Bharathidasan University

Tiruchirappalli – 620 023, Tamil Nadu

6 Yr. Int. M.Tech. Geological Technology and Geoinformatics

Course code : **MTIGT0604**

GEOINFORMATICS IN WATER RESOURCES MANAGEMENT

Unit-4 : Geoinformatics in Groundwater Resources

Dr. K. Palanivel
Professor, Department of Remote Sensing

Course Objectives

- ❖ To know the potential sources, origin, occurrences of water resources
- ❖ To understand the concepts of water resources prospecting, water quality mapping and conservation
- ❖ To learn the capabilities of Geoinformatics and its applications for water resources targeting, quantification, budgeting and management
- ❖ To learn the Geological Technology and Geoinformatics in understanding the functions of aquifers and groundwater movement
- ❖ To learn the basics and applications of hydrogeological models.

MTIGT0604: GEOINFORMATICS IN WATER RESOURCES MANAGEMENT

--- 4 Credits

1. Surface Water Resources: Hydrological Cycle - Global Distribution of Surface water Bodies – Drainage Morphometry – Sources of Surface water – Snow, Rainfall and groundwater table. Modelling assumptions - choice of equation - phenomena and model geometry - choice of variables and parameters - data and knowledge acquisition - model building – calibration and verification, results presentation. **12Hrs.**

2. Geoinformatics in Surface Water Resources: Satellite data based Surface water budgeting and Quantification – Automated drainage Mapping Using DEM – Spectral Response Pattern of Water – Water quality mapping and monitoring using Remote Sensing – Infra Red data based Water Quantity Forecasting – Water quality Mapping and Monitoring using satellite data. **12 Hrs.**

3. Groundwater Resources: Groundwater Origin & Occurrence: Sources of Groundwater – Classification of Groundwater. Aquifer Types: Crystalline Aquifer, Sedimentary aquifer, Unconsolidated Sedimentary Aquifer, Geomorphic aquifer. Darcy's Law in homogeneous and heterogeneous media, Groundwater quality, Application of H and O isotopes in groundwater studies; Targeting: General Investigations - Geological mapping- Geological Cross sections - Well inventory – Geophysical Methods – Drilling and Exploration - Pump tests - Groundwater Assessment and Budgeting - Issues and conservation Strategies. **16 Hrs.**

4. Geoinformatics in Groundwater Resources: Geoinformatics and evaluation of lithologically controlled, Structurally controlled and Geomorphologically controlled aquifers – Concept of Hydro geomorphic mapping. Natural and Artificial recharge site selection - detection of site specific mechanisms – Quantification of allowable recharge. **12 Hrs.**

5. Hydrological Models: Surface Water Hydrological Models: Snow melt Runoff modeling – GIS based Runoff modeling – Various hydrological models using Geoinformatics. Models for Inter watershed water transfer. Groundwater models: Stochastic – MOD Flow- Linear – Finite Element Modeling. **12 Hrs.**

Course outcomes

After the successful completion of this course, the students are able to:

- ✓ Understand the availability, sources and importance of the water resources prospect for both surface and groundwater resources using Geoinformatics technology
- ✓ Determine the types of aquifers, their characteristics and their recuperation ability
- ✓ Delineate suitable sites and mechanisms for natural and artificial recharge
- ✓ Understand the application of Geoinformatics technology for surface and groundwater resources exploration, targeting, quantification, budgeting, conservation and management
- ✓ Learn the application of Geological technology and Geoinformatics tools in developing various hydrological models.

Text Books:

1. David Keith Todd, Groundwater Hydrology, Wiley Student Edition.
2. Raghunath H.M., Ground Water, New Age International (P) Limited Publishers, 1987.
3. Ramakrishnan. S. Groundwater, 1998.

References:

1. Chang, H.H. Fluvial processes in river engineering, John Wiley and Sons, New York. 1988.
2. Bedient, P.B, Hydrology and flood Plain analysis, Addision westery publishing company. 1988.
3. Driscoll, F.S. Groundwater & Wells, 2nd Edition, Scientific Publishers, Joclpur, 1986.
4. Karanth K.R., Groundwater Assessment Development and Management, Tata McGraw Hill Publishing Company Limited, New Delhi, 1987.
5. Clorer. R.C., Groundwater Management.
6. Scalf M.R., Manual of SW Quality Sampling procedure
7. Mutreja, K.N Applied Hydrology, Tata McGraw Hill Publishing Company Limited, New Delhi, 1986.
8. Thomann R.V, Principles of Surface Water Quality Modeling and Control, HIE, Harper & Row, Publishers, New York, 1987.
9. Mohammed Ali, George E Radosevich, Water Resource Policy for Asia, A. A. Balkema/Rotterdam/Boston, 1987.

10. Mc Donald AT, Water Resources: Issues and Strategies, Longman Scientific & Technical, 1988.
11. Pillai, K.M., Water Management and Planning, Himalaya Publishing House, 1987.
12. Gower. A.M., Water Quality in Catchment Ecosystem, John Willey & Sons, 1980.
13. Ramesam. V. Trends in Groundwater Research, The Geological Society of India, Bangalore, 1987.
14. Trivedi, R.N., Shatrunjay Kumar Sing, Water Resources and Quality Management, Commonwealth Publishers, New Delhi, 1990.
15. Fetter C.W. Applied Hydrology, CBS Publishers & Distributors, 1988.
16. Gautam Mahajan. Groundwater Surveys and investigations, Ashish Publishing House, New Delhi, 1995.
17. Chow V.T., maidment, D.R., and Mays, L.W. applied Hydrology, McGraw Hill, New York, pp.530 to 537. 1988.
18. Deman, MCJ. Smith G.S and H.T.Verstappen (eds), Remote Sensing for resources development and environmental management, A.A. Ballkema Publishers, Totterdam, Netherlands. 1986.

Unit-4: Geoinformatics in Groundwater Resources

4. Geoinformatics in Groundwater Resources:
Geoinformatics and evaluation of lithologically controlled, Structurally controlled and Geomorphologically controlled aquifers – Concept of Hydro geomorphic mapping. Natural and Artificial recharge site selection - detection of site specific mechanisms – Quantification of allowable recharge.

STUDIES CONDUCTED AT CERS, BDU ON GROUNDWATER MANAGEMENT

1. Groundwater Prospecting
2. Groundwater Targetting
3. Aquifer Function Modelling
4. Groundwater Quality Modelling
5. Natural Recharge
6. Artificial Recharge
7. Quantification of Allowable Recharge
8. Groundwater Flow Modeling in GIS
9. Water Resources Information System (WRIS)

STUDY - 1

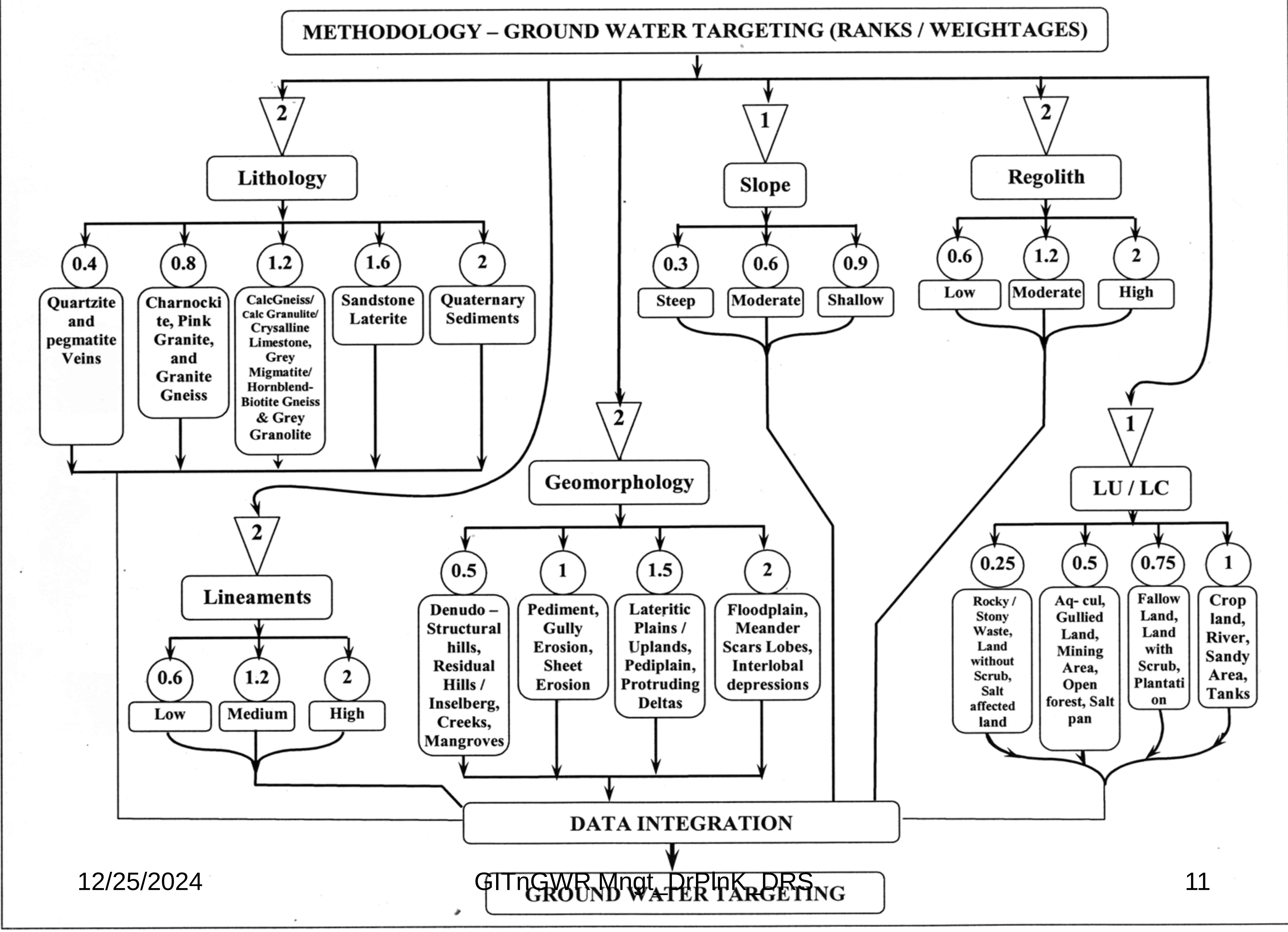
Groundwater Prospecting

Back

GROUNDWATER DEVELOPMENT
Groundwater Prospecting

- For prospecting and developing of groundwater, a new methodology of assigning Ranks and Weightages to various geo-systems was adopted.

Sl.No.	Item	Rank (Maximum Weightages)
1	Lithology	2
2	Lineament Density	2
3	Geomorphology	2
4	Slope	1
5	Regolith	2
6	Landuse/Land Cover	1


METHODOLOGY – GROUND WATER TARGETING (RANKS / WEIGHTAGES)
2
Lithology
0.4
Quartzite and pegmatite Veins
0.8
Charnockite, Pink Granite, and Granite Gneiss
1.2
CalcGneiss/ Calc Granulite/ Crysalline Limestone, Grey Migmatite/ Hornblend-Biotite Gneiss & Grey Granolite
1.6
Sandstone Laterite
2
Quaternary Sediments
1
Slope
0.3
Steep
0.6
Moderate
0.9
Shallow
2
Regolith
0.6
Low
1.2
Moderate
2
High
2
Lineaments
0.6
Low
1.2
Medium
2
High
2
Geomorphology
0.5
Denudo – Structural hills, Residual Hills / Inselberg, Creeks, Mangroves
1
Pediment, Gully Erosion, Sheet Erosion
1.5
Lateritic Plains / Uplands, Pediplain, Protruding Deltas
2
Floodplain, Meander Scars Lobes, Interlobal depressions
1
LU / LC
0.25
Rocky / Stony Waste, Land without Scrub, Salt affected land
0.5
Aq- cul, Gullied Land, Mining Area, Open forest, Salt pan
0.75
Fallow Land, Land with Scrub, Plantation
1
Crop land, River, Sandy Area, Tanks
DATA INTEGRATION
GROUND WATER TARGETING

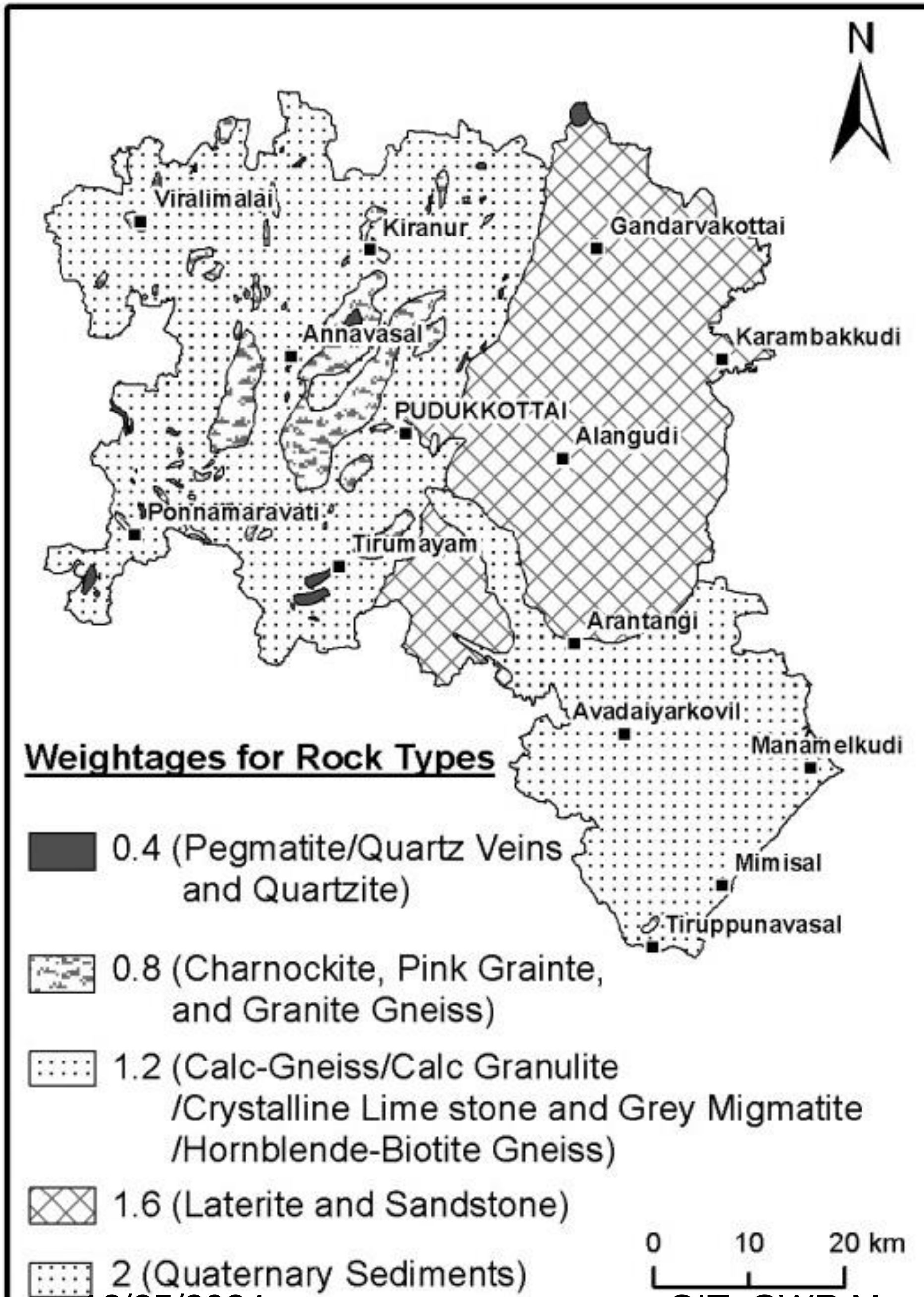


Fig.6.27 Lithology

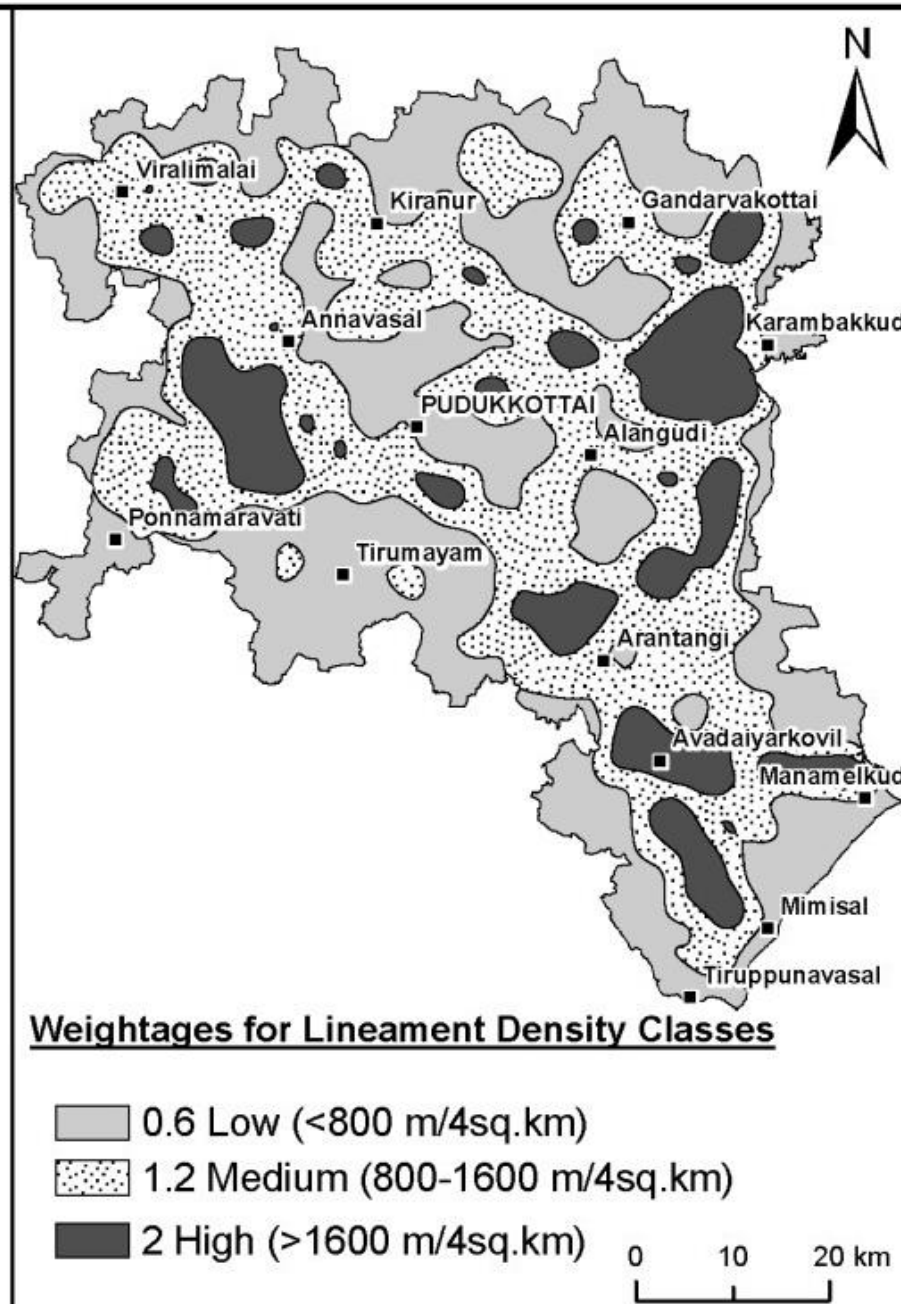


Fig.6.28 Lineament Density

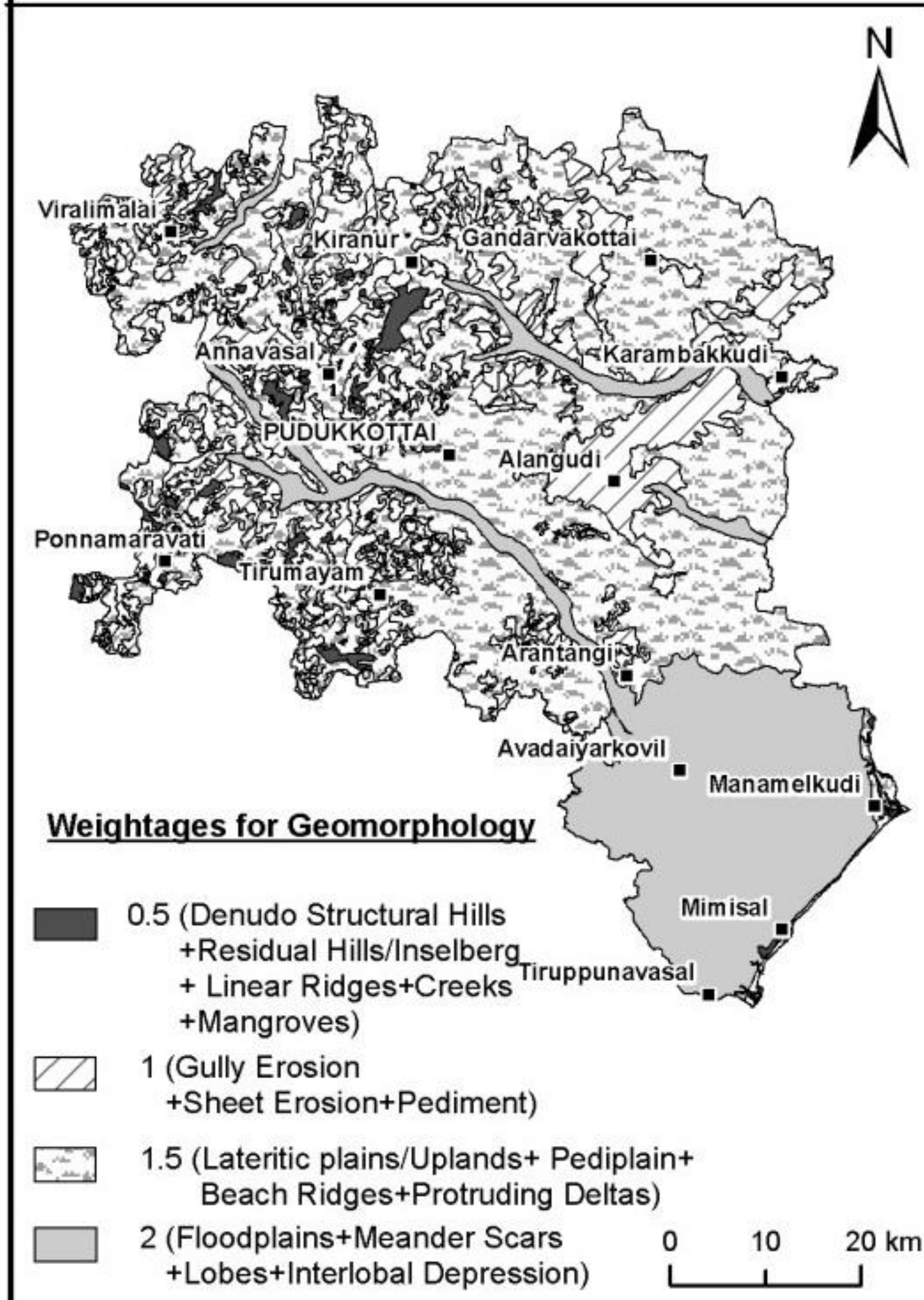


Fig.6.29 Geomorphology

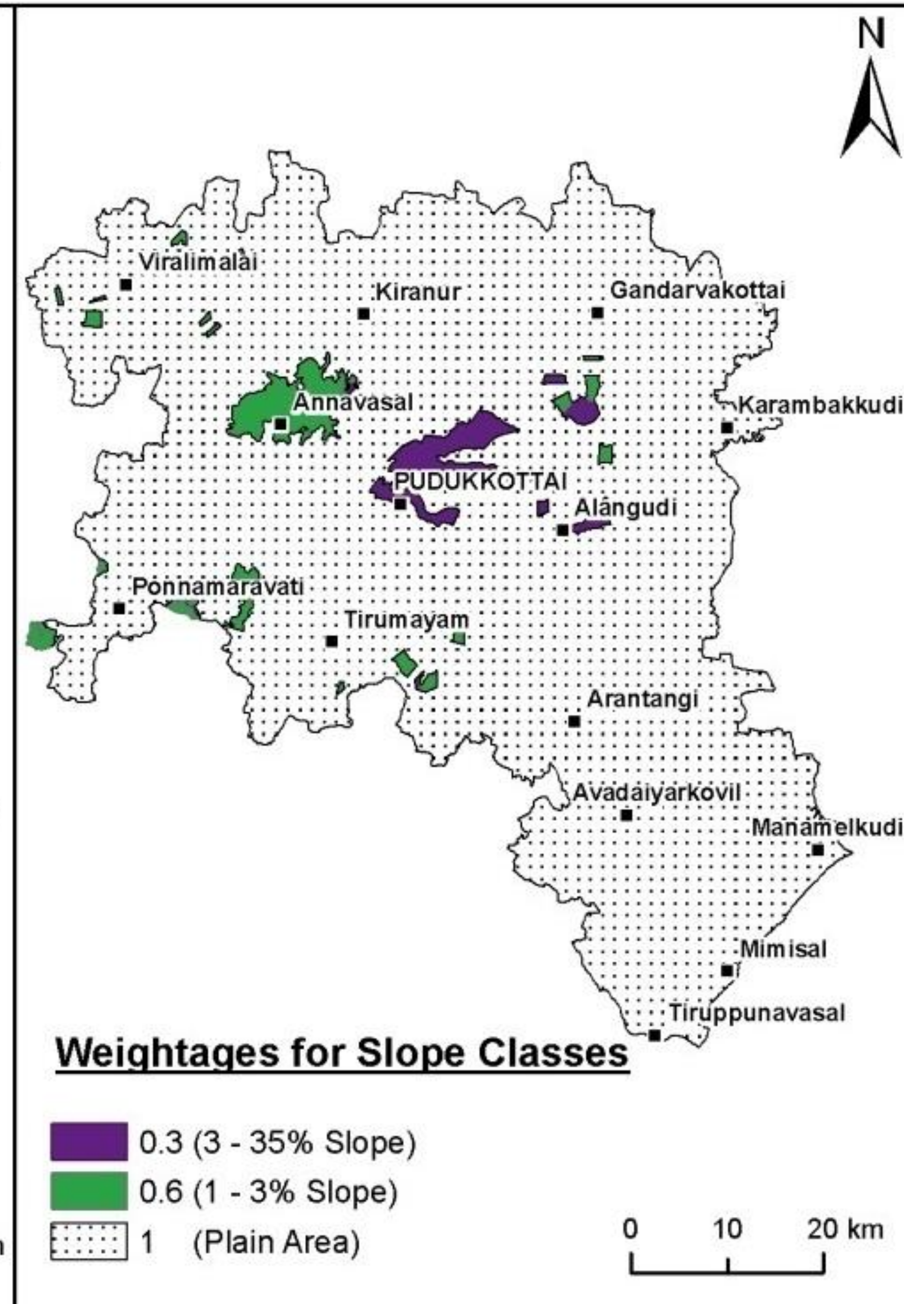


Fig.6.30 Slope

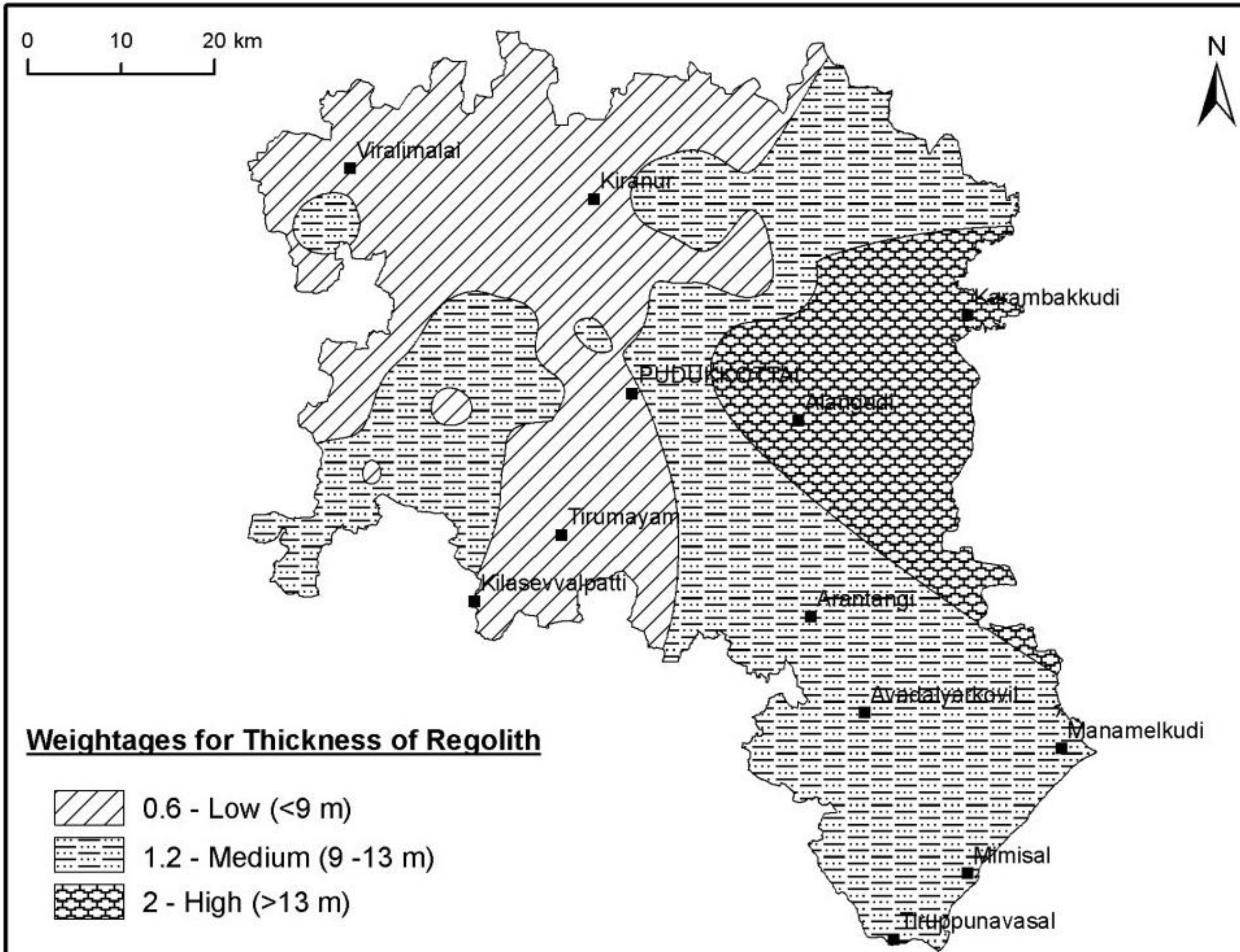


Fig.6.31 Regolith

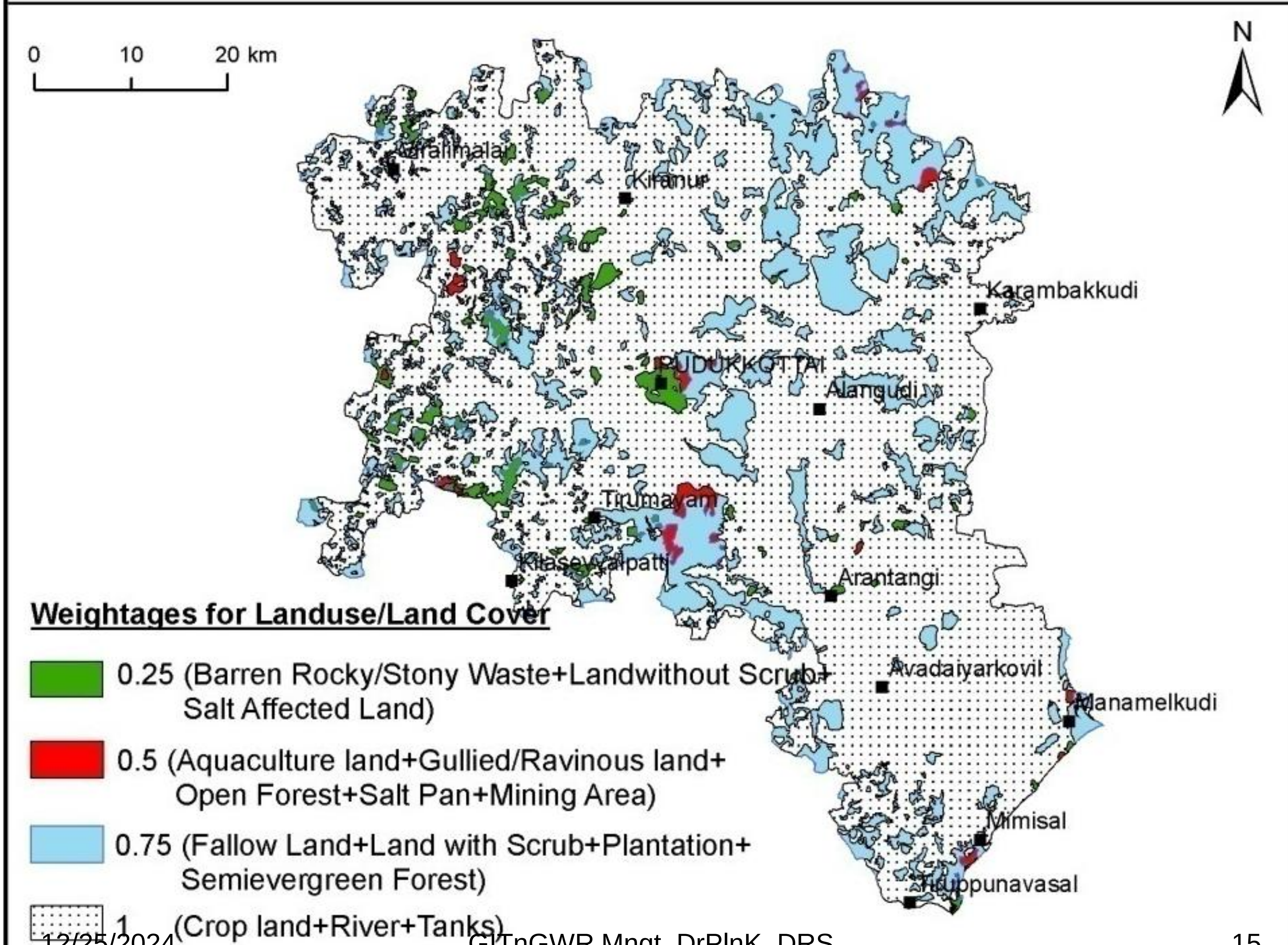


Fig.6.32 Land Use/Land Cover

Groundwater Prospects

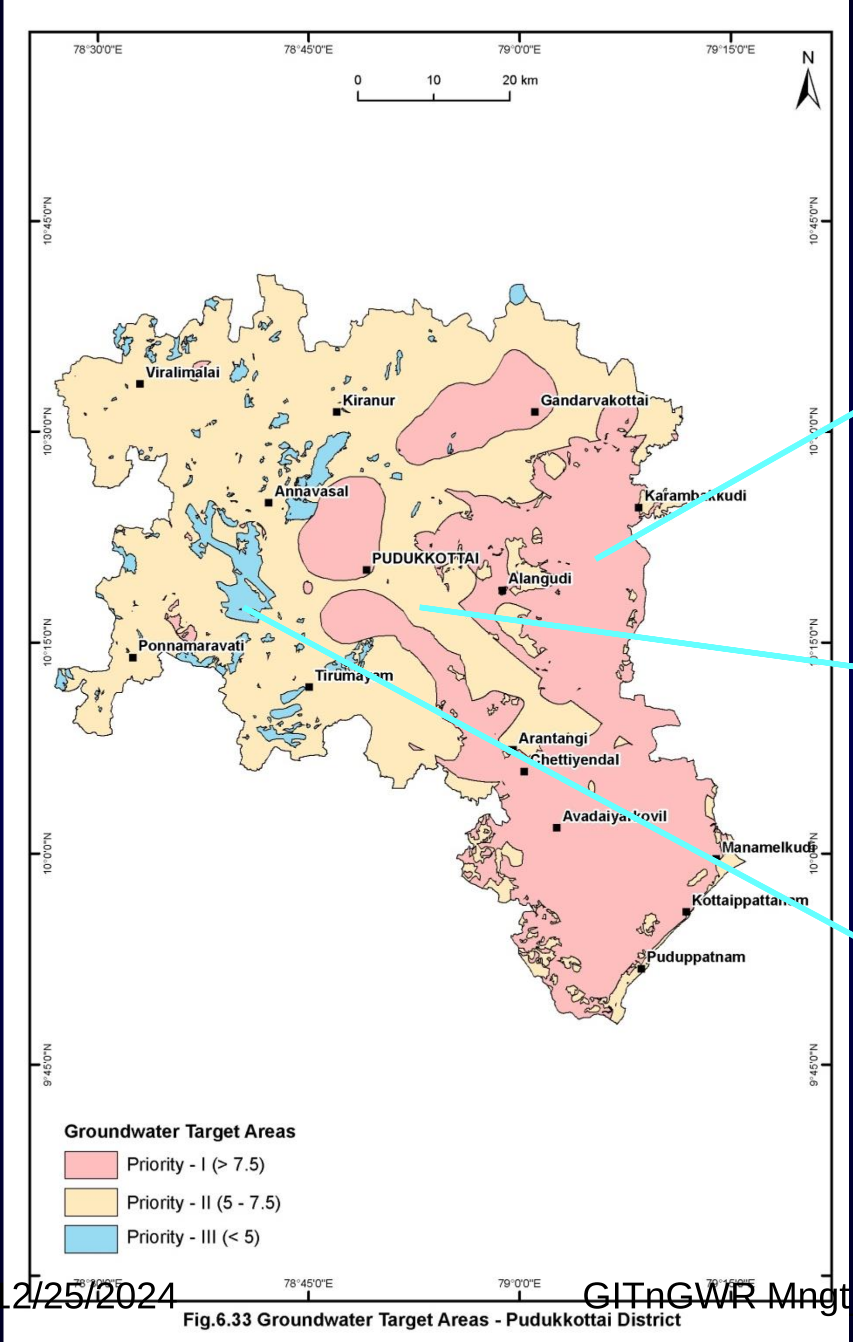


Fig.6.33 Groundwater Target Areas - Pudukkottai District

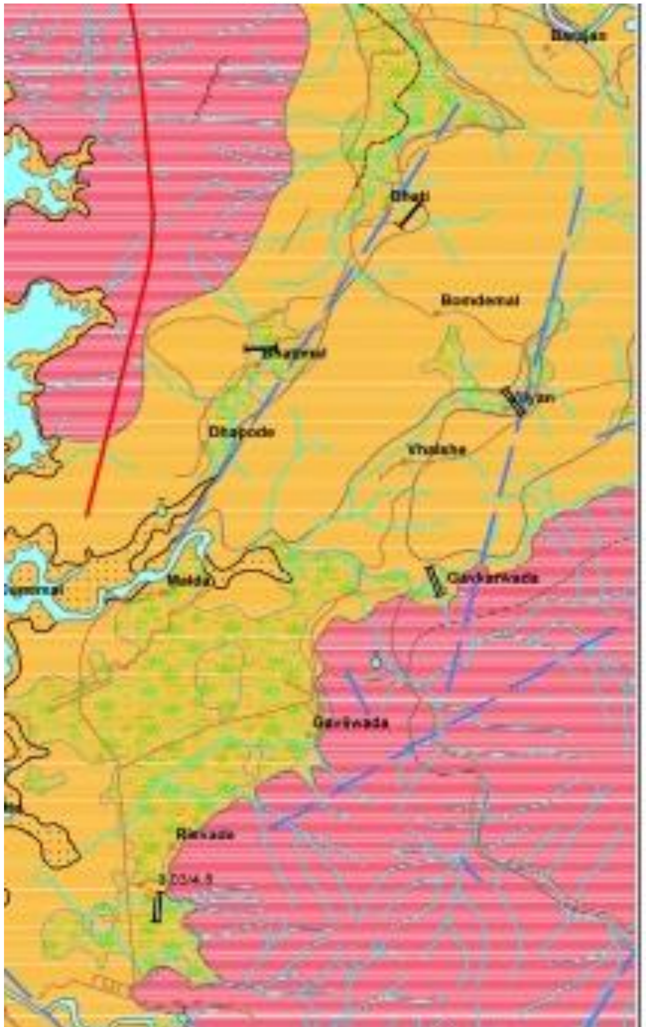
Priority Area – I (>7.5)

Priority Area - II (5-7.5)

Priority Area – III (<5)

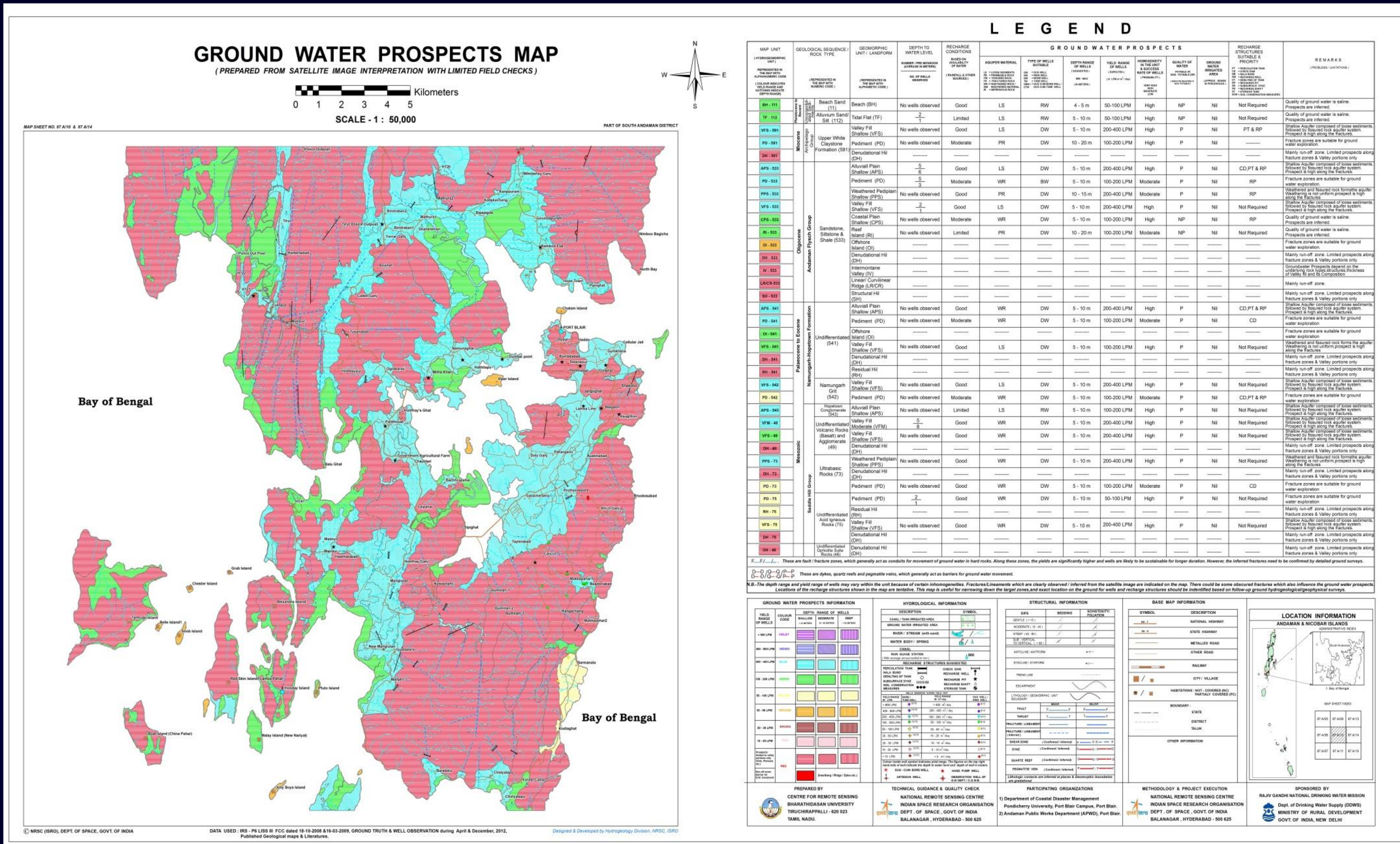
Groundwater Prospect and Groundwater Quality Maps prepared under RGNDWM scheme of NRSC & MoWR for Gundar Basin, Tamil Nadu, Maharashtra, Kerala, Goa, Andaman & Nicobar, Rajasthan

South Goa District

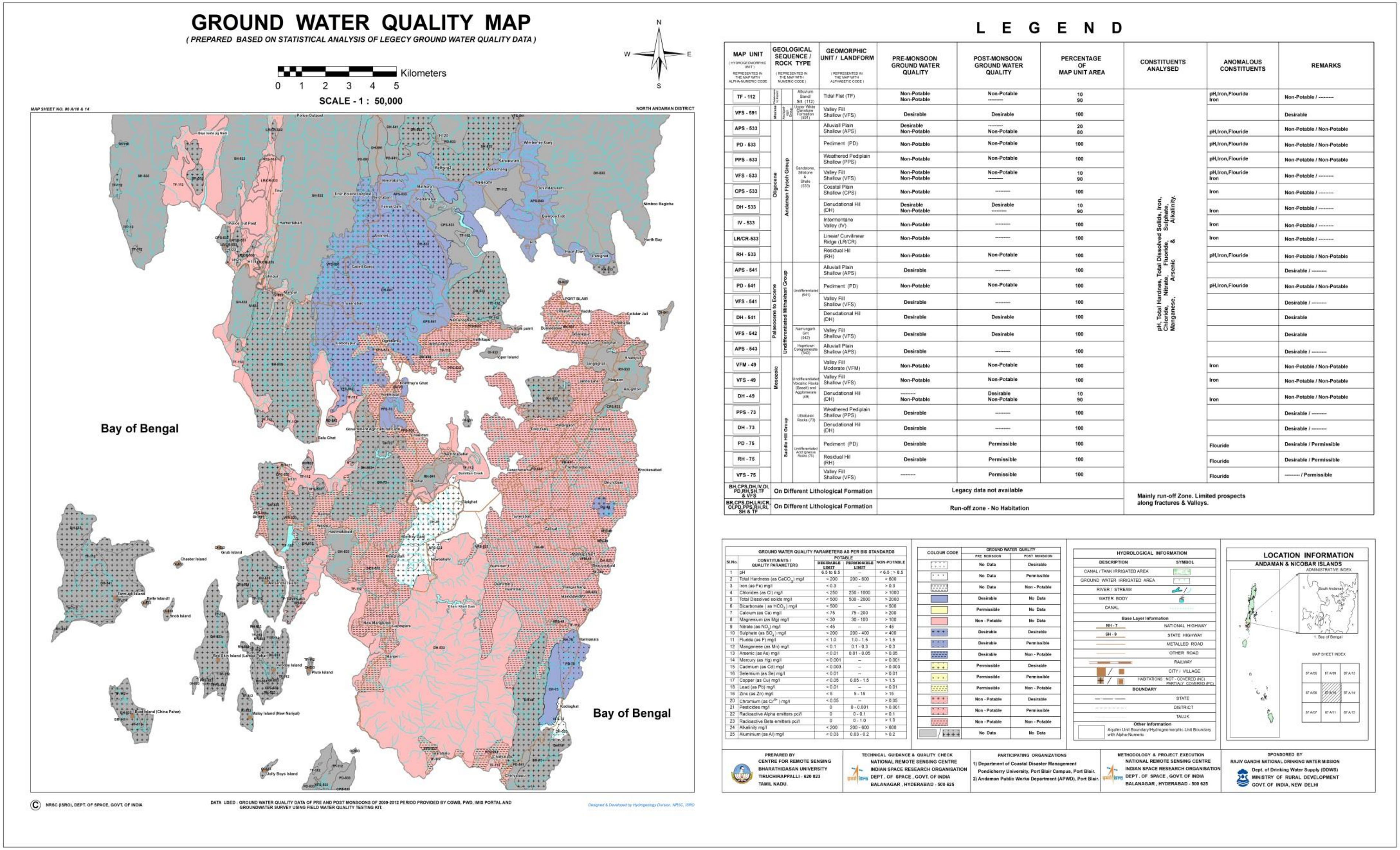


PLS-982	Archaean to Lower Proterozoic	Sanvordem Formation	Greywacke with Conglomerates (982)	Plateau Slightly Dissected (PLS)	No wells observed	Limited
DH-982				Denudational Hill (DH)	----------	----------
V-982				Valley (V)	----------	----------
PD-952			Quartzite (952)	Pediment (PD)	No wells observed	Moderate
HS/DS-952				Hill Slope / Denudational Slope (HS/DS)	----------	----------
APS-924		Barcem Formation	Quartz-Chlorite Schist (924)	Alluvial Plain Shallow (APS)	No wells observed	Good
PD-924				Pediment (PD)	No wells observed	Moderate
PPS-924				Weathered Pediplain Shallow (PPS)	$\frac{5}{2}$	Moderate
DH-924				Denudational Hill (DH)	----------	----------
HS/DS-924				Hill Slope / Denudational Slope (HS/DS)	----------	----------
V-924				Valley (V)	----------	----------
DH-42			Meta acid volcanics (42)	Denudational Hill (DH)	----------	----------
V-42				Valley (V)	----------	----------
PD-41			Metabasalt / metagabbro / meta-anorthositic gabbro (41)	Pediment (PD)	No wells observed	Moderate
DH-41				Denudational Hill (DH)	----------	----------
HS/DS-41				Hill Slope / Denudational Slope (HS/DS)	----------	----------
V-41				Valley (V)	----------	----------
CPS-83	Archaean		Granites/Acidic Rocks (83)	Coastal Plain Shallow (CPS)	No wells observed	Good
APS-83				Alluvial Plain Shallow (APS)	$\frac{3}{1}$	Good
OI-83				Offshore Island (OI)	----------	----------
PD-83				Pediment (PD)	$\frac{3}{1}$	Moderate
PLH-83				Plateau Highly Dissected (PLH)	No wells observed	Moderate
PPC-83				Weathered Pediplain Under Canal Command (PPC)	No wells observed	Moderate
PPS-83				Weathered Pediplain Shallow (PPS)	No wells observed	Moderate

Part of South Andaman



Part of South Andaman



Back

STUDY - 2

Groundwater Targeting

Back

STUDY - 2

Groundwater Targeting using Well Inventory data in GIS

5 Basic steps involved are:

- Date base Generation
- Normalization / Standardization
- Rasterization
- Pixel based addition and
- Groundwater target delineation

Through Pump Test/well inventory, calculate

- Transmissivity (T)
- Permeability (K)
- Specific yield (S) and then
- Inverted Water level (1/WL)

$$\left(\frac{(X\text{-}X_{min})}{(X_{max} - X_{min})} * 99\right) + 1$$

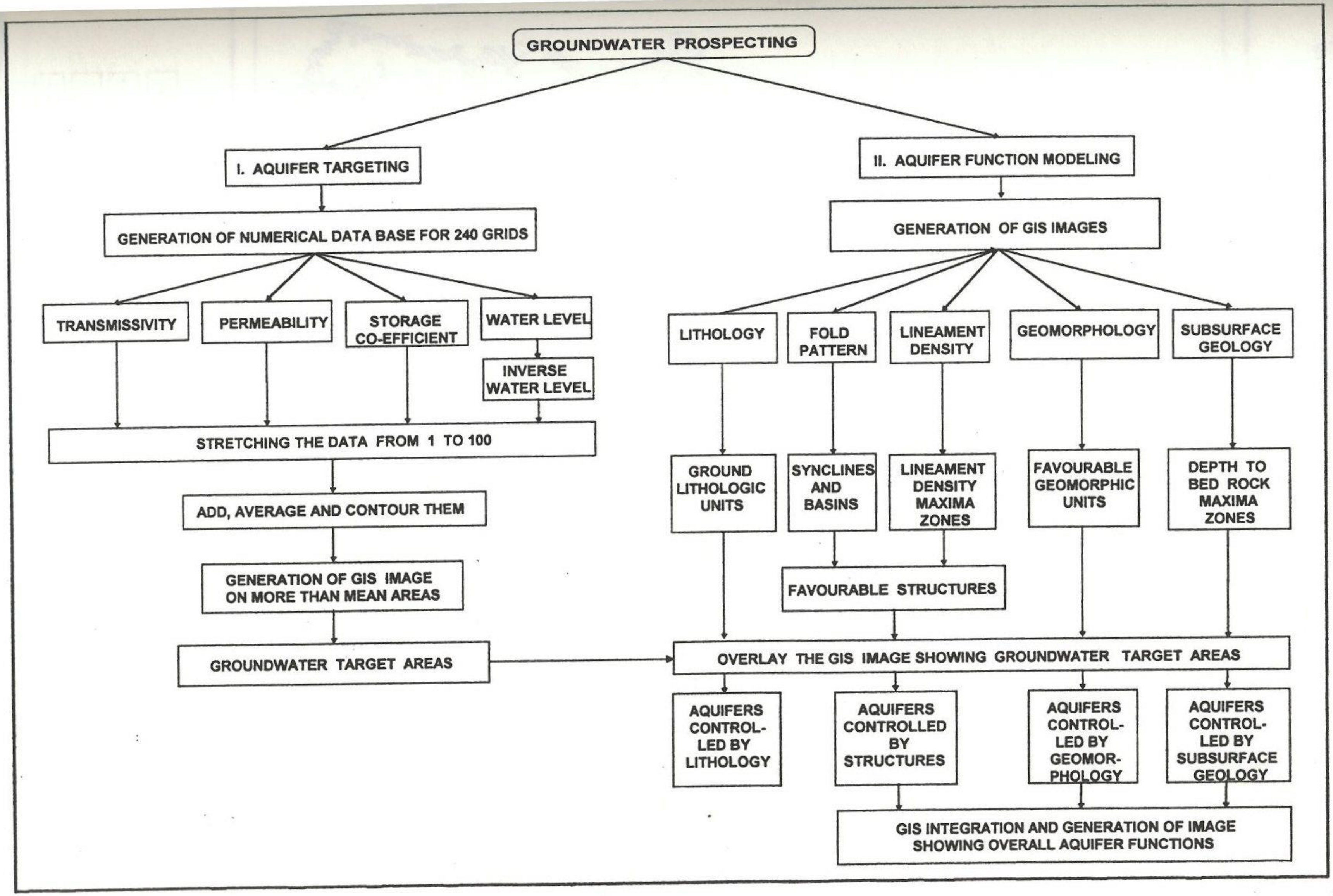


FIGURE 3.15 METHODOLOGY FLOW CHART

TABLE 4

TRANSMISSIVITY, SPECIFIC CAPACITY, PERMEABILITY AND WATER LEVEL DATA

(Sample Data)

1 GRIDNO	2 TRANSMI-SSIVITY	3 TRANSMI-SSIVITY STRETCH-ED DATA	4 SPECIFIC CAPACITY	5 SPECIFIC CAPACITY STRETCH-ED DATA	6 PERMEAB-ILITY	7 PERMEAB-ILITY STRETCH-ED DATA	8 WATER LEVEL	9 WATER LEVEL INVERSE DATA	10 WATER LEVEL INVERSE STRETCH-ED DATA
1	1.508	6	1.511	4	1.405	18	1.83	0.546	1
2	4.761	16	4.795	10	4.457	55	5.90	0.169	1
3	3.752	13	3.786	8	3.549	44	4.79	0.209	1
4	2.489	9	2.522	6	2.439	30	3.27	0.306	1
5	3.343	12	2.835	6	2.841	35	4.18	0.239	1
6	2.061	8	1.905	4	1.906	24	2.81	0.356	1
....	.....	..	.....	..	.....	..	....	.....	..
....	.....	..	.....	..	.....	..	....	.....	..
....	.....	..	.....	..	.....	..	....	.....	..
3130	0.445	2	0.273	1	0.014	1	1.12	0.893	2
3131	0.252	2	0.049	1	0.010	1	0.66	1.515	2
3132	1.248	5	0.250	1	0.050	2	2.78	0.360	1
3133	0.527	3	0.367	2	0.022	1	1.17	0.855	2
3134	0.646	3	0.320	2	0.019	1	1.05	0.952	2
3135	0.136	1	0.101	1	0.005	1	0.27	3.704	5


N
GROUNDWATER TARGET AREAS
(T.K.S & 1/WL MAXIMA ZONES)
(WESTERN GHATS REGION, TAMIL NADU)
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM
LEGEND
GROUNDWATER TARGETS
(ZONES OF TRANSMISSIVITY, PERMEABILITY AND STORAGE CO-EFFICIENT MAXIMA AND SHALLOW WATER LEVEL)
OTHER AREAS
SCALE
0 10 20 km

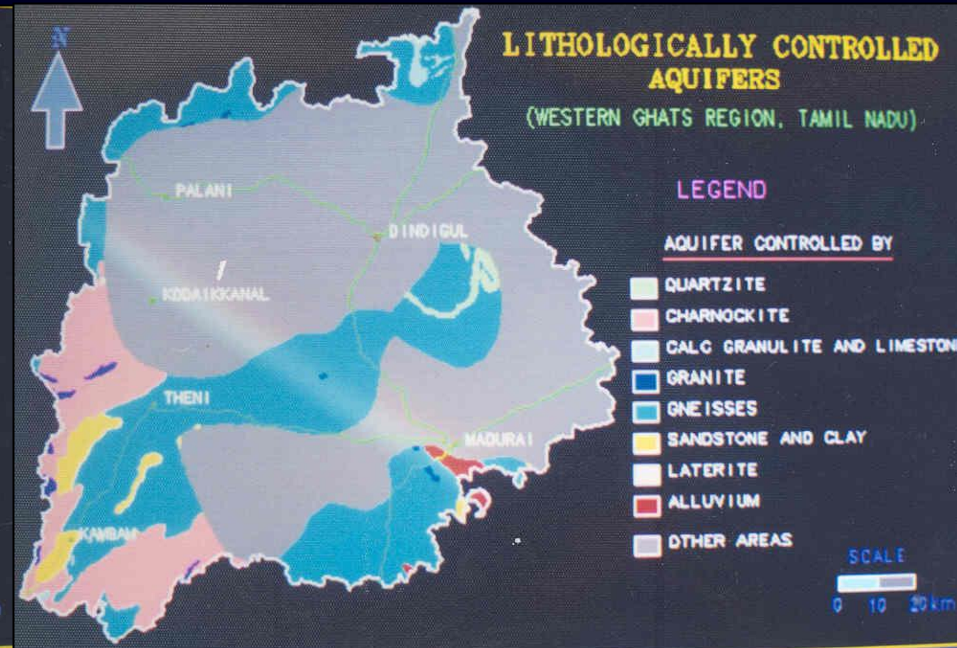
Back

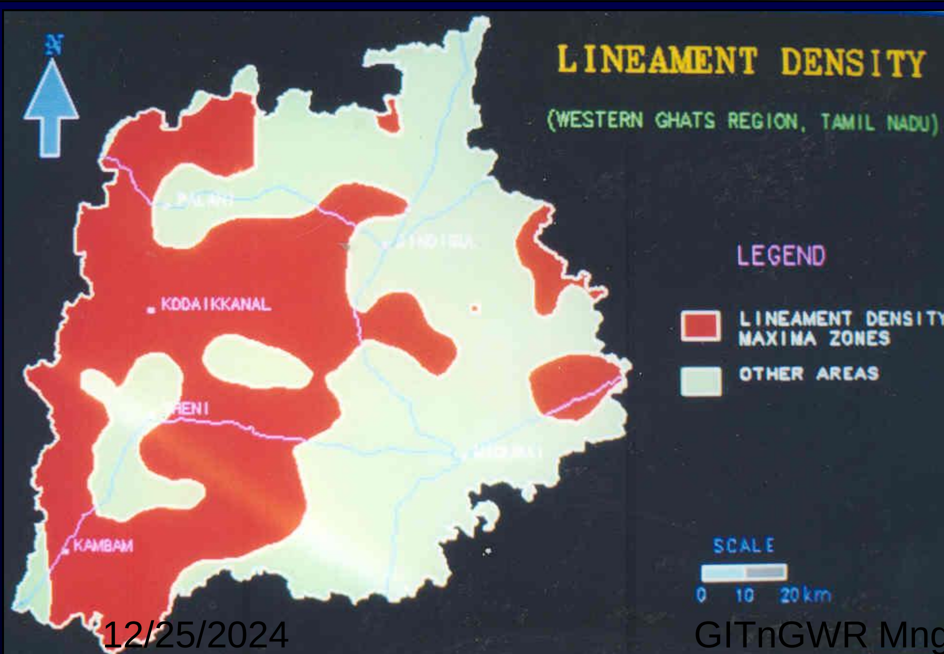
STUDY - 3

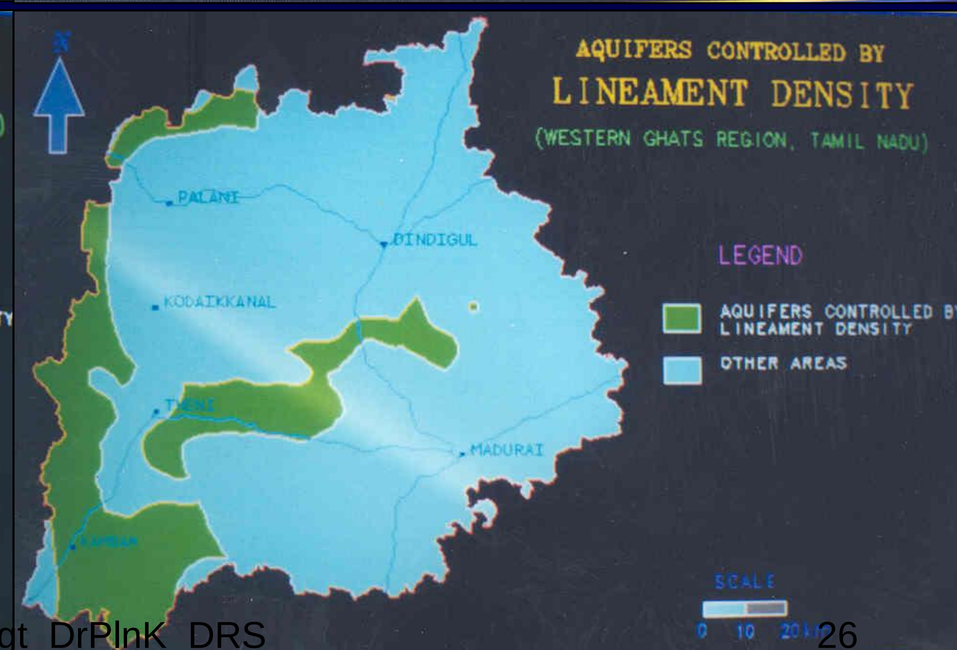
AQUIFER FUNCTION MODELLING

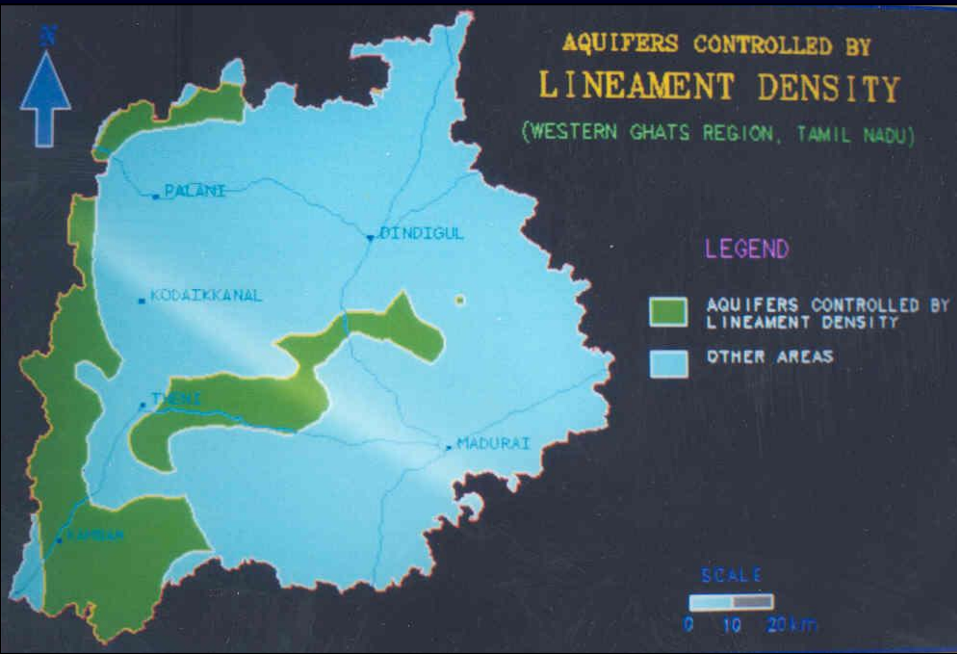
Back

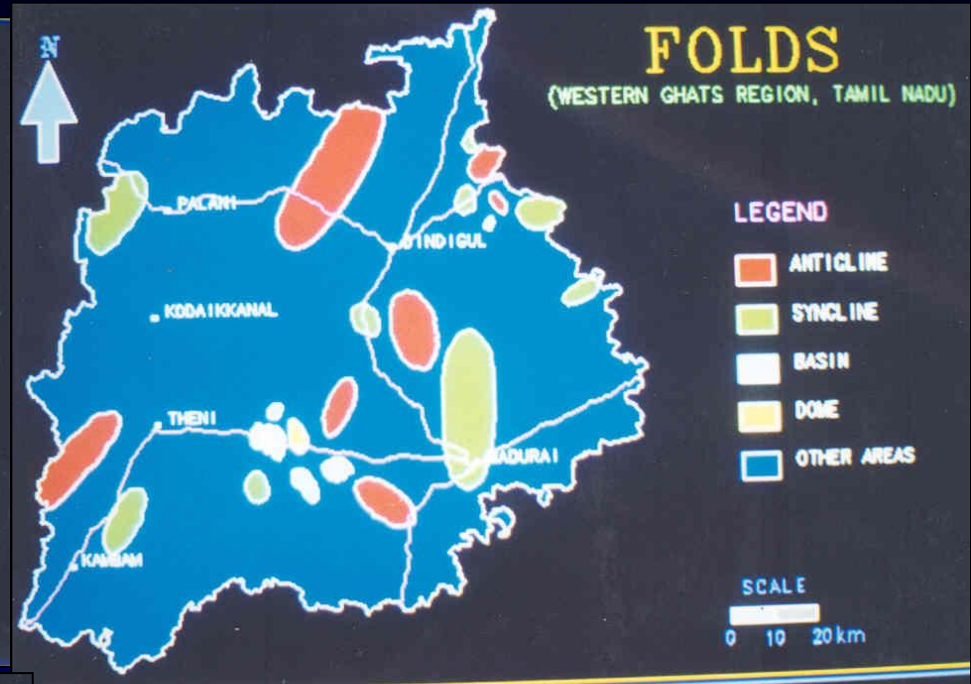

LITHOLOGY
(WESTERN GHATS REGION, TAMIL NADU)
LEGEND
QUARTZITE
CHARNOCKITE
CALC GRANULITE AND LIMESTONE
GRANITE
GNEISSES
SANDSTONE AND CLAY
LATERITE
ALLUVIUM
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM
SCALE
0 10 20 km


LITHOLOGICALLY CONTROLLED AQUIFERS
(WESTERN GHATS REGION, TAMIL NADU)
LEGEND
AQUIFER CONTROLLED BY
QUARTZITE
CHARNOCKITE
CALC GRANULITE AND LIMESTONE
GRANITE
GNEISSES
SANDSTONE AND CLAY
LATERITE
ALLUVIUM
OTHER AREAS
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM
SCALE
0 10 20 km

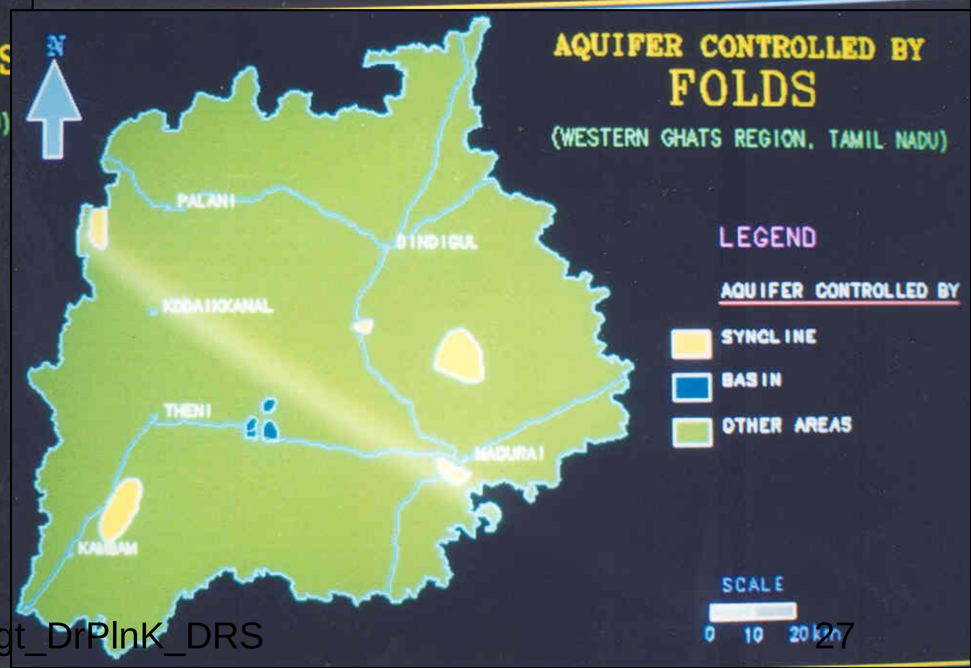

LINEAMENT DENSITY
(WESTERN GHATS REGION, TAMIL NADU)
LEGEND
LINEAMENT DENSITY MAXIMA ZONES
OTHER AREAS
KODAIKKANAL
KAMBAM
SCALE
0 10 20 km


AQUIFERS CONTROLLED BY
LINEAMENT DENSITY
(WESTERN GHATS REGION, TAMIL NADU)
LEGEND
AQUIFERS CONTROLLED BY LINEAMENT DENSITY
OTHER AREAS
PALANI
DINDIGUL
KODAIKKANAL
MADURAI
SCALE
0 10

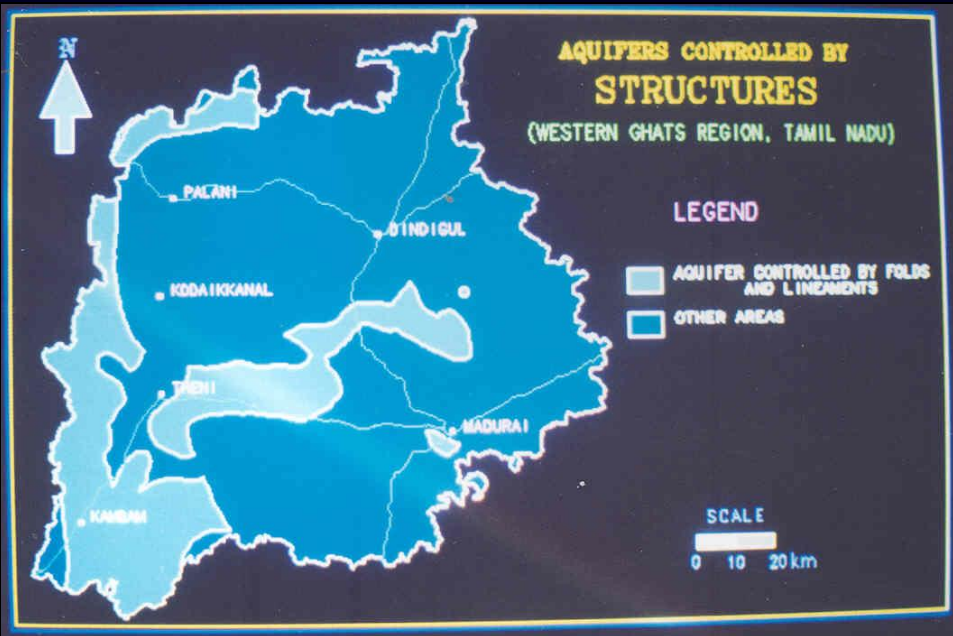

N
AQUIFERS CONTROLLED BY
LINEAMENT DENSITY
(WESTERN GHATS REGION, TAMIL NADU)
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM
LEGEND
AQUIFERS CONTROLLED BY LINEAMENT DENSITY
OTHER AREAS
SCALE
0 10 20km

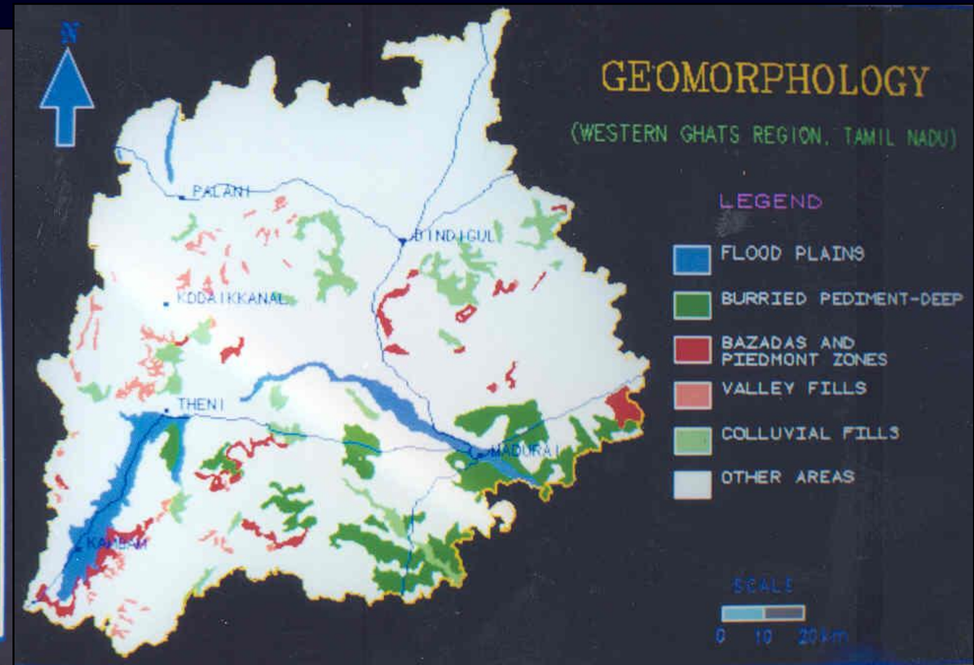

N
FOLDS
(WESTERN GHATS REGION, TAMIL NADU)
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM
LEGEND
ANTICLINE
SYNCLINE
BASIN
DOME
OTHER AREAS
SCALE
0 10 20km

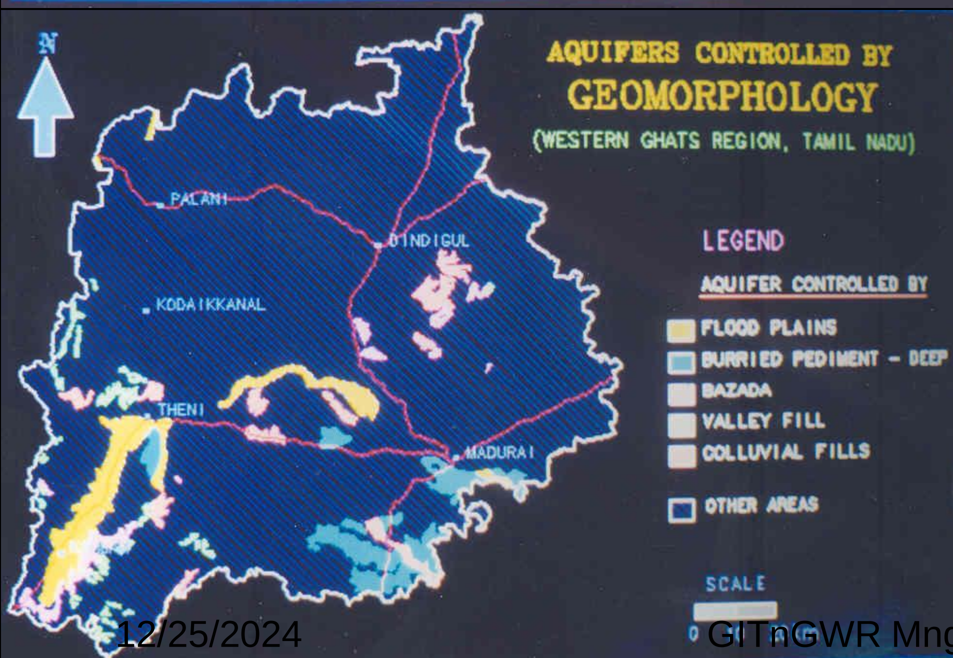

N
SYNCLINES / BASINS
(WESTERN GHATS REGION, TAMIL NADU)
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM
LEGEND
SYNCLINE
BASIN
OTHER AREAS
SCALE

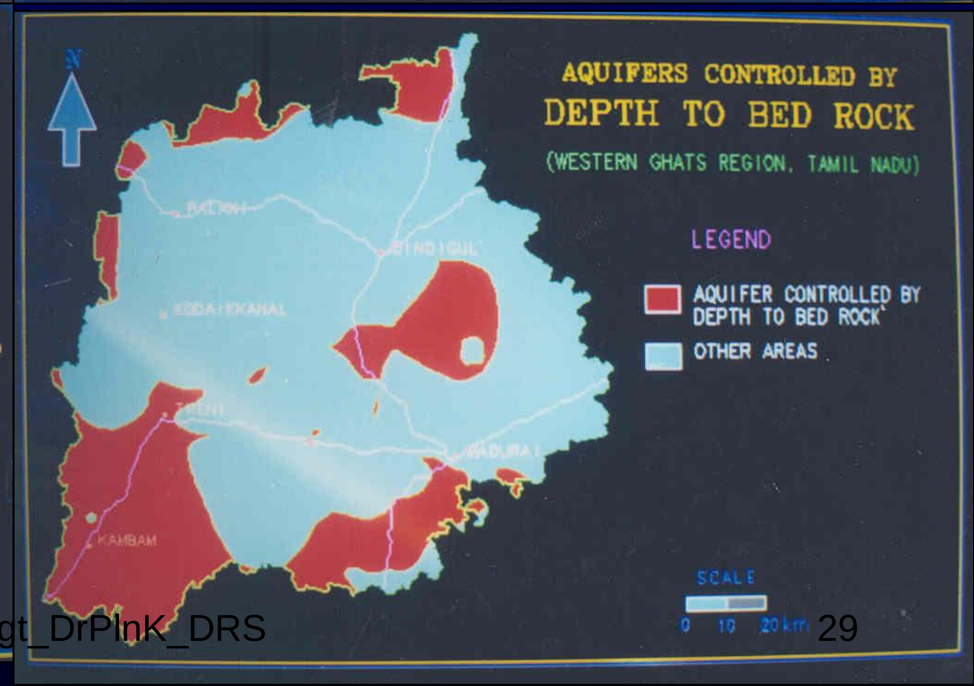

N
AQUIFER CONTROLLED BY
FOLDS
(WESTERN GHATS REGION, TAMIL NADU)
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM
LEGEND
AQUIFER CONTROLLED BY
SYNCLINE
BASIN
OTHER AREAS
SCALE

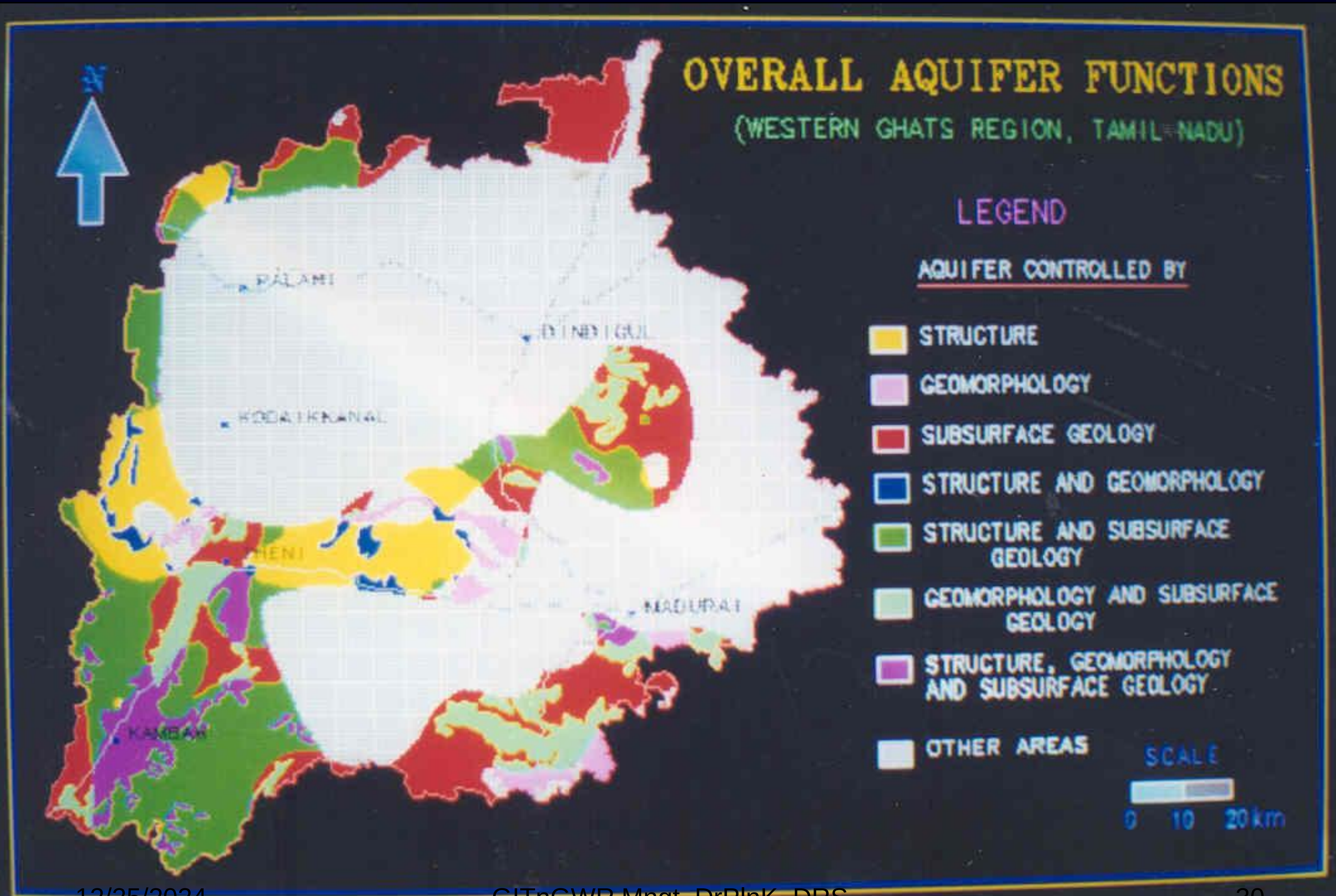

N
GROUNDWATER TARGET AREAS
(T.K.S & 1/WL MAXIMA ZONES)
(WESTERN GHATS REGION, TAMIL NADU)
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM
LEGEND
GROUNDWATER TARGETS
(ZONES OF TRANSMISSIVITY, PERMEABILITY AND STORAGE CO-EFFICIENT MAXIMA AND SHALLOW WATER LEVEL)
OTHER AREAS
SCALE
0 10 20 km


N
AQUIFERS CONTROLLED BY
STRUCTURES
(WESTERN GHATS REGION, TAMIL NADU)
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM
LEGEND
AQUIFER CONTROLLED BY FOLDS AND LINEAMENTS
OTHER AREAS
SCALE
0 10 20km


N
GEOMORPHOLOGY
(WESTERN GHATS REGION, TAMIL NADU)
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM
LEGEND
FLOOD PLAINS
BURRIED PEDIMENT-DEEP
BAZADAS AND PIEDMONT ZONES
VALLEY FILLS
COLLUVIAL FILLS
OTHER AREAS
SCALE
0 10 20km


N
AQUIFERS CONTROLLED BY
GEOMORPHOLOGY
(WESTERN GHATS REGION, TAMIL NADU)
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
LEGEND
AQUIFER CONTROLLED BY
FLOOD PLAINS
BURRIED PEDIMENT - DEEP
BAZADA
VALLEY FILL
COLLUVIAL FILLS
OTHER AREAS
SCALE


N
AQUIFERS CONTROLLED BY
DEPTH TO BED ROCK
(WESTERN GHATS REGION, TAMIL NADU)
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM
LEGEND
AQUIFER CONTROLLED BY DEPTH TO BED ROCK
OTHER AREAS
SCALE
0 10 20km



N
OVERALL AQUIFER FUNCTIONS
(WESTERN GHATS REGION, TAMIL NADU)
LEGEND
AQUIFER CONTROLLED BY
STRUCTURE
GEOMORPHOLOGY
SUBSURFACE GEOLOGY
STRUCTURE AND GEOMORPHOLOGY
STRUCTURE AND SUBSURFACE GEOLOGY
GEOMORPHOLOGY AND SUBSURFACE GEOLOGY
STRUCTURE, GEOMORPHOLOGY AND SUBSURFACE GEOLOGY
OTHER AREAS
SCALE
0 10 20 km
PALANI
DINDIGUL
KODAIKKANAL
MADURAI

Back

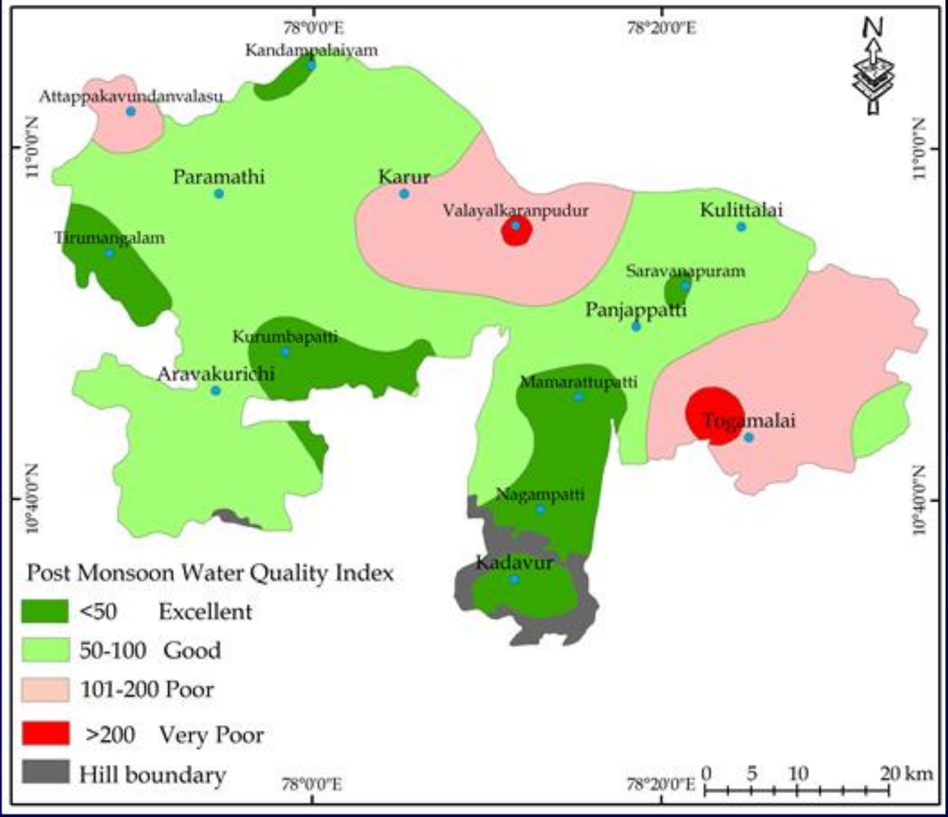
STUDY - 4

Groundwater Quality Modelling

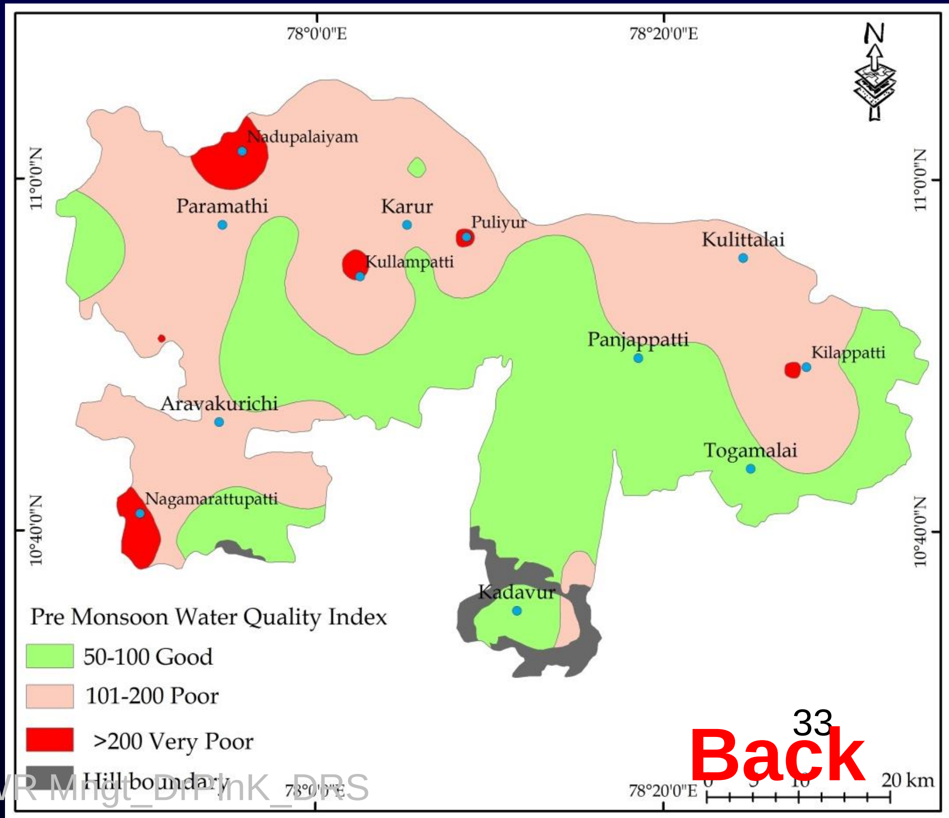
Back

Based on the water quality standards prescribed by ISI / BIS / WHO, the zones of potable water, irrigable water and water for industrial and other uses can be mapped using GIS interpolation, isoline mapping, buffering and / or layer indexing and integration tools.

Drinking Water Specifications (IS 10,500:1991)		
Characteristics	**Desirable limit**	**Permissible limit**
Essential Characteristics		
Colour, Hazen Units, Max	5	25
Odour	Unobjectionable	-
Taste	Agreeable	-
Turbidity, NTU, Max	5	10
pH value	6.5 to 8.5	-
Total Hardness (as $CaCo_3$), mg/l, Max	300	600
Iron (as Fe), mg/l, Max	0.3	1.0
Chlorides (as Cl), mg/l, Max	250	1,000
Residual free chlorine, mg/l, Max	0.2	-



Post monsoon Water Quality Index



Pre monsoon Water Quality Index

GROUND WATER RECHARGE

Back

RECHARGE APPROACH:

- **Understanding of Aquifer Conditions.**
- **Evaluation of various controlling parameters.**
  - **Geological conditions (Lithology, Structures Geomorphology & Subsurface Lithology)**
  - **Soil Characters**
  - **Slope (terrain inclination/flatness) and**
  - **Landuse / Land cover.**
- **Suggestion of Site suitable mechanisms for recharge.**

TYPES OF RECHARGE:

- Natural recharge
- Artificial recharge

Back

STUDY – 5

NATURAL RECHARGE

Back

NATURAL RECHARGE:

Variation in water level increase after the rain, i.e.,

- **Some area with 50cm raise**
- **Some other area with 5-10 meter raise**

So, we need to find the reasons for such variance.

Natural Recharge of groundwater is defined as the natural process of infiltration of surface water into the ground and percolates further deep inside so as to fill the aquifer formation due to which the groundwater level comes up.

EVALUATION OF NATURAL RECHARGE:

- **Determination of Natural Recharge pattern of the area using 30 years of pre- and post-monsoon water level data**

- **Preparation of various thematic maps on probable controlling parameters of natural recharge.**

- **Mathematical and Thematic integrated analysis for finding out the controlling parameters**

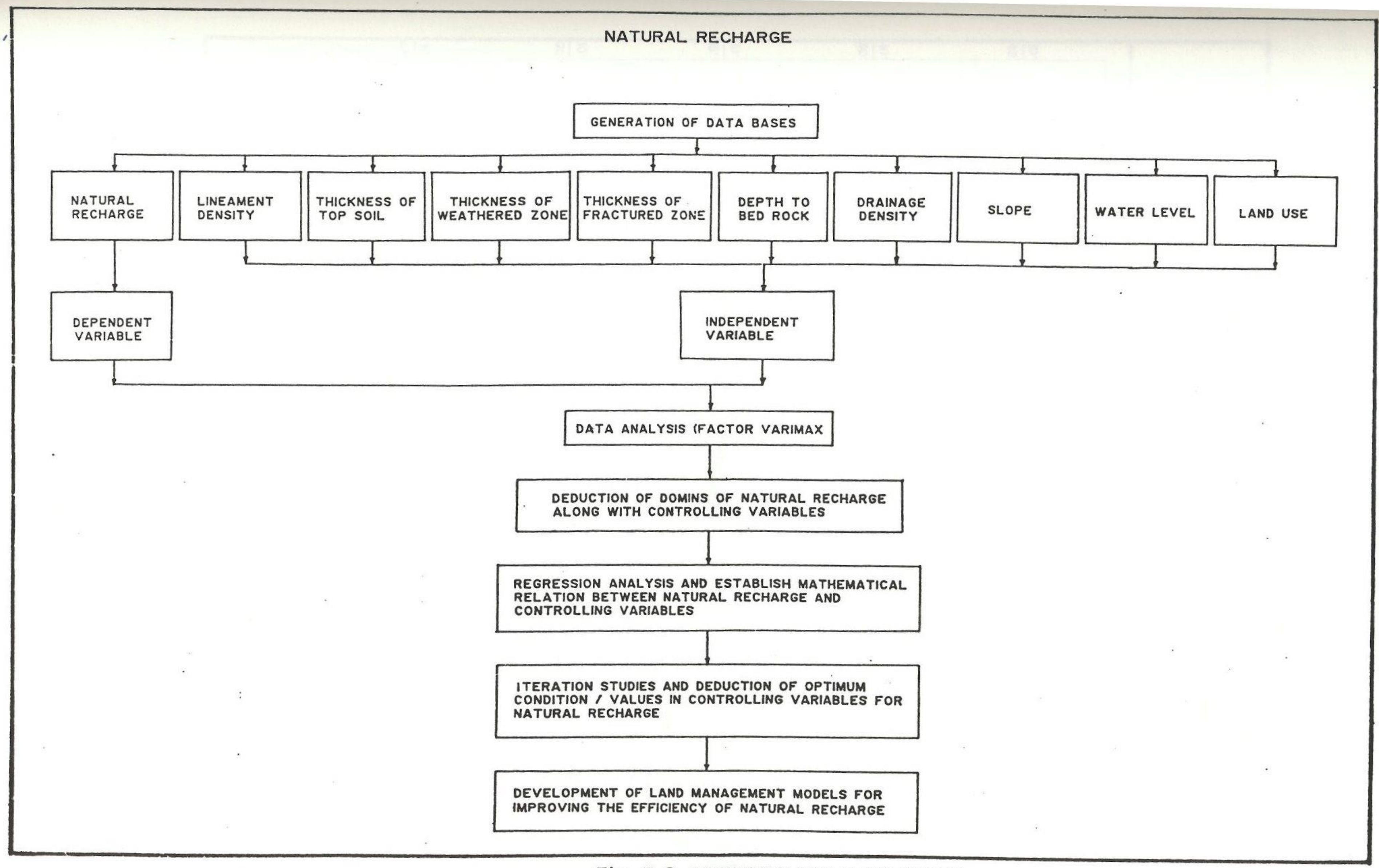
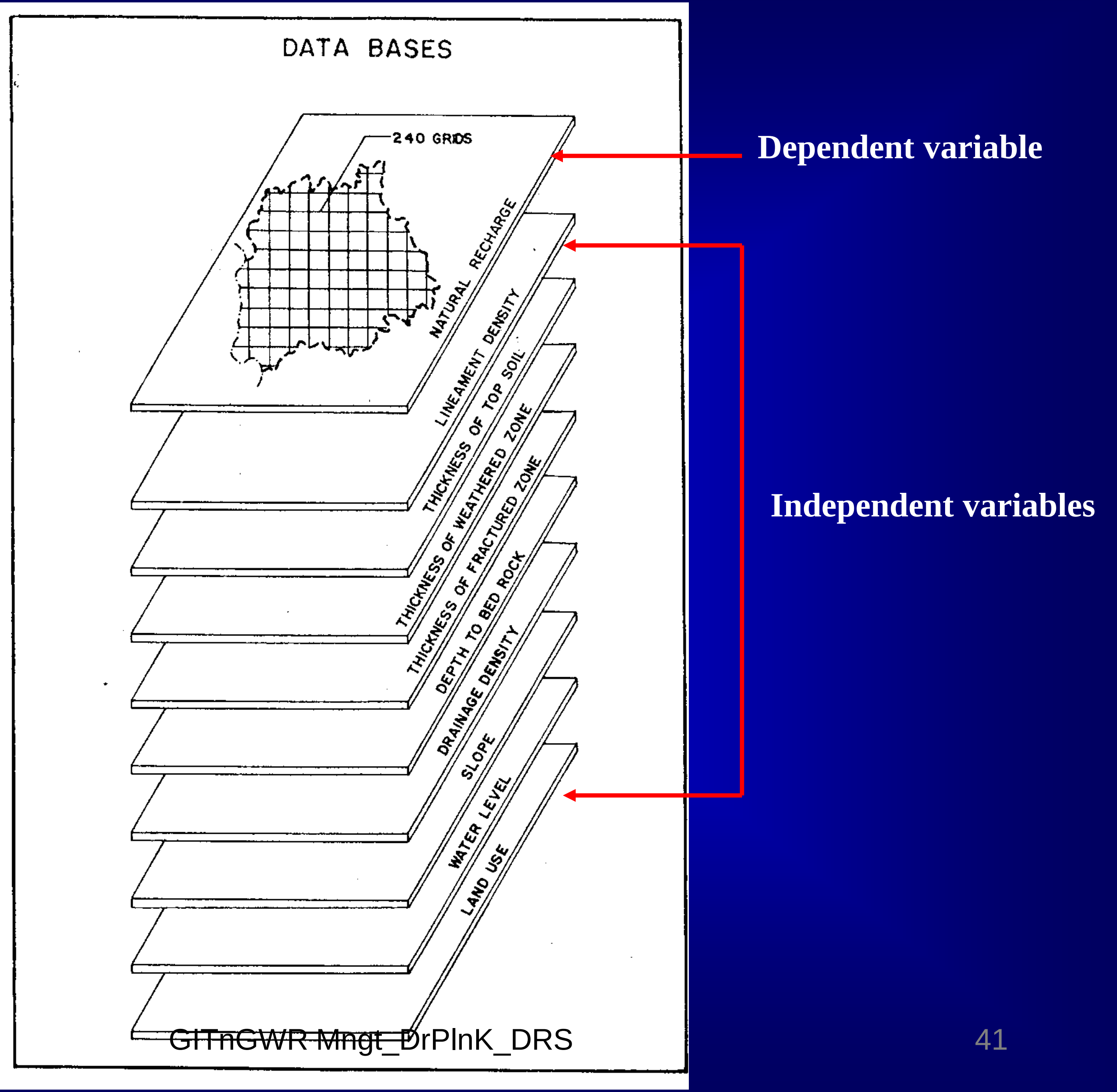


Fig. 6.2 METHODOLOGY FLOW CHART


DATA BASES
240 GRIDS
NATURAL RECHARGE
LINEAMENT DENSITY
THICKNESS OF TOP SOIL
THICKNESS OF WEATHERED ZONE
THICKNESS OF FRACTURED ZONE
DEPTH TO BED ROCK
DRAINAGE DENSITY
SLOPE
WATER LEVEL
LAND USE
Dependent variable
Independent variables

STPES INVOLVED

- Generate gridwise database on NR & CP
- Standardize the data – using linear stretching
- Calculate correlation matrix and then Eigen values – Factor scores – Factor loadings
- Filter out highly relevant variables
- Filter out the grids with high loadings and the database
- Calculate Regression values – build model
- By fitting the required CP value – identify the quantum of variables for improvement
- Iterate the same practice for other sets of values

NUMERICAL ANALYSIS

Generate Numerical Database for each theme - gridwise on:

Dependent variable:

- **Natural recharge – in m**

  (Difference in water levels prior and after monsoons – Identify recharge and discharge areas)

Independent variables

- **Lineament Density – in km/64sq.km**
- **Thickness of Topsoil – in m**
- **Thickness of Weathered Zone – in m**
- **Thickness of Fractured Zone – in m**
- **Depth to Bedrock – in m**
- **Drainage Density – in km/64 sq.km**
- **Slope - in degrees**
- **Water level – in m and**
- **Land use / Land cover – by assigning NR capability based notional numerical grades and then values.**

- After standardizing, run correlation and factor analysis to derive Eigen Values and Eigen Vectors
- Identify the factor loadings and then list out the factor scores – to decide the effective regions / grids having considerable relations between NR and Ind.Variables
- Filter out the database (**TTS, TWZ, TFZ, DBR, SLP & WL in effective grids only);** and run Regression analysis
- Buildup the numerical model
- Fit-in the regrouped data as input in the model to find out the quantum of Ind.Var. needed to attain required amount of NR.

Linear Regression Model

NR = 35.72938 + (0.1014 * TTS) – (0.5427 * TWZ) + (0.0851 * TFZ) – (0.3363 * DBR) - (0.0693 * SLP) – (0.4634 * WL)

Where, NR = Natural Recharge, TTS = Thickness of Top Soil; TWZ = Thickness of Weathered Zone;

TFZ = Thickness of Fractured Zone; DBR = Depth to Bed Rock; SLP = Sope; WL = Groundwater Level

Constant Co-efficient A= 35.72938;

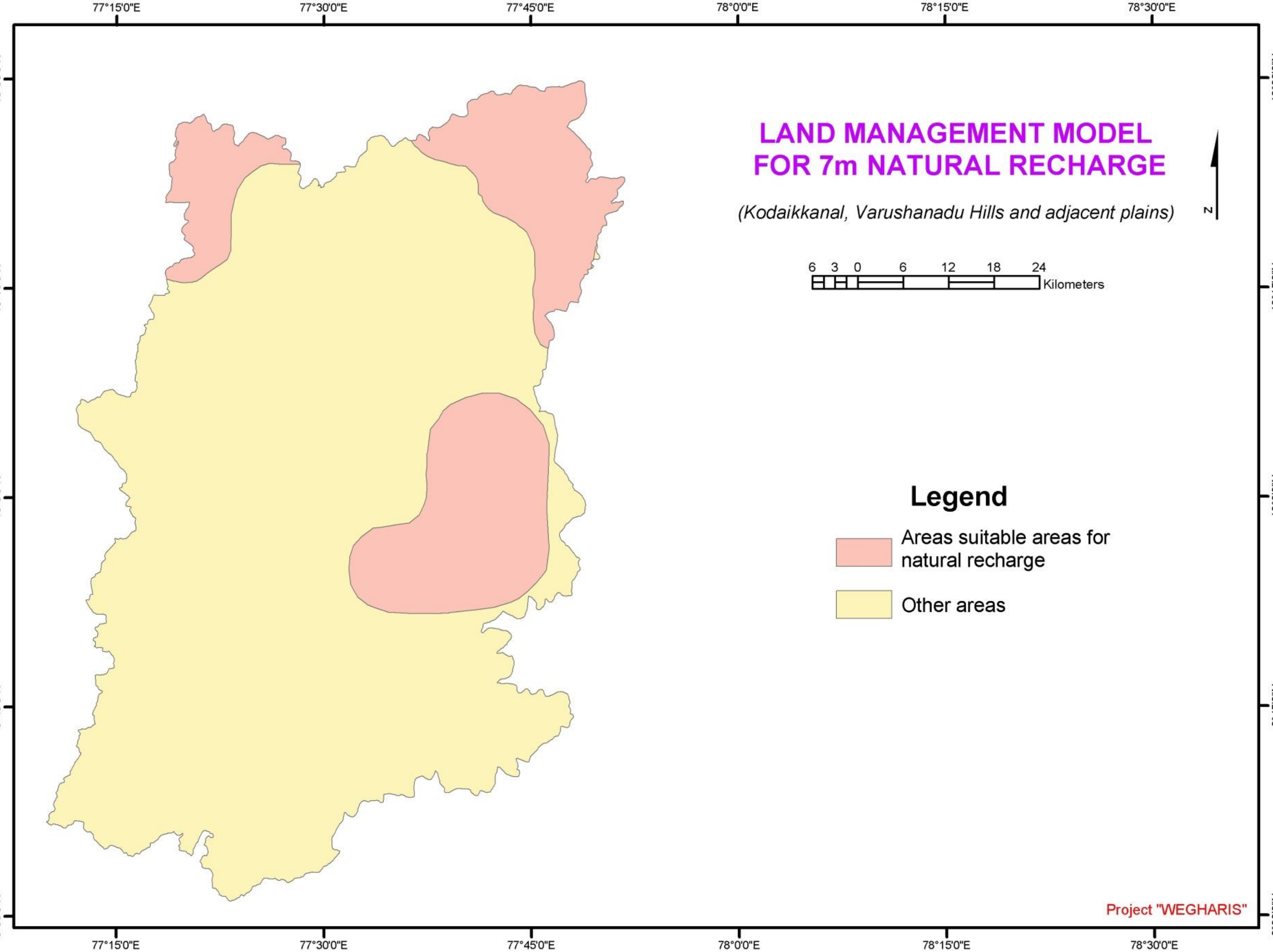
Constant Co-efficient B1 = +0.1014 (TTS) ; Constant Co-efficient B2 = – 0.5427 (TWZ);

Constant Co-efficient B3 = +0.0851 (TFZ); Constant Co-efficient B4 = –0.3363 (DBR);

Constant Co-efficient B5 = -0.0693 (SLP); Constant Co-efficient B6 = –0.4634 (WL)

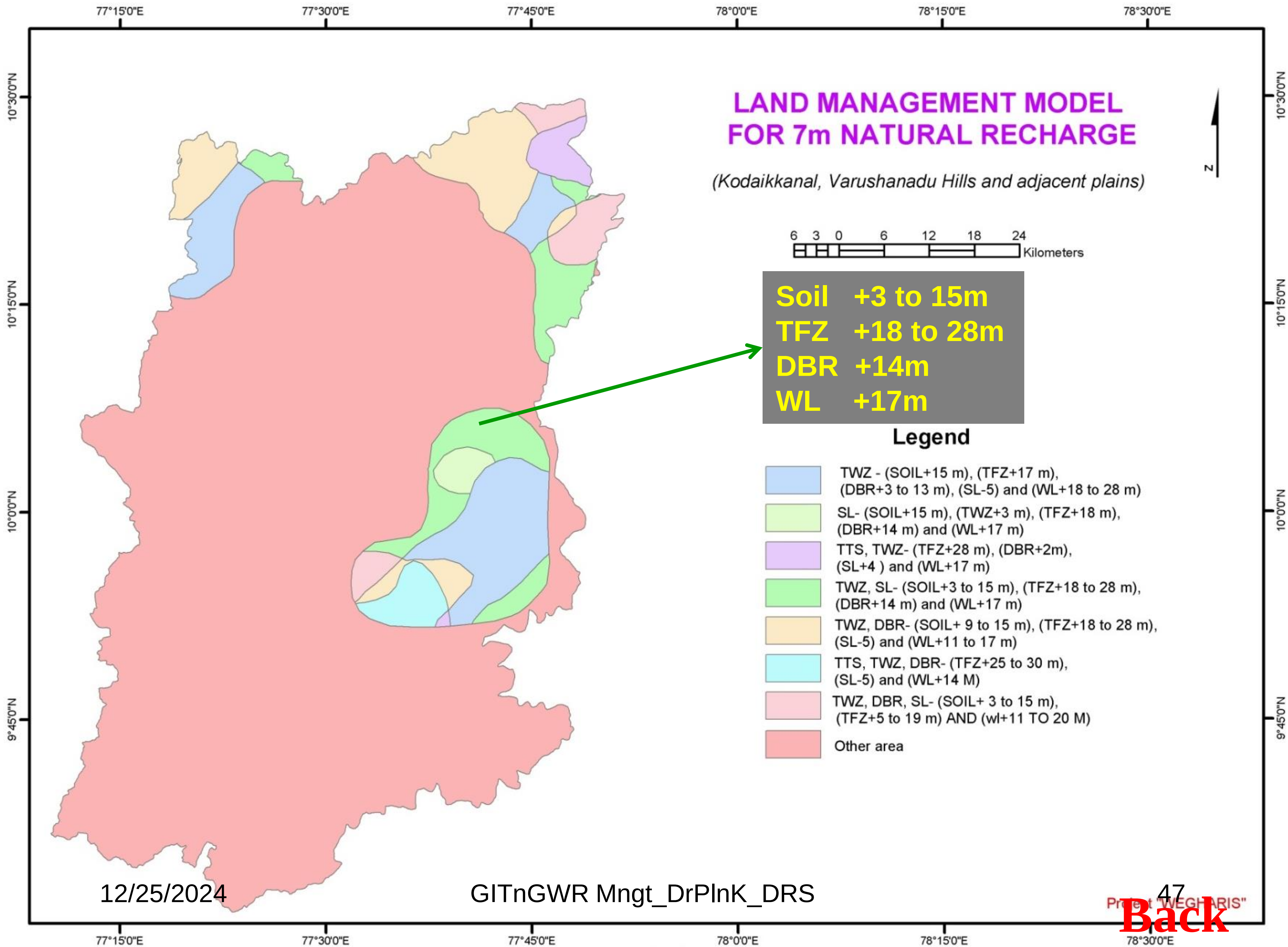
Regression analysis brings out the:

- Natural recharge domains according to the controlling parameters
- One to one mathematical relationship between natural recharge controlling Parameters and
- Optimization of controlling parameters for achieving efficient level of recharge during rainy season.



LAND MANAGEMENT MODEL
FOR 7m NATURAL RECHARGE
(Kodaikkanal, Varushanadu Hills and adjacent plains)
N
6 3 0 6 12 18 24
Kilometers
Legend
Areas suitable areas for natural recharge
Other areas
Project "WEGHARIS"
77°15'0"E
77°30'0"E
77°45'0"E
78°0'0"E
78°15'0"E
78°30'0"E
10°30'0"N
10°15'0"N
10°0'0"N
9°45'0"N
9°30'0"N

Fig. 4.1


LAND MANAGEMENT MODEL
FOR 7m NATURAL RECHARGE
(Kodaikkanal, Varushanadu Hills and adjacent plains)
6 3 0 6 12 18 24 Kilometers
N
Soil +3 to 15m
TFZ +18 to 28m
DBR +14m
WL +17m
Legend
TWZ - (SOIL+15 m), (TFZ+17 m), (DBR+3 to 13 m), (SL-5) and (WL+18 to 28 m)
SL- (SOIL+15 m), (TWZ+3 m), (TFZ+18 m), (DBR+14 m) and (WL+17 m)
TTS, TWZ- (TFZ+28 m), (DBR+2m), (SL+4) and (WL+17 m)
TWZ, SL- (SOIL+3 to 15 m), (TFZ+18 to 28 m), (DBR+14 m) and (WL+17 m)
TWZ, DBR- (SOIL+ 9 to 15 m), (TFZ+18 to 28 m), (SL-5) and (WL+11 to 17 m)
TTS, TWZ, DBR- (TFZ+25 to 30 m), (SL-5) and (WL+14 M)
TWZ, DBR, SL- (SOIL+ 3 to 15 m), (TFZ+5 to 19 m) AND (wl+11 TO 20 M)
Other area
77°15'0"E
77°30'0"E
77°45'0"E
78°0'0"E
78°15'0"E
78°30'0"E
10°30'0"N
10°15'0"N
10°0'0"N
9°45'0"N

STUDY -6

ARTIFICIAL RECHARGE

Back

ARTIFICIAL RECHARGE:

Inducing the surface water to get infiltrated below the surface and percolated deep inside the ground by artificial means by improving the prevailing terrain conditions and thus recharge the aquifer potentially is known as artificial recharge.

- **To identify suitable site or improve the site more porous and pervious for artifical recharge**
- **To push maximum flood water into the aquifer system through appropriate site specific mechanism**
- **To suggest suitable structures to be constructured to increase the storage and the infiltration increased which in turn recharge the ground water.**

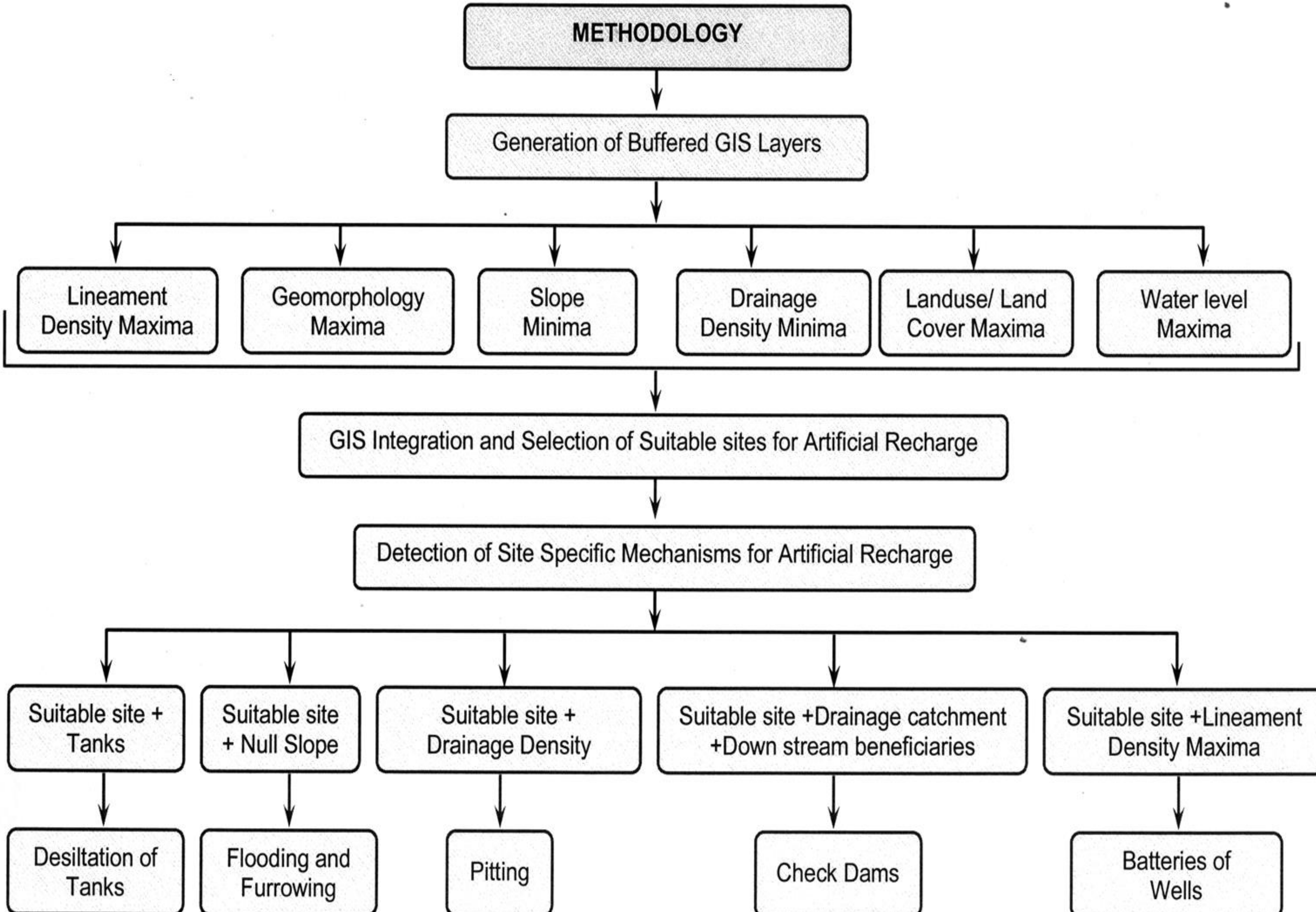
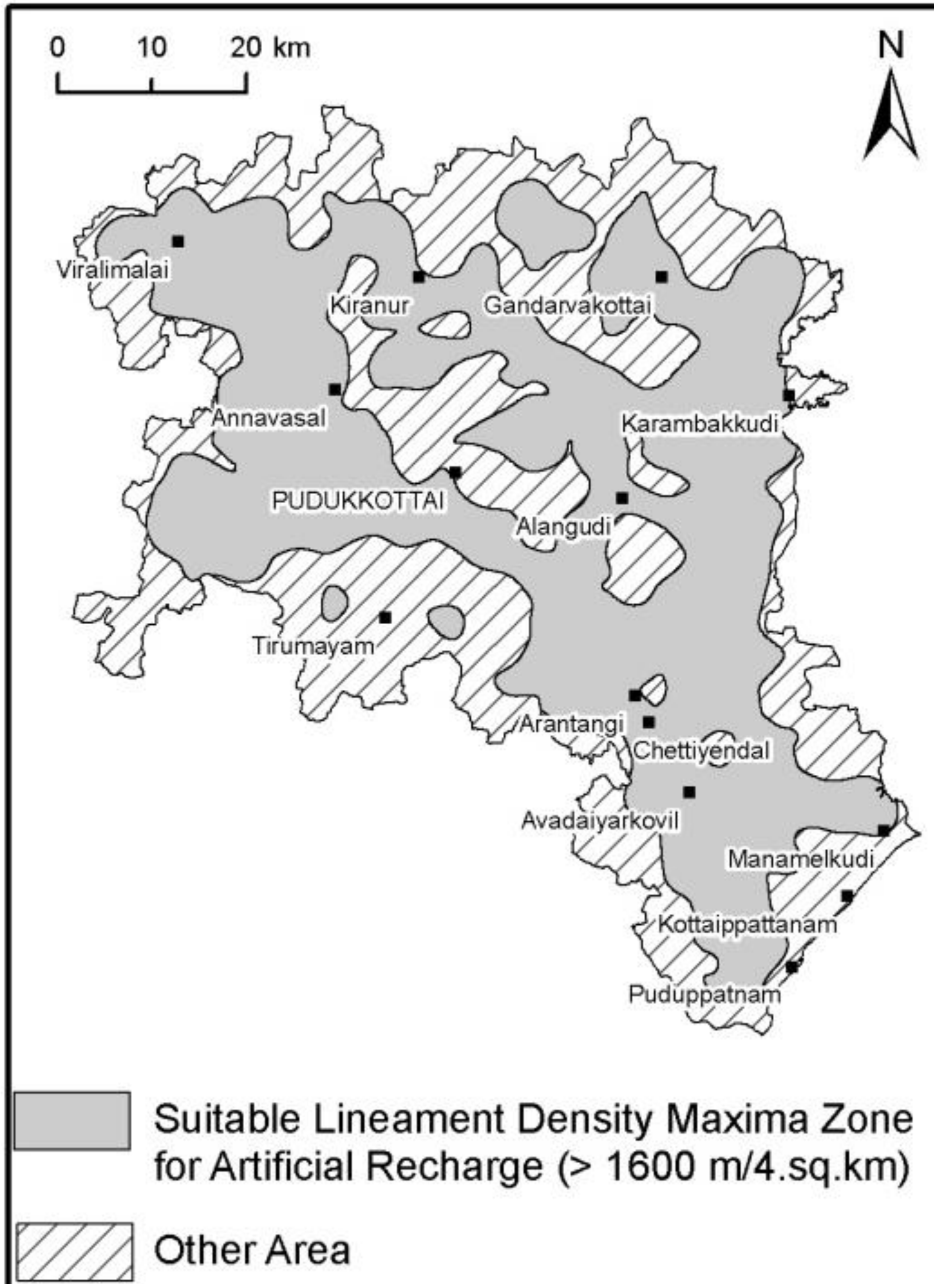


Fig. 6.36 Methodology – Site Selection and Mechanism Detection for Artificial Recharge



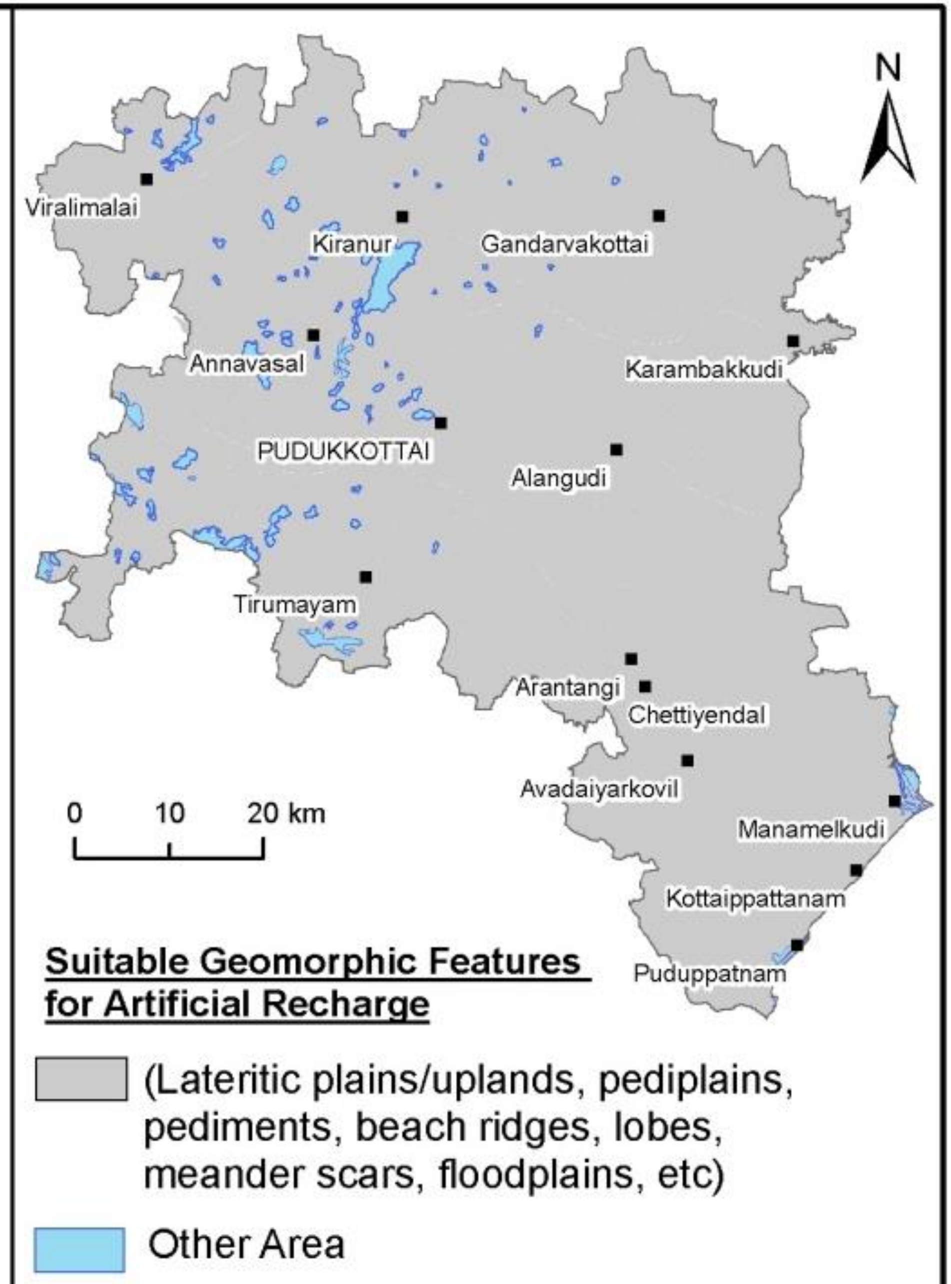


Fig.6.37 Lineament Density

Fig.6.38 Geomorphology

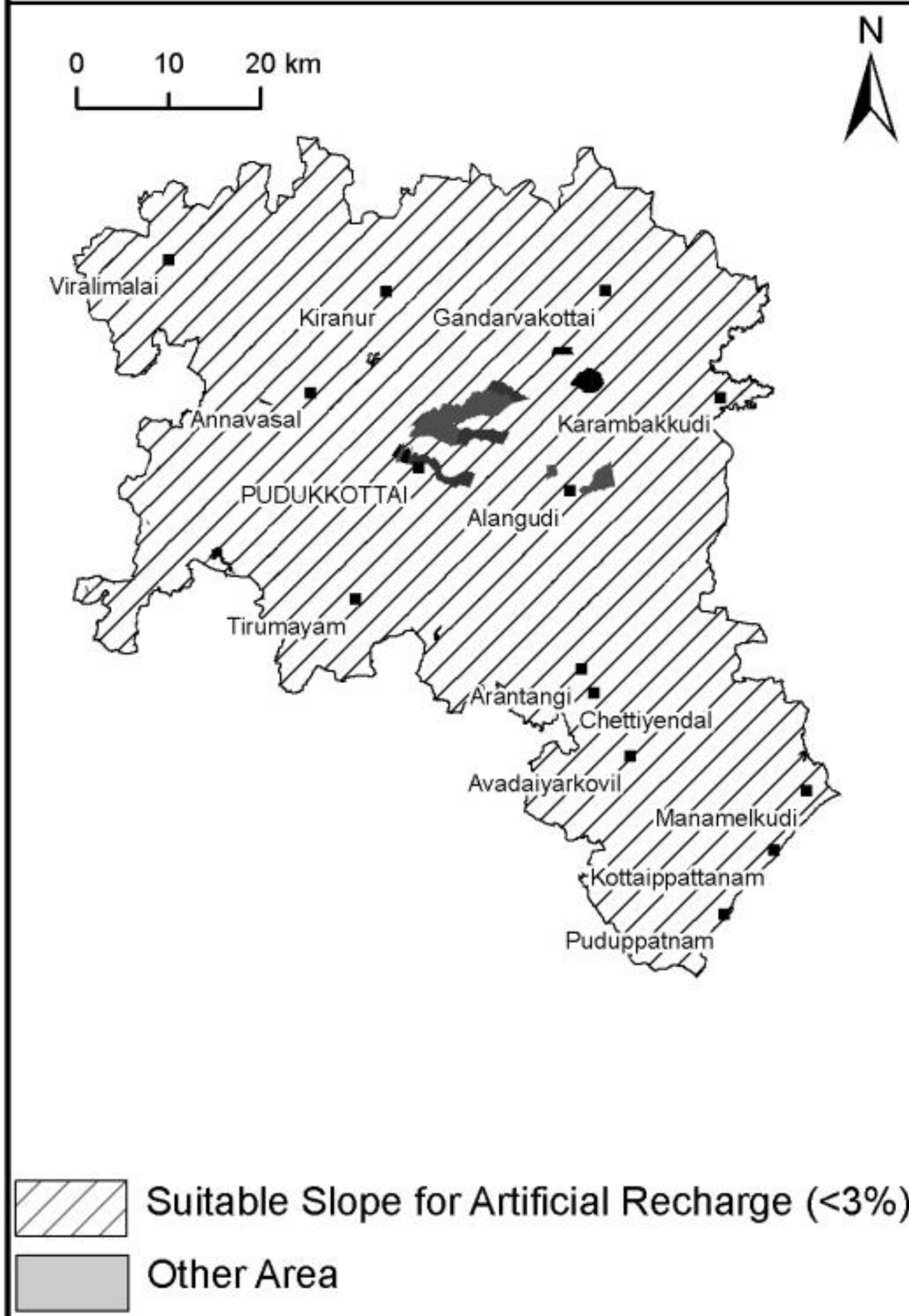


Fig.6.39 Slope

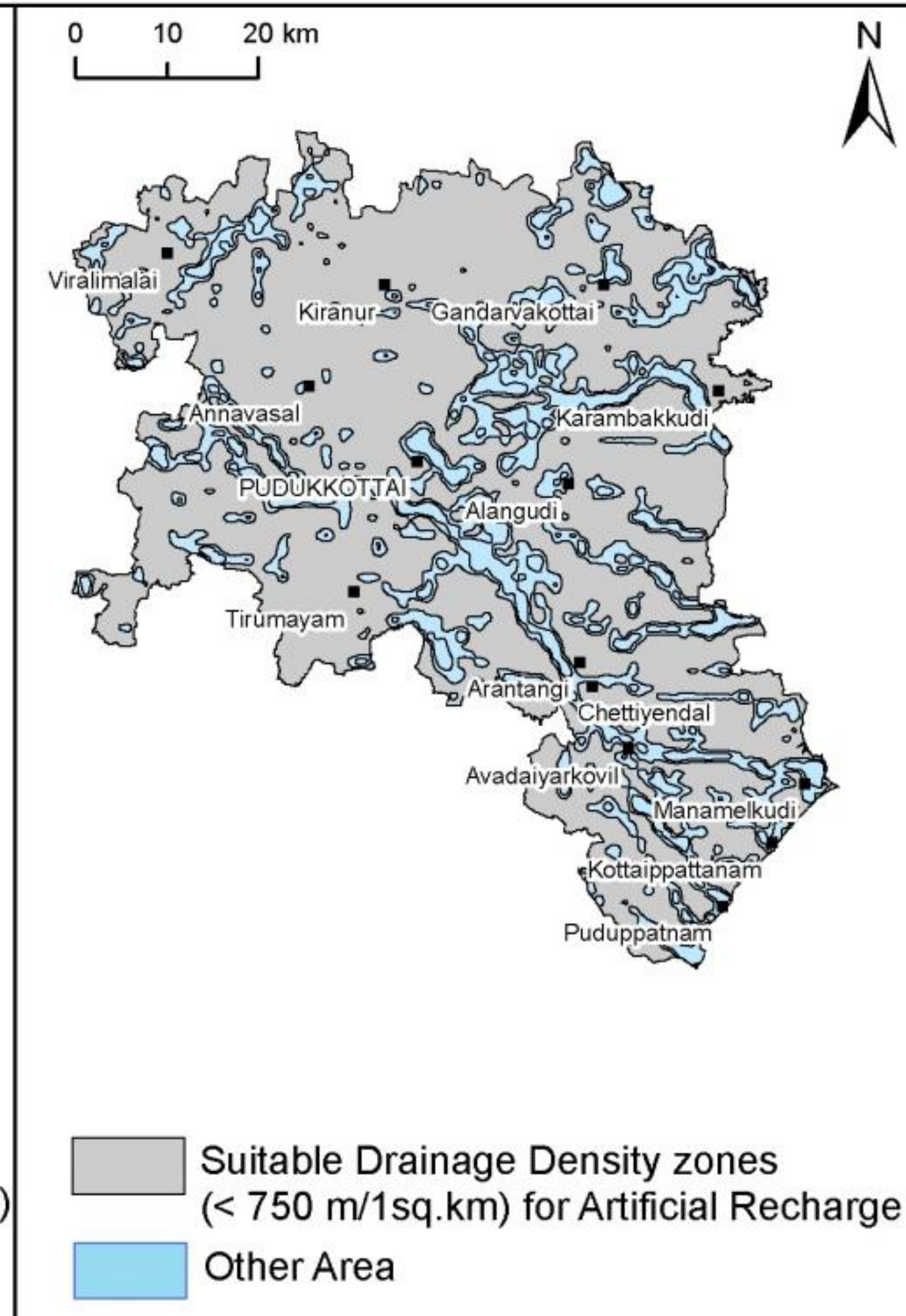


FIg.6.40 Drainage Density

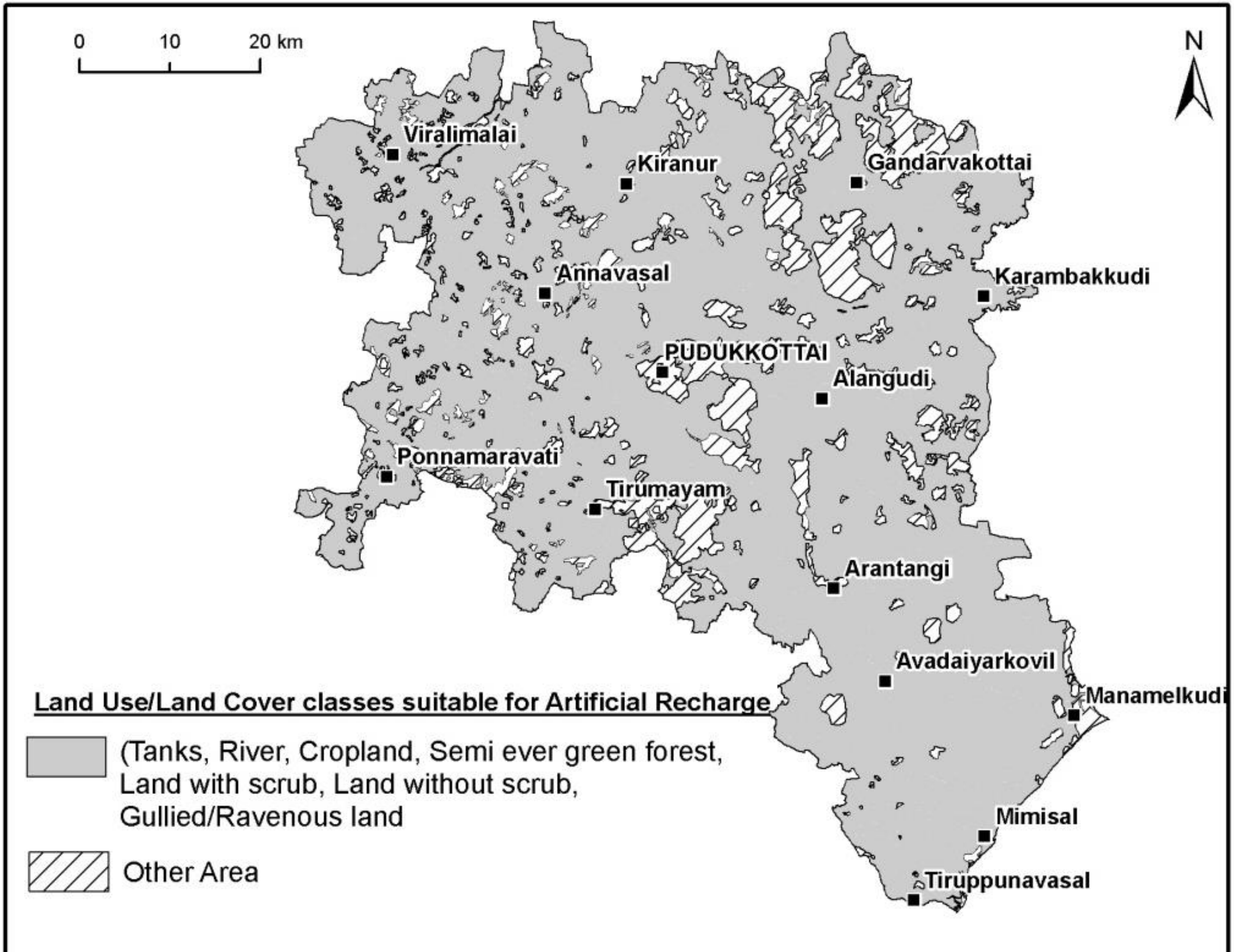


Fig.6.41 Land Use/Land Cover

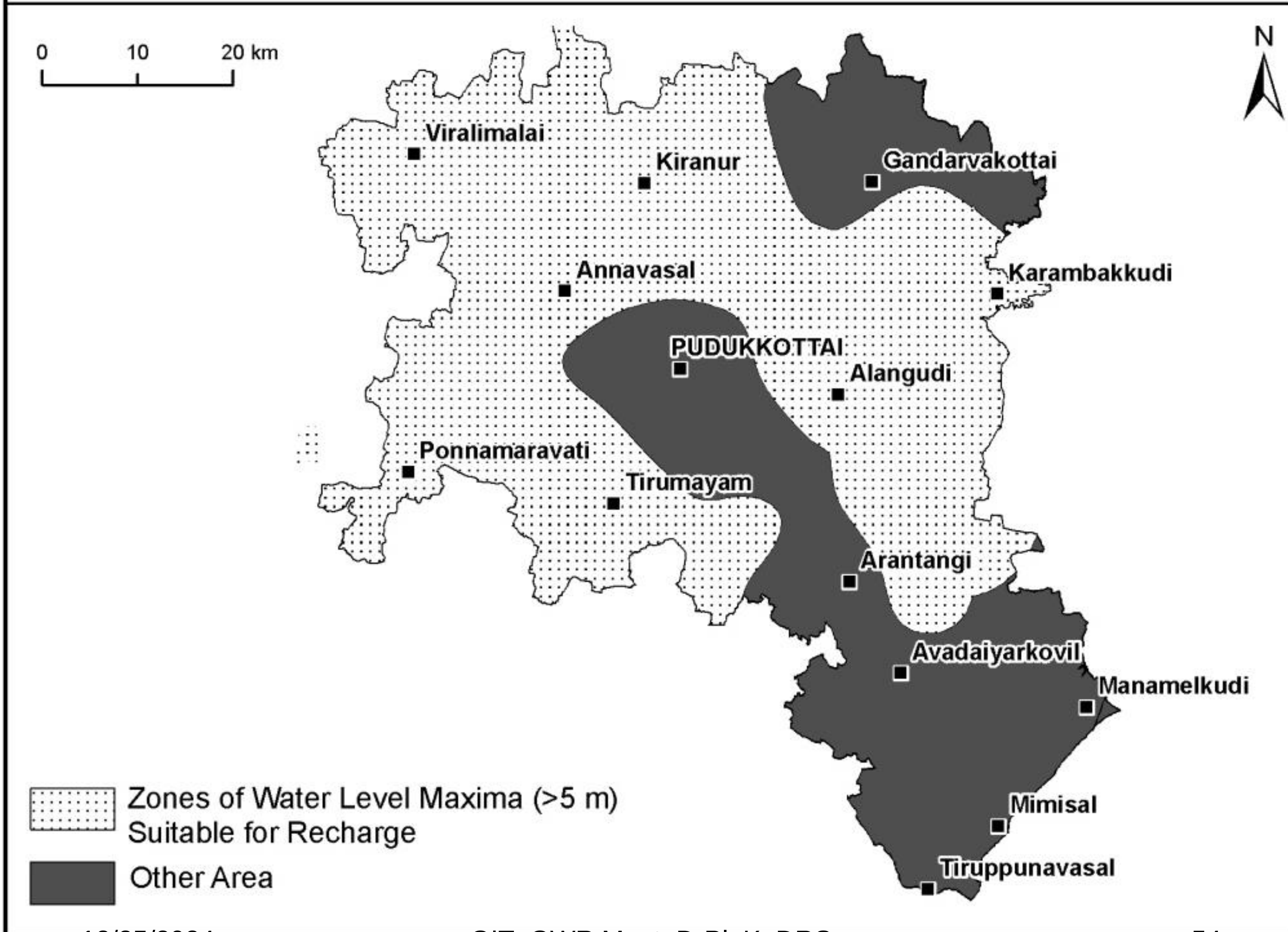


Fig. 6.42 Water Level

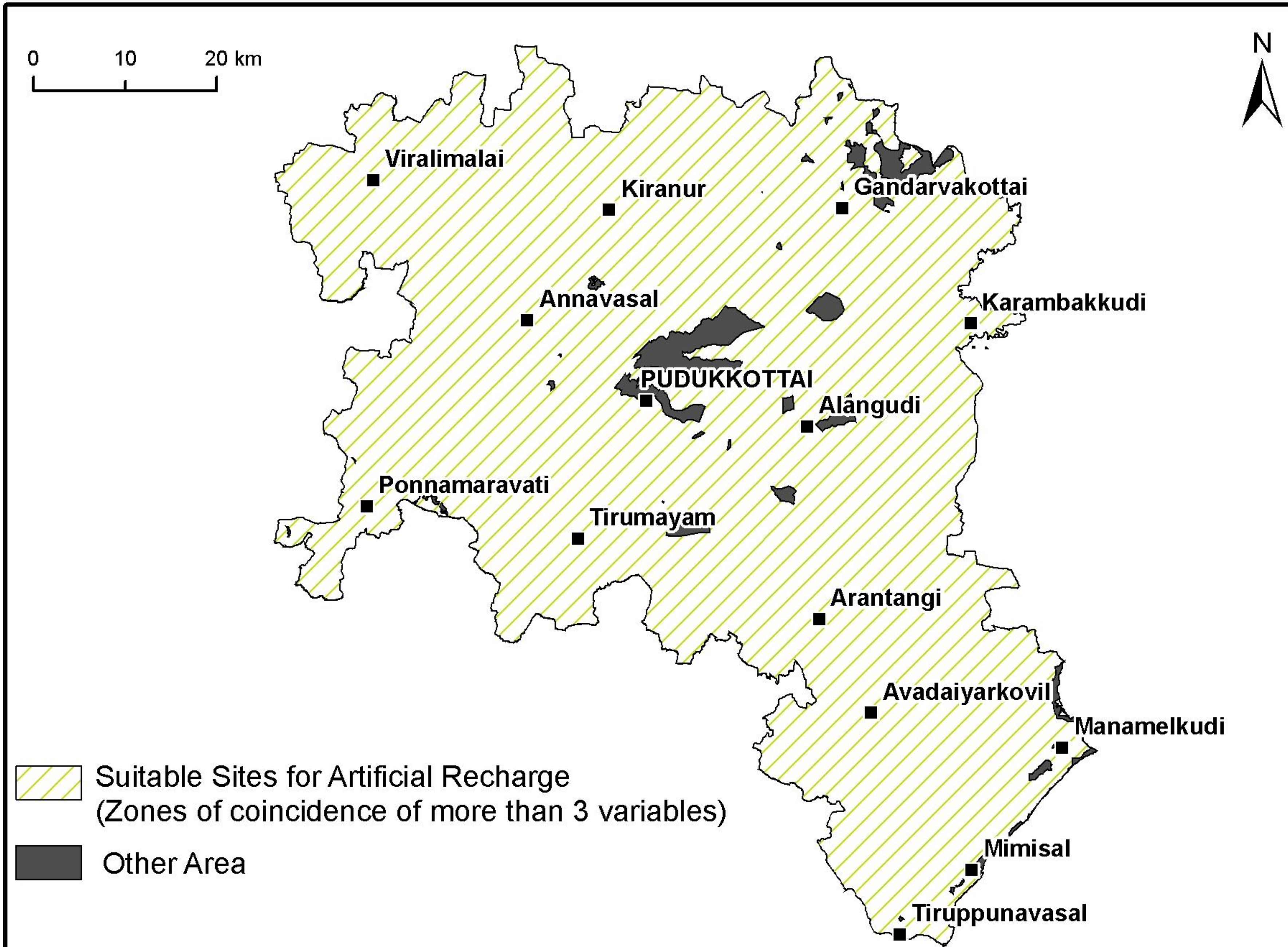


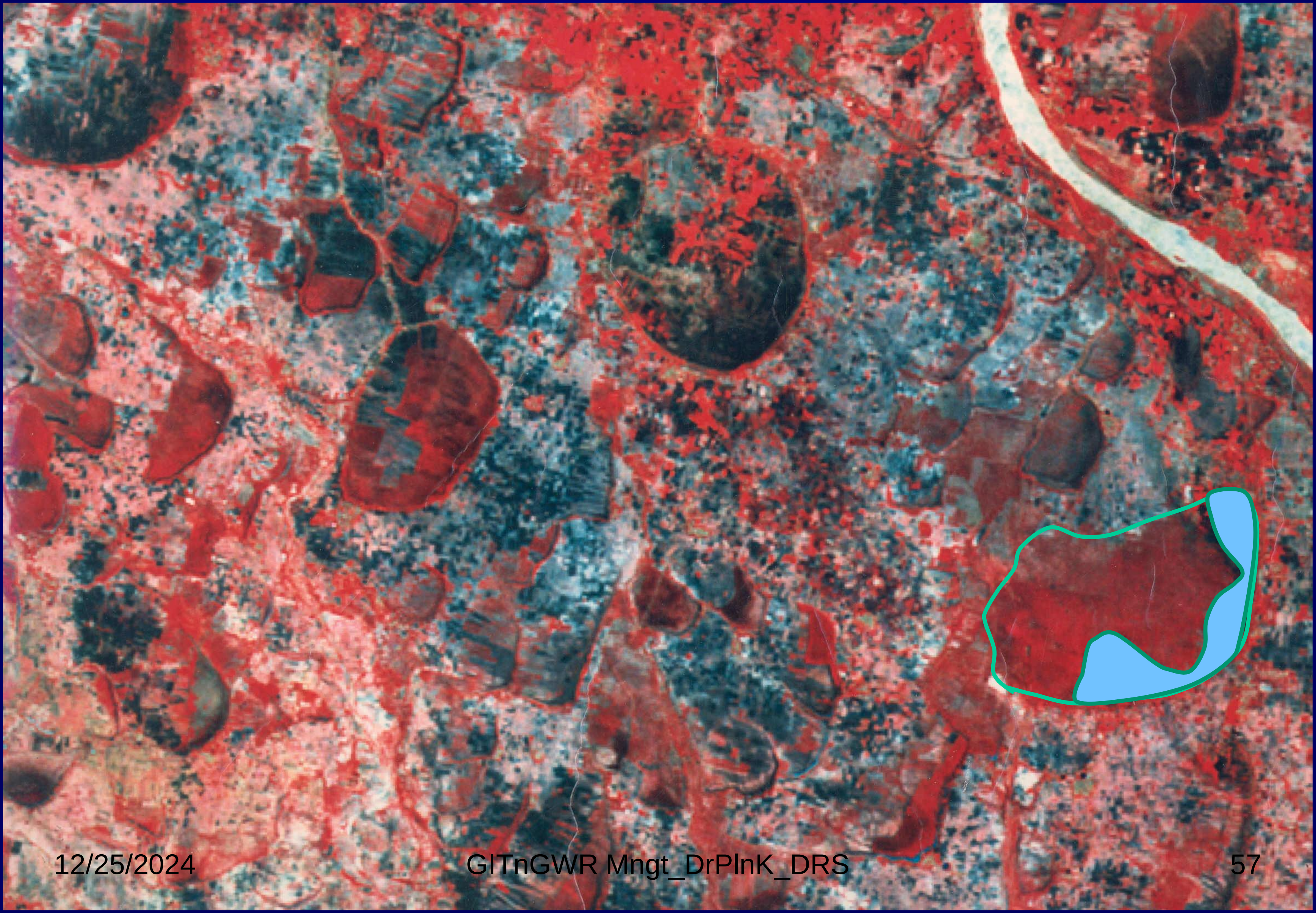
Fig.6.43 Suitable Sites for Artificial Recharge

Recharge structures

- Check dams
- Hydro-fracturing
- Sub-surface dykes
- Recharge Ditches
- Percolation ponds
- Dendritic furrowing
- Recharge Pitting
- En-echelon damming
- Batteries of wells, etc…

- ❖ Induced recharge
- ❖ Desiltation of tanks

DESILTATION OF TANKS

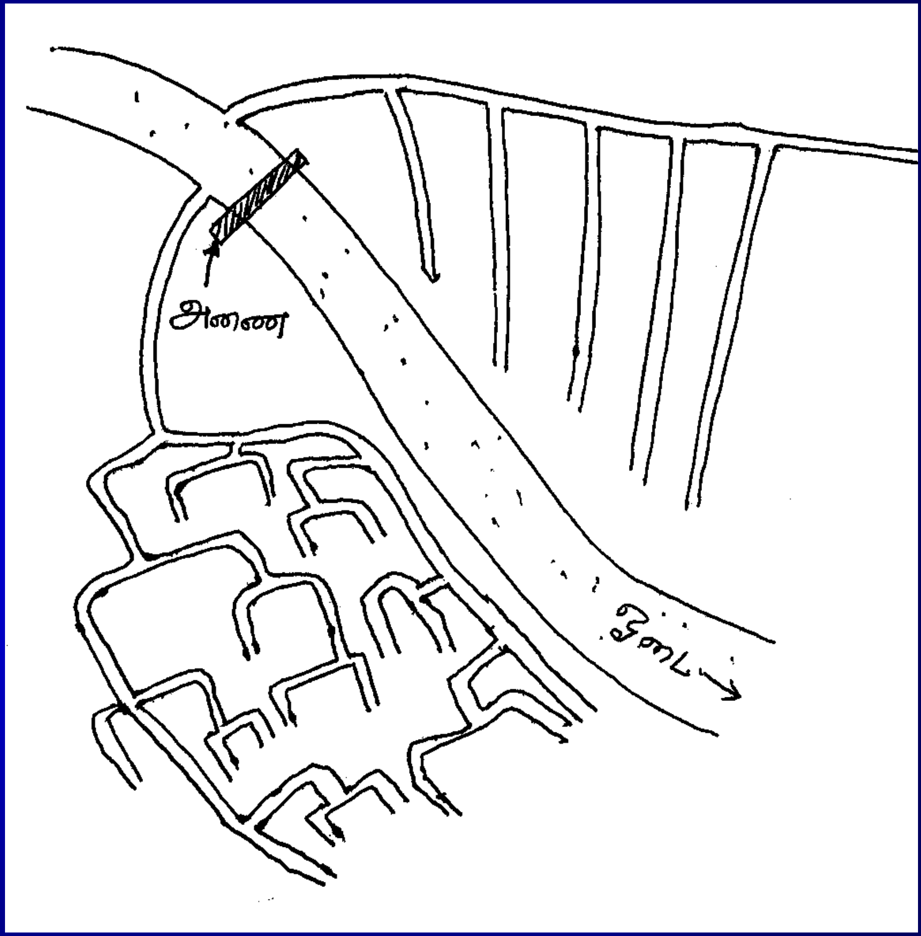


Flooding & Furrowing

Suitable area:

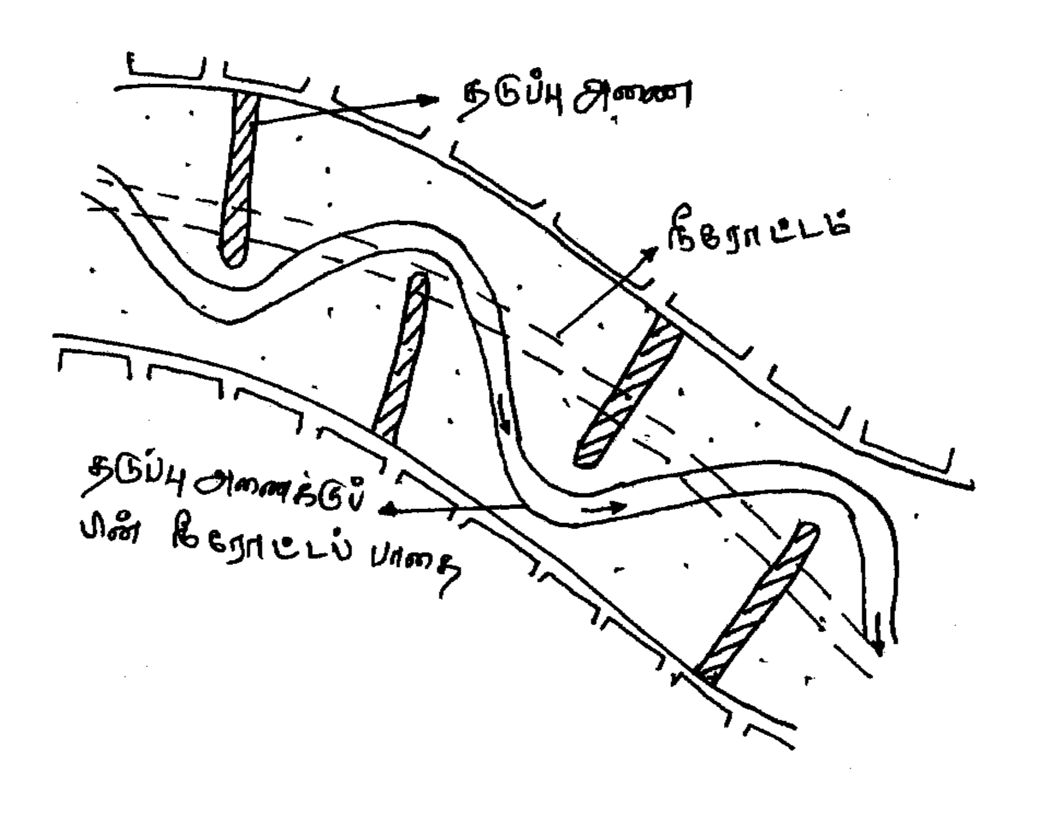
- ❖**Null slope**
- ❖**Pervious soil at the surface**

In the areas of high recharge zone



Flooding and Furrowing

EN-ECHELON DAMS:



Suitable areas:

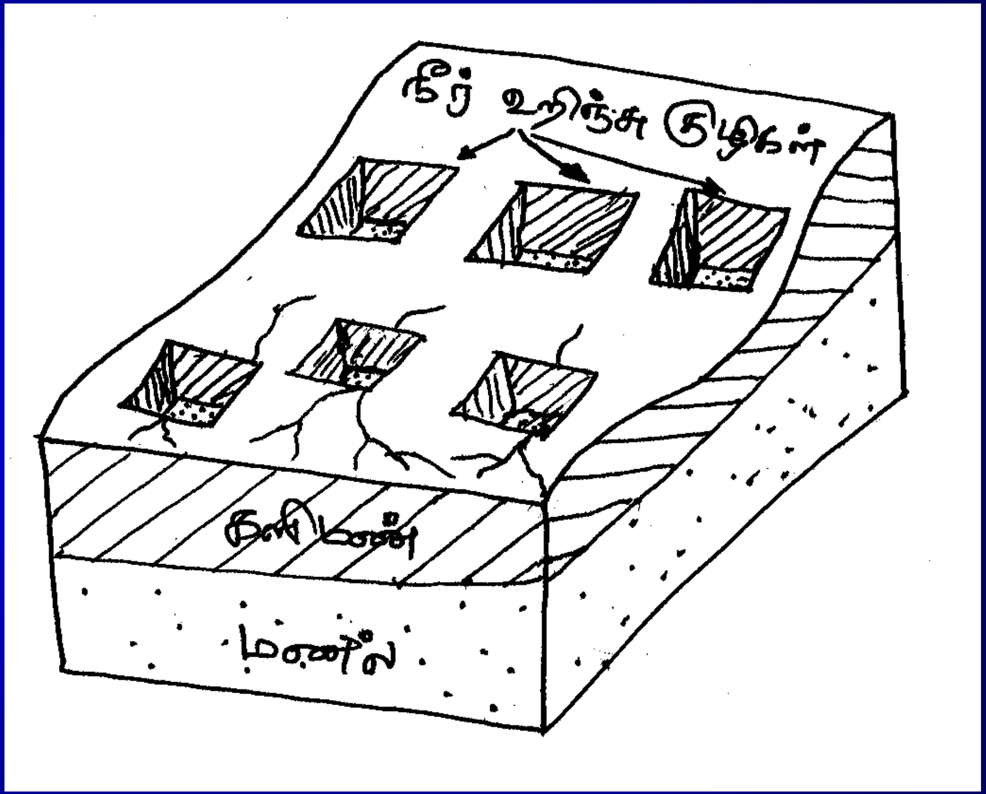
- Straight drainage
- Wide span

In the areas of high recharge zone

RECHARGE PITTING

In the areas where,

- Impervious layer at the surface and the pervious layer below
- More than mean drainage density area



(h) NALA BUND:

- On the 1st to 4th order streams flowing through the plains and valleys where acquisition of land for inundation of large areas is not possible.

- In this case, limited water will be stored in the river bed for some time which increases recharge

INDUCED RECHARGE

Suitable areas:

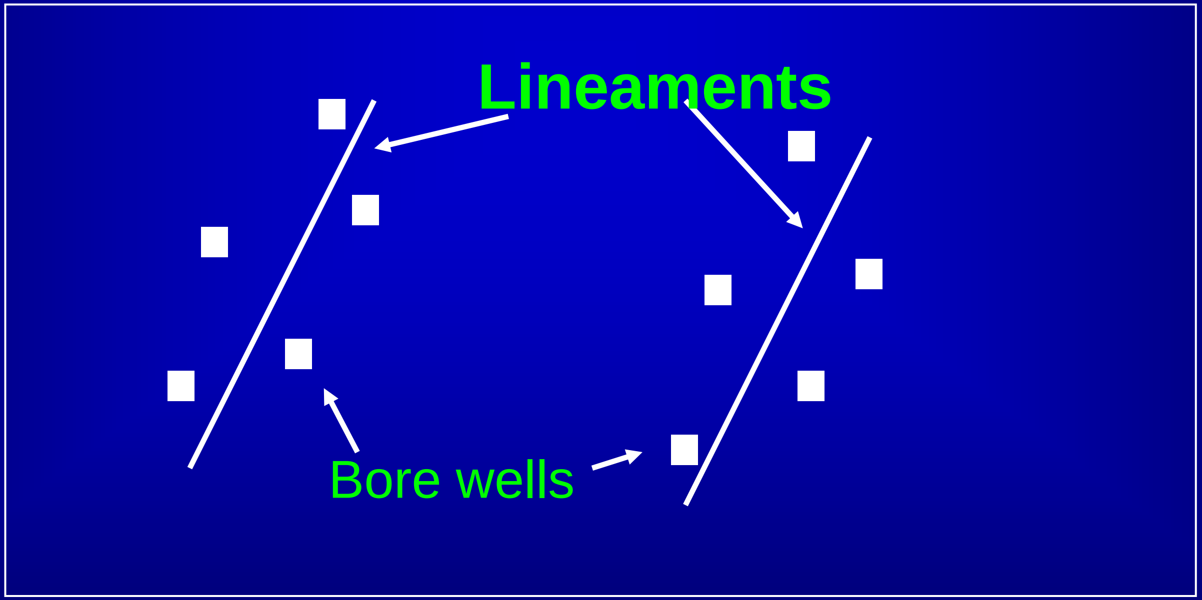
- **Water level minima Zone**
- **Drainage density maxima Zone**

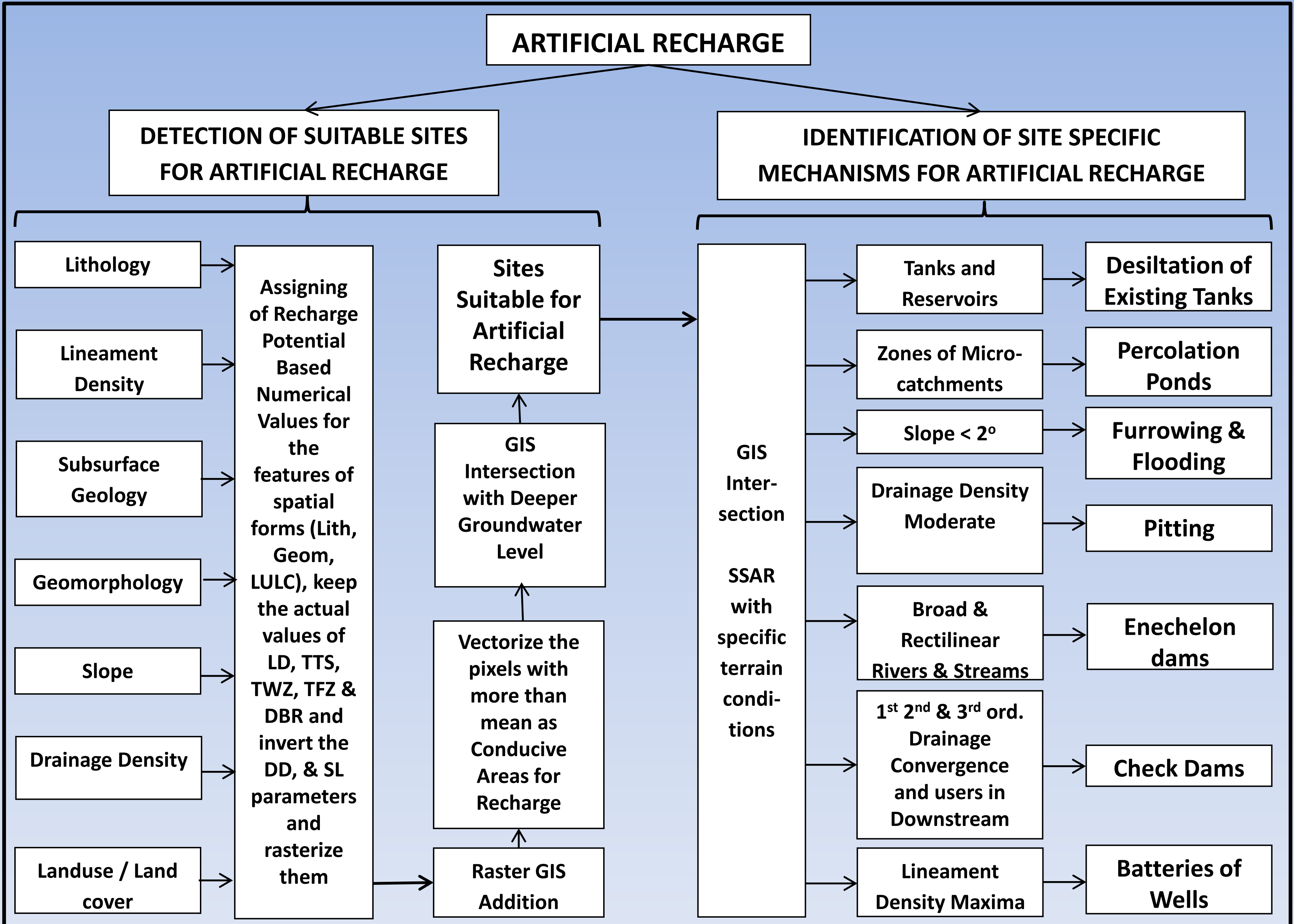
In these zones pump the water through bore wells.

BATTERIES OF WELLS

In the areas of lineament density maxima zones

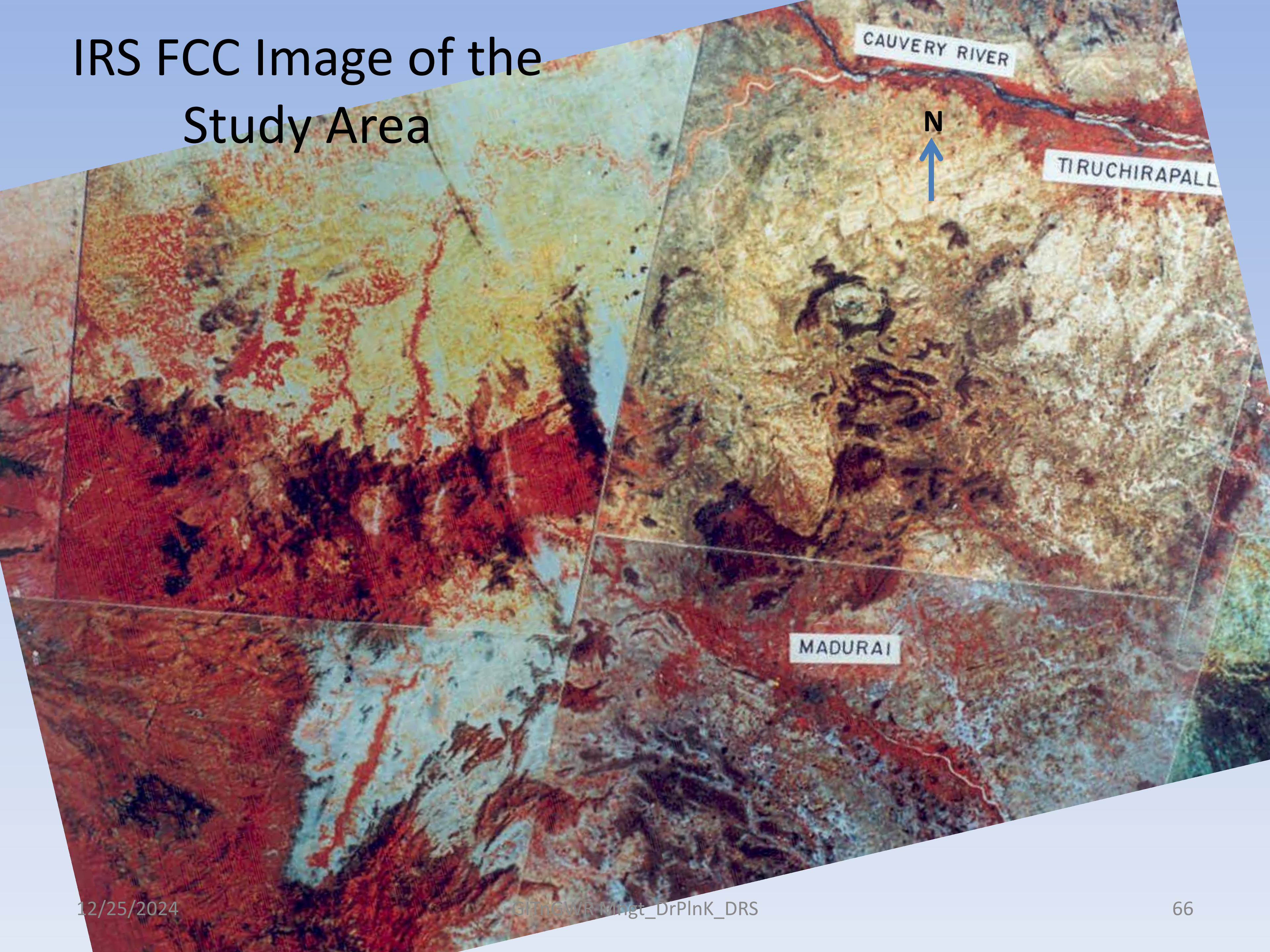
Bore wells on both sides of the fracture density maxima axes / major fractures





Methodology Flow chart :– Suitable site selection and Site Specific Mechanism identification for Artificial Recharge

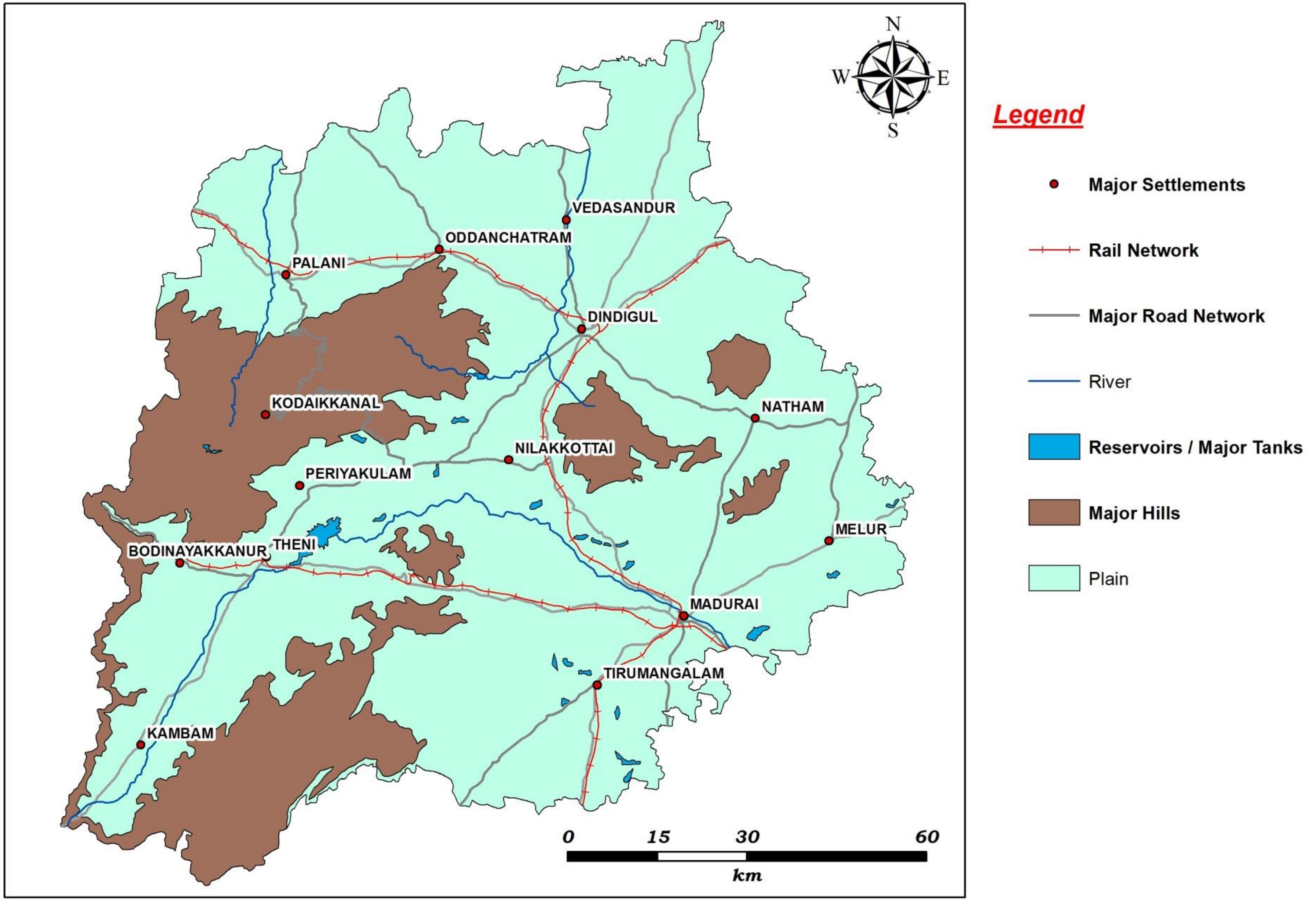
IRS FCC Image of the Study Area

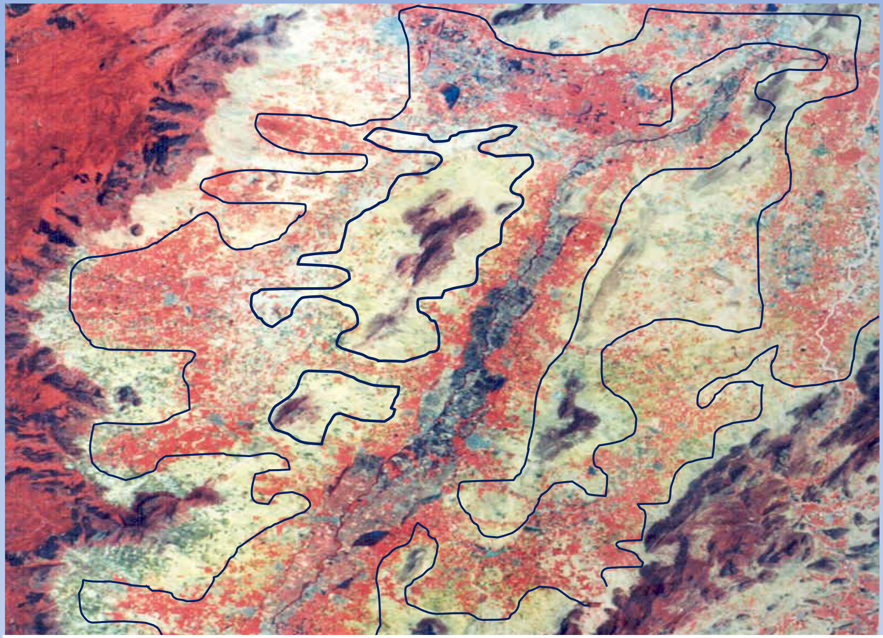


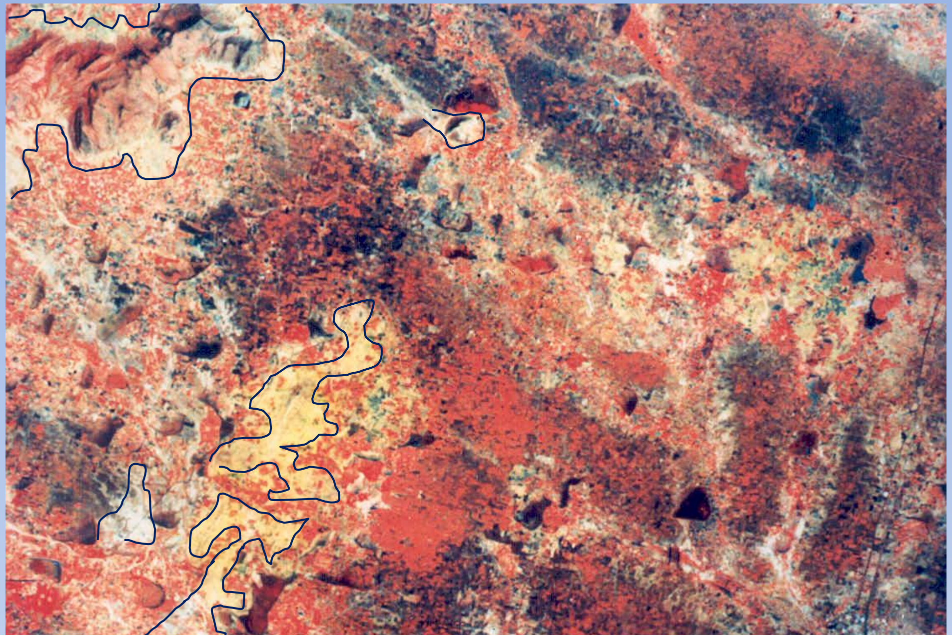
Geosystem maps prepared for this study

- Base map
- Lithology
- Structure – Fault, Lineament and Fracture systems & Lineament density
- Geomorphology
- Subsurface Lithology – Depth to Bed Rock
- Slope
- Micro-catchments (1st order streams emanating from plains) and other Drainages
- Drainage Density
- Groundwater level

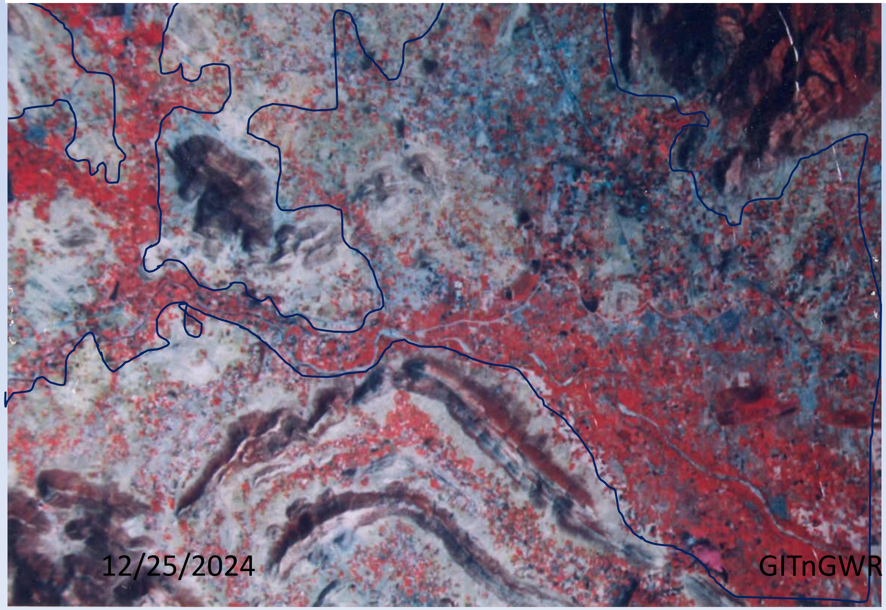
BASE MAP
Parts of Western Ghats, Tamil Nadu

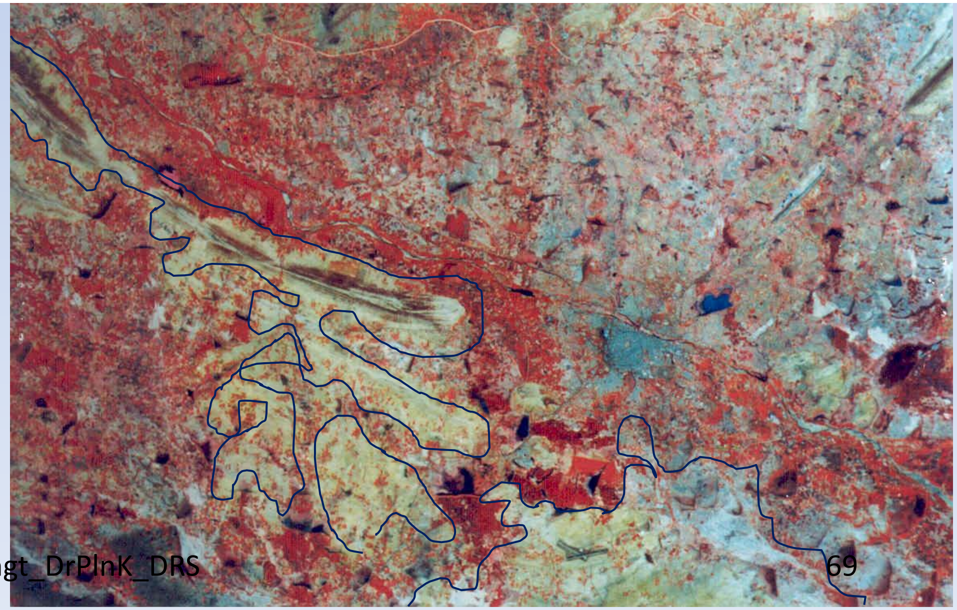




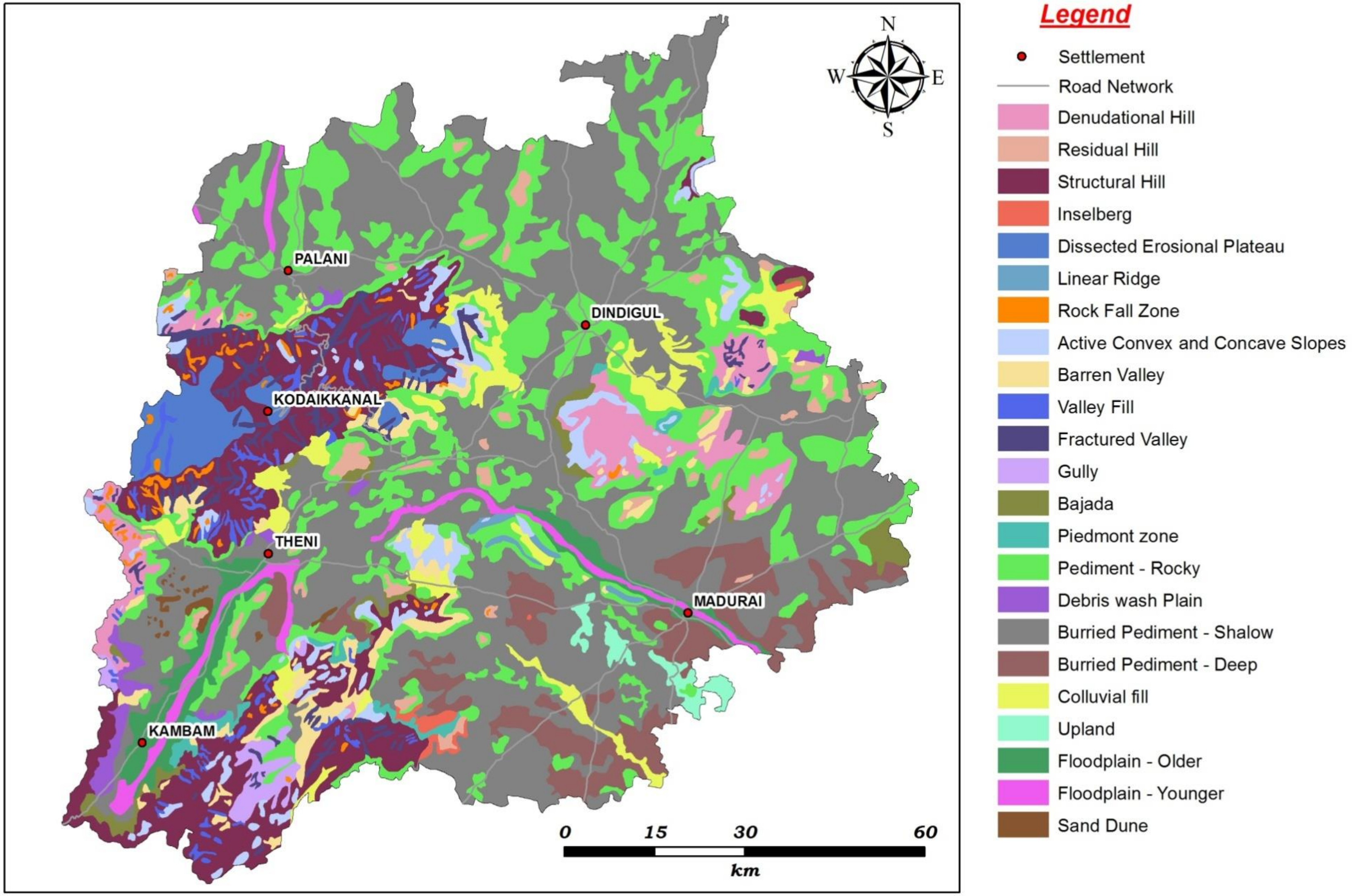


IRS satellite FCC Images showing favourable Lithological, Structural, Geomorphological and Landuse/land cover features of the study area





GEOMORPHOLOGY



Assigning Values to Spatial forms of Geosystem parameters

Recharge Potential Based Numerical Grades on Geomorphology for Artificial Recharge

Sl.No.	GEOMORPHIC FEATURES	GRADES	VALUES
1.	Burried Pediment-Deep, Colluvial Fill	Grade-I	80
2.	Flood Plain-Younger, Flood Plain-Older, Valley Fill and Barren Valley	Grade-II	70
3.	Burried Pediment-Shallow	Grade-III	60
4.	Bajada, Piedmont Zone and Debris Wash Plain	Grade-IV	50
5.	Uplands, Gullies and Palaeo Sand Dunes	Grade-V	40
6.	Pediment	Grade-VI	30
7.	Denudational Hills, Dissected Plateau	Grade-VII	20
8.	Structural Hills, Linear Ridges, Rock Fall Zones, Active Slopes, Residual Hills, Inselbergs and Fractured Valley	Grade-VIII	10

Sl.No.	LITHOLOGIC UNITS	GRADES	VALUES
1.	Alluvium	Grade-I	80
2.	Laterite	Grade-II	70
3.	Sandstone and Clay	Grade-III	60
4.	All Gneisses	Grade-IV	50
5.	All Granites	Grade-V	40
6.	Calc-Granulites and Limestones	Grade-VI	30
7.	Charnockites	Grade-VII	20
8.	Quartzites	Grade-VIII	10

Sl.No.	LANDUSE / LAND COVER UNITS	GRADES	VALUES
1.	Land with scrub	Grade-I	50
2.	Land without scrub	Grade-II	40
3.	Lakes, Reservoirs and Tanks	Grade-III	30
4.	Barren Rocky / Stony Wastes	Grade-IV	20
5.	Others (Settlements, Agricultural lands, Forests, etc.)	Grade-V	10

Sample Numerical Database on Lithology, Geomorphology, Drainage Density and Slope

GRID NO.	GEOM	LITH	GEOM_ST	LITH_ST	DD_INV_ST	SL_INV_ST
1	2.08	3.78	2.5	4.76	6.4995	1.0644
2	2.27	5.03	2.76	6.46	3.1533	1.0644
3	4.98	4.73	6.54	6.04	2.5494	2.4256
4	12.51	10.68	17.04	14.11	1.5891	1.8712
5	13.16	21.88	17.94	29.27	1.4059	1.1634
6	19.84	32.53	27.25	43.7	1.2129	1.0644
7	8.85	9	11.94	11.83	1.4802	1.495
8	31.85	24.51	43.99	32.83	1.5148	3.0493
9	35.12	34.83	48.54	46.81	1.401	1.8168
10	21.4	22.5	29.43	30.12	1.2574	1.495
11	42.47	20	58.78	26.73	1.2277	1.0644
12	44.22	18.46	61.22	24.64	1.2673	1.4208
13	12.09	8.7	16.46	11.42	1.6435	1.1139
14	4.79	1.96	6.29	2.29	4.1928	3.6384
15	1.72	1.4	2	1.54	5.3065	11.89
16	33.73	26.02	46.6	34.87	1.792	49.015
17	35.4	29.57	48.93	39.68	1.7623	98.515
18	27.53	29.78	37.97	39.97	2.0098	98.515
19	26.6	25.84	36.67	34.63	2.2227	98.515
20	5.26	6.35	6.93	8.25	50.5	98.515
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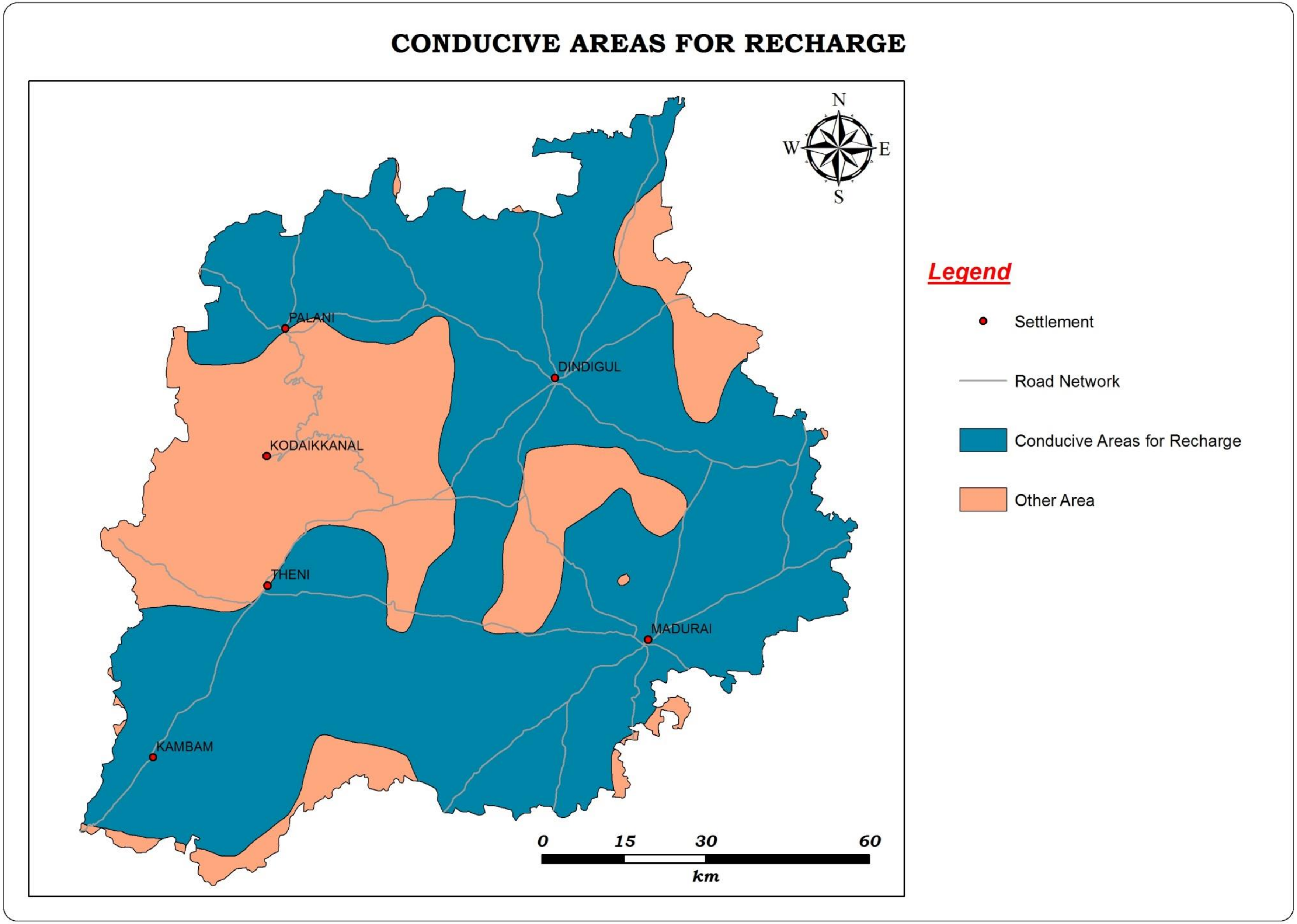
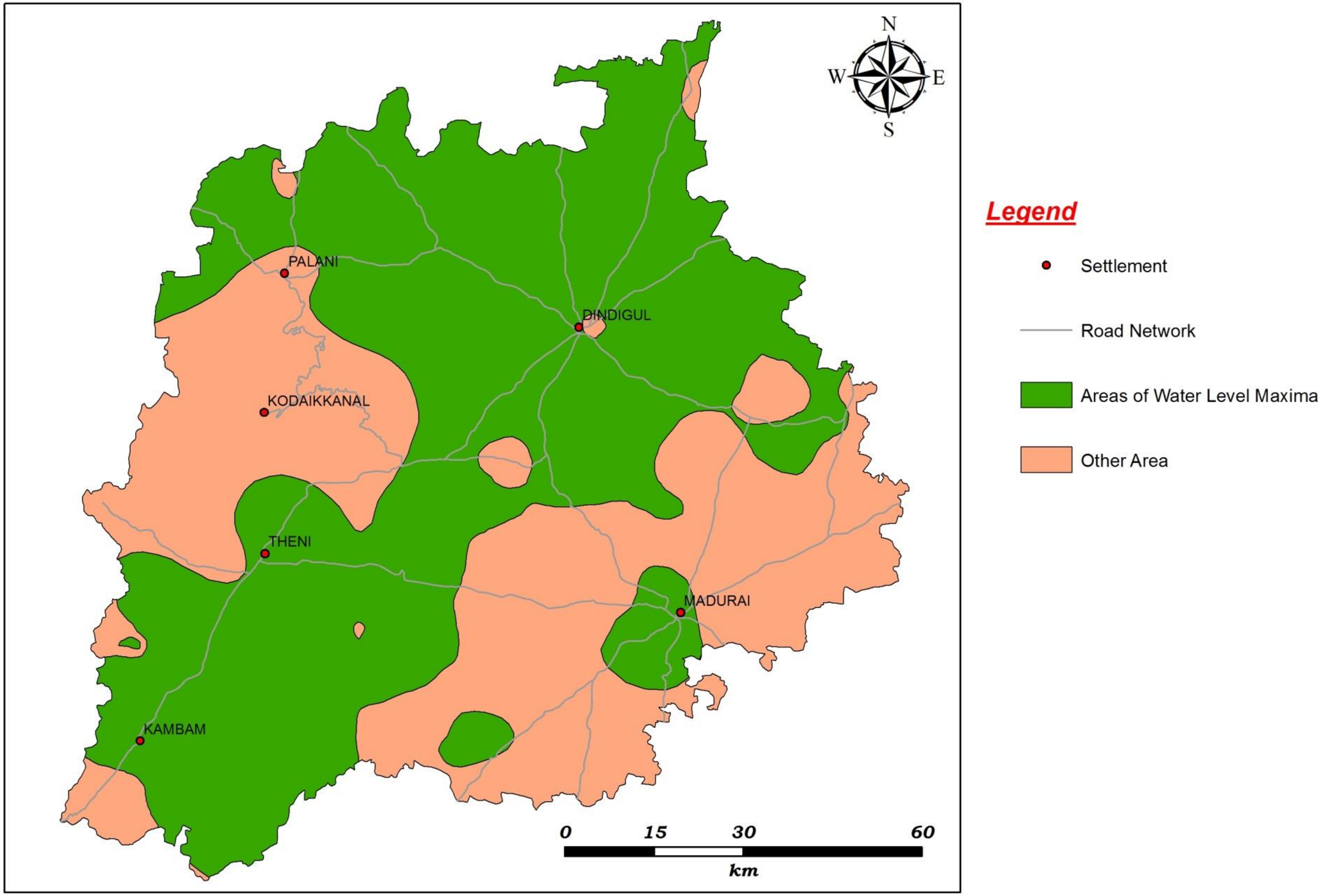
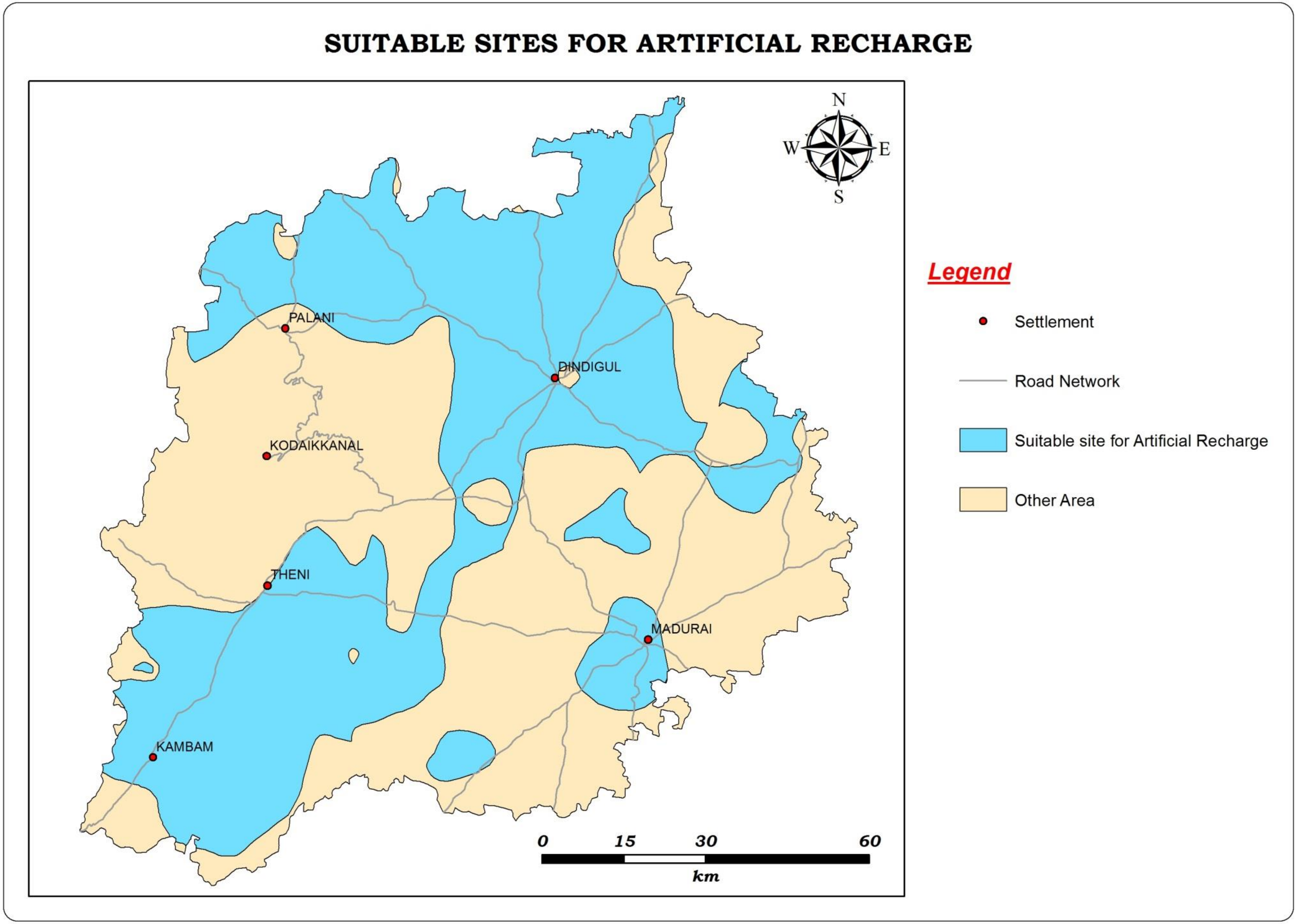


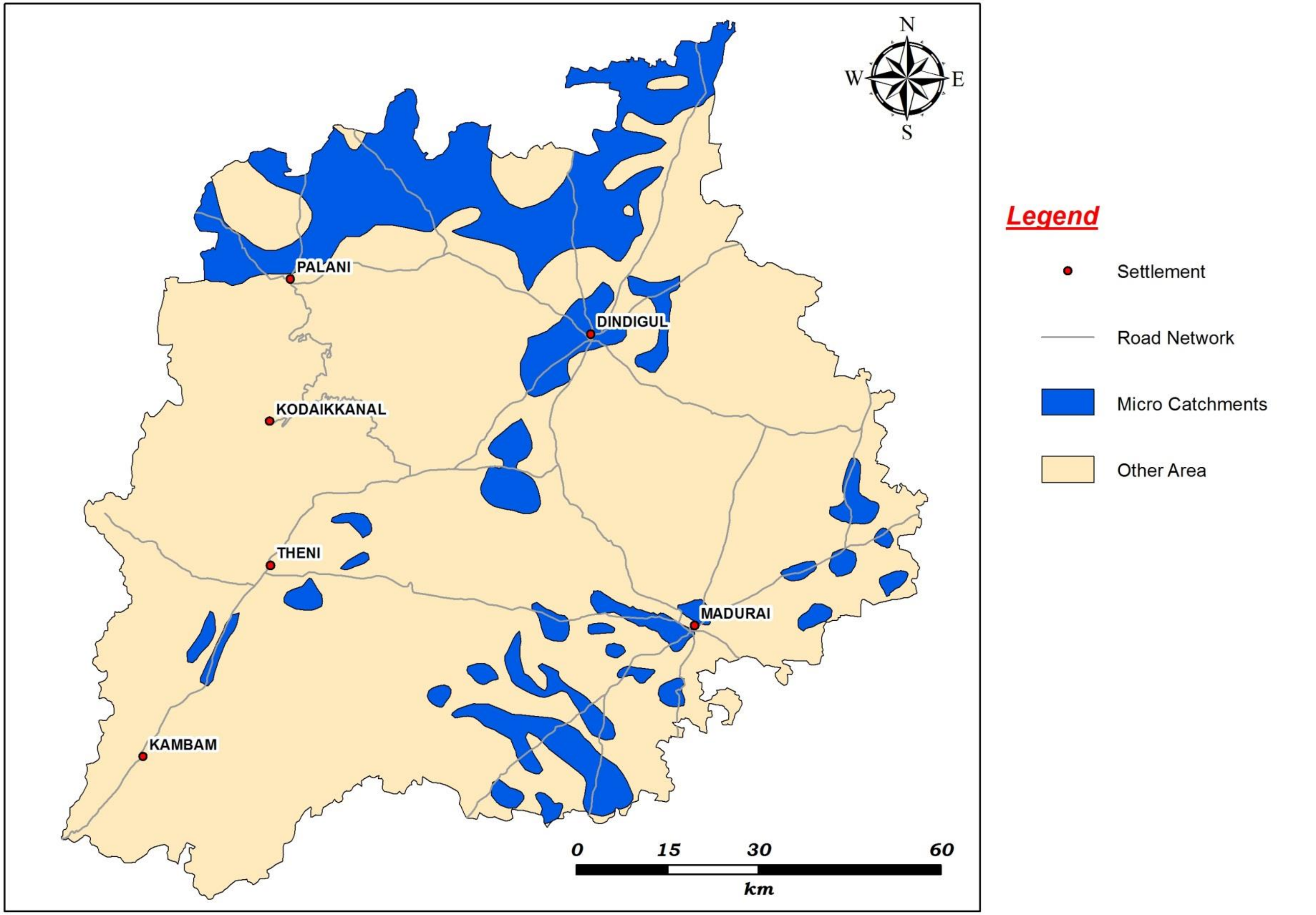
CONDUCIVE AREAS FOR RECHARGE
N
W
E
S
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM
0
15
30
60
km
Legend
Settlement
Road Network
Conducive Areas for Recharge
Other Area

WATER LEVEL MAXIMA

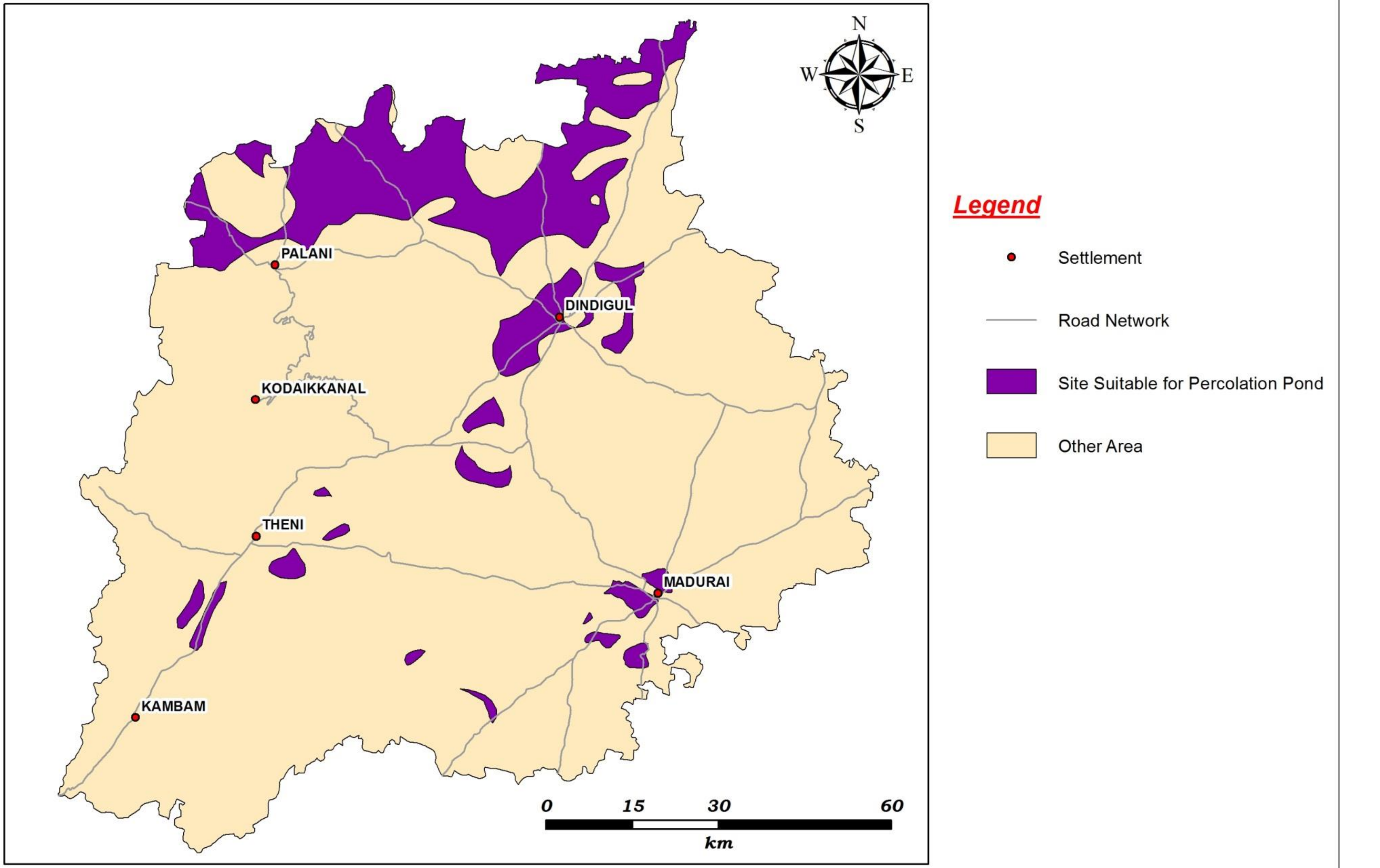



SUITABLE SITES FOR ARTIFICIAL RECHARGE
N
W
E
S
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM
0
15
30
60
km
Legend
Settlement
Road Network
Suitable site for Artificial Recharge
Other Area

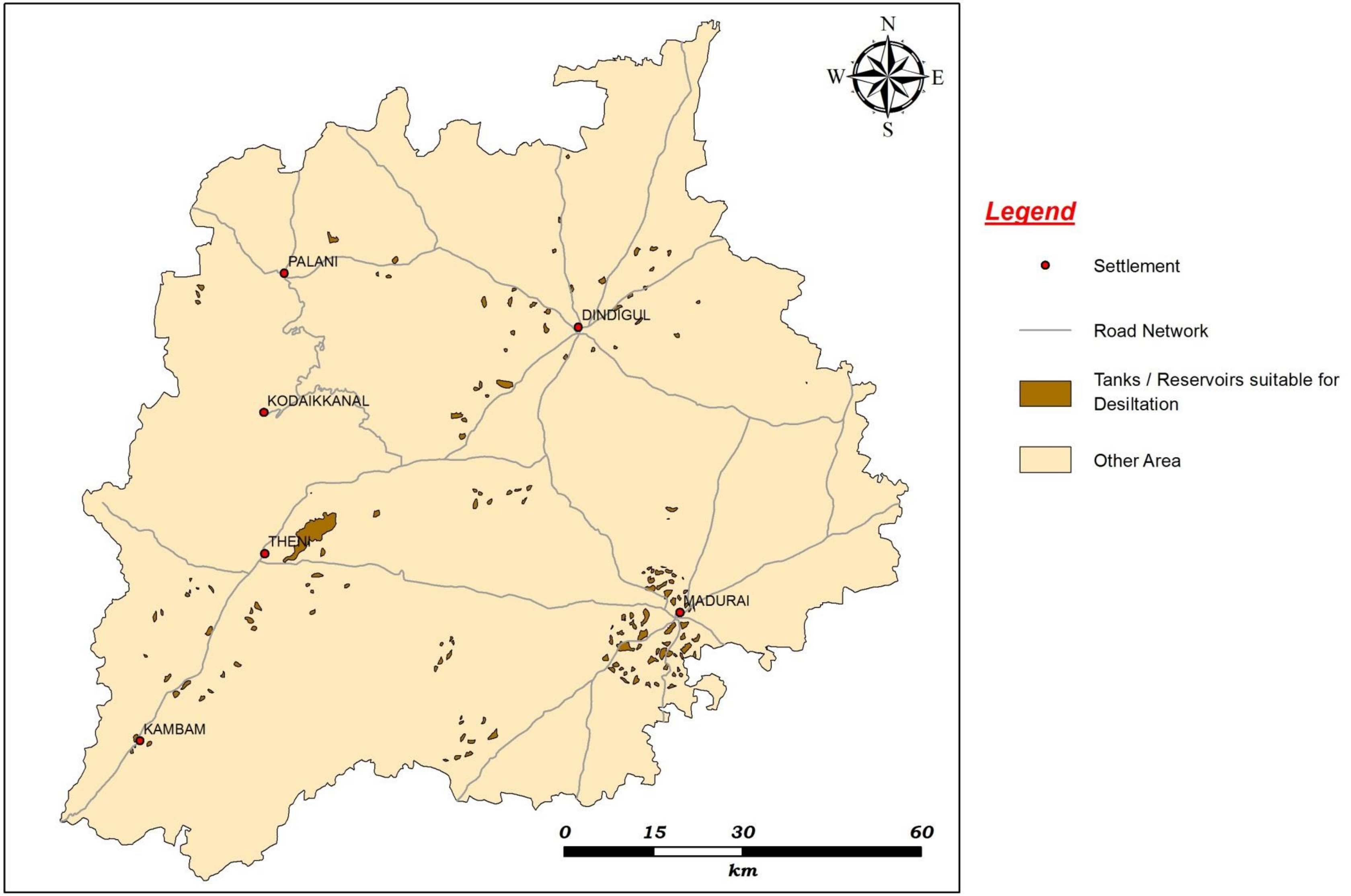
ZONES OF MICRO CATCHMENTS



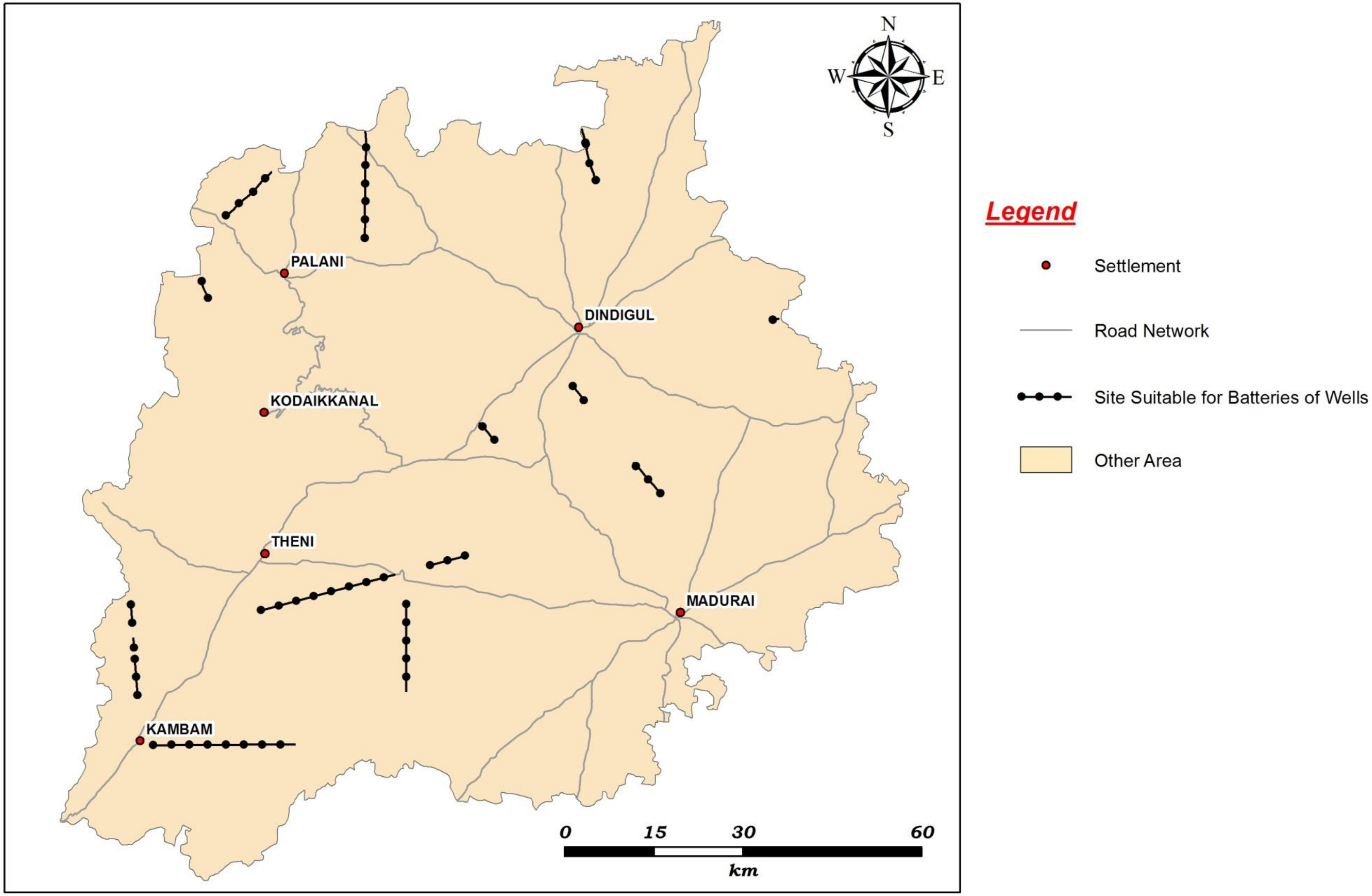
SUITABLE SITES FOR PERCOLATION PONDS



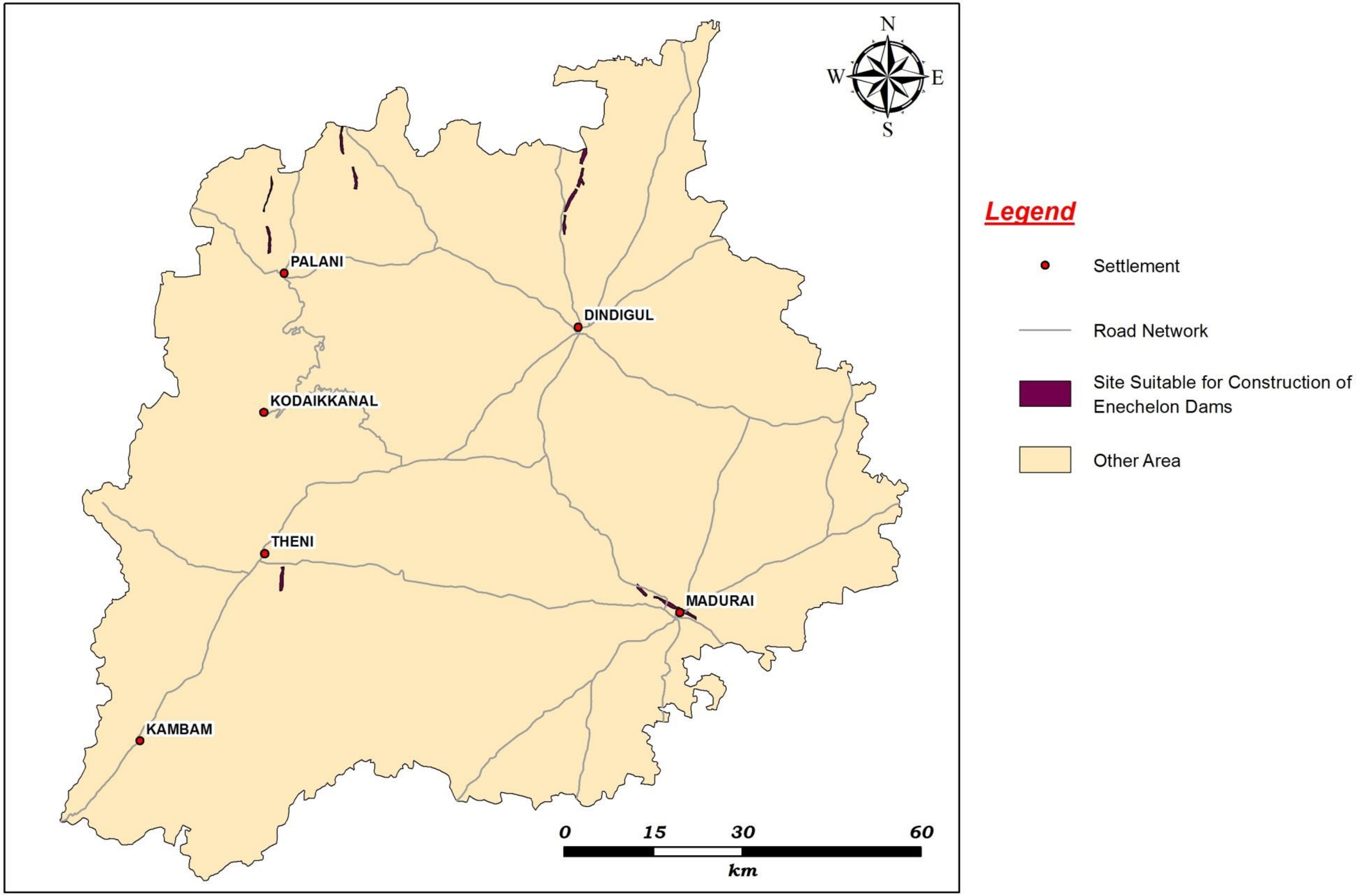
SITES SUITABLE FOR DESILTATION OF EXISTING TANKS



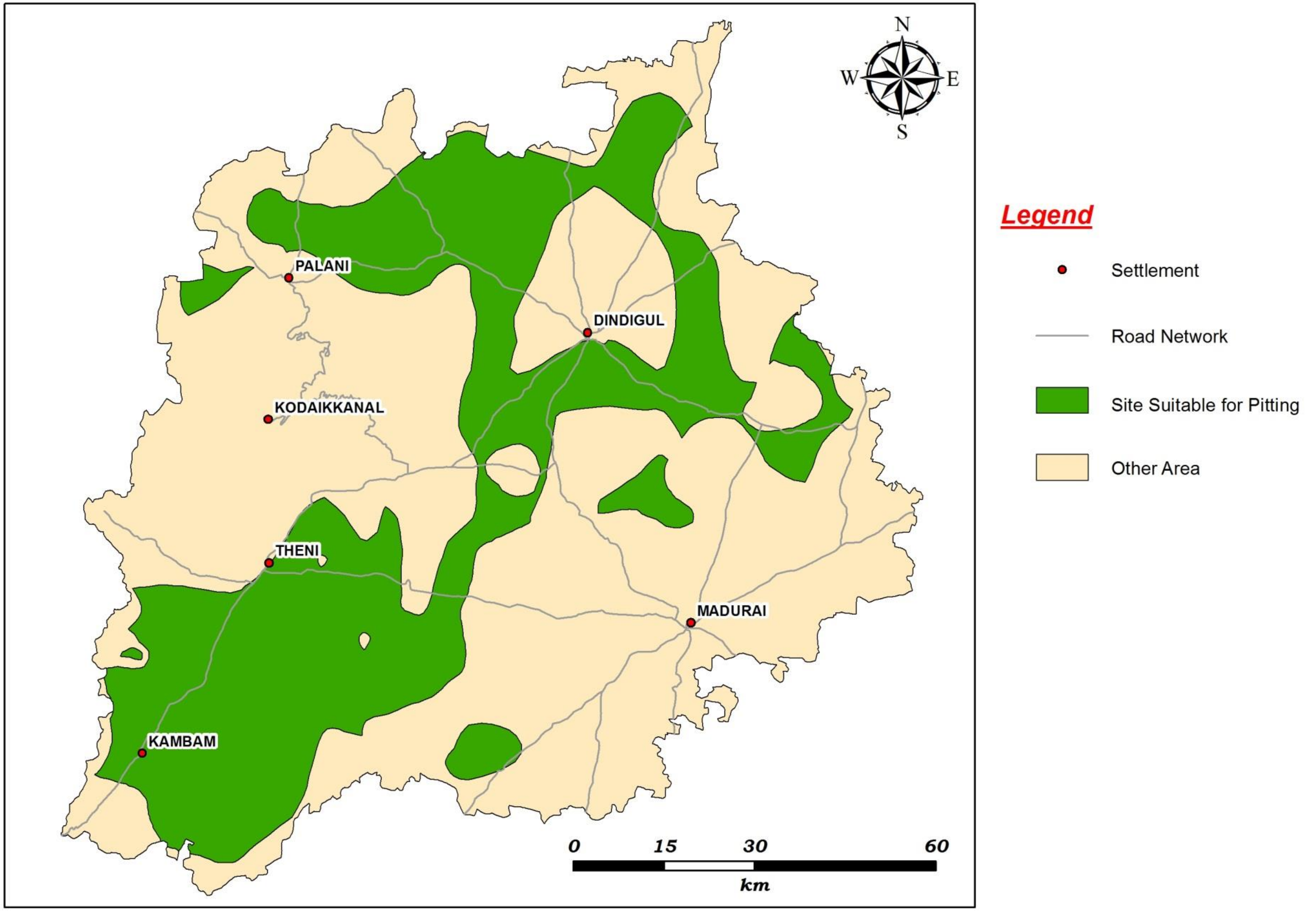
SITE SUITABLE FOR BATTERIES OF WELLS



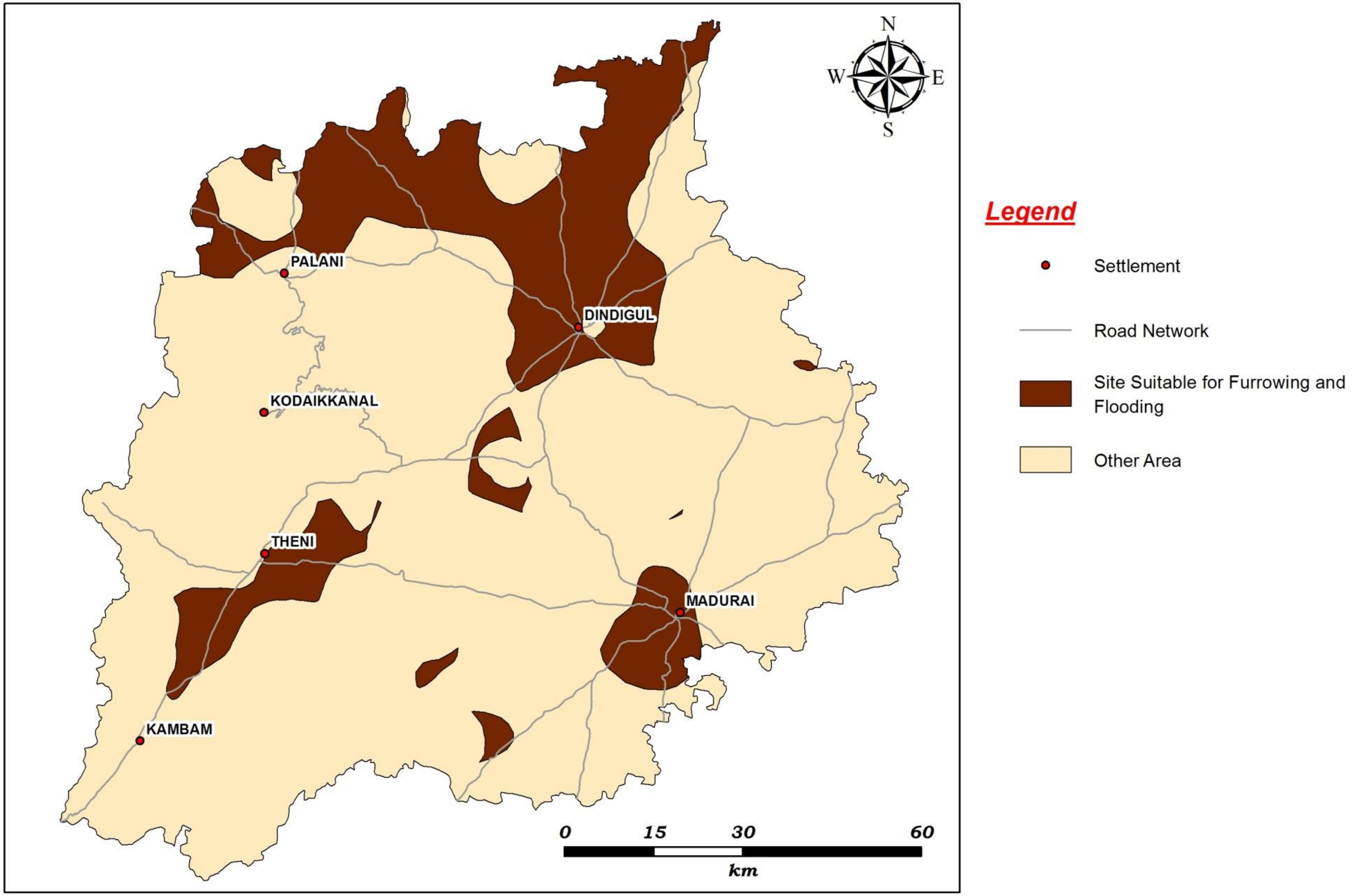
SITE SUITABLE FOR CONSTRUCTION OF ENECHELON DAMS



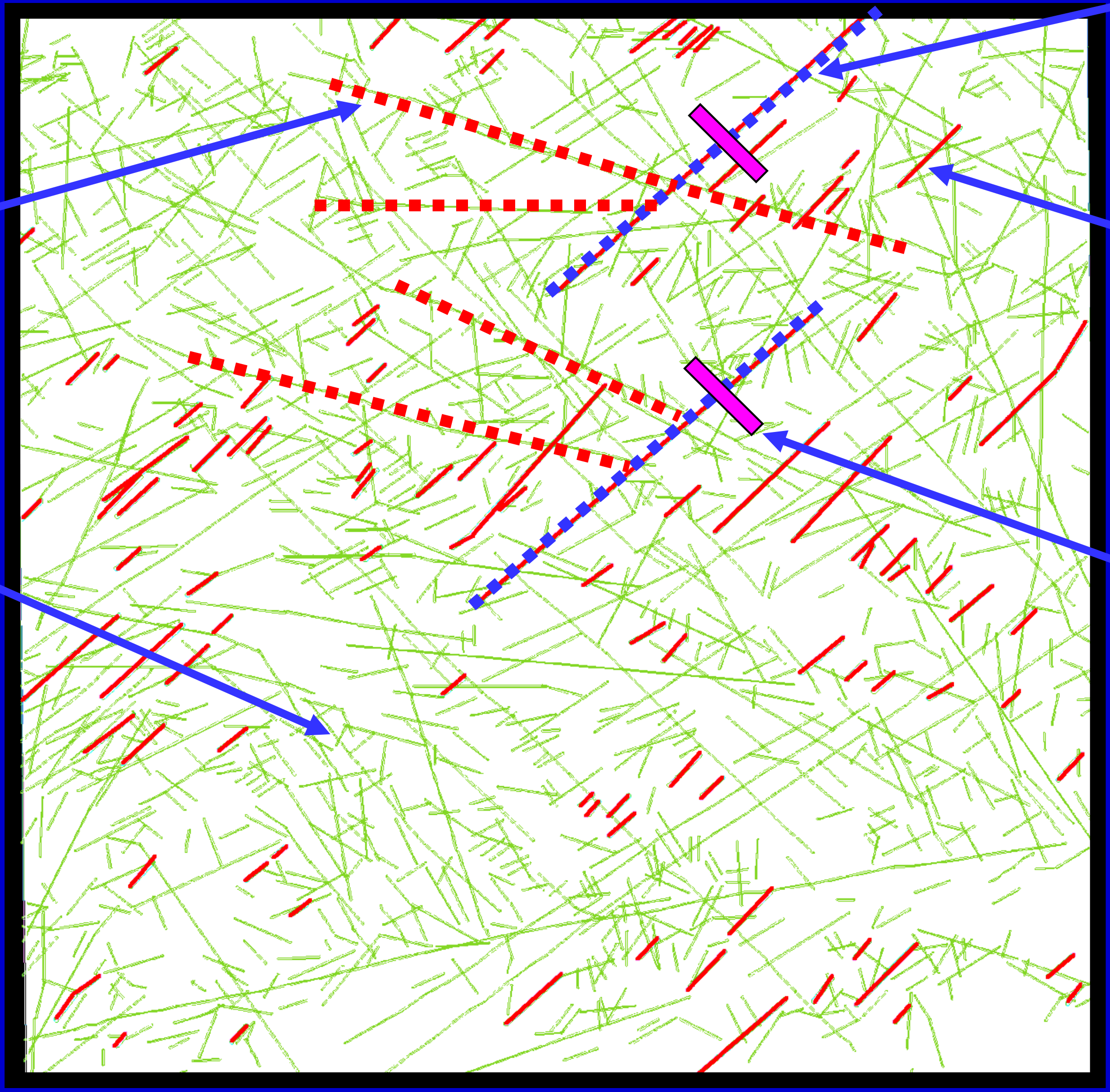
SUITABLE SITES FOR PITTING



SUITABLE SITES FOR FURROWING & FLOODING



RECHARGE THROUGH FRACTURES



Back

STUDY –7

Other studies on Water Resources Management

Back

STUDY –7

Quantification of Allowable Recharge

- Determination of size of the Aquifer / GW Reservoir / Container by Geophysical methods & Pump Tests
- Calculation of Water level changes during a period of 30 – 50 years of pre- and post- monsoon seasons – Estimation of container size and available groundwater in the Aquifer
- WR Budgetting – Estimation of available surface water resources for various purposes
- Quantification of available SW for Recharge of the container.

Back

STUDY – 8

Groundwater flow modeling in GIS

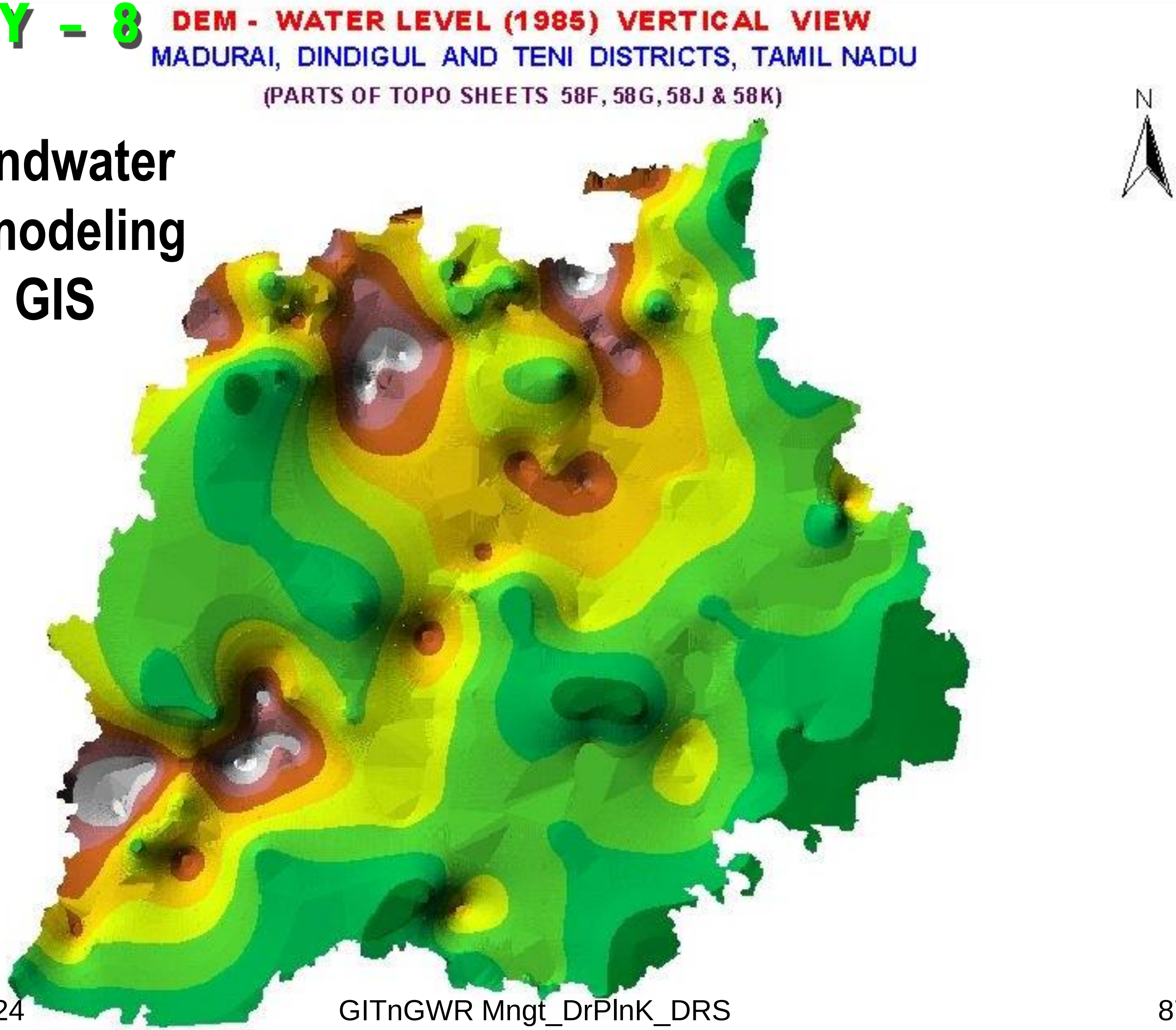


FIG. 1.8

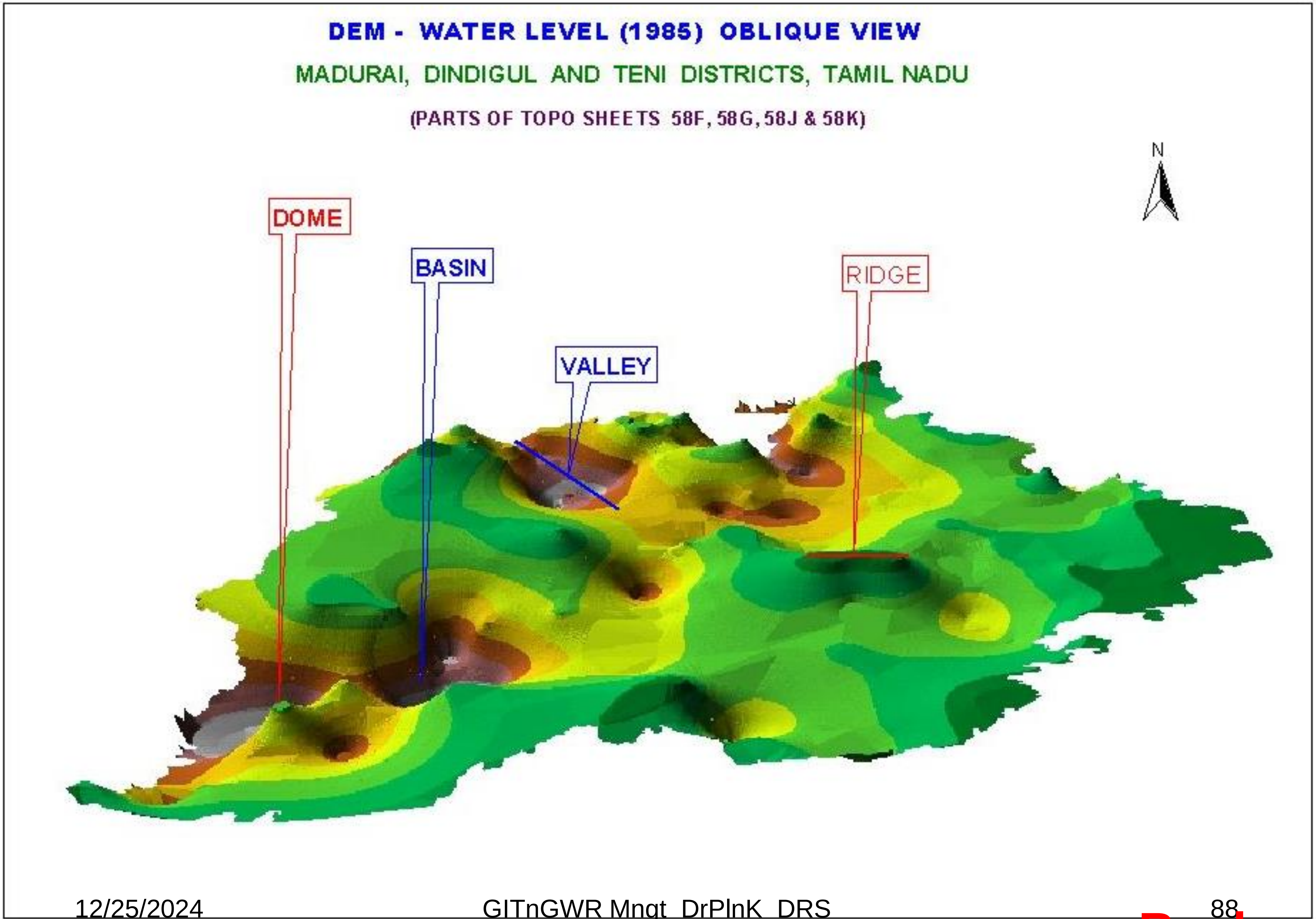

DEM - WATER LEVEL (1985) OBLIQUE VIEW
MADURAI, DINDIGUL AND TENI DISTRICTS, TAMIL NADU
(PARTS OF TOPO SHEETS 58F, 58G, 58J & 58K)
N
DOME
BASIN
VALLEY
RIDGE

FIG. 1.9

Back

Groundwater Aquifer Squeezing

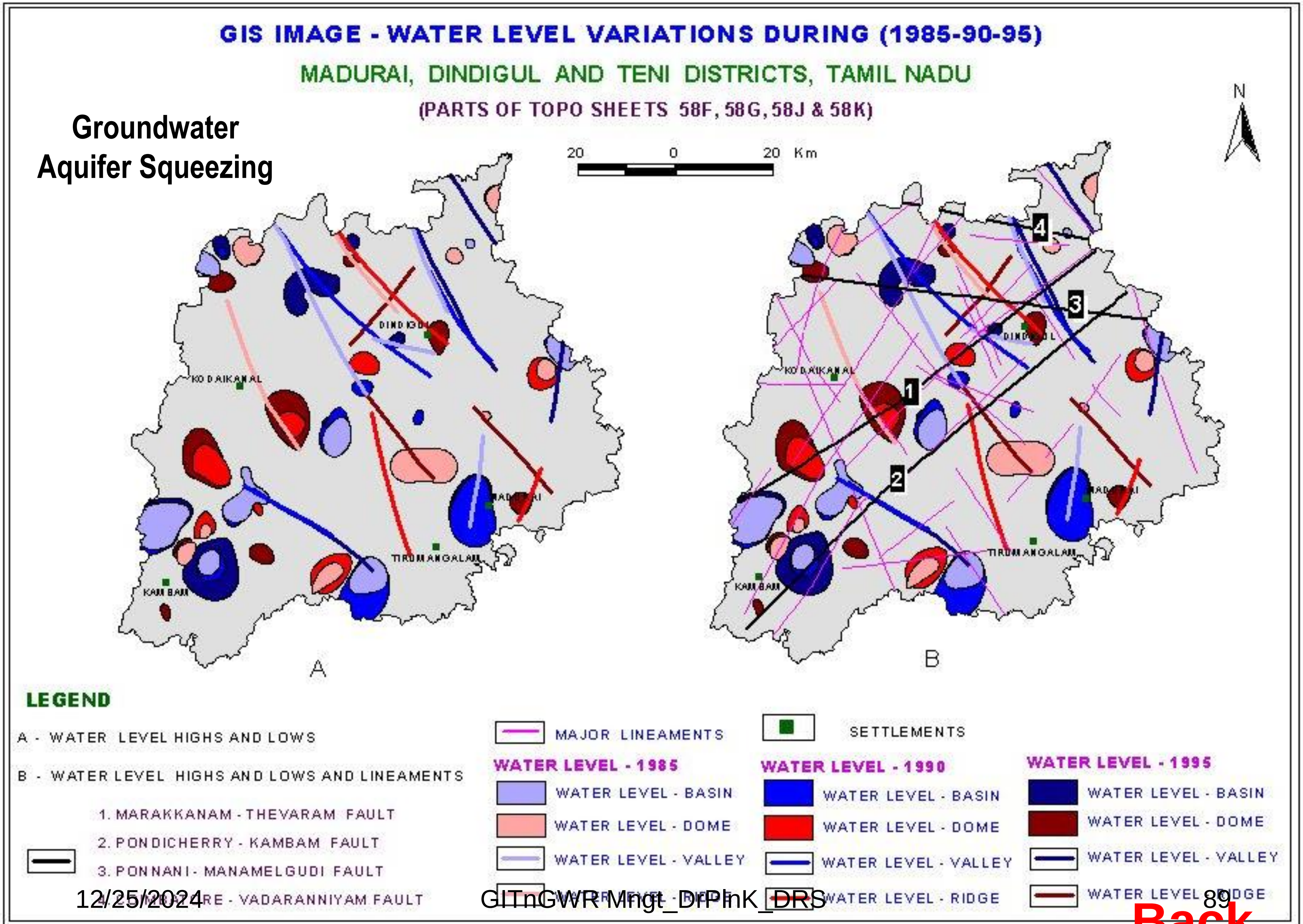
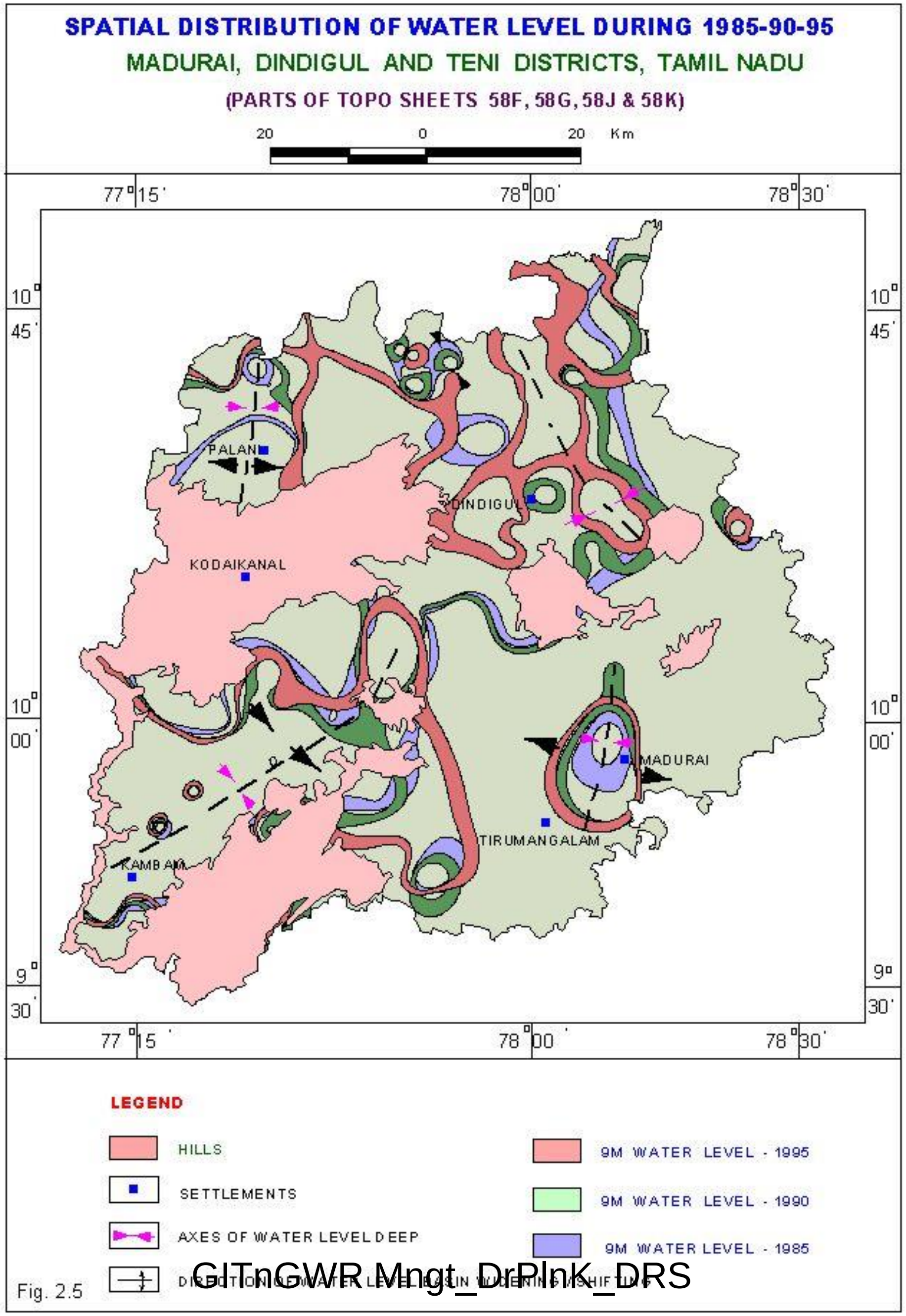


FIG. 2.4

Back


SPATIAL DISTRIBUTION OF WATER LEVEL DURING 1985-90-95
MADURAI, DINDIGUL AND TENI DISTRICTS, TAMIL NADU
(PARTS OF TOPO SHEETS 58F, 58G, 58J & 58K)
20 0 20 Km
77°15'
78°00'
78°30'
10° 45'
10° 00'
9° 30'
PALANI
DINDIGUL
KODAIKANAL
MADURAI
TIRUMANGALAM
KAMBAM
LEGEND
HILLS
SETTLEMENTS
AXES OF WATER LEVEL DEEP
9M WATER LEVEL - 1995
9M WATER LEVEL - 1990
9M WATER LEVEL - 1985
Fig. 2.5

STUDY – 9

WATER RESOURCES INFORMATION SYSTEM

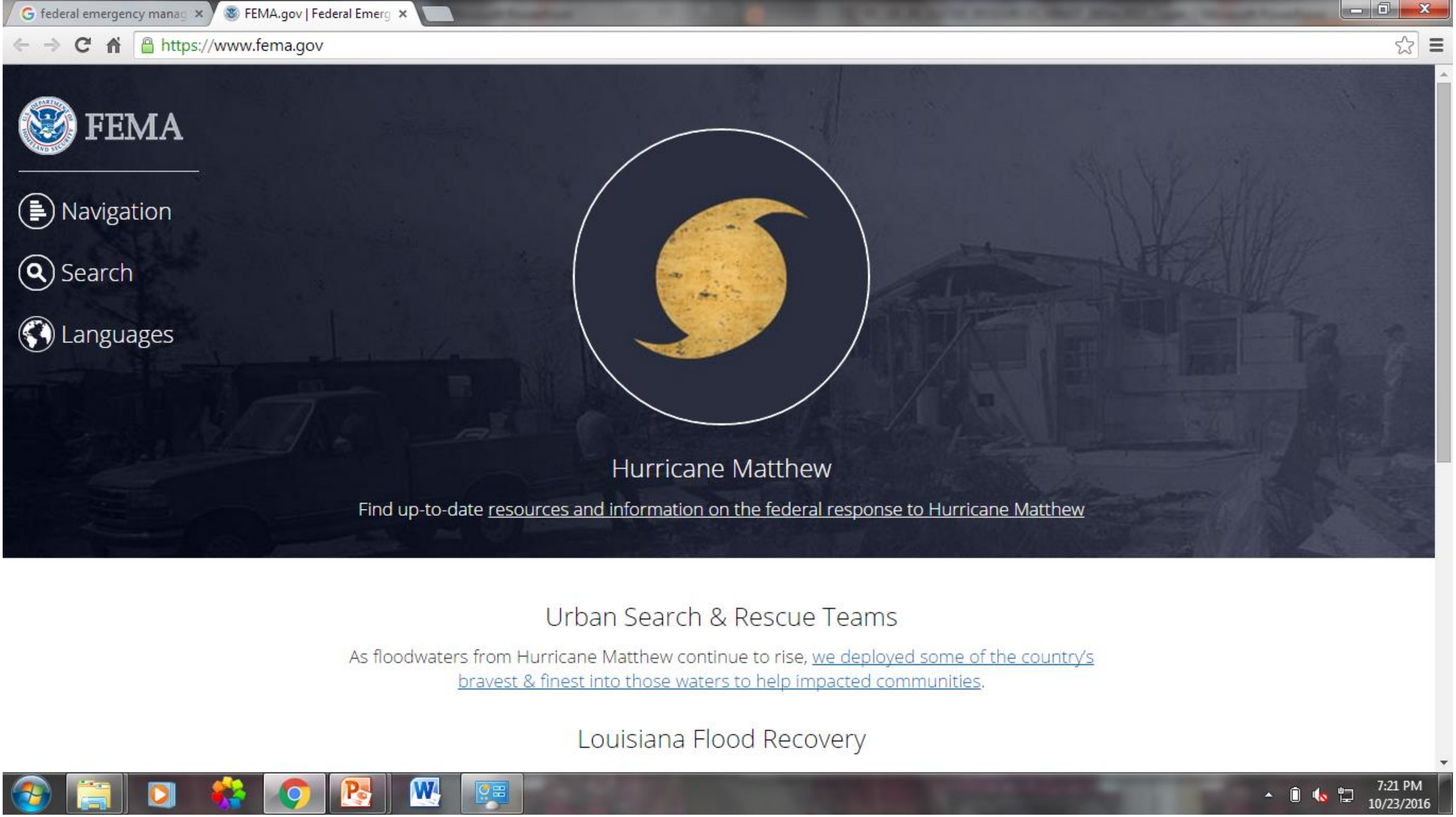
SPATIAL DECISION SUPPORT SYSTEM - SDSS

Back

Credibility of WRIS

WRIS

- Easy to access and readily available information in a single mouse click or two.
- More useful for Planners, Administrators and users having no knowledge on GIS.
- Simple to make any type of spatial queries and
- Useful in quick and easy Decision Making spatially.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FEMA.gov | Federal Emerg
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Find up-to-date resources and information on the federal response to Hurricane Matthew
Urban Search & Rescue Teams
As floodwaters from Hurricane Matthew continue to rise, we deployed some of the country's bravest & finest into those waters to help impacted communities.
Louisiana Flood Recovery
7:21 PM
10/23/2016

federal emergency manag × | FEMA Flood Map Service (×

https://msc.fema.gov/portal/

FEMA

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The FEMA Flood Map Service Center (MSC) is the official public source for flood hazard information produced in support of the National Flood Insurance Program (NFIP). Use the MSC to find your official flood map, access a range of other flood hazard products, and take advantage of tools for better understanding flood risk.

FEMA flood maps are continually updated through a variety of processes. Effective information that you download or print from this site may change or become superseded by new maps over time. For additional information, please see the Flood Hazard Mapping Updates Overview Fact Sheet

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10/23/2016

Back

CONCLUSIONS:

Geoinformatics technology is a very efficient and cost effective one for,

- **Groundwater resources prospecting & accurate targetting for setting up bore holes for immediate exploitation,**
- **Runoff and Aquifer Volume estimation,**
- **Aquifer function modelling**
- **Groundwater Pollution mapping and monitoring and**
- **Planning for conservation and management.**

Many more applications have also been tried and succeeded such as, Modelling of Groundwater level modifications, Harvesting of Flood water for GW recharge, Water Resources Information System, etc., using Geoinformatics Technology.

GIT is also being effectively used for implementation and monitoring phases too.