Integrated Remote Sensing and GIS for Groundwater Exploration and Detection of Non-Natural Recharge Sites

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INTRODUCTION

- Water is the elixir of life, a precious gift of nature to mankind and other species in the earth.
- It has been established that the total quantity of water on this planet is constant though it may be constantly under movement and changing from one physical state to another as depicted in the hydrological cycle and man has not found out ways of **creating** more water.
- Thus the total availability is fixed and the present problem is to identify the existing resources and their proper utilisation.
- Economical extraction and intelligent utilsation of water resources are crucial in the development programme of any country.
- Even advanced countries possessing plentiful water resources have started realising the need for careful planning in the conservation, utilisation and management of water.

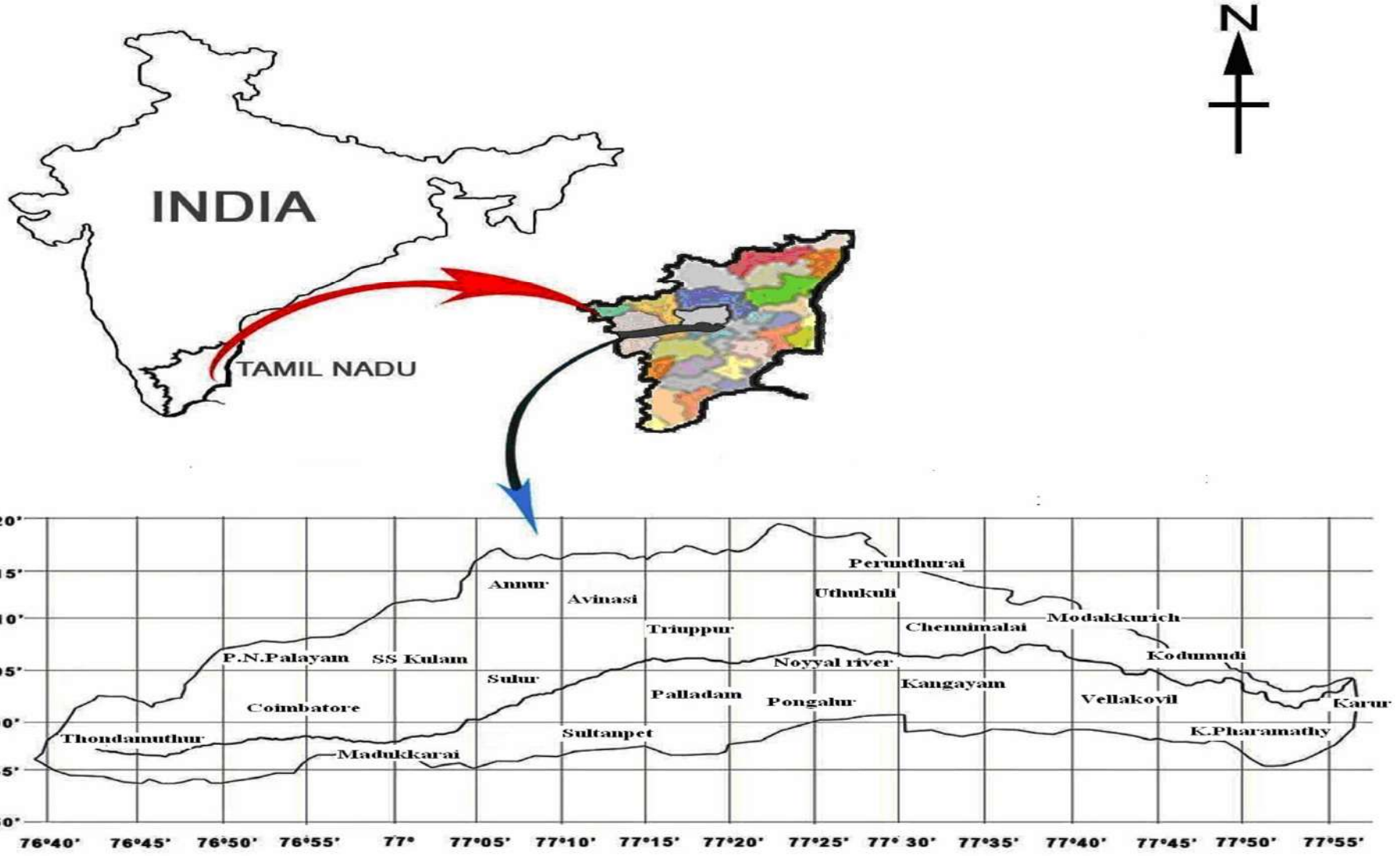
Our water sources are under pressure.


IT’S TIME TO GIVE
WATER A SERIOUS

Cont.

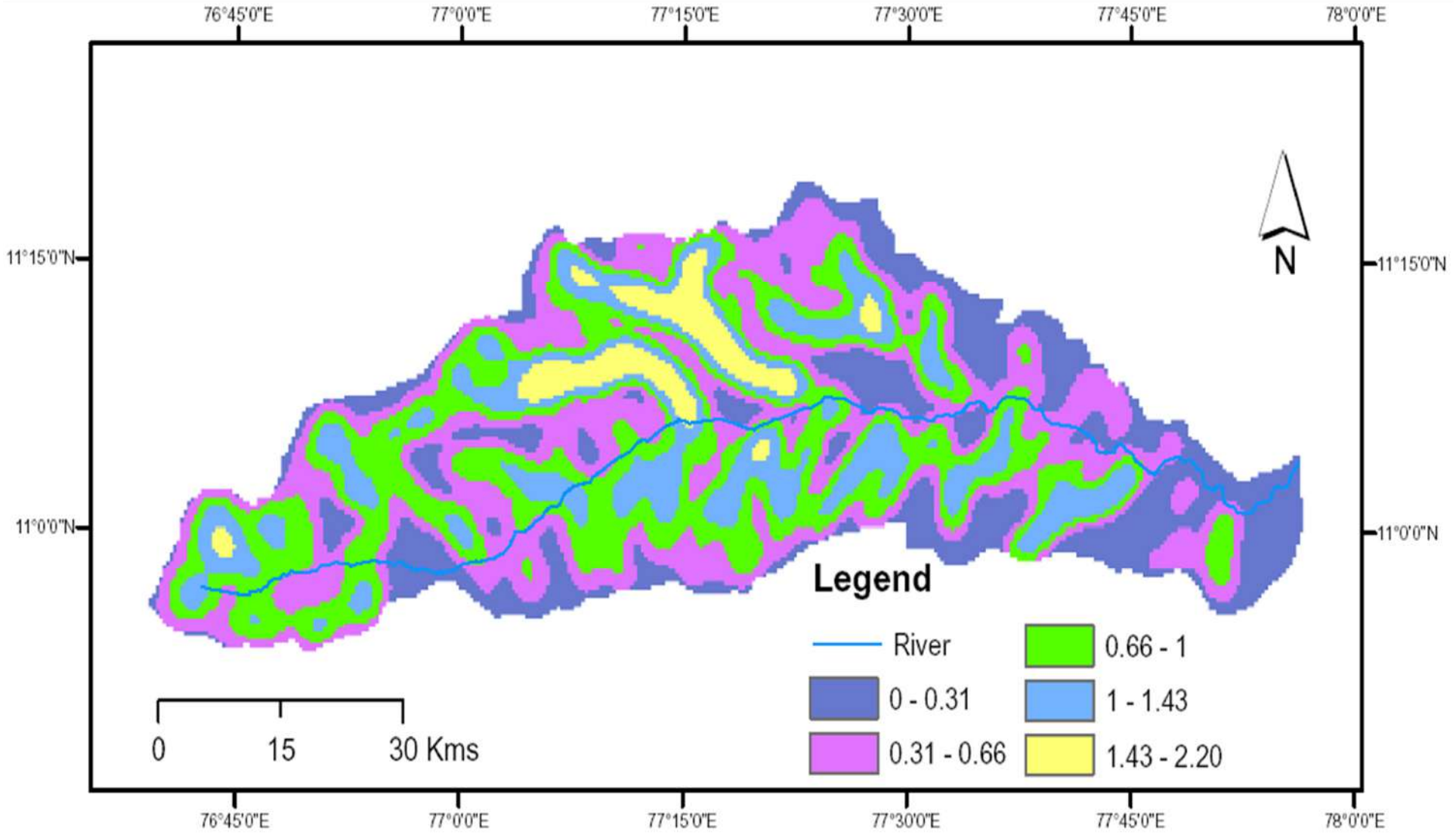
- The population and area of Tamil Nadu is 7% and 4% of the country respectively. But the available water resources is only 3% of the country.
- The average rainfall is 925 mm against the average rainfall of 1170 mm of the country.
- It varies from 1200 mm near coastal area to 550 mm in inland area.
- In Tamil Nadu 34 rivers are flowing including minor rivers and river Cauvery is one among them.
- River Noyyal is a tributary of Cauvery and it is a seasonal river which has good flow only for short periods during the northeast and southwest monsoons.
- The nature of the river Noyyal is slowly deteriorating due to various man made hazards, which had altered the chemical properties of the groundwater.

Location Map of the Study Area

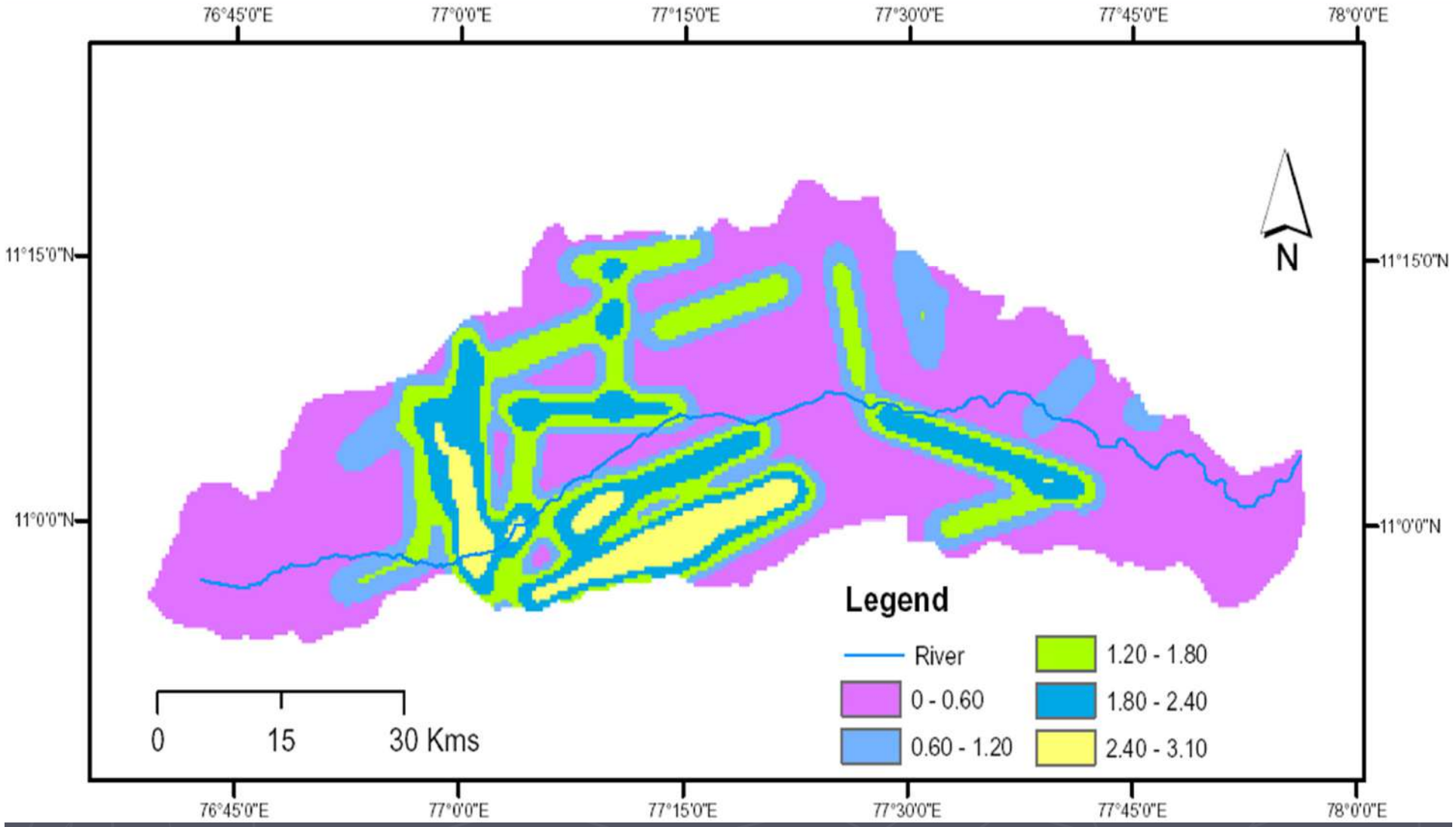


METHODOLOGY

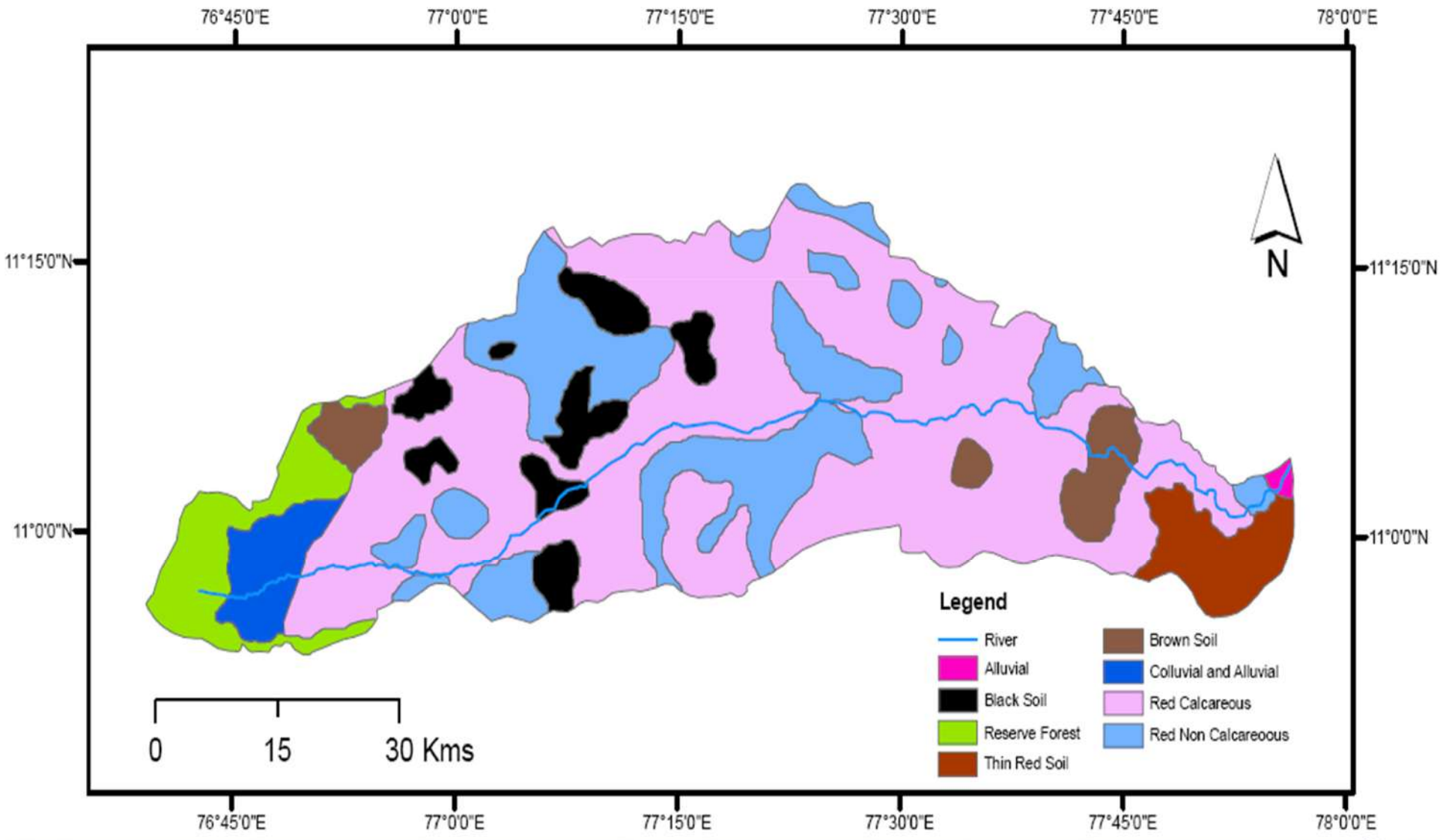
Drainage Density Map(km/km^2)



Lineament Density Map(km/km^2)



Soil Map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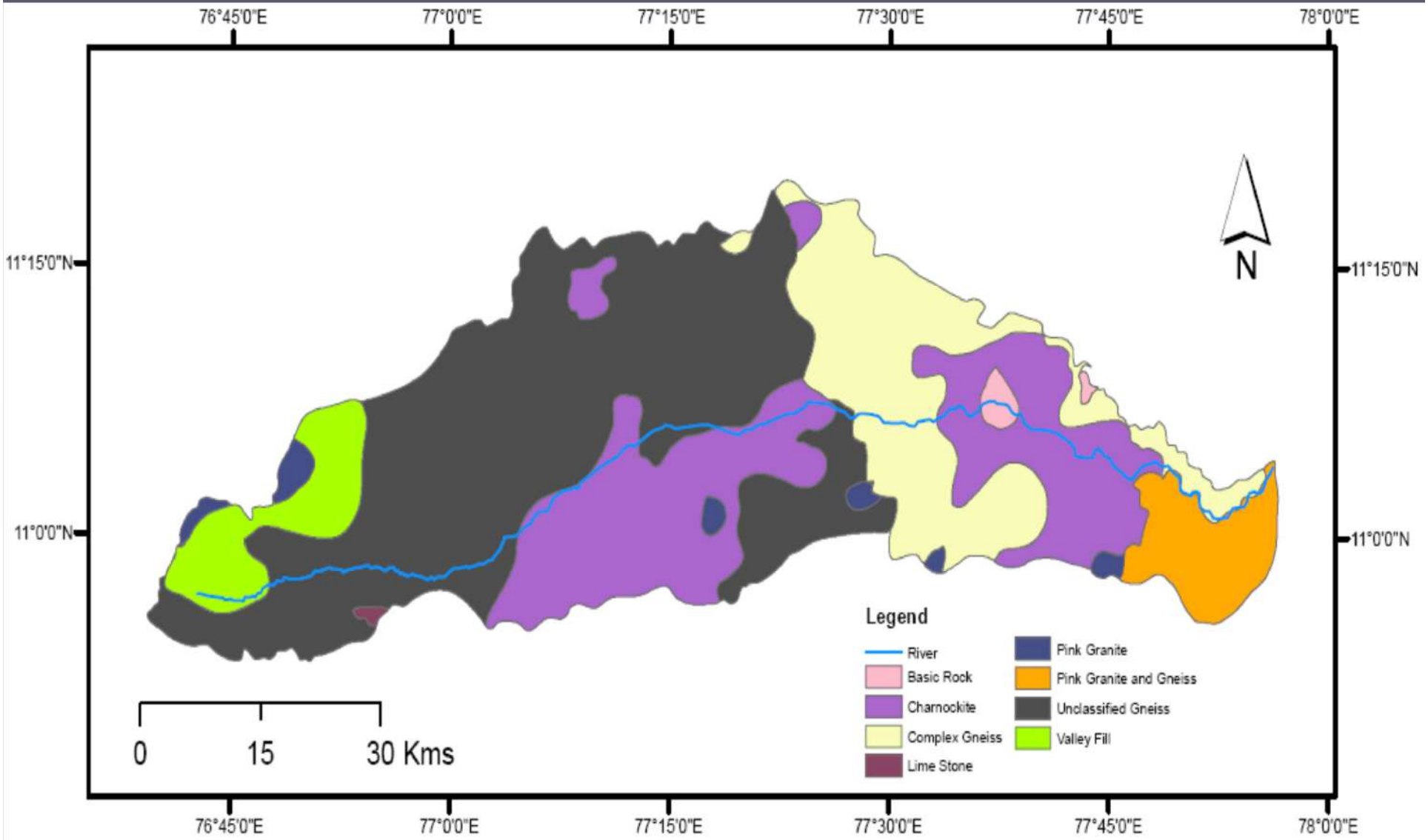
77°15'0"E
77°30'0"E
77°45'0"E
78°0'0"E
11°15'0"N
11°0'0"N
N
0
15
30 Kms
Legend
River
Alluvial
Black Soil
Reserve Forest
Thin Red Soil
Brown Soil
Colluvial and Alluvial
Red Calcareous
Red Non Calcareoous

Geology Map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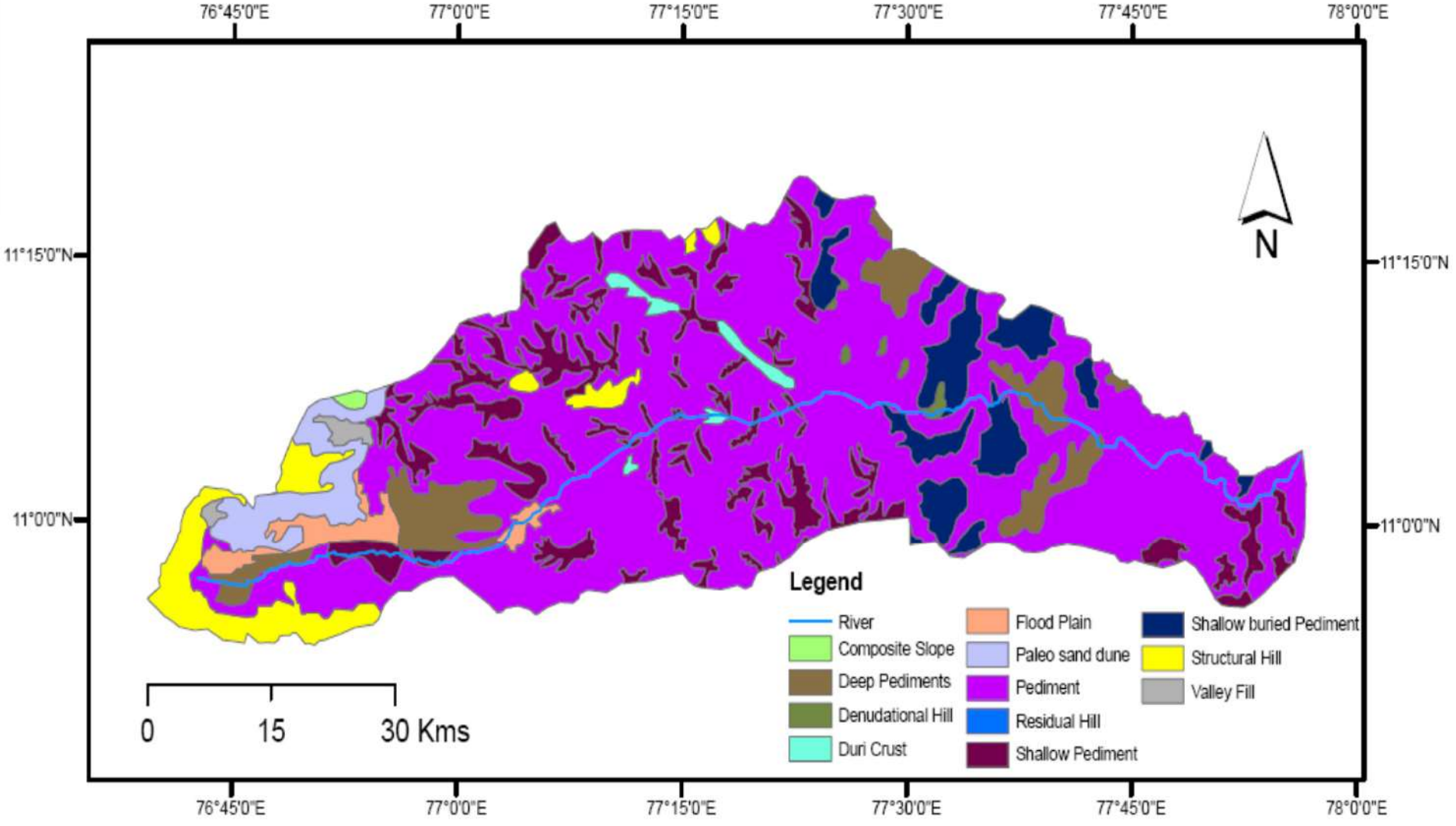
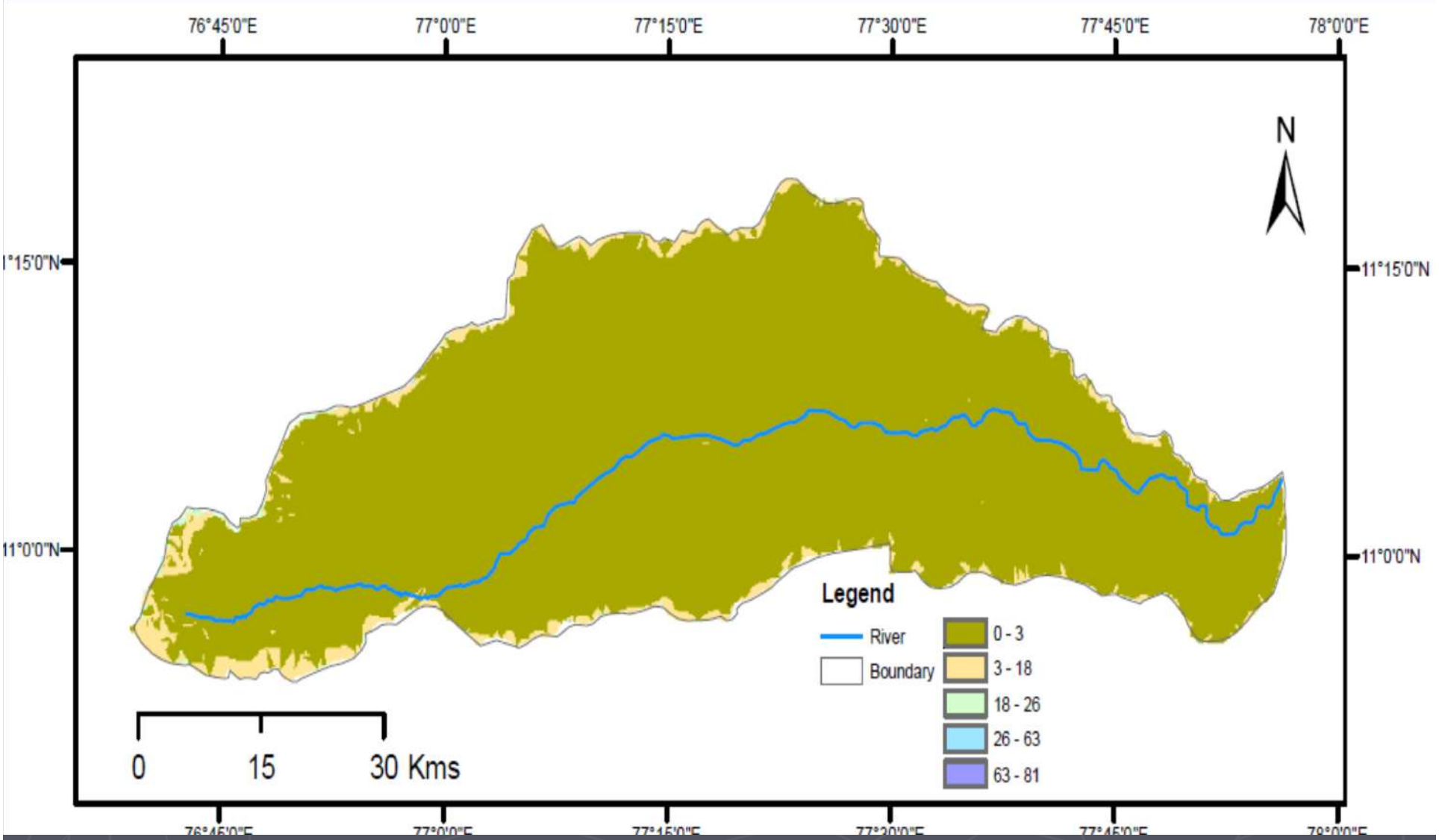
11°0'0"N
N
Legend
River
Basic Rock
Charnockite
Complex Gneiss
Lime Stone
Pink Granite
Pink Granite and Gneiss
Unclassified Gneiss
Valley Fill
0
15
30 Kms

Geomorphology Map



Slope Map


76°45'0"E
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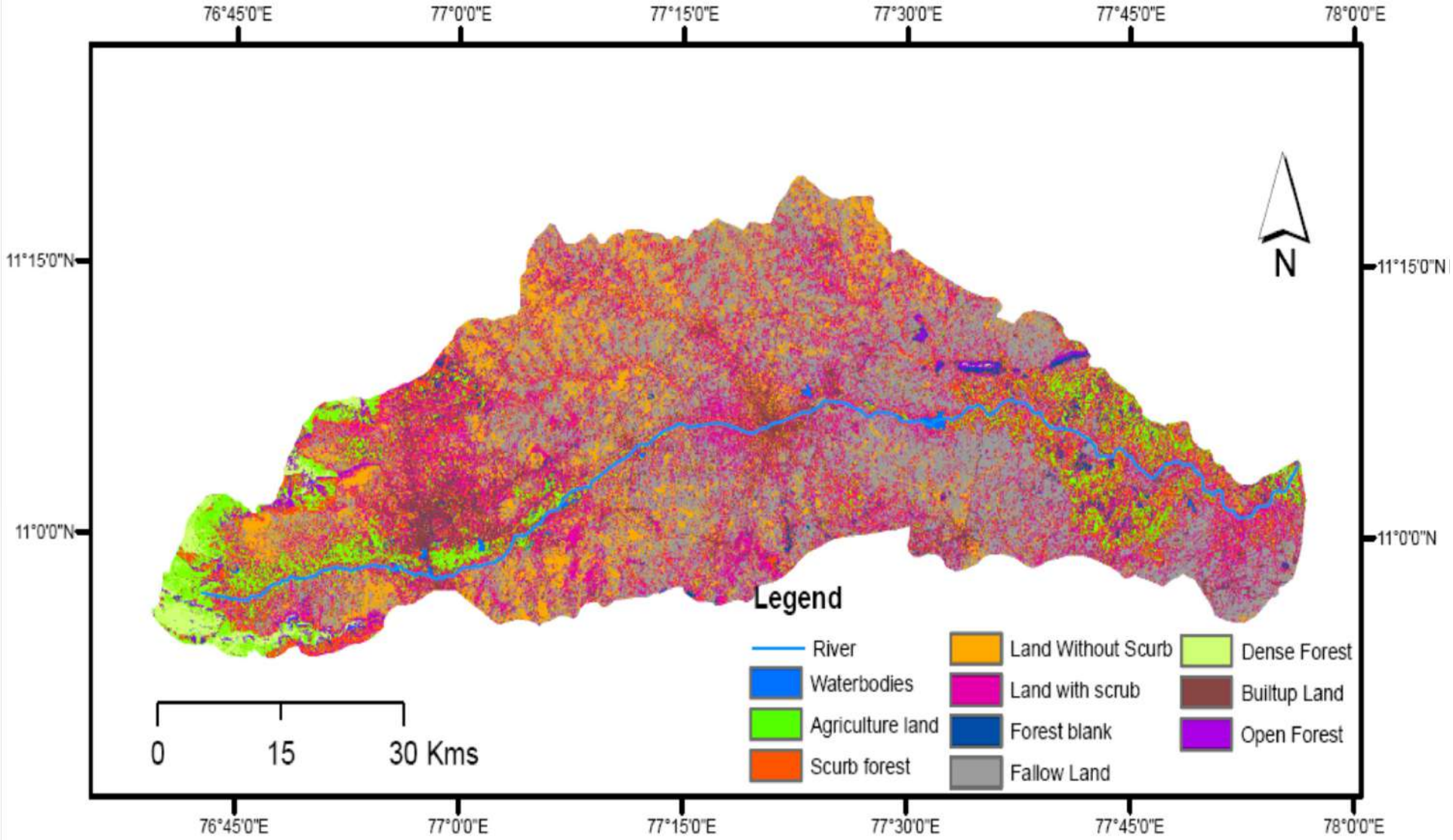
77°30'0"E
77°45'0"E
78°0'0"E
11°15'0"N
11°0'0"N
N
Legend
River
Boundary
0 - 3
3 - 18
18 - 26
26 - 63
63 - 81
0
15
30 Kms

Land Use/land Cover Classification



IDENTIFICATION OF GROUNDWATER POTENTIAL ZONES AND NON-NATURAL RECHARGE SITES BY USING GIS AND RS

- Remote sensing and Geographic Information System has become one of the leading tools in the field of hydrogeological science, which helps in assessing, monitoring and conserving groundwater resources.
- Analysis of remotely sensed data along with Survey of India topographical sheets and collateral information with necessary field checks helps in generating the base line information for groundwater targeting.
- The geology, geomorphology, slope, drainage density, lineament density and land use/land cover maps have been used for the preparation of groundwater potential zones
- The geology, geomorphology, slope, drainage density, lineament density, rainfall, water level and land use/land cover maps have been used for the preparation of Non-Natural recharge sites

WEIGHTED INDEX OVERLAY ANALYSIS

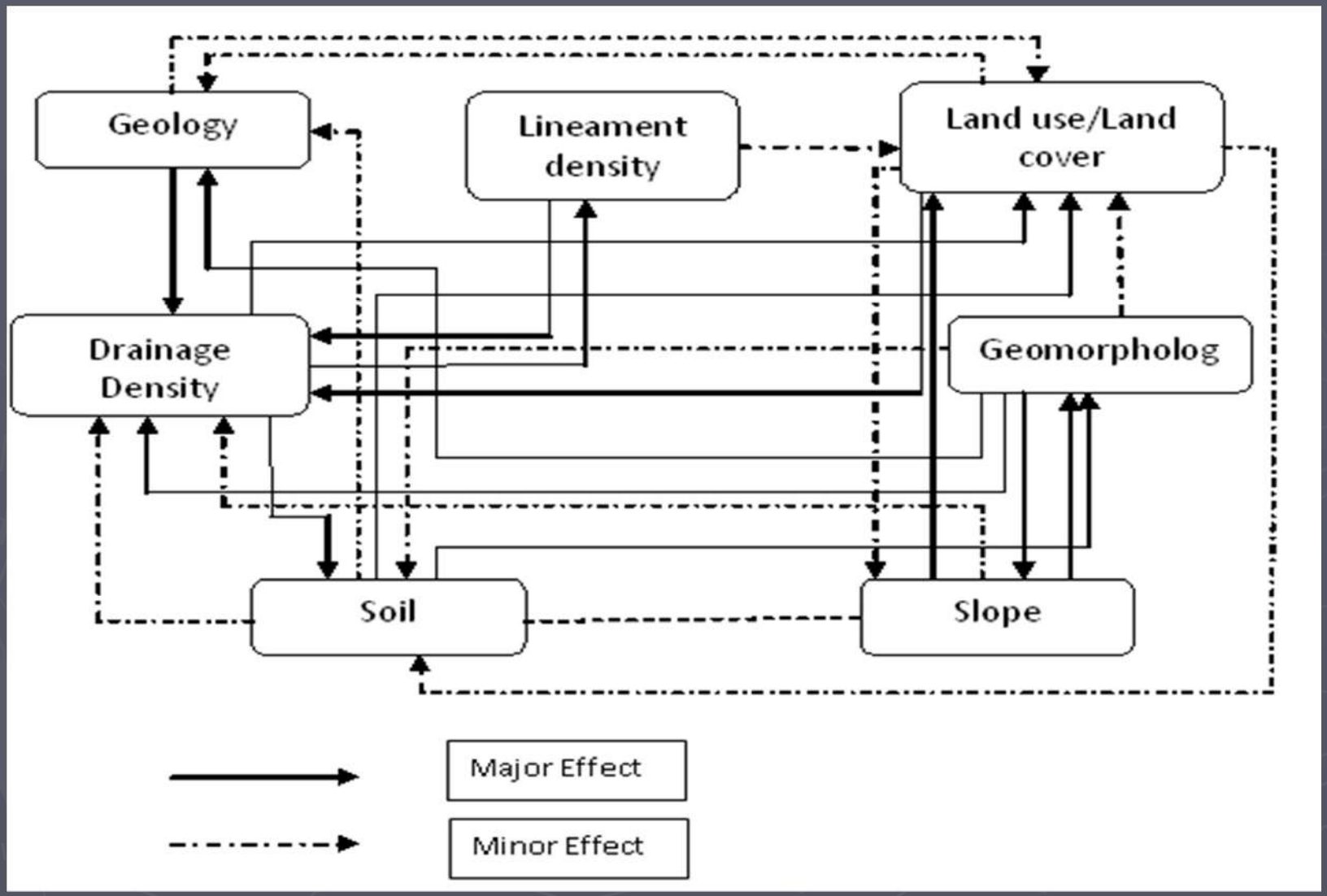
- The occurrence and movement of groundwater in an area is controlled by various factors. The influence of all factors need not be the same in the area. Therefore, each parameter was assigned a weightage depending on its influence towards the movement and storage of groundwater.

- The weightage for the major relationship between two factors was assigned 1 and the weightage for the minor relationship between two factors was assigned as 0.5. Finally, the total weight of each factor represents the weight for groundwater potential and Non-Natural recharge.

- The occurrence and movement of groundwater in an area is controlled by various parameters in each factors. The influence of all parameters need not be the same in the area. Therefore, each parameter is assigned a rank depending on its influence on the movement and storage of groundwater. The parameter has been categorised into five zones from groundwater potential and Non-Natural recharge point of view.

- The percentage influence for groundwater potential zone and the score of each recharge potential factors was calculated as 100 multiplied by the weight of the recharge potential divided by the total weight of the each recharege potential factor

- The final map has been categorized into five zones in which ranking 1 denotes poorly zone, 2 denotes moderately zone, 3 denotes moderate to good zone, 4 denotes good zone and 5 denotes very good zone for groundwater potential and Non-Natural recharge.


Geology
Lineament density
Land use/Land cover
Drainage Density
Geomorpholog
Soil
Slope
Major Effect
Minor Effect

Weightage Influence for Groundwater Potential

S.No	Factors	Major Relationship	Minor Relationship	Weightage
1	Geology	Drainage density, Lineament density	Land use/land cover	2.5
2	Lineament density	Drainage density,	Land use/land cover	1.5
3	Land use/land cover	Drainage density,	Slope, Geology, Soil	2.5
4	Geomorphology	Slope, Geology, Drainage density	Land use/land cover, Soil	4
5	Soil	Land use/land cover, Geomorphology	Geology, Drainage density	3
6	Drainage density	Land use/land cover, Slope		2
7	Slope	Land use/land cover, Geomorphology	Drainage density	2.5

Weightage Influence for Non-Natural Recharge Sites

S.No	Factors	Major Relationship	Minor Relationship	Weightage
1	Geology	Drainage density, Lineament density	Land use/land cover	2.5
2	Lineament density	Drainage density, Land use/land cove	Slope	2.5
3	Land use/land cover	Drainage density,	Slope, Geology, Soil	2.5
4	Geomorphology	Slope, Geology, Drainage density	Land use/land cover, Soil	4
5	Soil	Land use/land cover, Geomorphology	Geology, Drainage density	3
6	Drainage density	Land use/land cover,	Slope, Geomorphology	2
7	Slope	Drainage density, Rainfall, Geomorphology	Land use/land cover	3.5
8	Rainfall	Land use/land cover, Geomorphology	Slope	2.5
9	Water level	Rainfall. Lineament density, Geology	Land use/land cover, Slope	4

Percentage Influence of Various Parameters on Groundwater Potential and Non-Natural Recharge Sites

Factors	Percentage of Influence	
	Groundwater Potential	Non-Natural Recharge Sites
Geology	13	8
Lineament density	9	10
Land use/land cover	15	6
Geomorphology	20	16
Soil	15	10
Drainage density	13	8
Slope	16	14
Rainfall	-	10
Water level	-	6

Factors of Thematic Layers and its Parameters

Thematic map	Parameter	Boolean Overlay Rank	WIOA Rank	Fuzzy Logic Rank
Geology	Unclassified Gneiss	1	4	0.80
	Lime Stone	1	4	0.80
	Charnokite	0	2	0.40
	Pink Granite	0	1	0.20
	Pink Granite & Gneiss	1	4	0.80
	Basic Rock	1	5	0.99
	Complex Gneiss	1	1	0.20
	Valley Fill	1	4	0.80
Soil	Colluvial & Alluvial	1	5	0.99
	Brown Soil	0	2	0.40
	Red Calcareous	1	4	0.80
	Black Soil	0	1	0.20
	Red Non Calcareous	0	2	0.40
	Thin red Soil	1	4	0.80
	Alluvial Soil	1	5	0.99

Thematic map	Parameter	Boolean Overlay Rank	WIOA Rank	Fuzzy Logic Rank
Geomorphology	Structural hill	0	1	0.20
	Shallow pediment	0	2	0.40
	Duri crust	0	1	0.20
	Shallow buried pediment	0	2	0.40
	Residual hill	0	1	0.20
	Denudational hills	0	1	0.20
	Deep pediment	1	4	0.80
	Valley fill	1	4	0.80
	Pediment	0	1	0.20
	Flood plain	1	5	0.99
	Composite slope	0	1	0.20
	Paleo sand dune	1	5	0.99
Land use / land cover	Crop land	1	4	0.80
	Fallow land	1	4	0.80
	Scrub forest	1	3	0.60
	Built up land	0	1	0.20
	Water bodies	1	5	0.99
	Land with scrub	0	2	0.40
	Land without scrub	1	3	0.60

Lineament density, Drainage density and Slope

Thematic map	Parameter	Boolean Overlay Rank	WIOA Rank	Fuzzy Logic Rank
Lineament density (km/km^2)	0-0.600	0	1	0.20
	0.600-1.200	1	2	0.40
	1.200-1.800	1	3	0.60
	1.800-2.400	1	4	0.80
	2.400-3.100	1	5	0.99
Drainage density (km/km^2)	0 – 0.31169	1	5	0.99
	0.31169 – 0.658	1	4	0.80
	0.658 – 0.995	1	3	0.60
	0.995 – 1.432	1	2	0.40
	1.432 – 2.20	0	1	0.20
Slope	0 – 1	0	1	0.20
	1 -3	1	2	0.40
	3 -7	1	3	0.60
	7 -15	1	4	0.80
	>15	1	5	0.99

Rank of Parameters for Identifying Non-Natural Recharge Sites

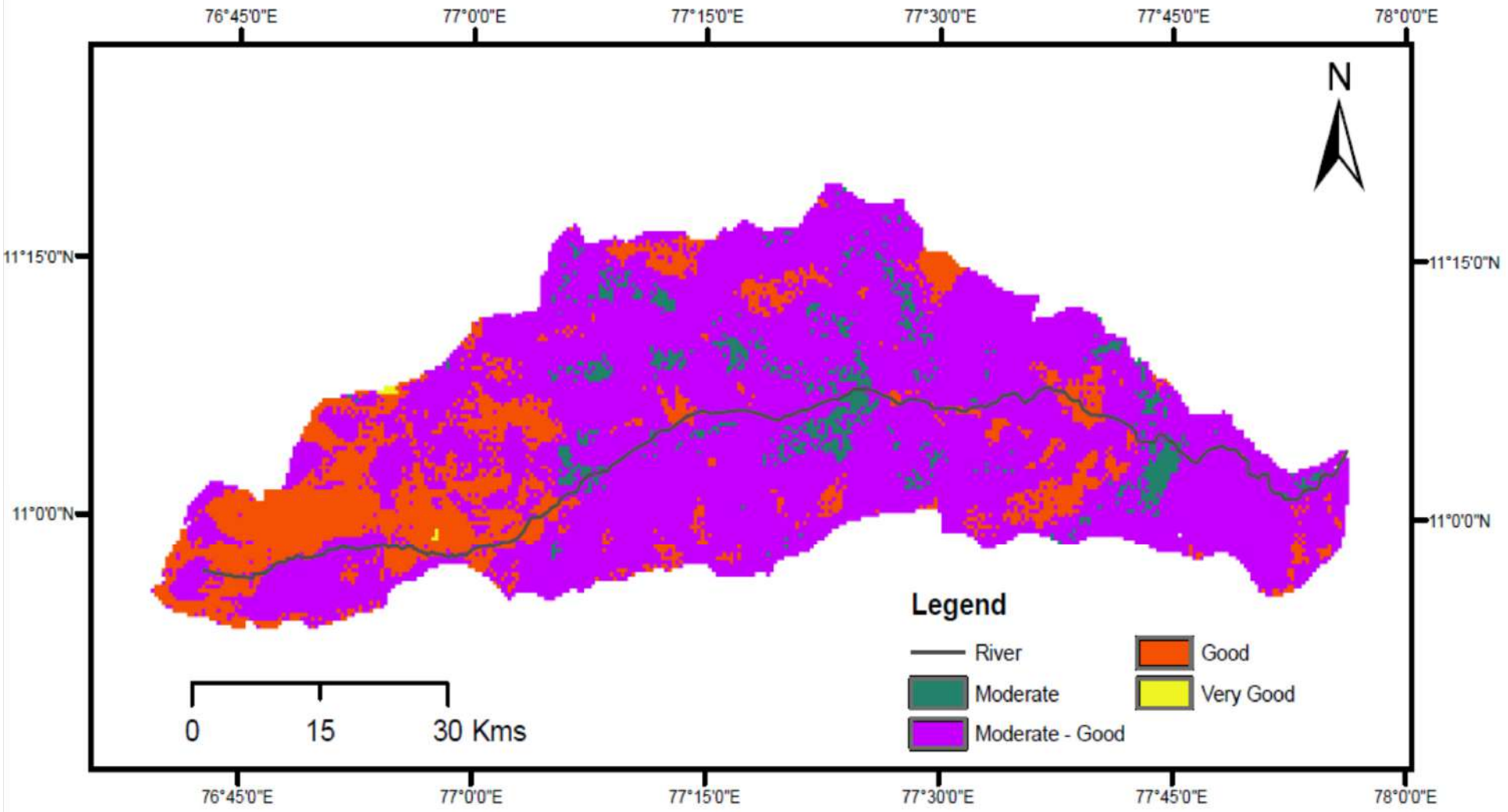
S.No	Factors	Parameters	Rank
1	Soil	Reserved forest	NA
		Colluvial & Alluvial	5
		Brown Soil	2
		Red Calcareous	4
		Black Soil	1
		Red Non Calcareous	2
		Thin red Soil	4
		Alluvial Soil	5
2	Geology	Unclassified Gneiss	4
		Lime Stone	4
		Charnokite	2
		Pink Granite	1
		Pink Granite & Gneiss	4
		Basic Rock	5
		Complex Gneiss	1
		Valley Fill	4

3	Geomorphology	Structural hill	1
		Shallow pediment	2
		Duri crust	1
		Shallow buried pediment	2
		Residual hill	1
		Denudational hills	1
		Deep pediment	4
		Valley fill	4
		Pediment	1
		Flood plain	3
		Composite slope	1
		Paleo sand dune	5
		Reserved forest	NA

4	Lineament Density	0-0.600	1
		0.600-1.200	2
		1.200-1.800	3
		1.800-2.400	4
		2.400-3.100	5
5	Drainage Density	0 − 0.31169	5
		0.31169 − 0.658	4
		0.658 − 0.995	3
		0.995 − 1.432	2
		1.432 − 2.20	1
6	Slope Gradient	0 − 1	4
		1 -3	5
		3 -7	3
		7 -15	2
		>15	1

7	Land use/Land cover	Dense forest	NA
		Crop land	4
		Fallow land	4
		Scrub forest	3
		Built up land	1
		Water bodies	3
		Forest blank	NA
		Land with scrub	3
		Land without scrub	4
		Open forest	NA
8	Water Level in m	1.8 − 10	5
		10.1 − 15	4
		15.1 − 20	3
		20.1 − 26	2
		26.1 - 32	1
9	Rainfall	352 − 541	1
		541.1 − 640	2
		640 − 811	3
		811 − 1103	4
		1103 - 1500	5

Groundwater Potential Map



Comparison between the Identified Groundwater Potential Zones by Different Methods

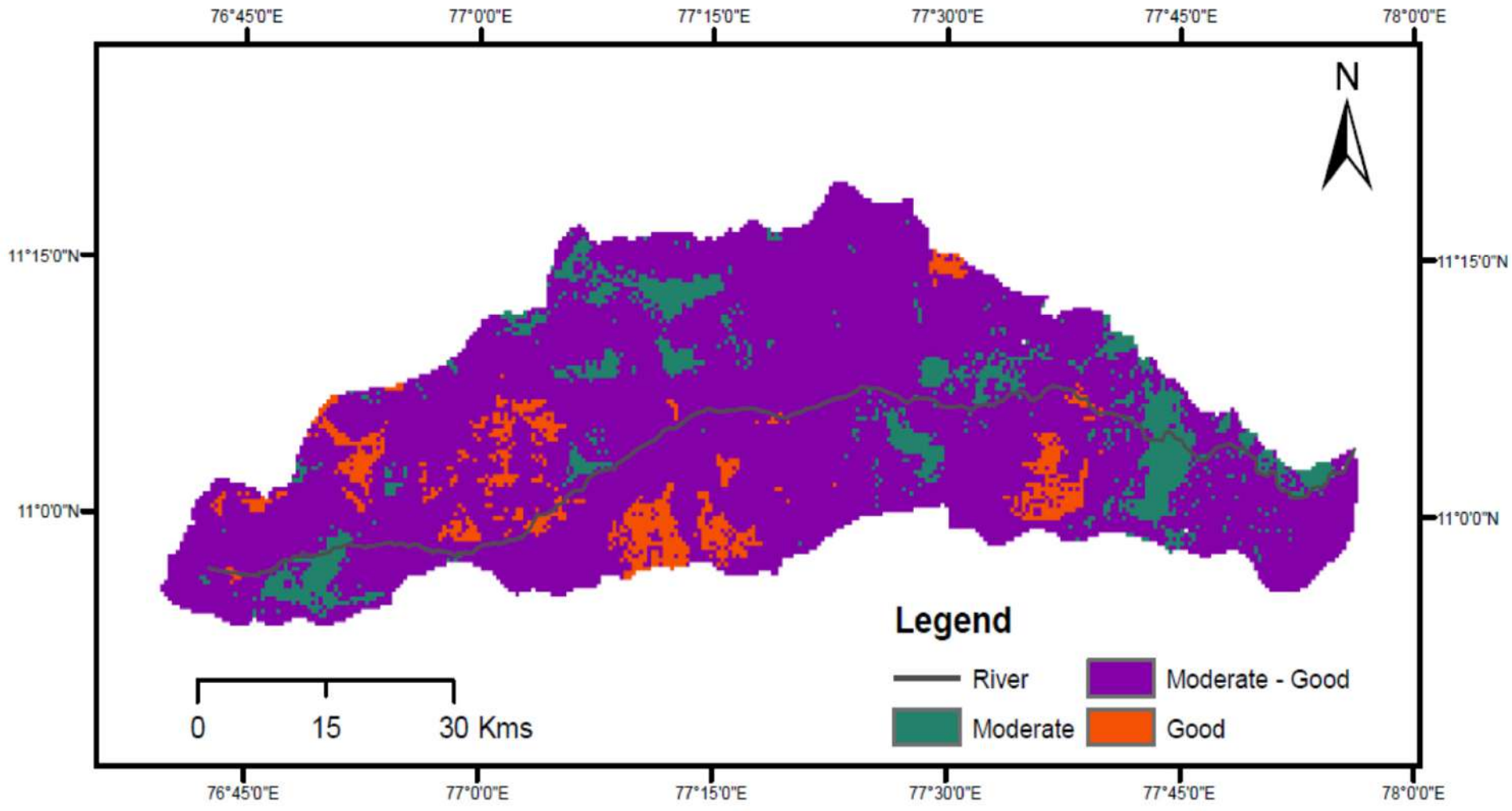
- The entire study area was predominant in moderate to good category (occupies approximately 76% of the study area) which was covered by red non calcareous, thin red soil, black soil, red calcareous, pediment, shallow pediment, charnockite, pink granite complex gneiss, pink granite and gneiss, fallow land, lineament and drainage density.
- The good category (occupies approximately 18% of the study area) was found in western side and few isolated parts in north eastern side of the study area which was covered by colluvial and alluvial, red non calcareous, deep pediment, flood plain, structural hill, valley fill, paleo sand dune, unclassified gneiss, valley fill, complex gneiss, charnockite, pink granite and gneiss, fallow land, agriculture land and land with scrub.
- The moderate category (occupies approximately 4% of the study area) was found in centre part of the study area which was covered by red non calcareous, black soil, brown soil, duri crust, pediment, unclassified gneiss, complex gneiss and charnockite and fallow land.
- The very good (occupies approximately less than 1% of the study area) was found in red calcareous, deep pediment, unclassified gneiss and it was found only in Thondamuthur block of Coimbatore district.

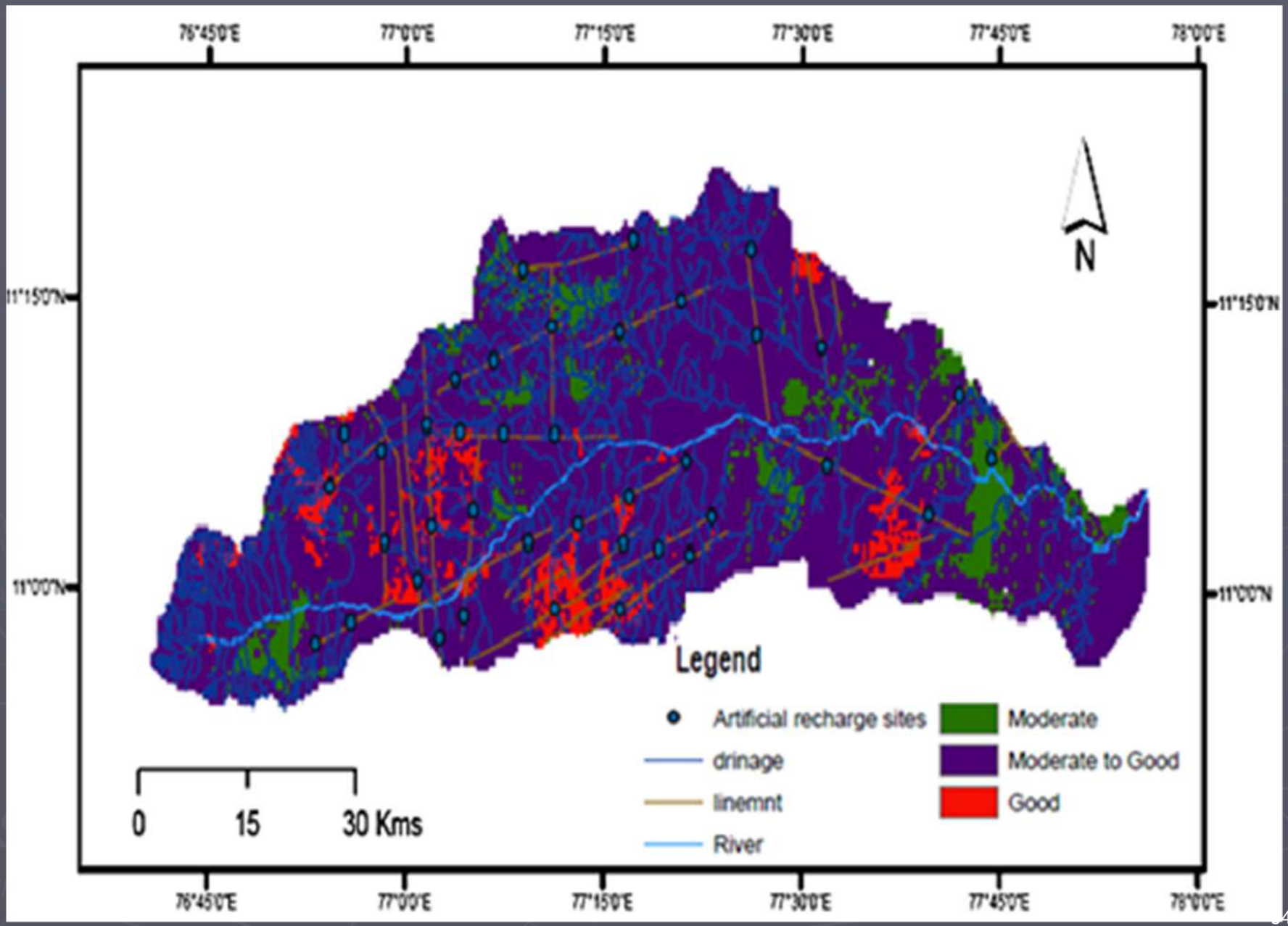
VALIDATION OF THE IDENTIFIED GROUNDWATER POTENTIAL ZONES BY DIFFERENT METHODS

S.No	Village Name	Identified Groundwater Potential			Pumpimg Rate (GPM)	Evaluation
		Boolean Overlay	Weighted Index Overlay Analysis	Fuzzy Logic Model		
1	Chokkampalayam	Nil	Moderate	Moderate	poor	“+”
2	Velayuthampalayam	Present	M to G	M to G	2.19	“+”
3	Kunnathur 2nd point	Present	M to G	M to G	2.19	“+”
4	Mudalipalayam	Present	M to G	M to G	6.05	“+”
5	Kunnathur	Present	M to G	M to G	6.05	“+”
6	J.E.Quaters	Present	M to G	M to G	6.05	“+”
7	Kurukkalpalayam 2nd point	Present	M to G	M to G	6.05	“+”
8	Nagampalayam	Present	M to G	M to G	6.05	“+”
9	Kumarandi Chavadi	Present	M to G	M to G	6.05	“+”
10	Chinnamuthur ist Point	Present	M to G	M to G	8.05	“+”
11	Kattampatti	Present	M to G	M to G	8.89	“+”
12	Veerasolapuram	Present	M to G	M to G	9	“+”
13	Veerasolapuram 2nd point	Present	M to G	M to G	10	“+”
14	Moothampalayam	Present	M to G	M to G	10	“-”
15	Rakkiapalayam	Present	M to G	M to G	10	“+”

16	Perumanallur-1	Present	M to G	M to G	10	“+”
17	Arugamapalayam	Present	M to G	M to G	12	“+”
18	Sundakkampalayam	Present	M to G	M to G	12.4	“+”
19	Kuthampalayam	Present	M to G	M to G	12.4	“+”
20	Karumathampatty	Present	M to G	M to G	12.4	“+”
21	Palladam Pap Colony	Present	M to G	M to G	12.4	“+”
22	Peelamedu	Present	M to G	M to G	12.4	“+”
23	Kallimadai	Present	M to G	M to G	12.5	“+”
24	Sulur	Present	M to G	M to G	16.7	“+”
25	Chandrapillaivalasu	Present	M to G	M to G	16.7	“+”
26	Veeranam	Present	M to G	M to G	16.7	“+”
27	Veerapandi	Present	M to G	M to G	21.7	“+”
28	T.Pudupalayam	Present	M to G	M to G	21.7	“+”
29	Chinna Agraharam	Present	M to G	M to G	21.7	“+”
30	Seernganur	Present	M to G	M to G	23	“+”

Non-Natural Recharge Sites Map

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77°30'0"E
77°45'0"E
78°0'0"E
11°15'0"N
11°0'0"N
N
Legend
Artificial recharge sites
drinage
linemnt
River
Moderate
Moderate to Good
Good
0
15
30 Kms

Cont.

- The Non-Natural recharge was predominant in moderate to good category (occupies 83.52% of the study area) due to the presence of pediments and gneiss, red calcareous and thin red soil with high lineament density.

- The good category (occupies 6.12% of the study area) was found in few patches of south western side and western side of the study area due to the presence of red calcareous, flood plain, pediment, shallow pediment and deep pediment, valley fill, unclassified gneiss, charnockite, complex gneiss and fallow land.

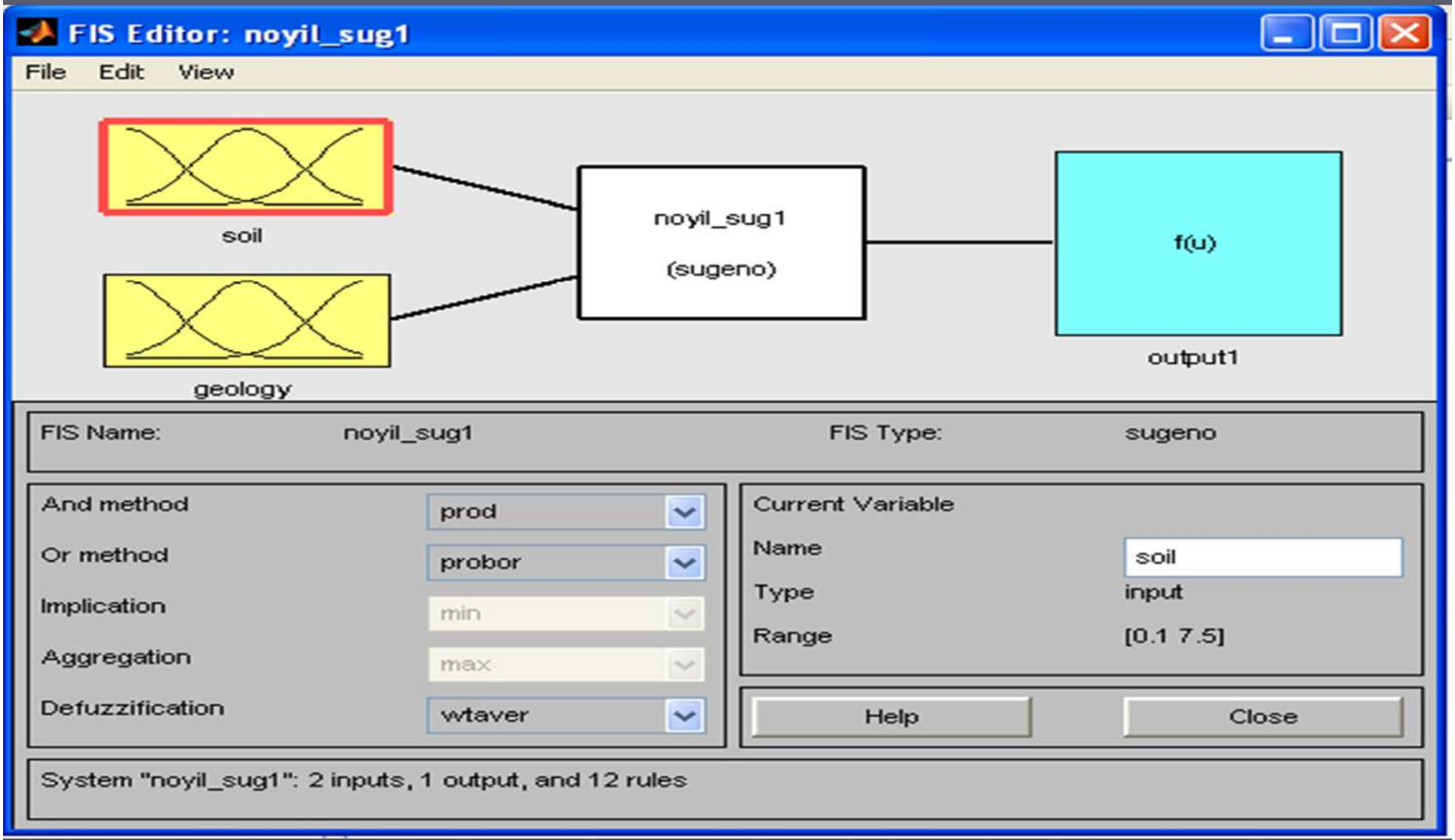
- The moderate category (occupies 10.36% of the study area) was found in western, south eastern and north eastern side of the study area due to the presence of red calcareous, black soil, colluvial and alluvial soil, shallow buried pediment, shallow pediment, pediment, charnockite, complex and unclassified gneiss.

FUZZY LOGIC

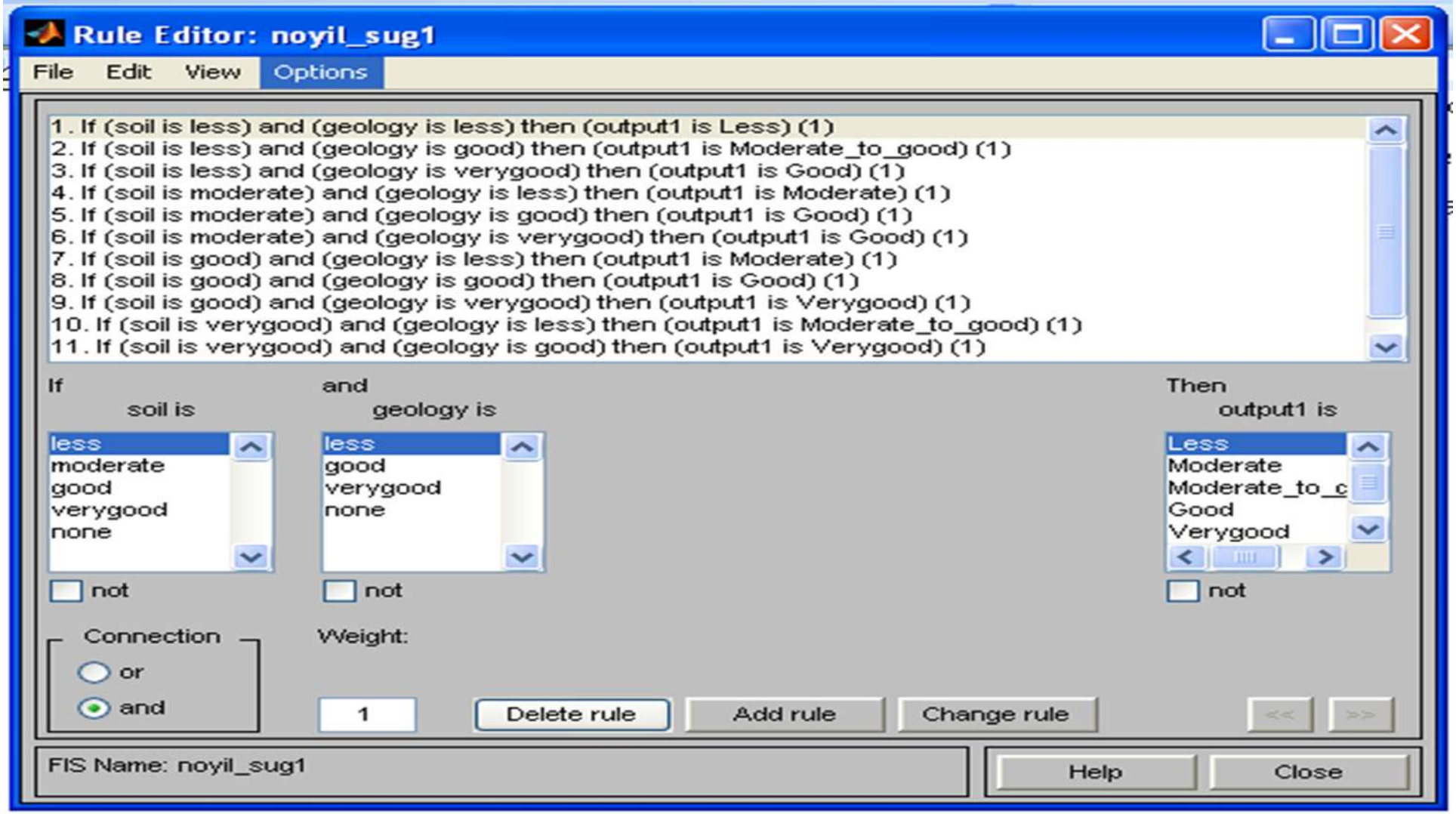
- A model was created using fuzzy logic for identifying Non-Natural recharge sites.
- The input in the model will be
  - Geology
  - Soil
  - Geomorphology
  - Lineament density
  - Drainage density
  - Slope
  - Land use/land cover
  - Rainfall
  - Groundwater level

  of a particular location and the model will give the suitability of Non-Natural recharge sites for that particular location.

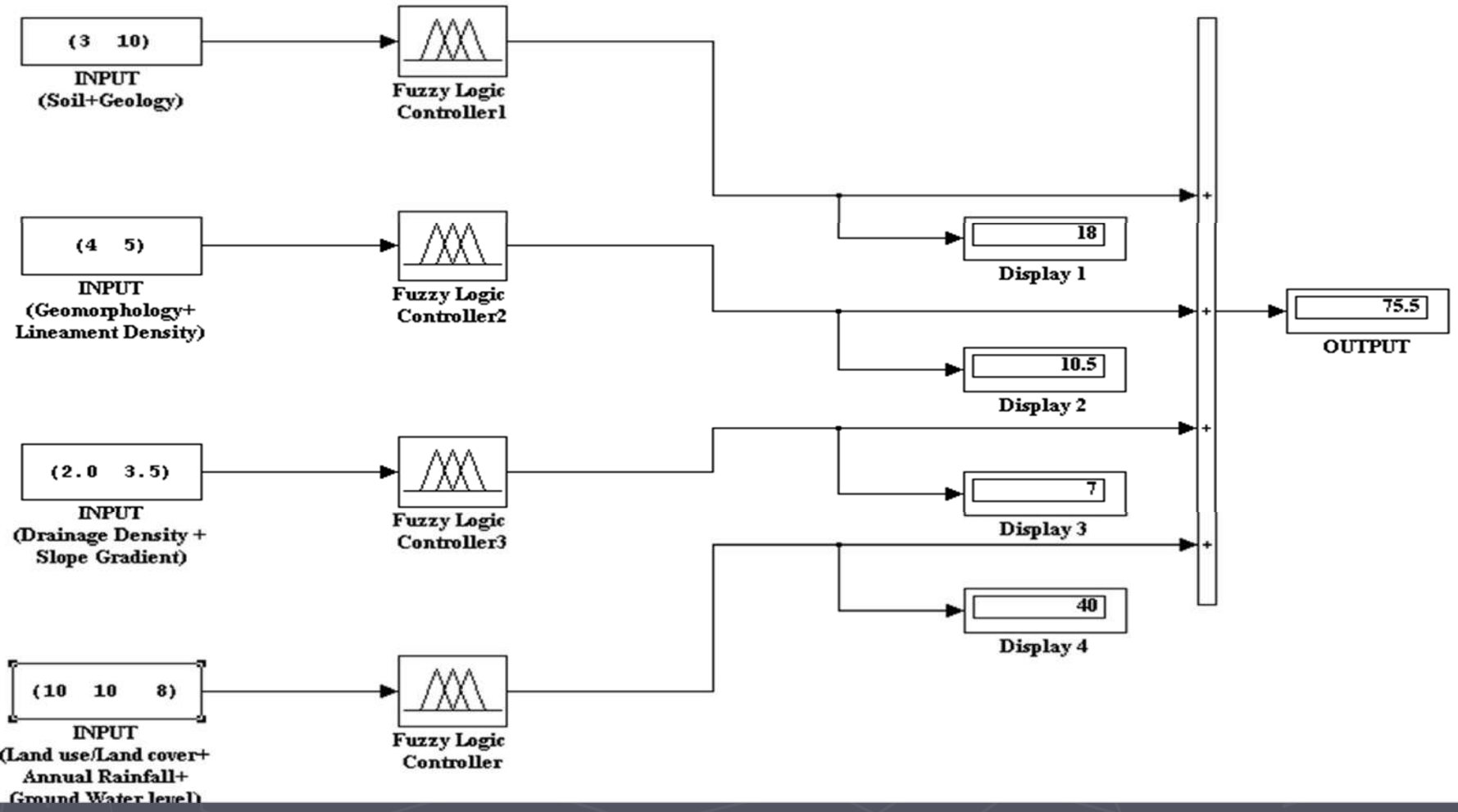
Input for Matlab



Rules for the Site Selection using Matlab - Fuzzy



Simulink Block Diagram for the Fuzzy Model



Output Values for Non-Natural Recharge Sites

S.No	Range	Result
1	25 – 45	Less
2	46 – 66	Moderate
3	67 – 87	Moderate to good
4	88 – 108	Good
5	109 - 126	Very good

Thank You