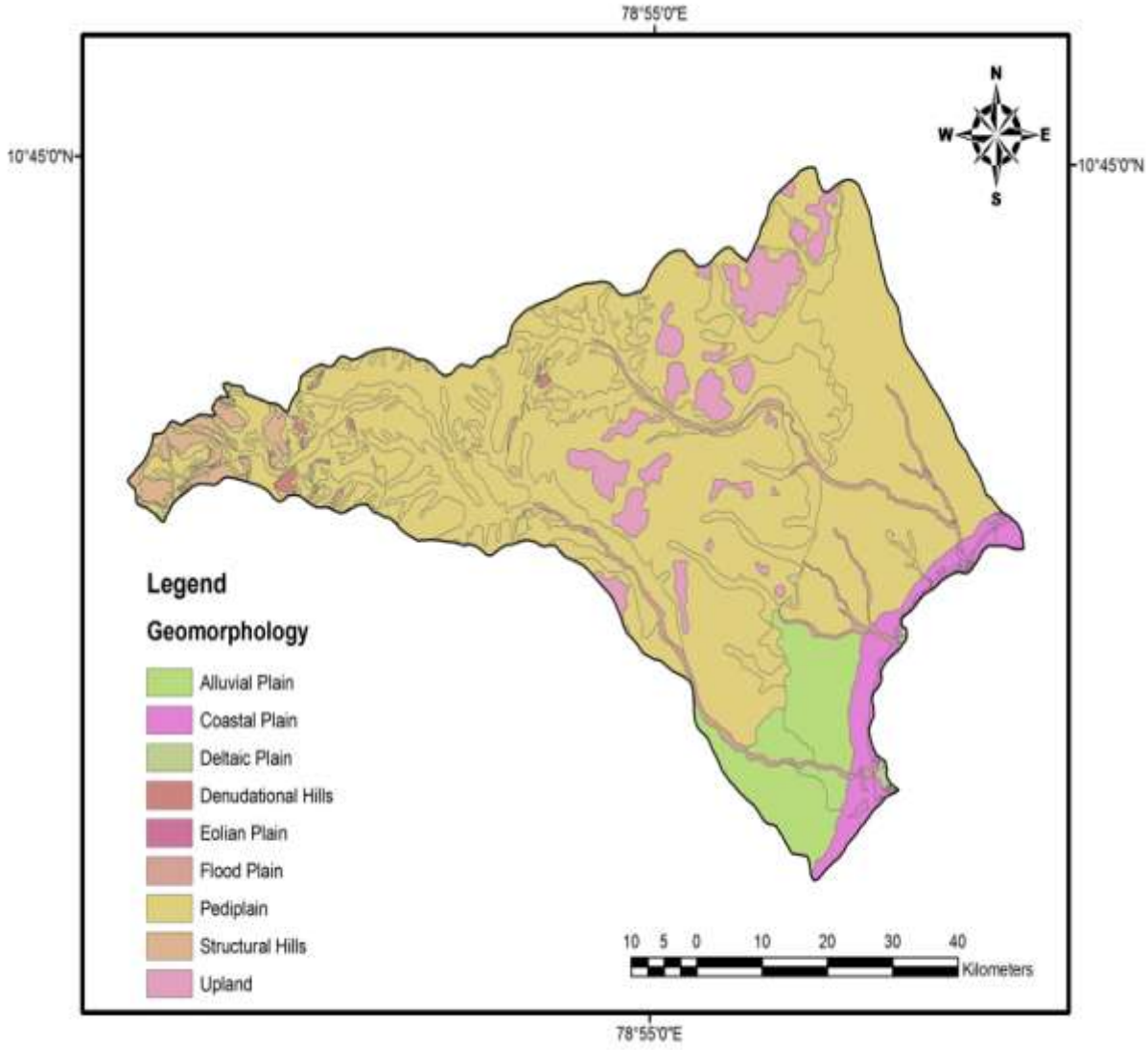

Figure 3.1 Geomorphology map of Agniyar river basin

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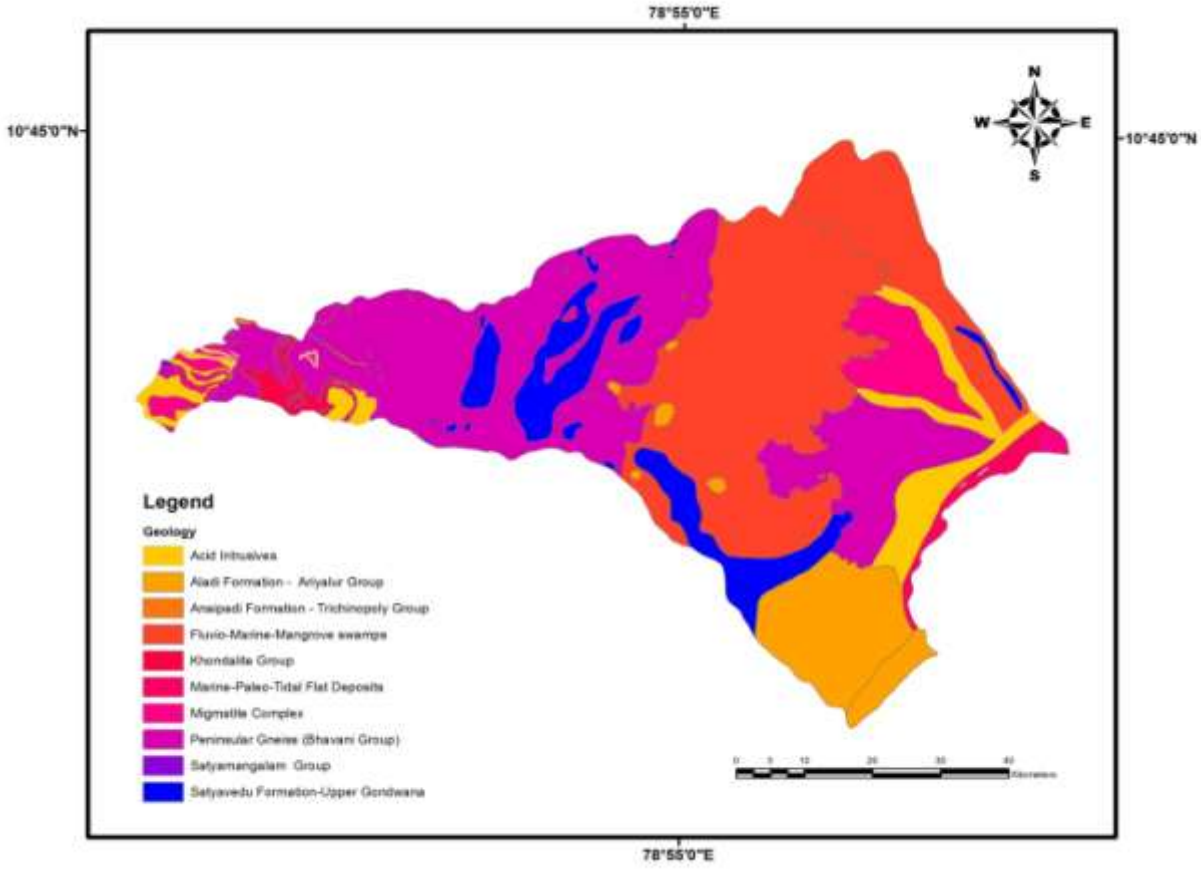

Figure 3.2 Geology map of Agniyar river basin

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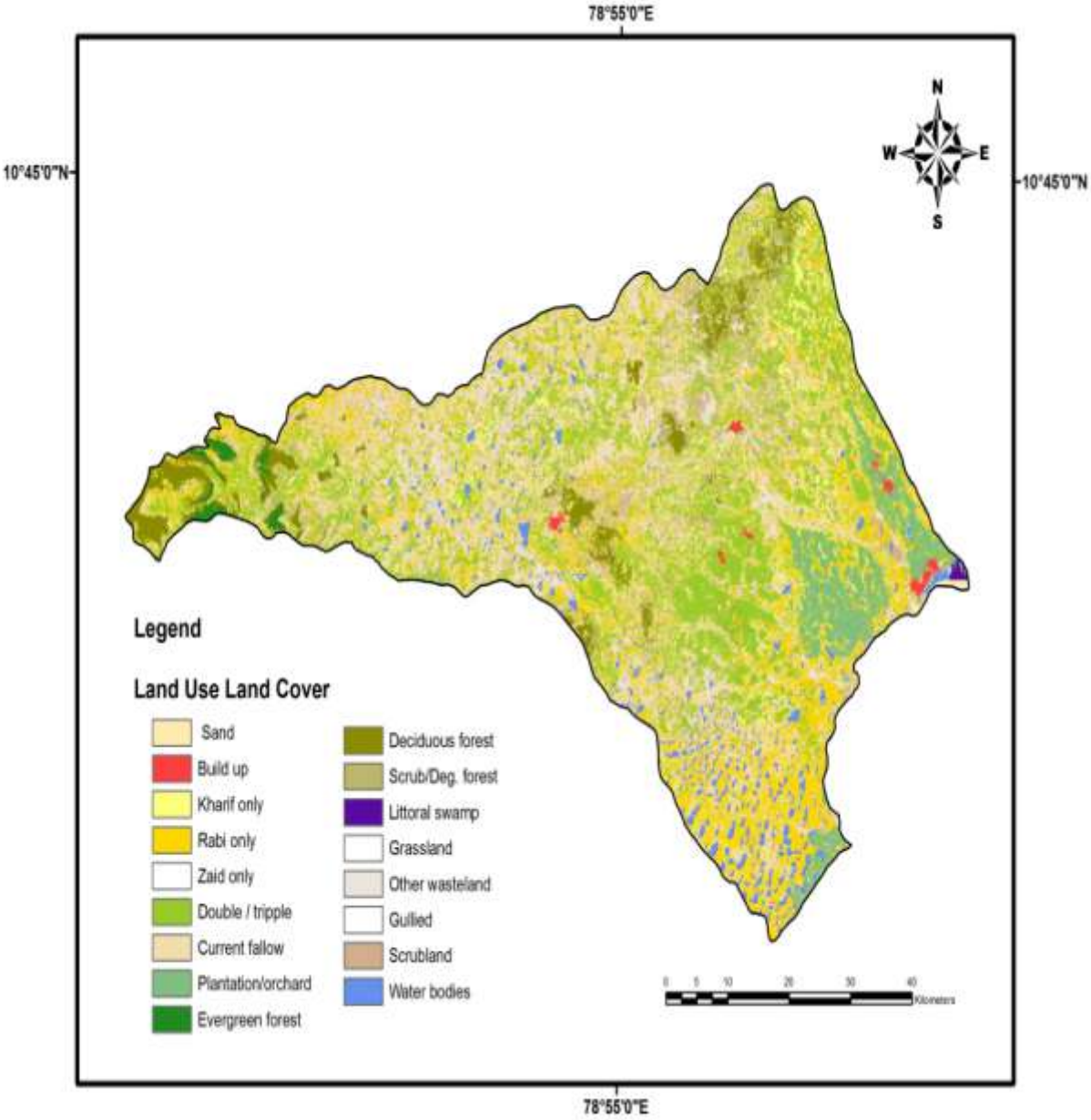

Figure 3.3 Land use / Land cover map of Agniyar river basin

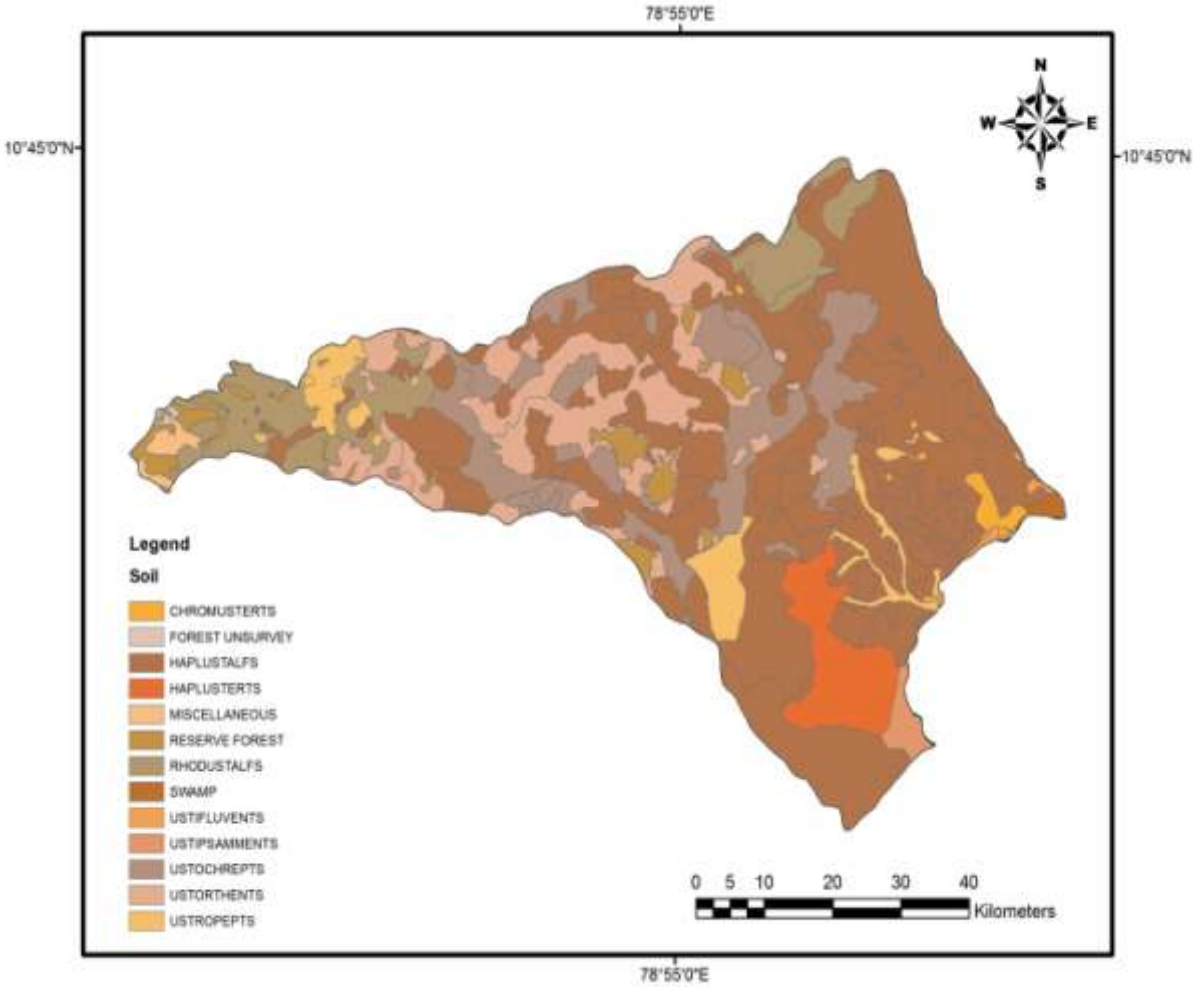

Figure 3.4 Soil map of Agniyar river basin

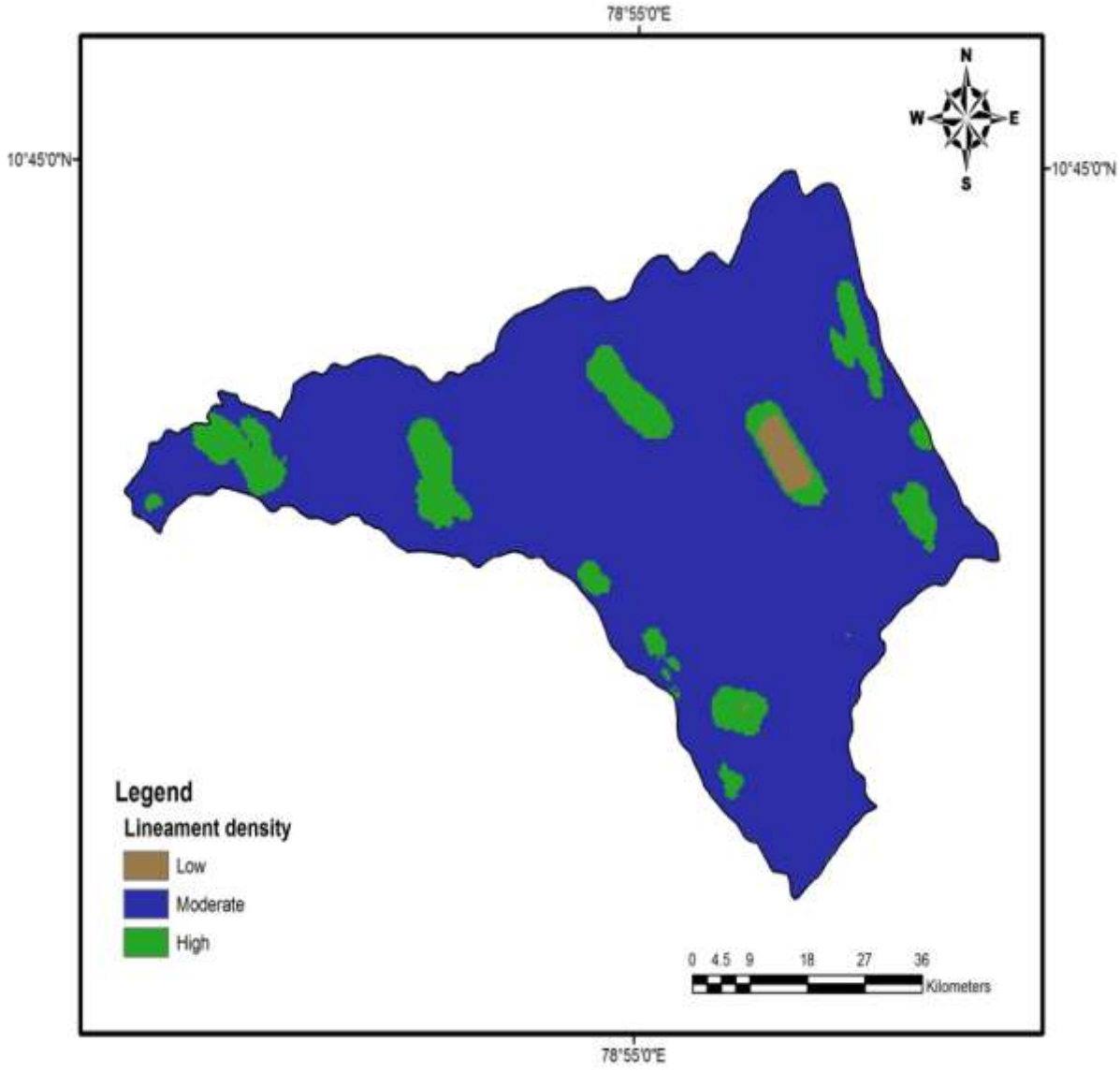

Figure 3.5 Lineament density map of Agniyar river basin

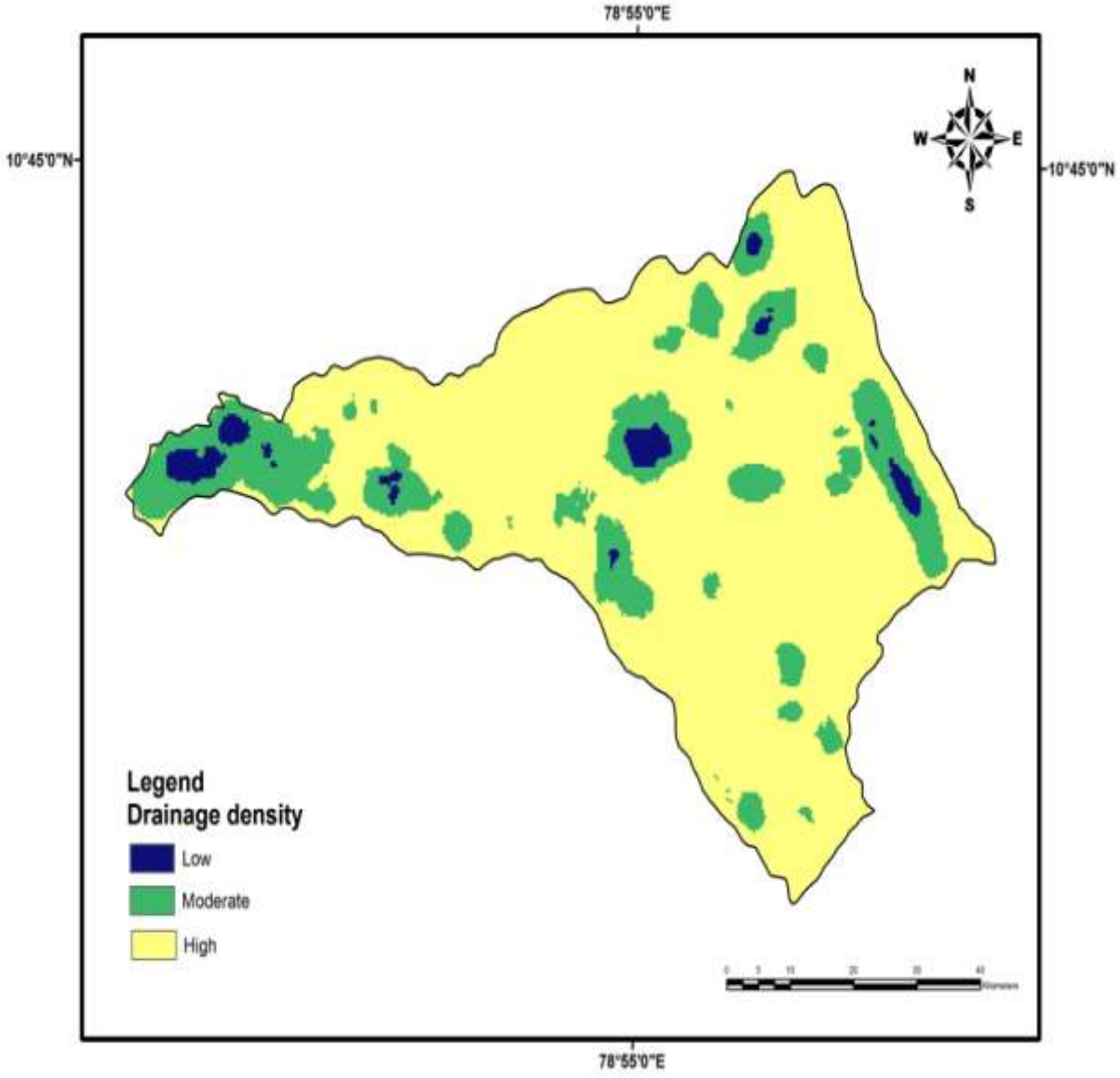

Figure 3.6 Drainage density map of Agniyar river basi

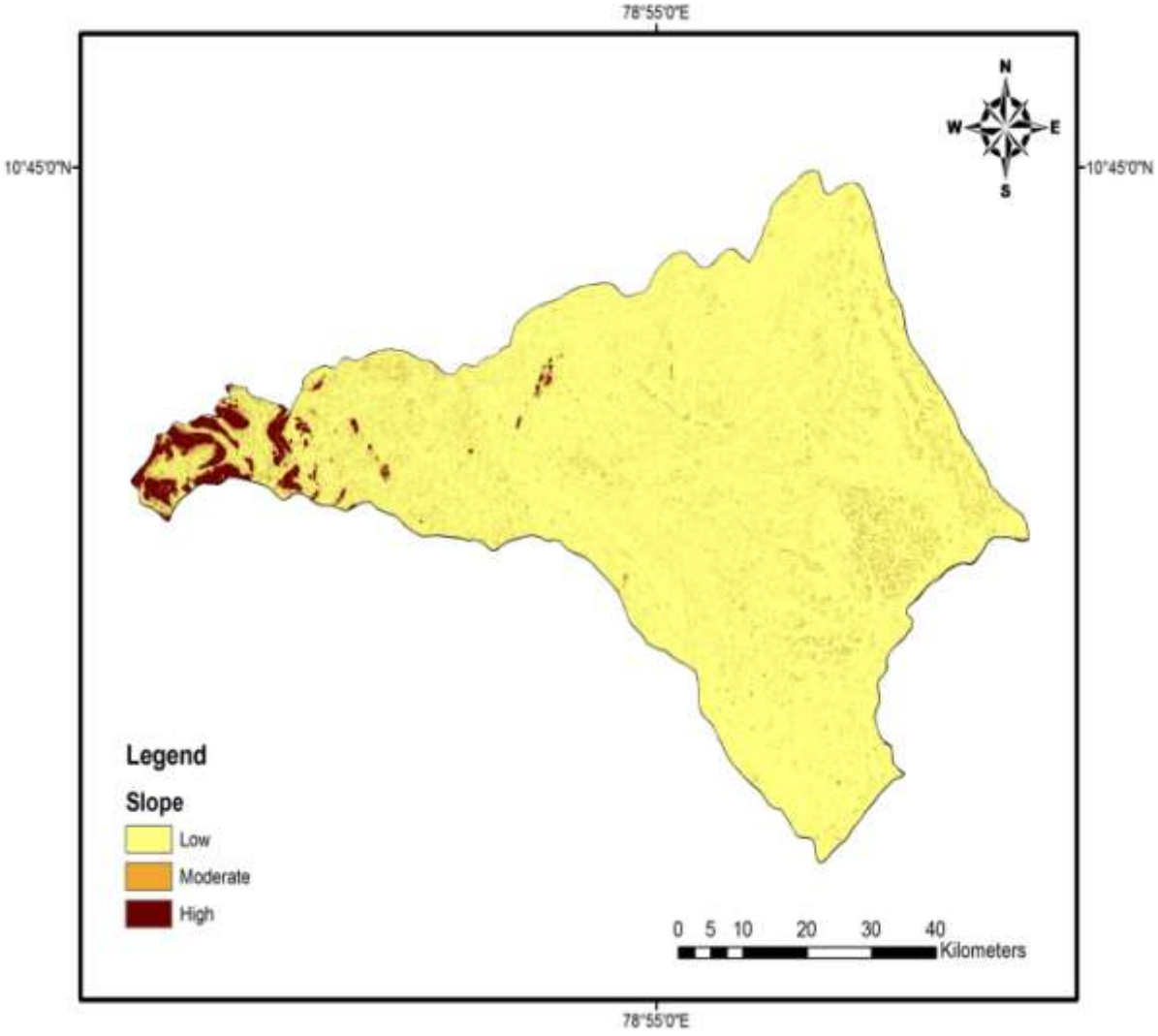

Figure 3.7 Slope map of Agniyar river basin

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Impact Factor: 7.624

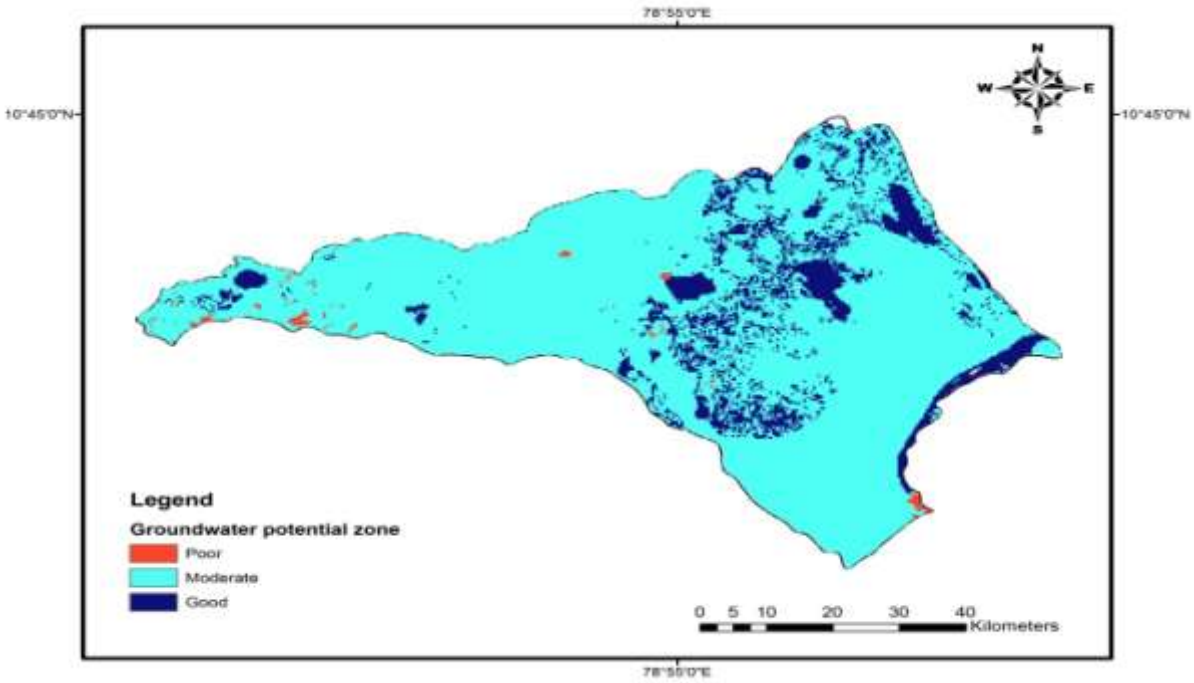

Figure 3.8 Groundwater potential zoning map of Agniyar river basin