STUDIES CONDUCTED AT CERS, BDU ON GROUNDWATER MANAGEMENT

9. Groundwater Prospecting
10. Groundwater Targetting
11. Aquifer Function Modelling
12. Groundwater Quality Modelling
13. Natural Recharge
14. Artificial Recharge
15. Quantification of Allowable Recharge
16. Groundwater Flow Modeling in GIS
17. Water Resources Information System (WRIS)

STUDY - 9

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

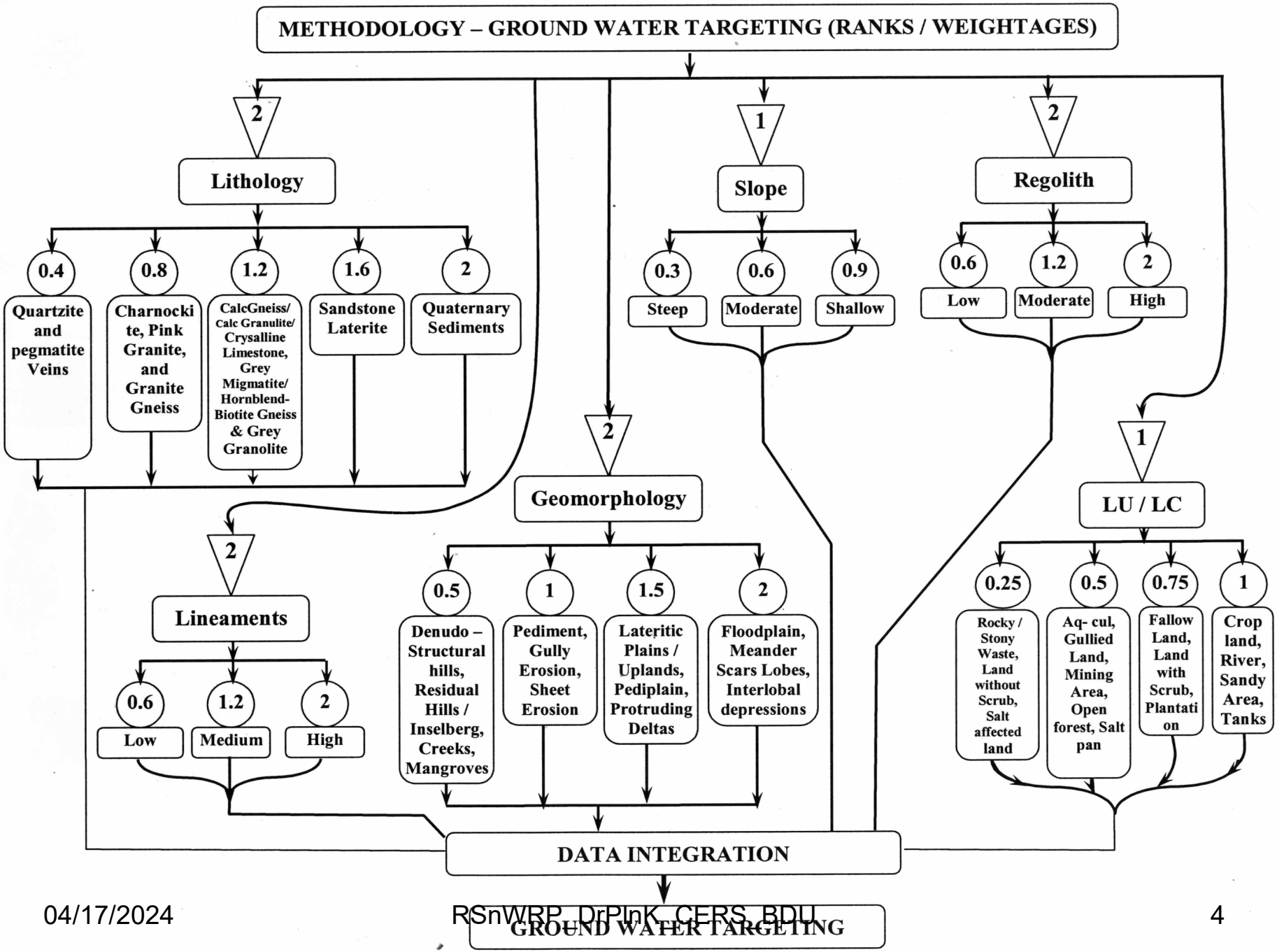

METHODOLOGY – GROUND WATER TARGETING (RANKS / WEIGHTAGES)
2
Lithology
0.4
Quartzite and pegmatite Veins
0.8
Charnockite, Pink Granite, and Granite Gneiss
1.2
CalcGneiss/ Calc Granulite/ Crysalline Limestone, Grey Migmatite/ Hornblend-Biotite Gneiss & Grey Granolite
1.6
Sandstone Laterite
2
Quaternary 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 6.26

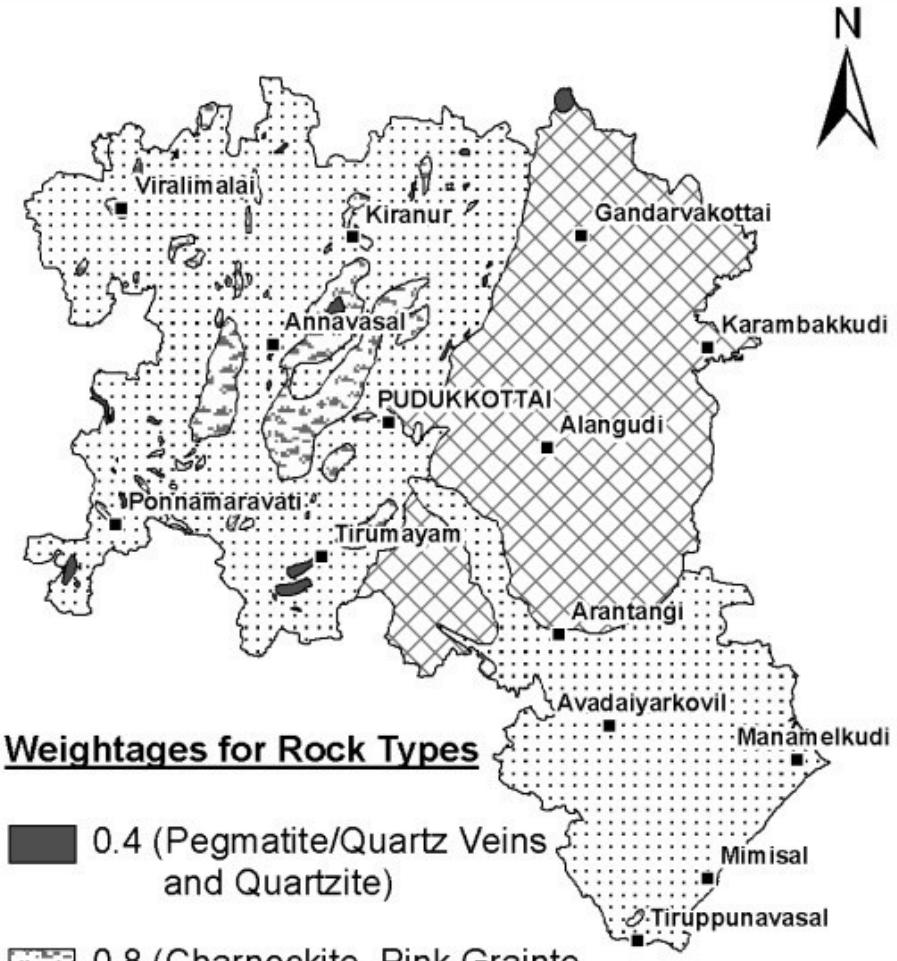


Fig.6.27 Lithology

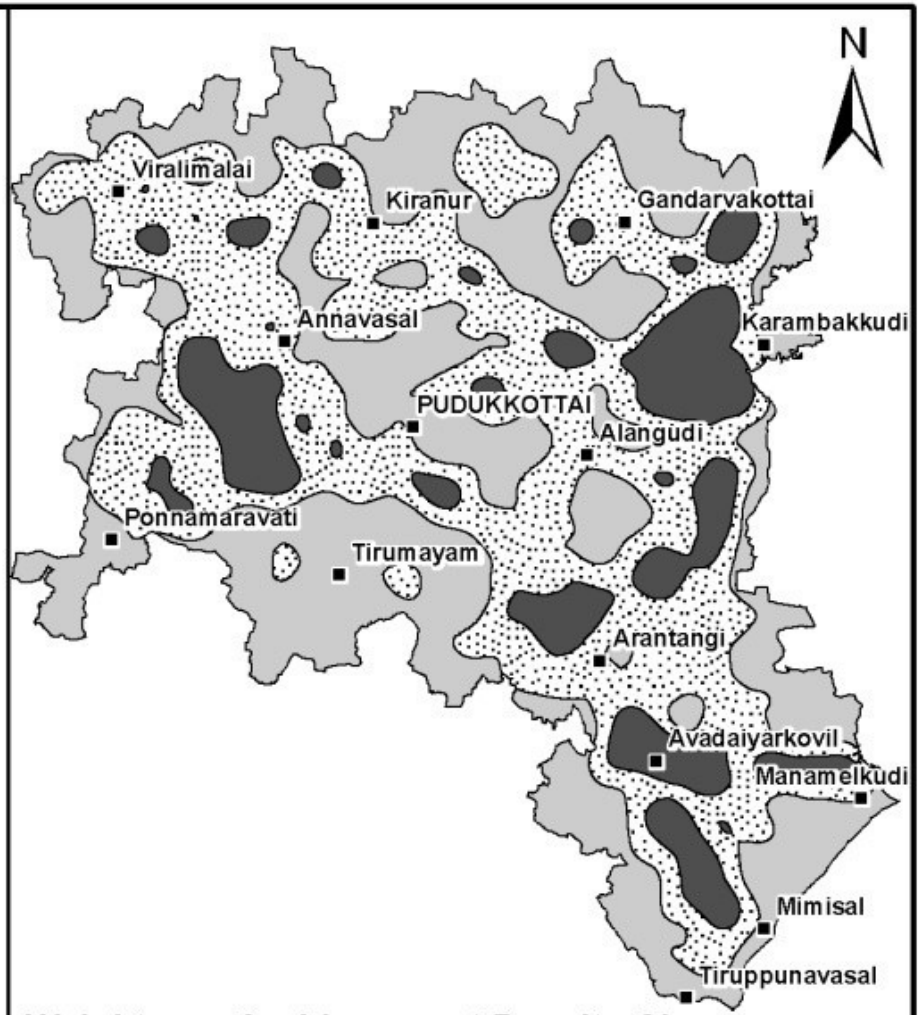


Fig.6.28 Lineament Density

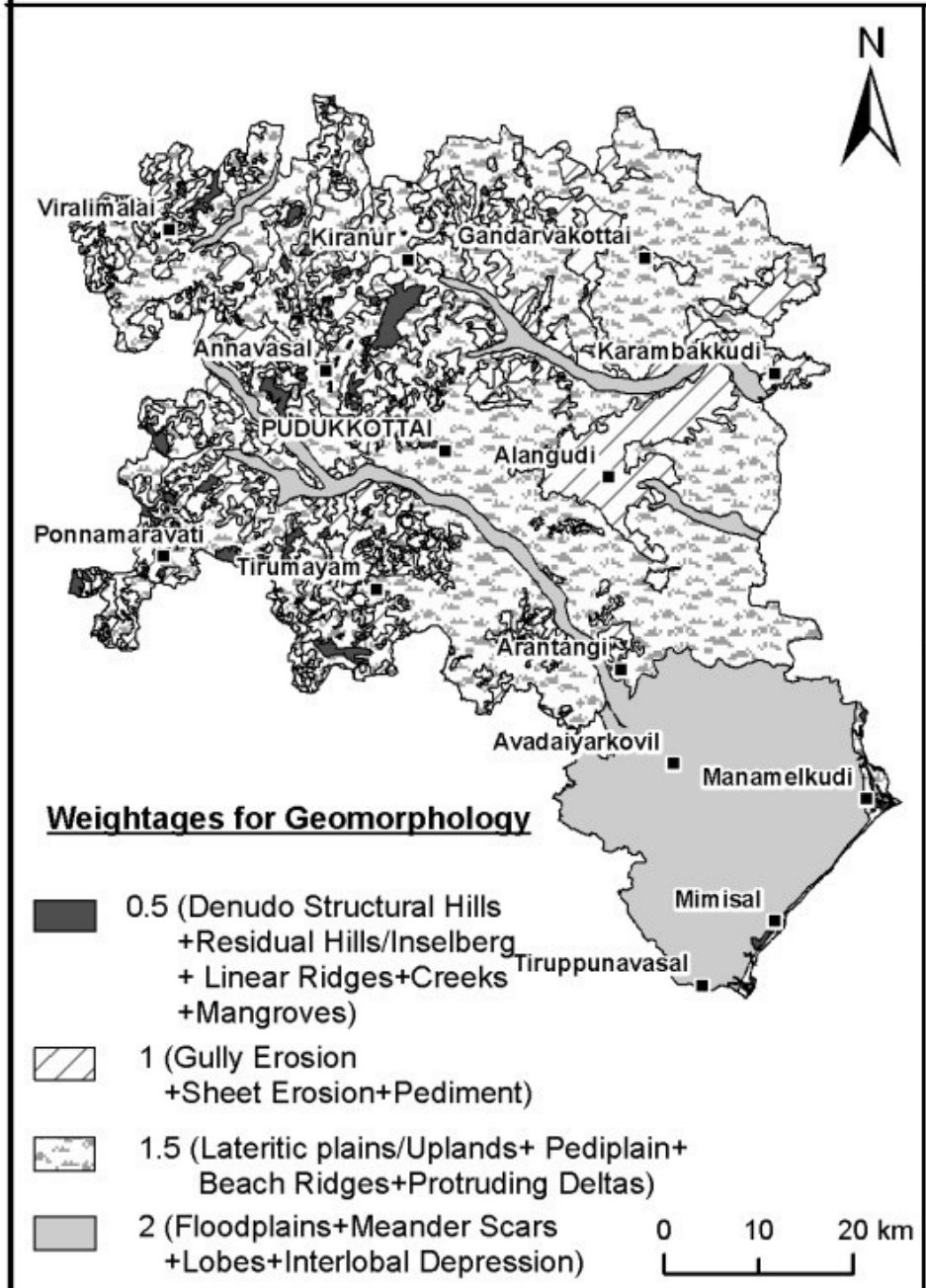


Fig.6.29 Geomorphology

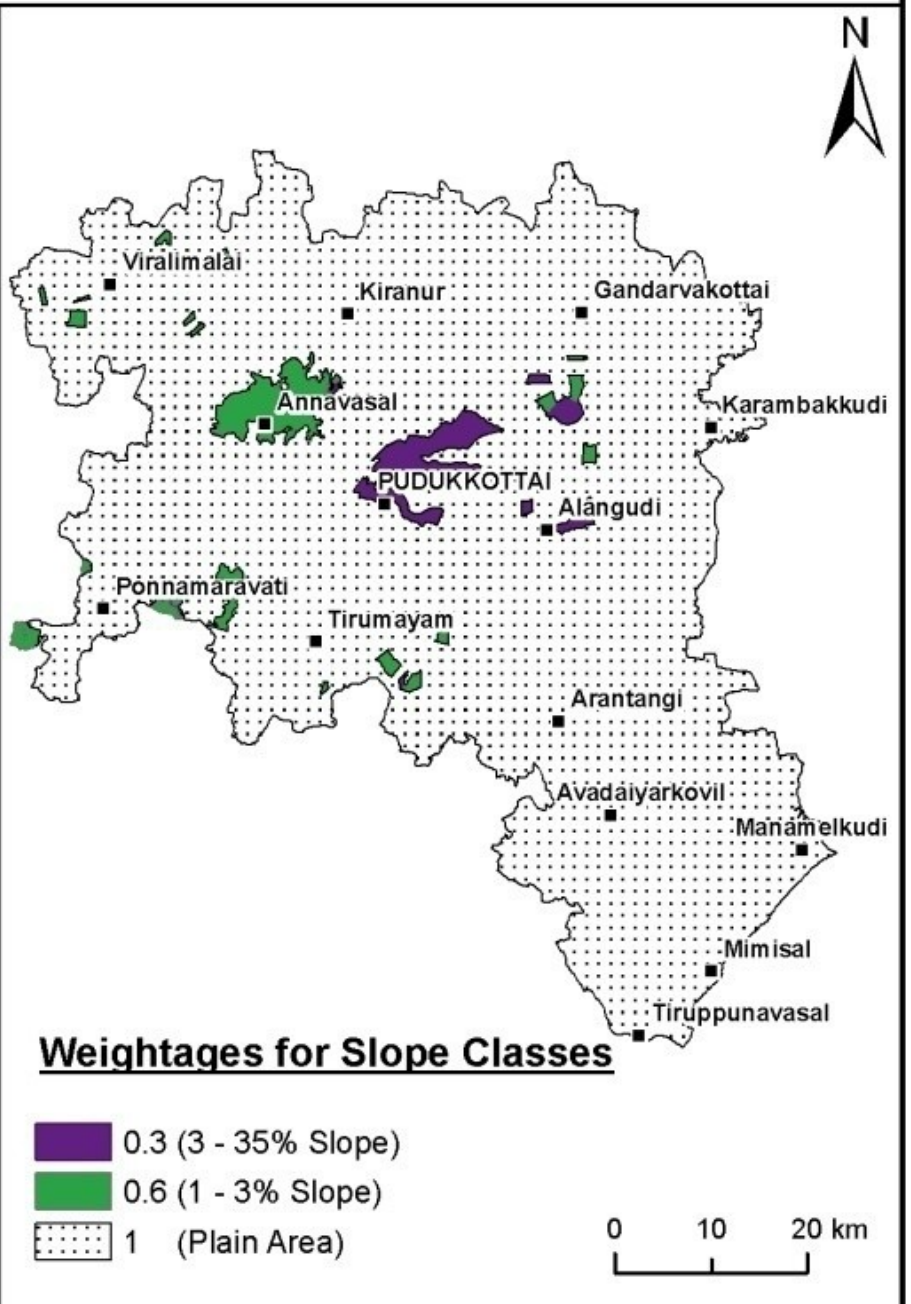


Fig.6.30 Slope

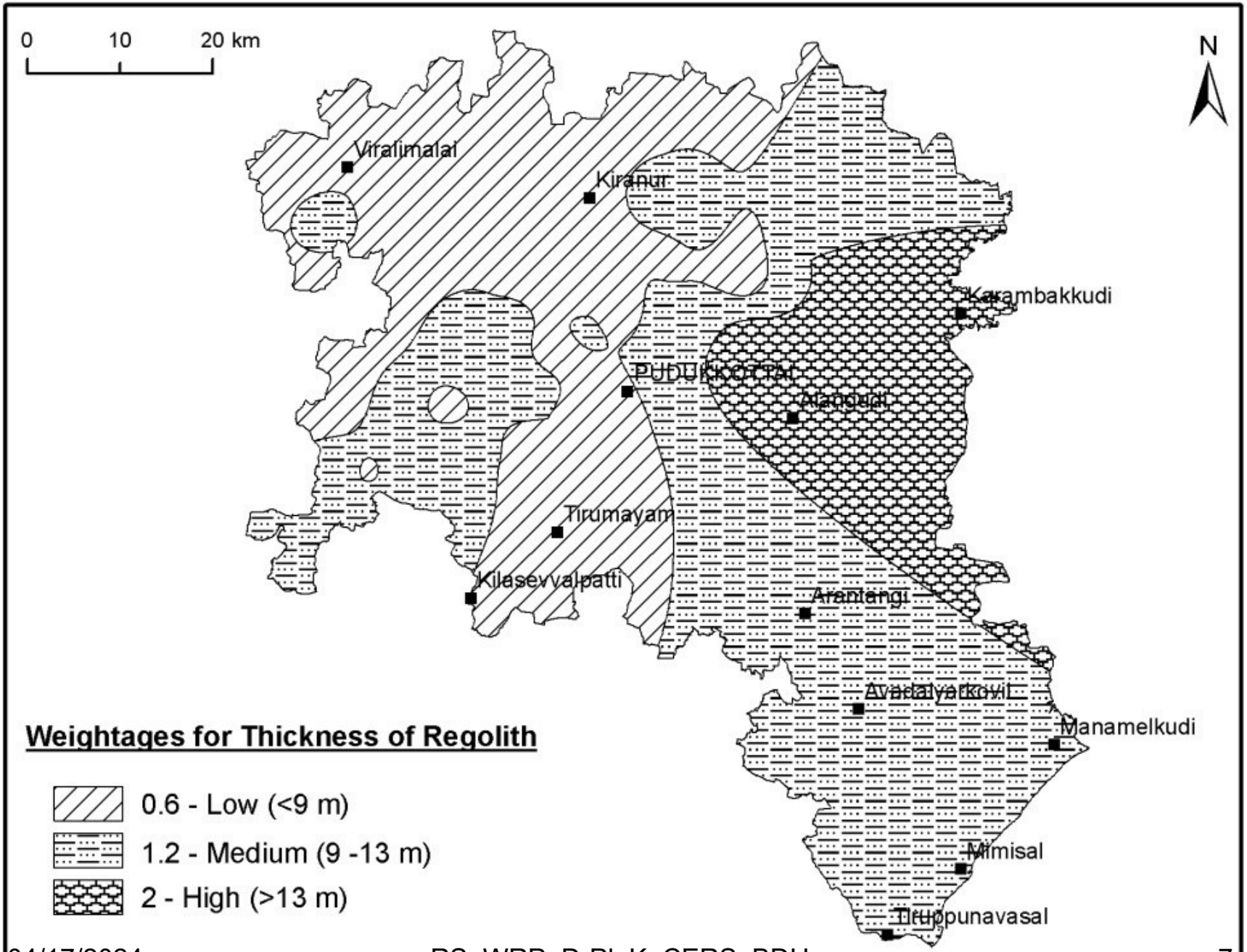


Fig.6.31 Regolith

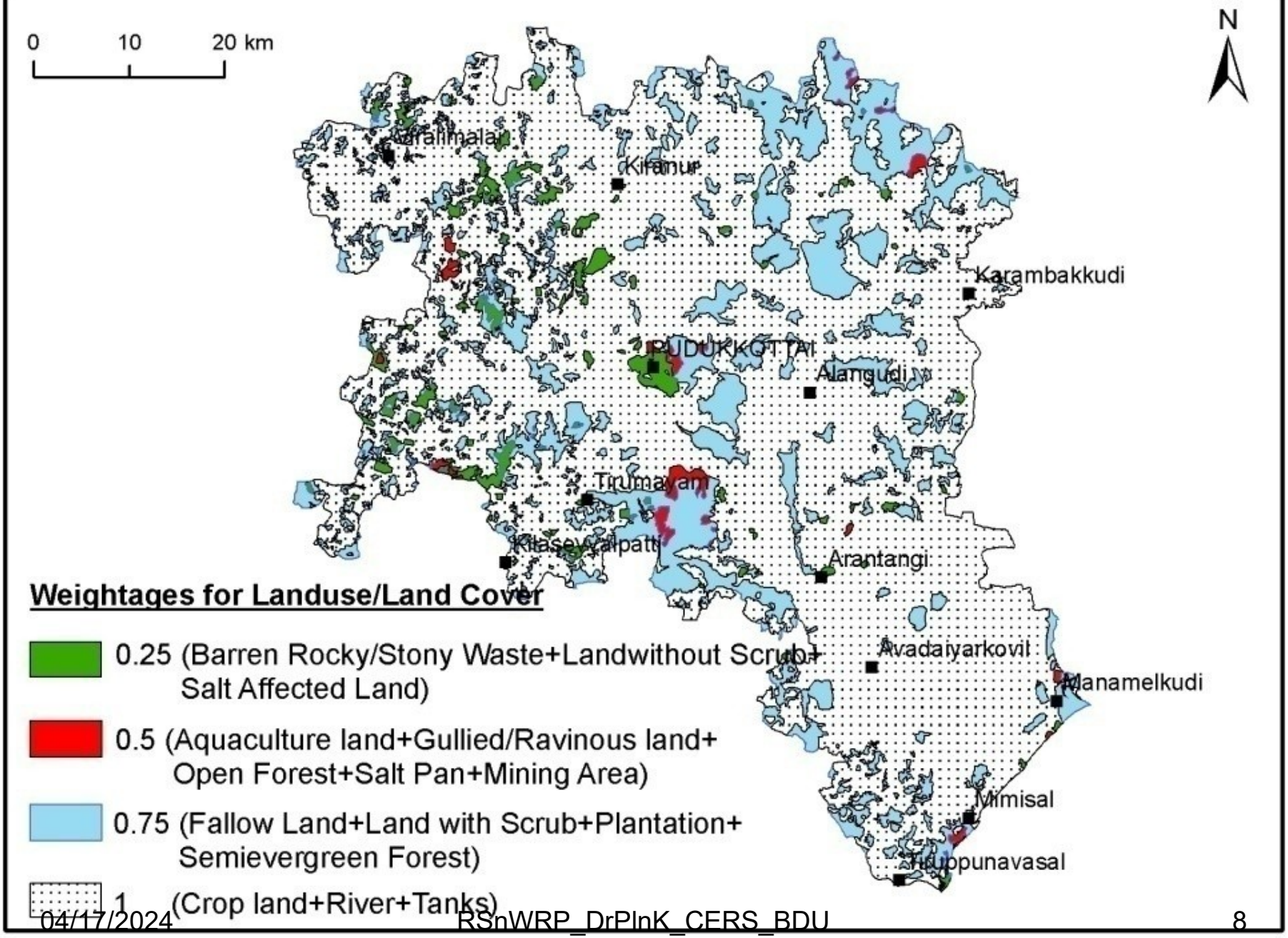


Fig.6.32 Land Use/Land Cover

Groundwater Prospects

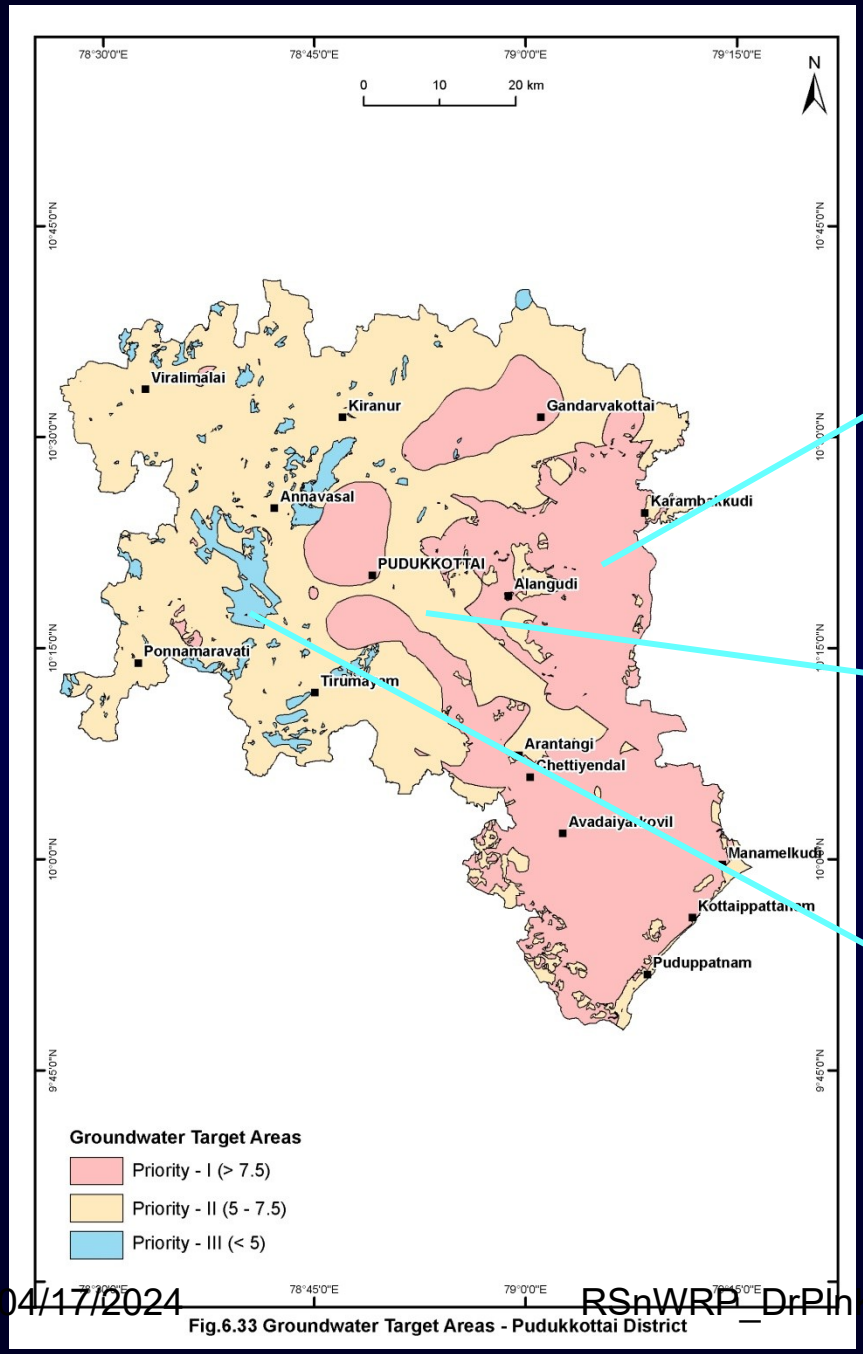


Fig.6.33 Groundwater Target Areas - Pudukkottai District

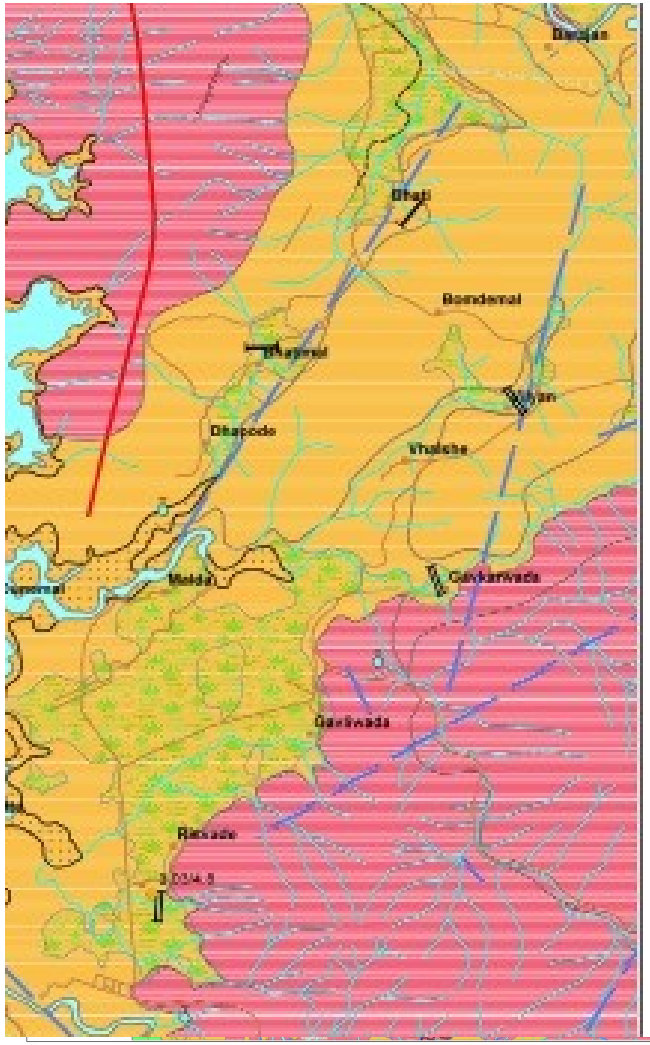
Priority Area – I (>7.5)

Priority Area - II (5-7.5)

Priority Area – III (<5)

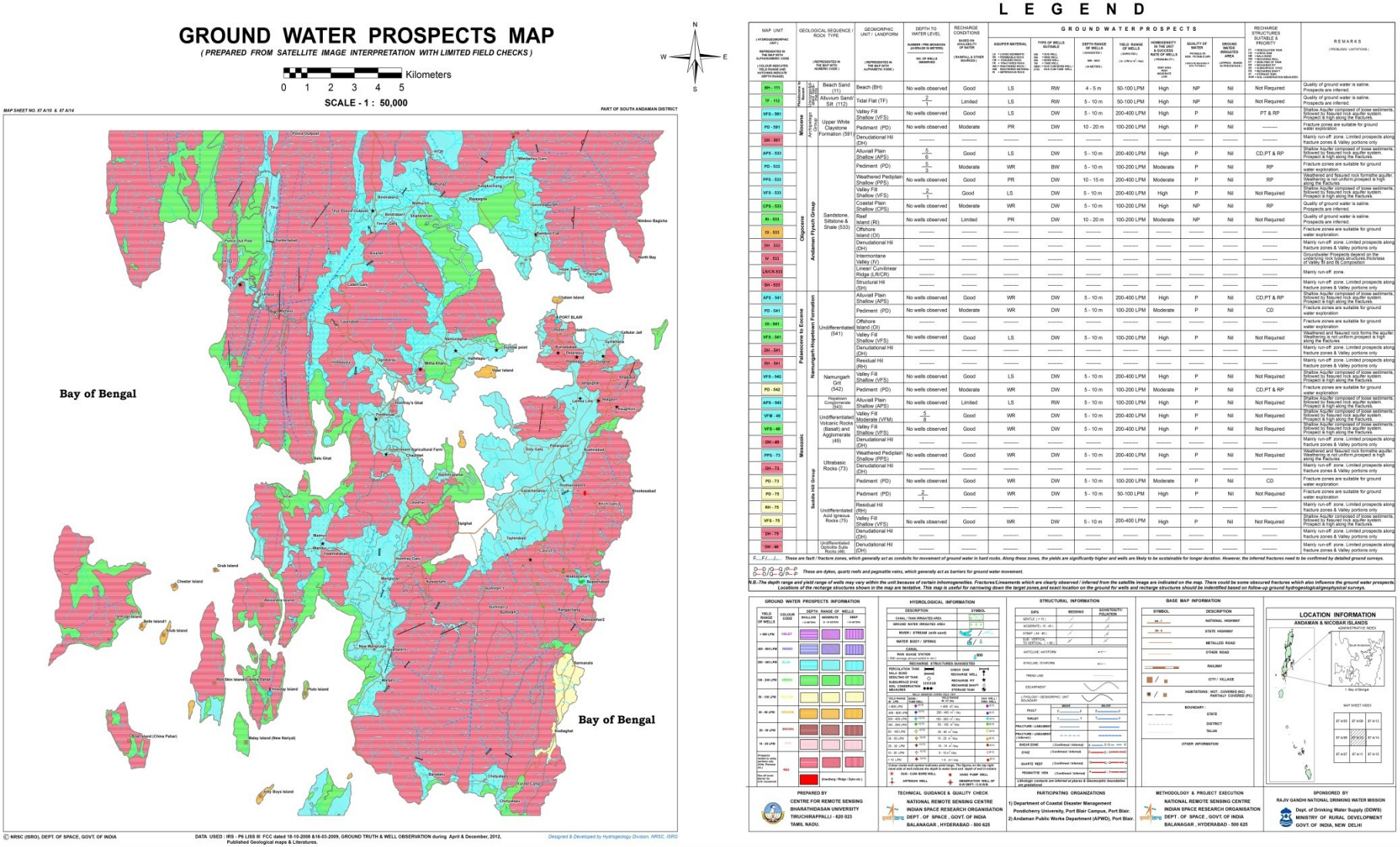
Groundwater Prospect and Groundwater Quality Maps prepared under RGNDWM scheme of NRSC & MoWR for Gundar Basin, Tamil Nadu, Maharashtra, Kerala, Goa, Andaman & Nicobar, Rajasthan

South Goa District

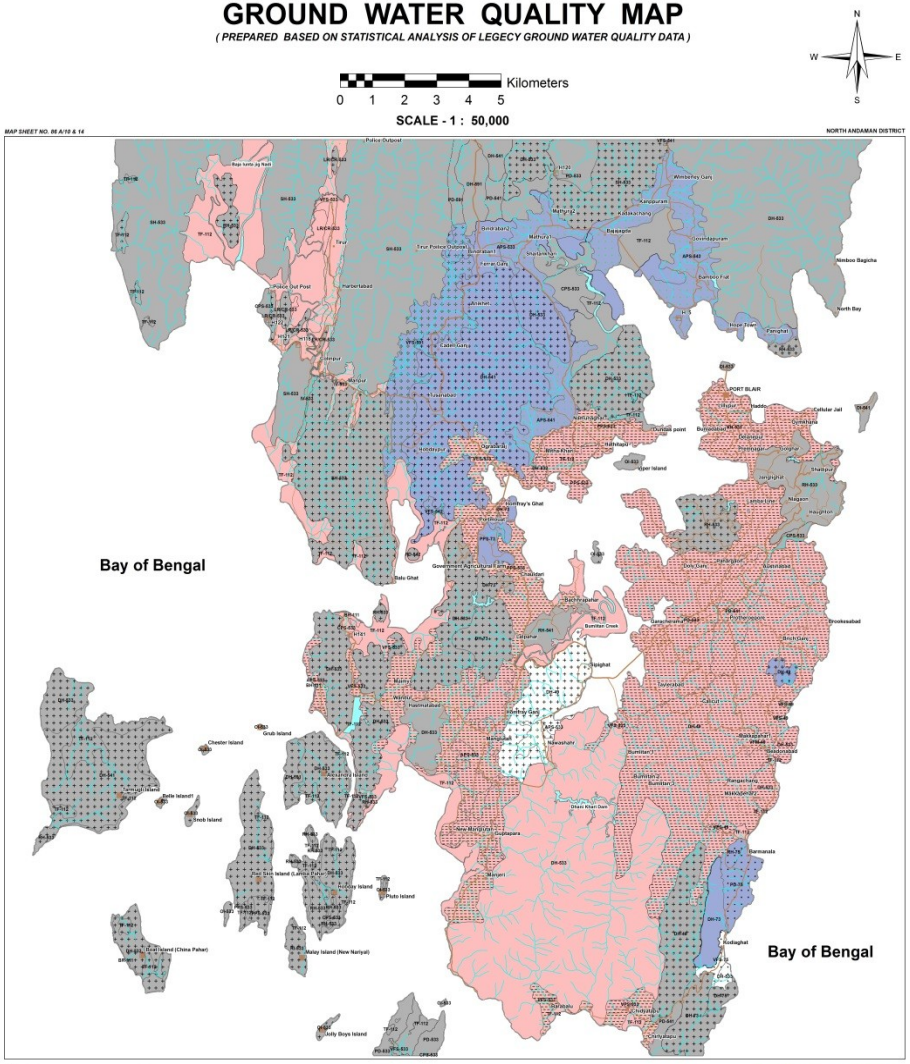


PLS- 982	Archaean to Lower Proterozoic	Sanvordem Formation	Greywacke with Conglomerates (982)	Plateau Highly Dissected (PLS)	No wells observed	Limited
DH - 982				Denudational Hill (DH)	---------	---------
V - 982				Valley (V)	---------	---------
PD - 952			Quartzite (952)	Pediment (PD)	No wells observed	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)	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-anortho -sitic 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)	3/1	Good
OI - 83				Offshore Island (OI)	---------	---------
PD - 83				Pediment (PD)	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



L E G E N D

MAP UNIT (HYDROGEOMORPHIC UNIT) REPRESENTED IN THE MAP WITH ALPHA-NUMERIC CODE	GEOLOGICAL SEQUENCE / ROCK TYPE (REPRESENTED IN THE MAP WITH NUMERIC CODE)	GEOMORPHIC UNIT / LANDFORM (REPRESENTED IN THE MAP WITH ALPHABETIC CODE)	PRE-MONSOON GROUND WATER QUALITY	POST-MONSOON GROUND WATER QUALITY	PERCENTAGE OF MAP UNIT AREA	CONSTITUENTS ANALYSED	ANOMALOUS CONSTITUENTS	REMARKS
TF - 112	Recent to Sub Recent / Alluvial Deposits	Alluvium Sand/ Silt (112)	Non-Potable Non-Potable	Non-Potable ----------	10 90	pH, Total Hardnes, Total Dissolved Solids, Iron, Chloride, Nitrate, Fluoride, Sulphate, Alkalinity, Manganese, & Arsenic	pH,Iron,Flouride Iron	Non-Potable / ---------- Desirable
VFS - 591	Miocene / Pliocene / Pleistocene	Upper White Daytrome Formation (591)	Valley Fill Shallow (VFS)	Desirable	Desirable	100		
APS - 533	Oligocene	Andaman Flysch Group (533)	Alluvial Plain Shallow (APS)	Desirable Non-Potable	---------- Non-Potable	20 80	pH,Iron,Flouride	Non-Potable / Non-Potable
PD - 533			Pediment (PD)	Non-Potable	Non-Potable	100	pH,Iron,Flouride	Non-Potable / Non-Potable
PPS - 533			Weathered Pediplain Shallow (PPS)	Non-Potable	Non-Potable	100	pH,Iron,Flouride	Non-Potable / Non-Potable
VFS - 533			Valley Fill Shallow (VFS)	Non-Potable Non-Potable	Non-Potable ----------	10 90	pH,Iron,Flouride Iron	Non-Potable / ---------- Non-Potable / ----------
CPS - 533			Coastal Plain Shallow (CPS)	Non-Potable	----------	100	Iron	Non-Potable / ----------
DH - 533			Denudational Hil (DH)	Desirable Non-Potable	Desirable ----------	10 90	Iron	Non-Potable / ----------
IV - 533			Intermontane Valley (IV)	Non-Potable	----------	100	Iron	Non-Potable / ----------
LR/CR -533			Linear/ Curvilinear Ridge (LR/CR)	Non-Potable	----------	100	Iron	Non-Potable / ----------
RH - 533			Residual Hil (RH)	Non-Potable	Non-Potable	100	pH,Iron,Flouride	Non-Potable / Non-Potable
APS - 541	Palaeocene to Eocene	Undifferentiated Mithakhari Group (541)	Alluvial Plain Shallow (APS)	Desirable	----------	100		Desirable / ----------
PD - 541			Pediment (PD)	Non-Potable	Non-Potable	100	pH,Iron,Flouride	Non-Potable / Non-Potable
VFS - 541			Valley Fill Shallow (VFS)	Desirable	----------	100		Desirable / ----------
DH - 541			Denudational Hil (DH)	Desirable	Desirable	100		Desirable
VFS - 542		Namunghorh Grit (542)	Valley Fill Shallow (VFS)	Desirable	Desirable	100		Desirable
APS - 543		Hopetown Conglomerate (543)	Alluvial Plain Shallow (APS)	Desirable	----------	100		Desirable / ----------
VFM - 49	Mesozoic	Undifferentiated Volcanic Rocks (Basalt) and Agglomerate (49)	Valley Fill Moderate (VFM)	Non-Potable	Non-Potable	100	Iron	Non-Potable / Non-Potable
VFS - 49			Valley Fill Shallow (VFS)	Non-Potable	Non-Potable	100	Iron	Non-Potable / Non-Potable
DH - 49			Denudational Hil (DH)	--------- Non-Potable	Desirable Non-Potable	10 90	Iron	Non-Potable / Non-Potable
PPS - 73		Ultrabasic Rocks (73)	Weathered Pediplain Shallow (PPS)	Desirable	----------	100		Desirable / ----------
DH - 73			Denudational Hil (DH)	Desirable	----------	100		Desirable / ----------
PD - 75		Undifferentiated Acid Igneous Rocks (75)	Pediment (PD)	Desirable	Permissible	100	Flouride	Desirable / Permissible
RH - 75			Residual Hil (RH)	Desirable	Permissible	100	Flouride	Desirable / Permissible
VFS - 75			Valley Fill Shallow (VFS)	----------	Permissible	100	Flouride	---------- / Permissible
BH,CPS,DH,IV,OL,PD,RH,SH,TF & VFS	On Different Lithological Formation		Legacy data not available			Mainly run-off Zone. Limited prospects along fractures & Valleys.		
BR,CPS,DH,LR/CR,OL,PD,PPS,RH,RL,SH & TF	On Different Lithological Formation		Run-off zone - No Habitation					

GROUND WATER QUALITY PARAMETERS AS PER BIS STANDARDS

Sl.No.	CONSTITUENTS / QUALITY PARAMETERS	POTABLE: DESIRABLE LIMIT	POTABLE: PERMISSIBLE LIMIT	NON-POTABLE
1	pH	6.5 to 8.5	---	< 6.5 ; > 8.5
2	Total Hardness (as $CaCO_3$) mg/l	< 200	200 - 600	> 600
3	Iron (as Fe) mg/l	< 0.3	---	> 0.3
4	Chlorides (as Cl) mg/l	< 250	250 - 1000	> 1000
5	Total Dissolved solids mg/l	< 500	500 - 2000	> 2000
6	Bicarbonate (as HCO_3) mg/l	< 500	---	> 500
7	Calcium (as Ca) mg/l	< 75	75 - 200	> 200
8	Magnesium (as Mg) mg/l	< 30	30 - 100	> 100
9	Nitrate (as NO_3) mg/l	< 45	---	> 45
10	Sulphate (as SO_4) mg/l	< 200	200 - 400	> 400
11	Fluride (as F) mg/l	< 1.0	1.0 - 1.5	> 1.5
12	Manganese (as Mn) mg/l	< 0.1	0.1 - 0.3	> 0.3
13	Arsenic (as As) mg/l	< 0.01	0.01 - 0.05	> 0.05
14	Mercury (as Hg) mg/l	< 0.001	---	> 0.001
15	Cadmium (as Cd) mg/l	< 0.003	---	> 0.003
16	Selenium (as Se) mg/l	< 0.01	---	> 0.01
17	Copper (as Cu) mg/l	< 0.05	0.05 - 1.5	> 1.5
18	Lead (as Pb) mg/l	< 0.01	---	> 0.01
19	Zinc (as Zn) mg/l	< 5	5 - 15	> 15
20	Chromium (as Cr^{6+}) mg/l	< 0.05	---	> 0.05
21	Pesticides mg/l	0	0 - 0.001	> 0.001
22	Radioactive Alpha emitters pci/l	0	0 - 0.1	> 0.1
23	Radioactive Beta emitters pci/l	0	0 - 1.0	> 1.0
24	Alkalinity mg/l	< 200	200 - 600	> 600
25	Aluminium (as Al) mg/l	< 0.03	0.03 - 0.2	> 0.2

COLOUR CODE	GROUND WATER QUALITY: PRE MONSOON	GROUND WATER QUALITY: POST MONSOON
	No Data	Desirable
	No Data	Permissible
	No Data	Non - Potable
	Desirable	No Data
	Permissible	No Data
	Non - Potable	No Data
	Desirable	Desirable
	Desirable	Permissible
	Desirable	Non - Potable
	Permissible	Desirable
	Permissible	Permissible
	Permissible	Non - Potable
	Non - Potable	Desirable
	Non - Potable	Permissible
	Non - Potable	Non - Potable
	No Data	No Data

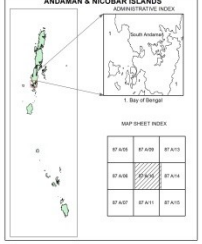
HYDROLOGICAL INFORMATION

DESCRIPTION	SYMBOL
CANAL / TANK IRRIGATED AREA	
GROUND WATER IRRIGATED AREA	
RIVER / STREAM	
WATER BODY	
CANAL	
Base Layer Information	
NH - 7	NATIONAL HIGHWAY
SH - 9	STATE HIGHWAY
	METALLED ROAD
	OTHER ROAD
	RAILWAY
	CITY / VILLAGE
	HABITATIONS - NOT COVERED (NC) PARTIALY COVERED (PC)
BOUNDARY	
	STATE
	DISTRICT
	TALUK
Other Information	
	Aquifer Unit Boundary/Hydrogeomorphic Unit Boundary with Alpha-Numeric

LOCATION INFORMATION

ANDAMAN & NICOBAR ISLANDS

ADMINISTRATIVE INDEX



MAP SHEET INDEX

PREPARED BY
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TIRUCHIRAPPALLI - 620 023
TAMIL NADU.

TECHNICAL GUIDANCE & QUALITY CHECK
NATIONAL REMOTE SENSING CENTRE
INDIAN SPACE RESEARCH ORGANISATION
DEPT . OF SPACE , GOVT. OF INDIA
BALANAGAR , HYDERABAD - 500 625

PARTICIPATING ORGANIZATIONS
1) Department of Coastal Disaster Management
Pondicherry University, Port Blair Campus, Port Blair.
2) Andaman Public Works Department (APWD), Port Blair.

METHODOLOGY & PROJECT EXECUTION
NATIONAL REMOTE SENSING CENTRE
INDIAN SPACE RESEARCH ORGANISATION
DEPT . OF SPACE , GOVT. OF INDIA
BALANAGAR , HYDERABAD - 500 625

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Dept. of Drinking Water Supply (DDWS)
MINISTRY OF RURAL DEVELOPMENT
GOVT. OF INDIA, NEW DELHI

Back

STUDY - 10

Groundwater Targeting

Back

STUDY - 10

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)**

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

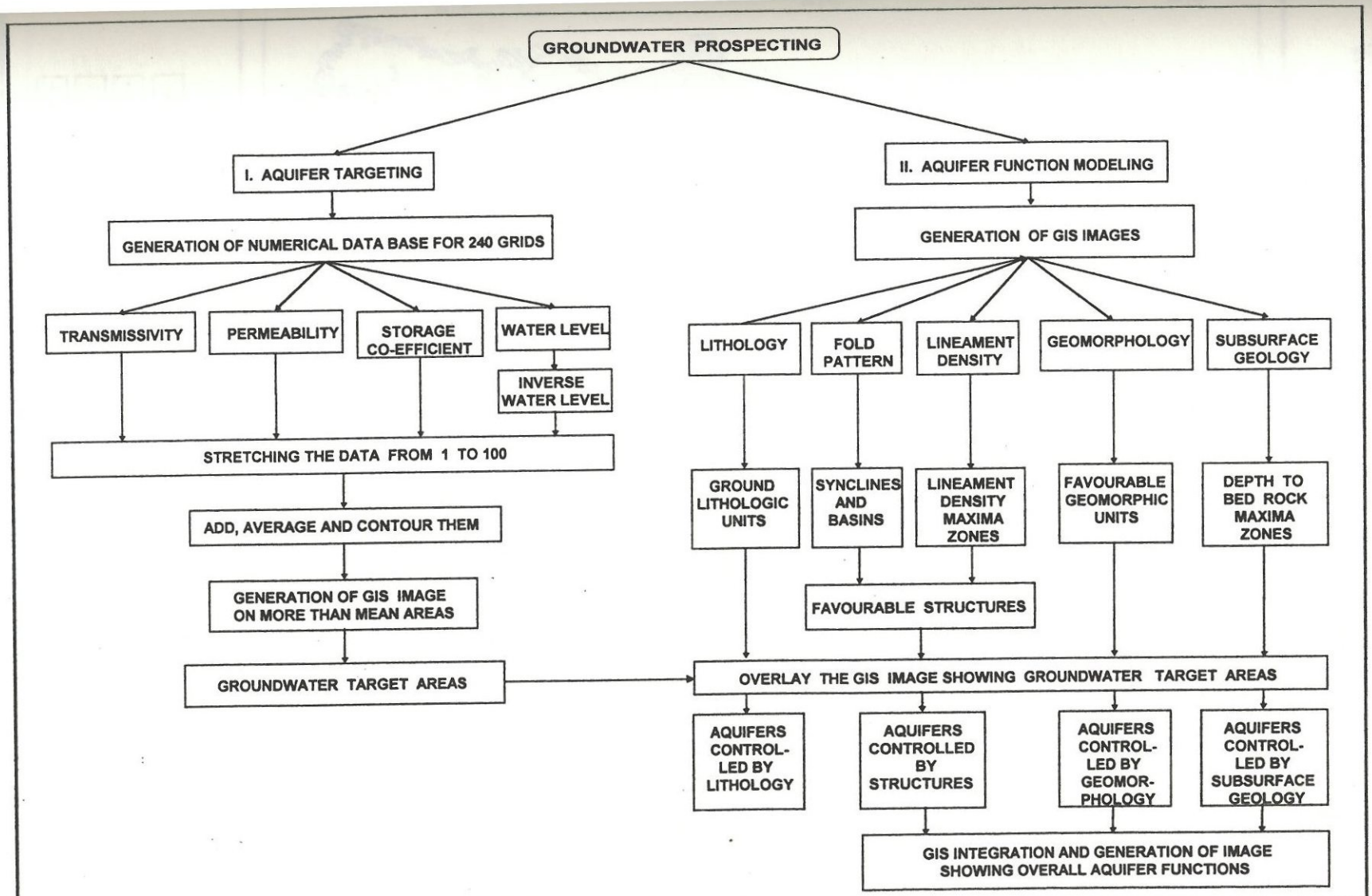


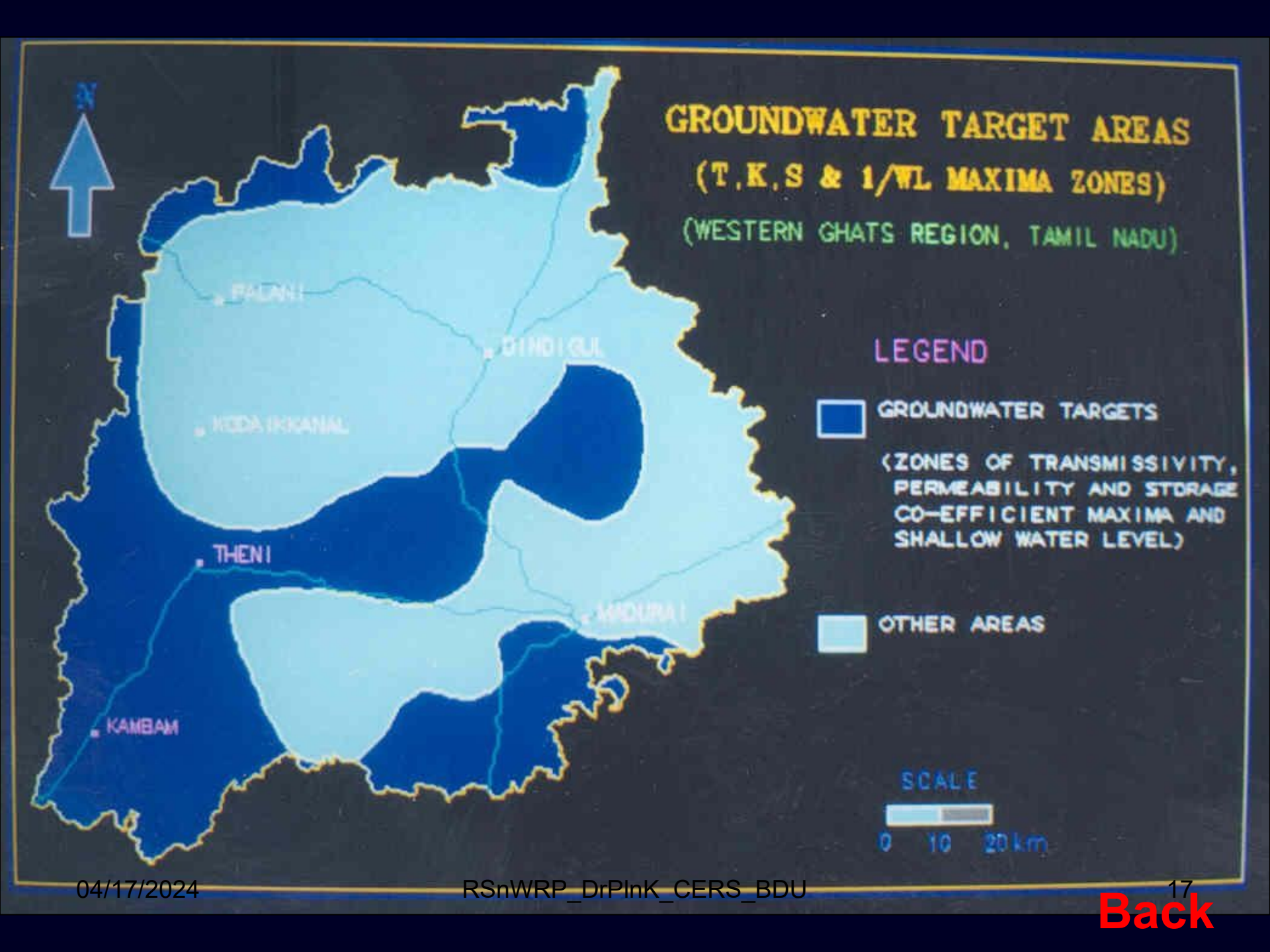
FIGURE 3.15 METHODOLOGY FLOW CHART

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

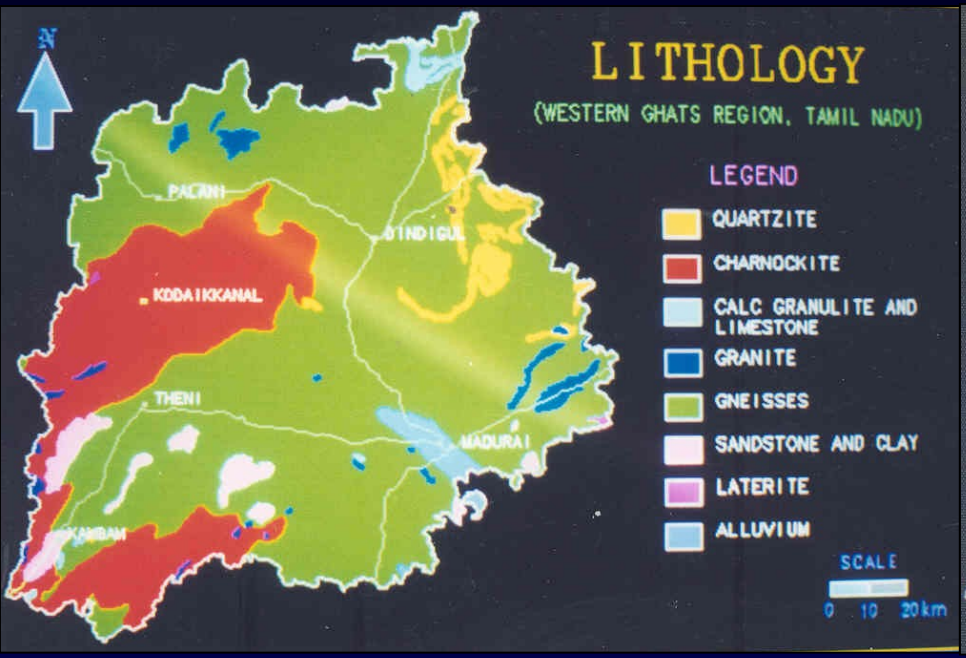

N
GROUNDWATER TARGET AREAS
(T,K,S & 1/WL MAXIMA ZONES)
(WESTERN GHATS REGION, TAMIL NADU)
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM
LEGEND
GROUNDWATER TARGETS
(ZONES OF TRANSMISSIVITY, PERMEABILITY AND STORAGE CO-EFFICIENT MAXIMA AND SHALLOW WATER LEVEL)
OTHER AREAS
SCALE
0 10 20 km

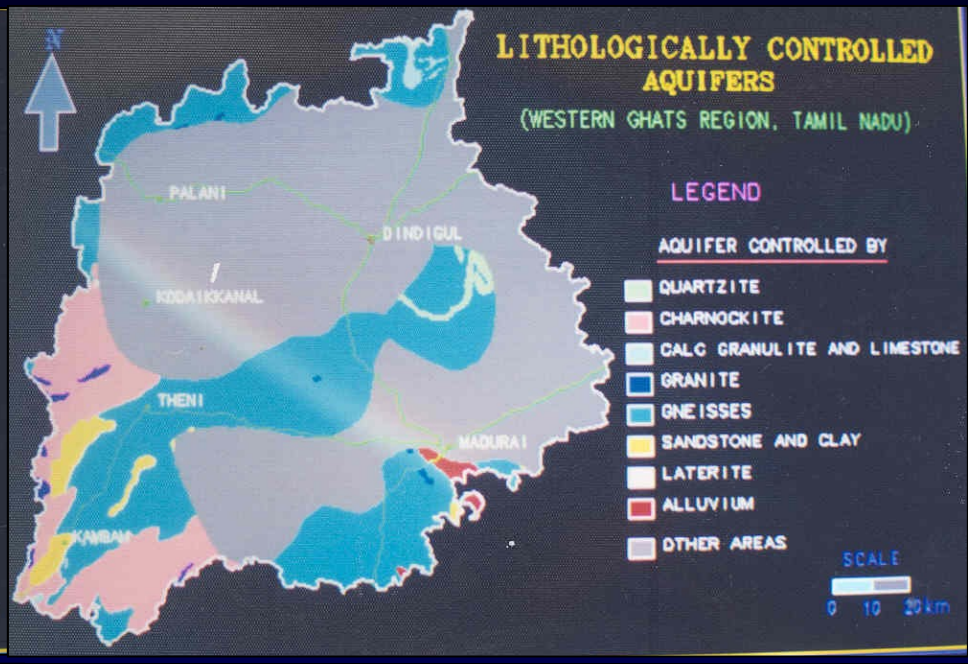
Back

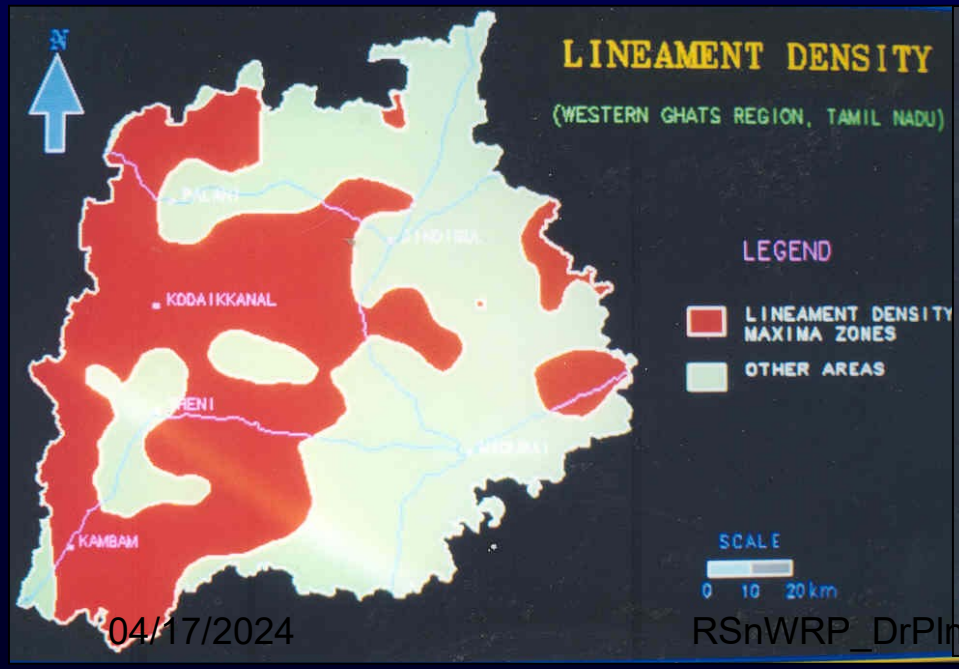
STUDY - 11

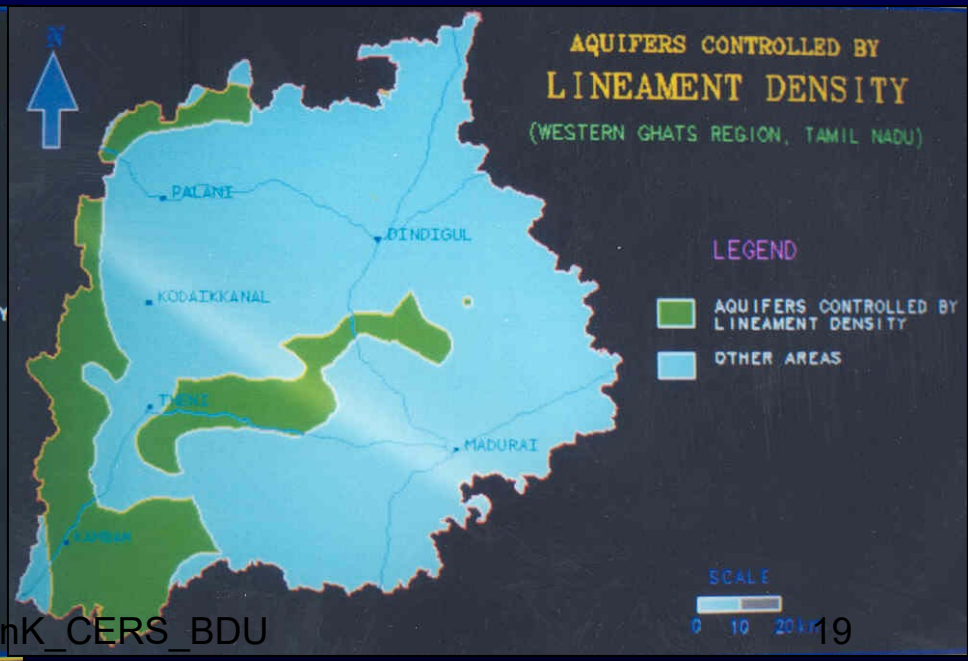
AQUIFER FUNCTION MODELLING

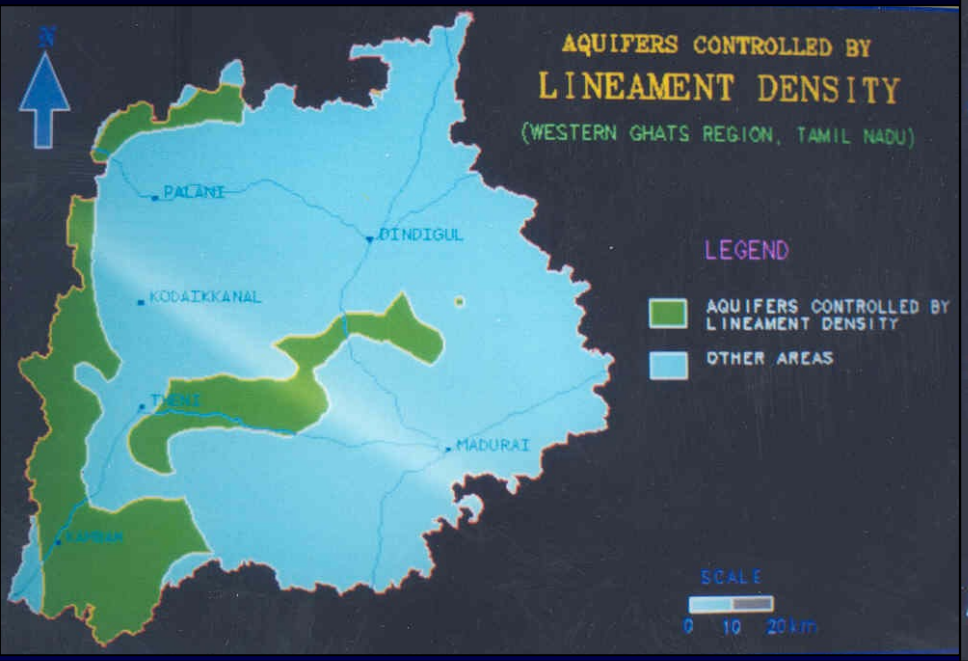
Back

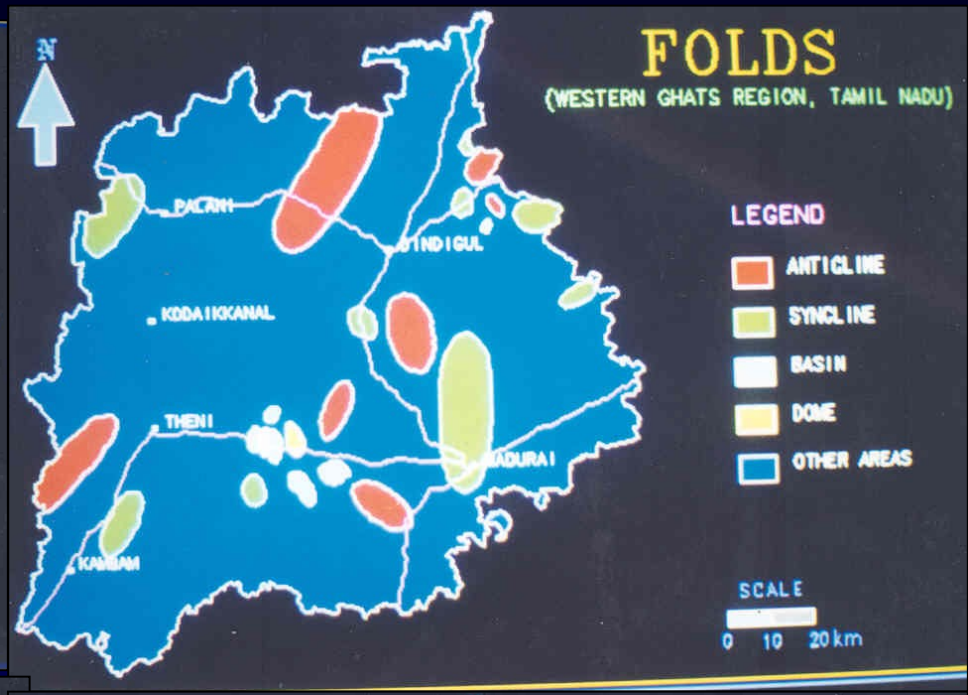

LITHOLOGY
(WESTERN GHATS REGION, TAMIL NADU)
LEGEND
QUARTZITE
CHARNOCKITE
CALC GRANULITE AND LIMESTONE
GRANITE
GNEISSES
SANDSTONE AND CLAY
LATERITE
ALLUVIUM
SCALE
0 10 20 km
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM

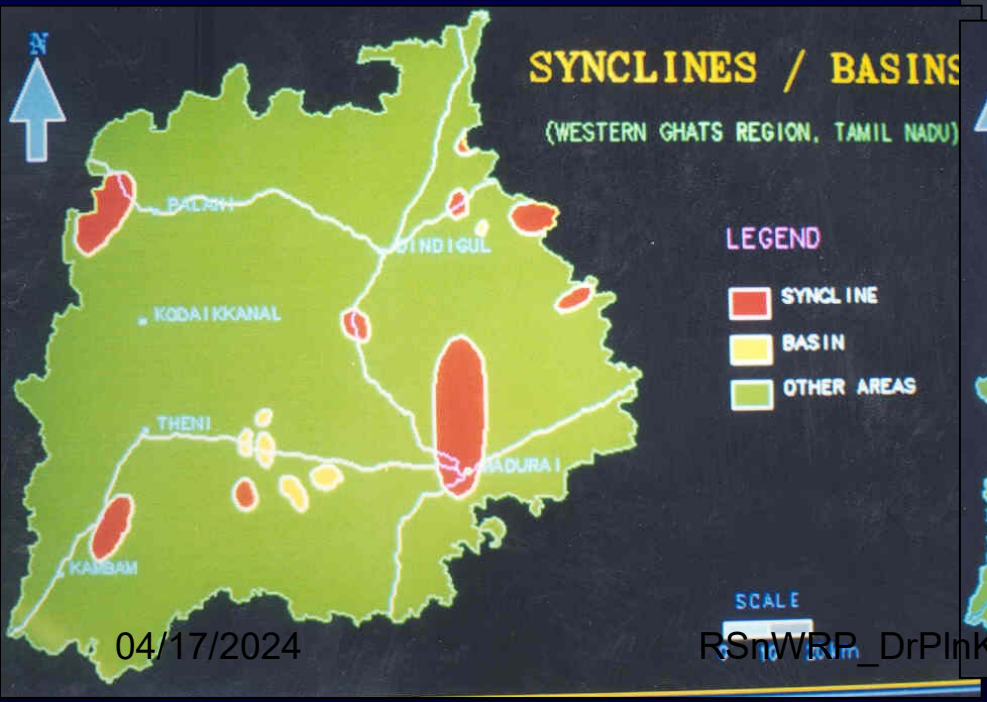

LITHOLOGICALLY CONTROLLED AQUIFERS
(WESTERN GHATS REGION, TAMIL NADU)
LEGEND
AQUIFER CONTROLLED BY
QUARTZITE
CHARNOCKITE
CALC GRANULITE AND LIMESTONE
GRANITE
GNEISSES
SANDSTONE AND CLAY
LATERITE
ALLUVIUM
OTHER AREAS
SCALE
0 10 20 km
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM


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


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

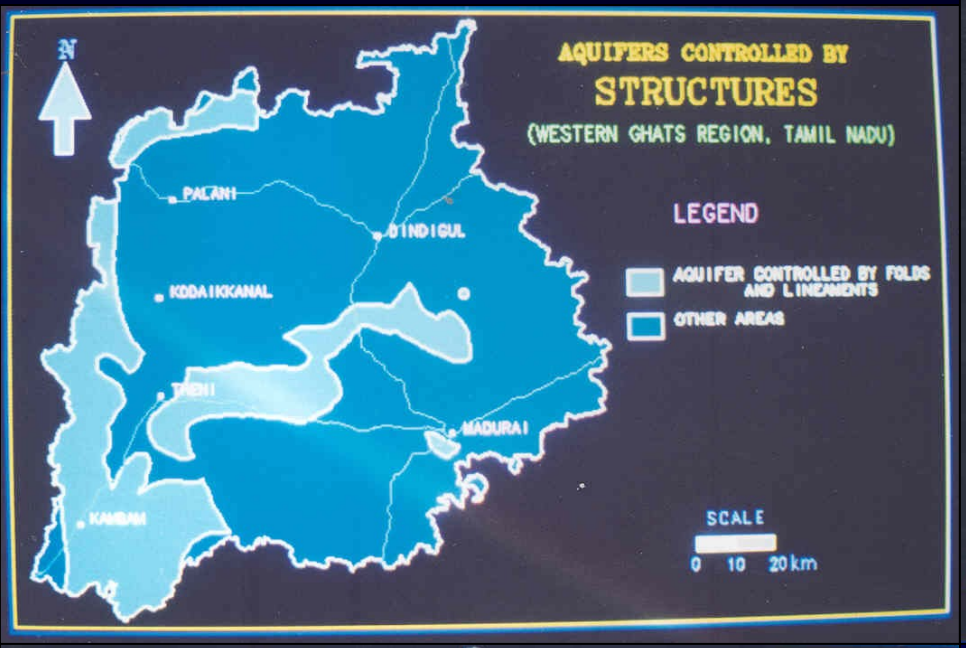

AQUIFERS CONTROLLED BY
LINEAMENT DENSITY
(WESTERN GHATS REGION, TAMIL NADU)
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
LEGEND
AQUIFERS CONTROLLED BY LINEAMENT DENSITY
OTHER AREAS
SCALE
0 10 20km

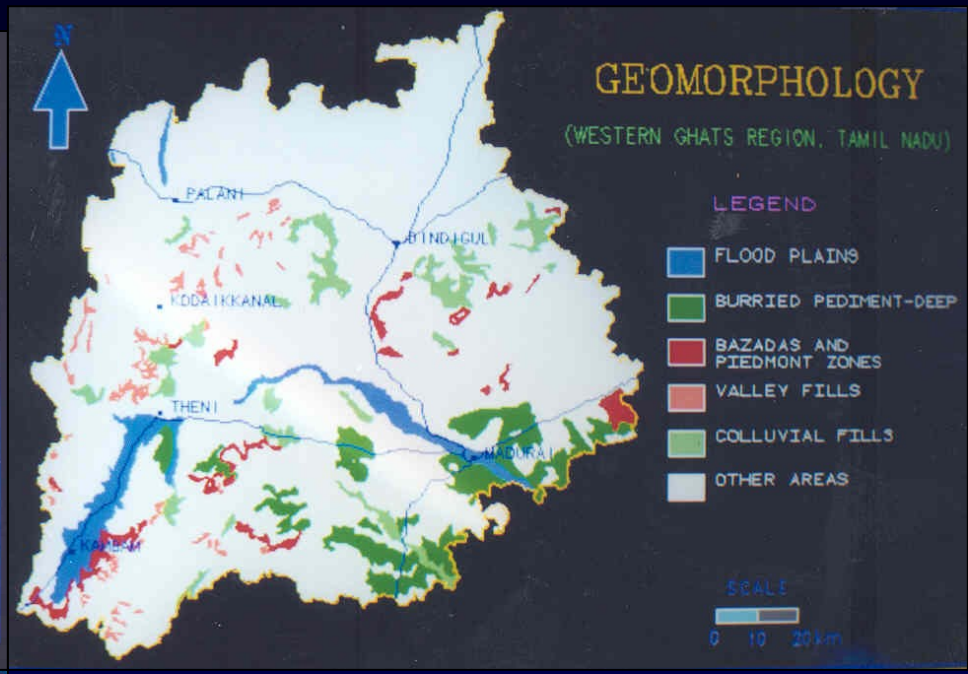

FOLDS
(WESTERN GHATS REGION, TAMIL NADU)
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
LEGEND
ANTICLINE
SYNCLINE
BASIN
DOME
OTHER AREAS
SCALE
0 10 20km

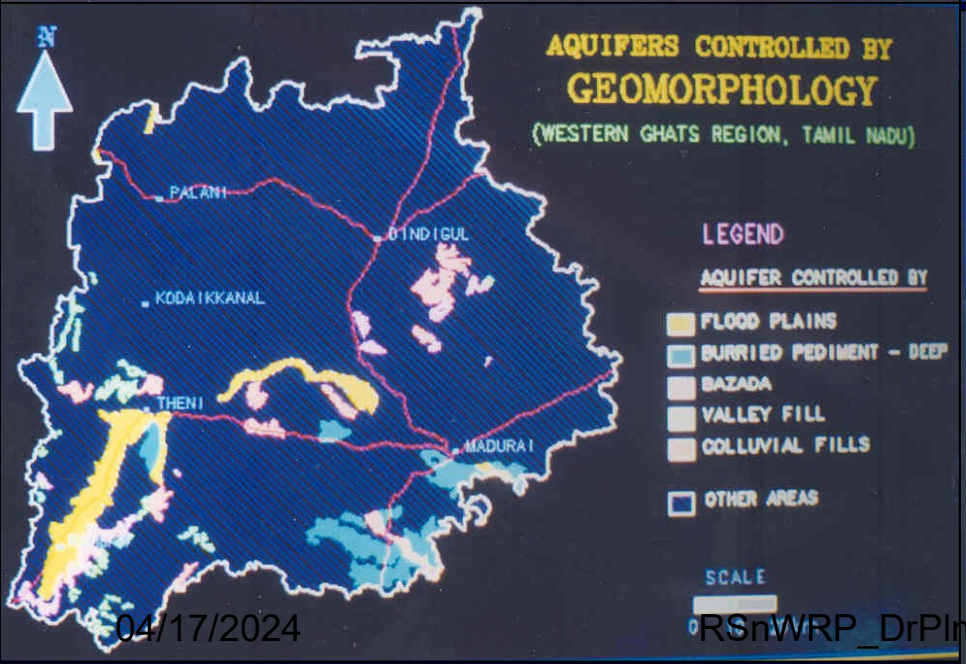

SYNCLINES / BASINS
(WESTERN GHATS REGION, TAMIL NADU)
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
LEGEND
SYNCLINE
BASIN
OTHER AREAS
SCALE

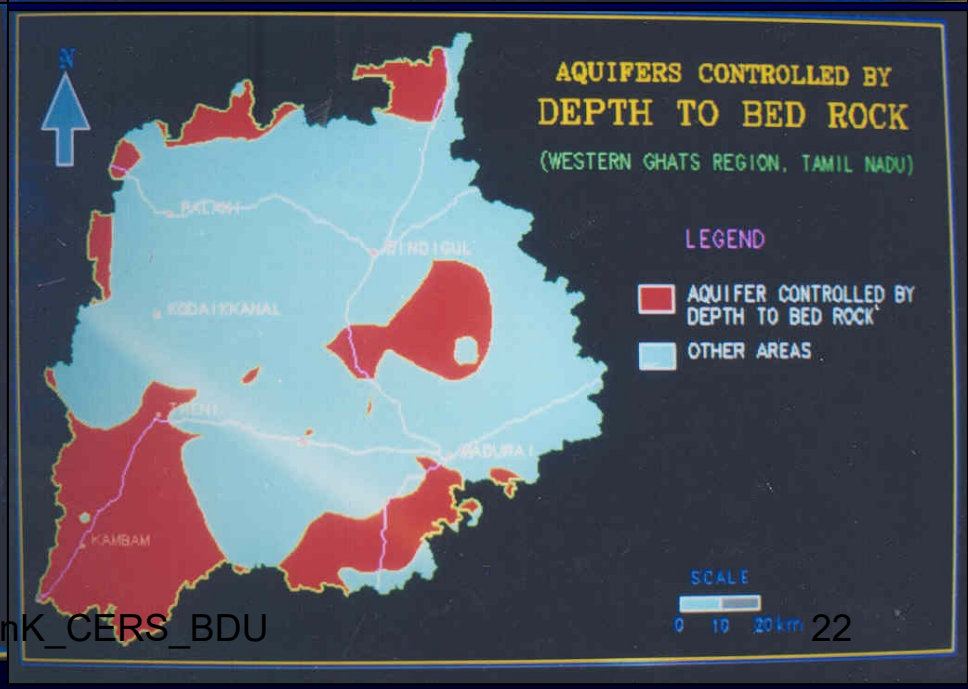

AQUIFER CONTROLLED BY
FOLDS
(WESTERN GHATS REGION, TAMIL NADU)
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
LEGEND
AQUIFER CONTROLLED BY
SYNCLINE
BASIN
OTHER AREAS
SCALE
0 10 20km

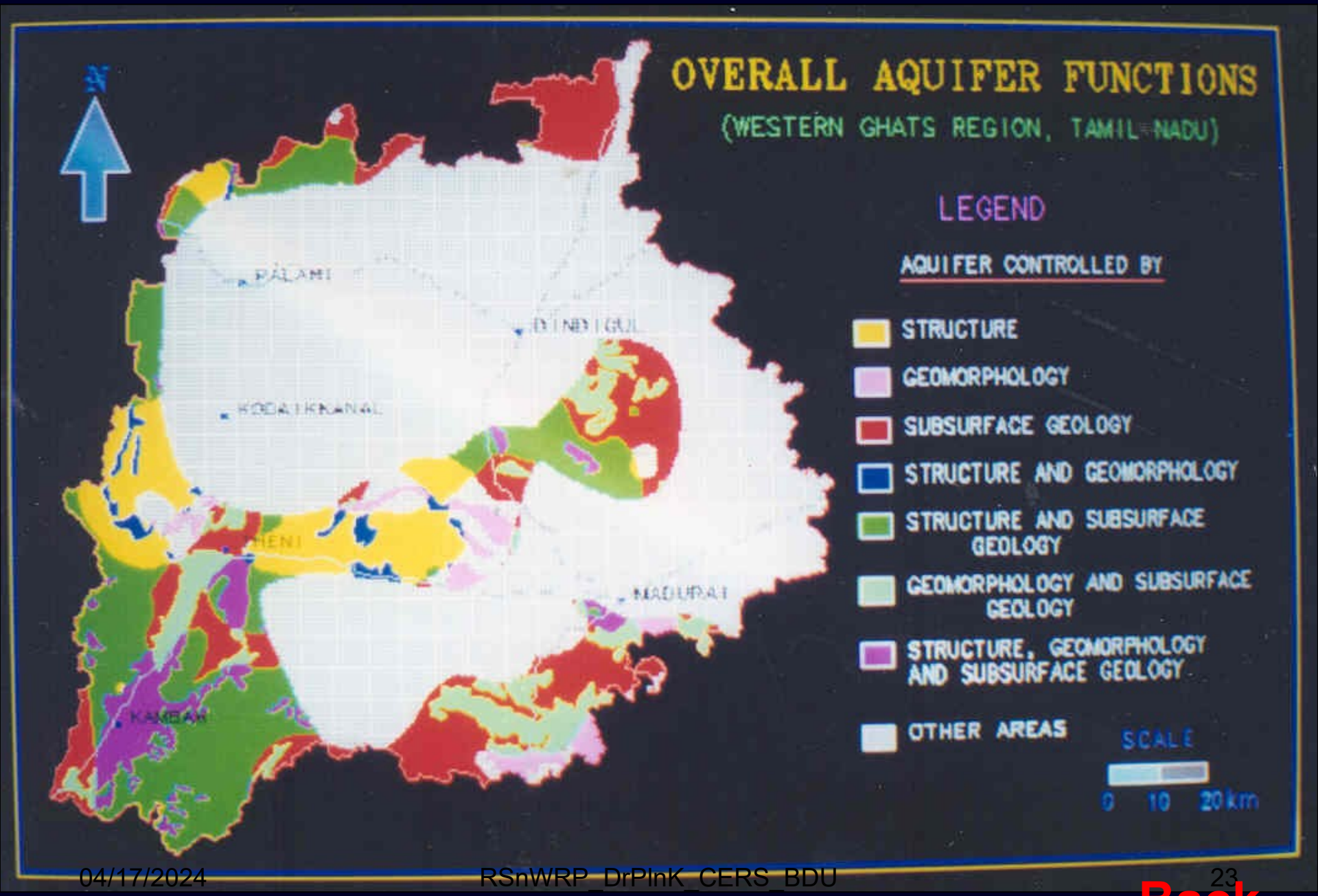

N
GROUNDWATER TARGET AREAS
(T,K,S & 1/WL MAXIMA ZONES)
(WESTERN GHATS REGION, TAMIL NADU)
PALANI
DINDIGUL
KODAIKKANAL
THENI
MADURAI
KAMBAM
LEGEND
GROUNDWATER TARGETS
(ZONES OF TRANSMISSIVITY, PERMEABILITY AND STORAGE CO-EFFICIENT MAXIMA AND SHALLOW WATER LEVEL)
OTHER AREAS
SCALE
0 10 20 km


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


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


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


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

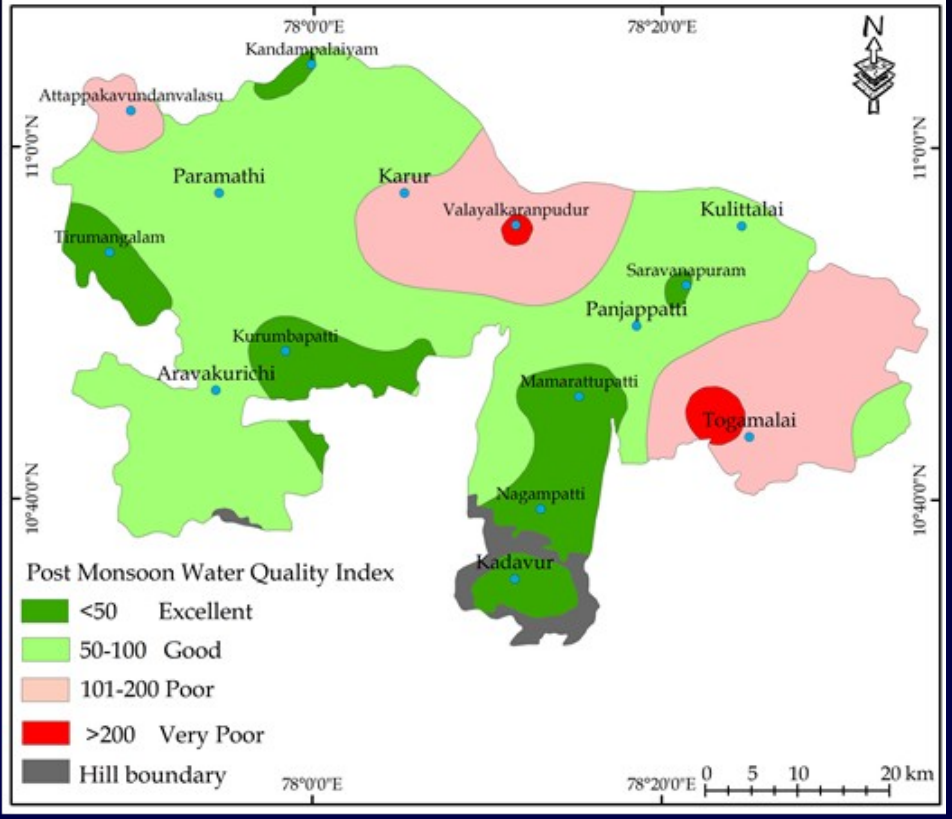

OVERALL AQUIFER FUNCTIONS
(WESTERN GHATS REGION, TAMIL NADU)
LEGEND
AQUIFER CONTROLLED BY
STRUCTURE
GEOMORPHOLOGY
SUBSURFACE GEOLOGY
STRUCTURE AND GEOMORPHOLOGY
STRUCTURE AND SUBSURFACE GEOLOGY
GEOMORPHOLOGY AND SUBSURFACE GEOLOGY
STRUCTURE, GEOMORPHOLOGY AND SUBSURFACE GEOLOGY
OTHER AREAS
SCALE
0 10 20 km
PALANI
KODAIKANAL
THENI
KAMBAM

Back

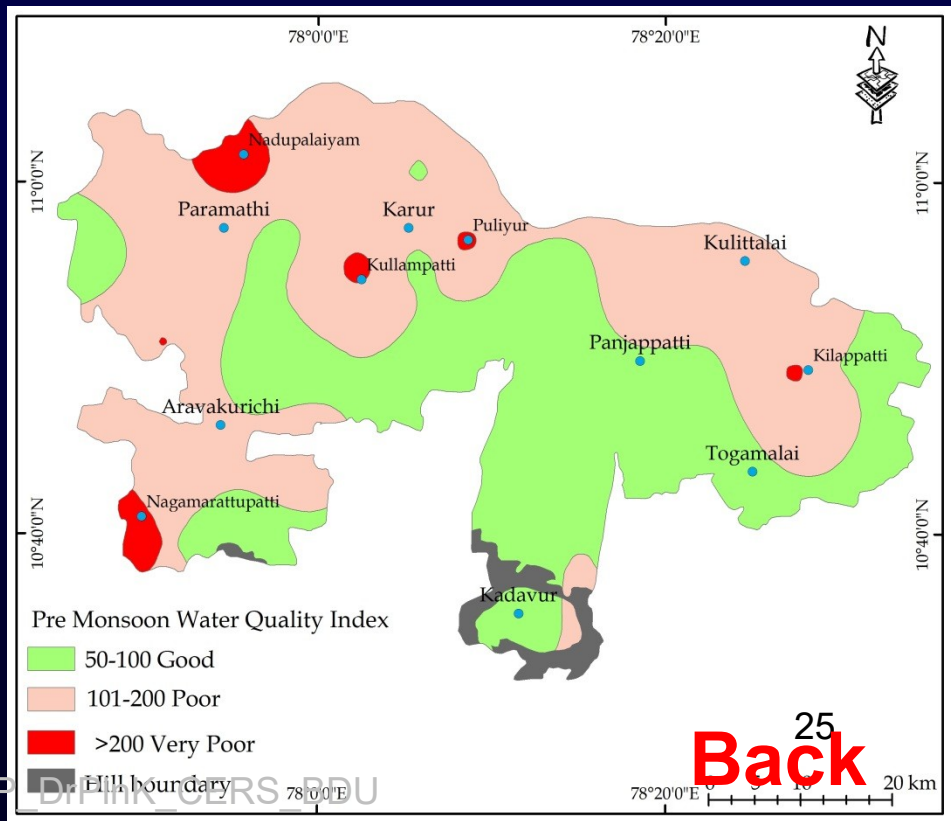
STUDY - 12

Groundwater Quality Modelling

Back



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 (Lithology & Structures)
  - Soil conditions / Characters
  - Slope
  - Land use / Land cover
- Suggestion of Site suitable mechanisms for recharge.

TYPES OF RECHARGE:

- Natural recharge
- Artificial recharge

Back

STUDY – 13

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

EVALUATION:

- Determination of Recharge pattern of the area from 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

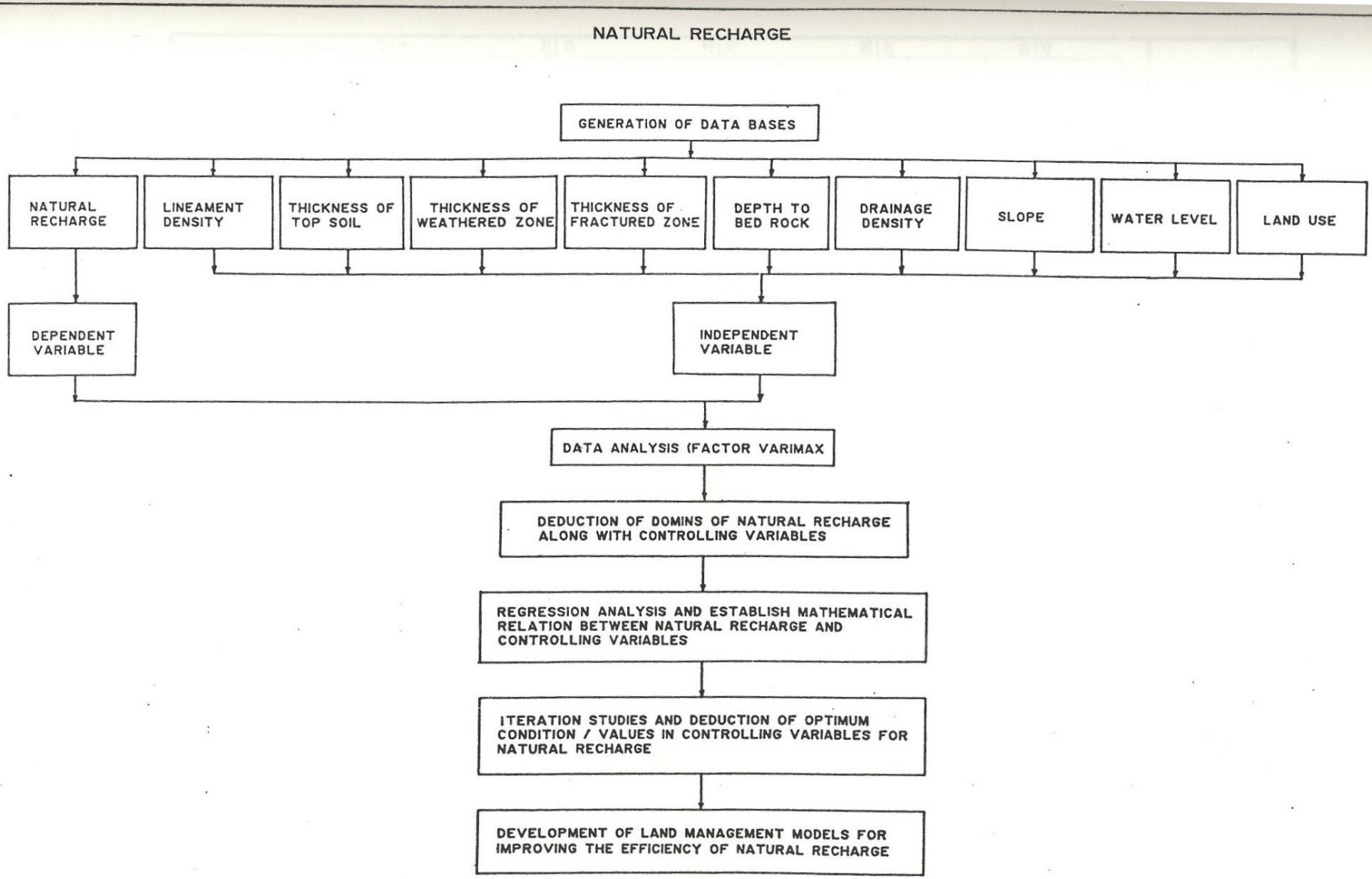
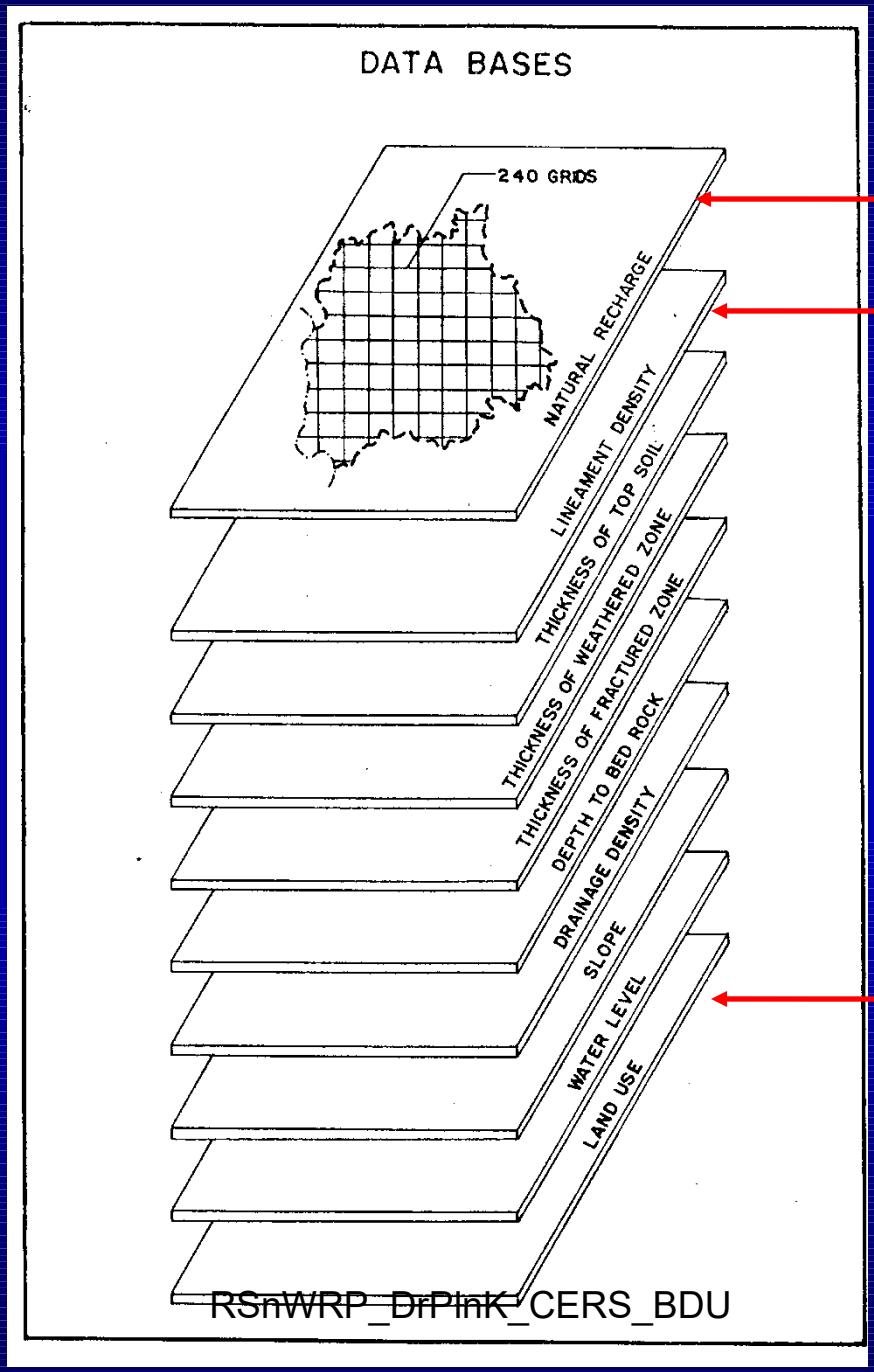


Fig. 6.2 METHODOLOGY FLOW CHART



Dependent variable

Independent variables

STPES INVOLVED

- Generate gridwise database
- 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 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 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

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

Regression analysis to find 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.

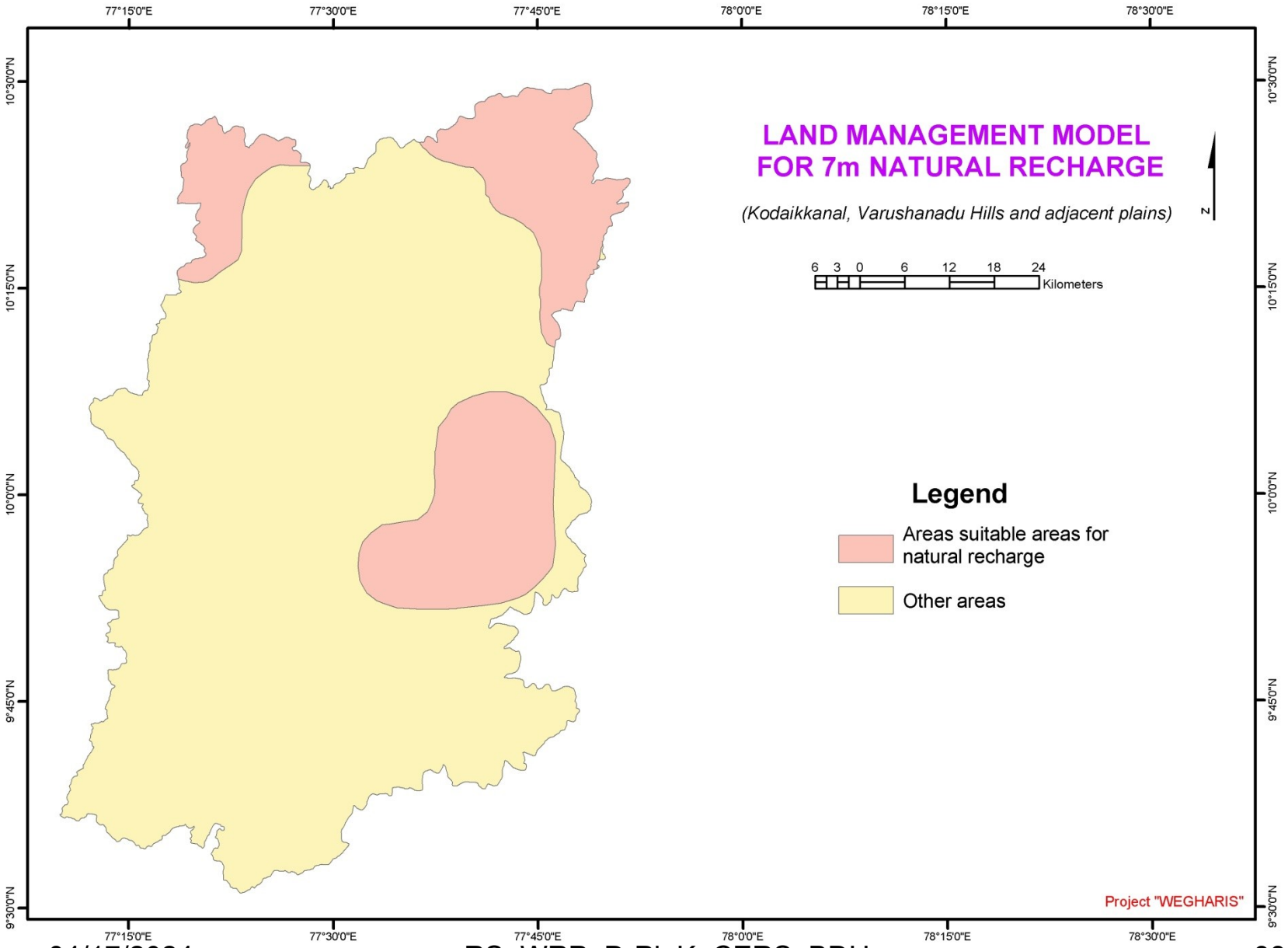
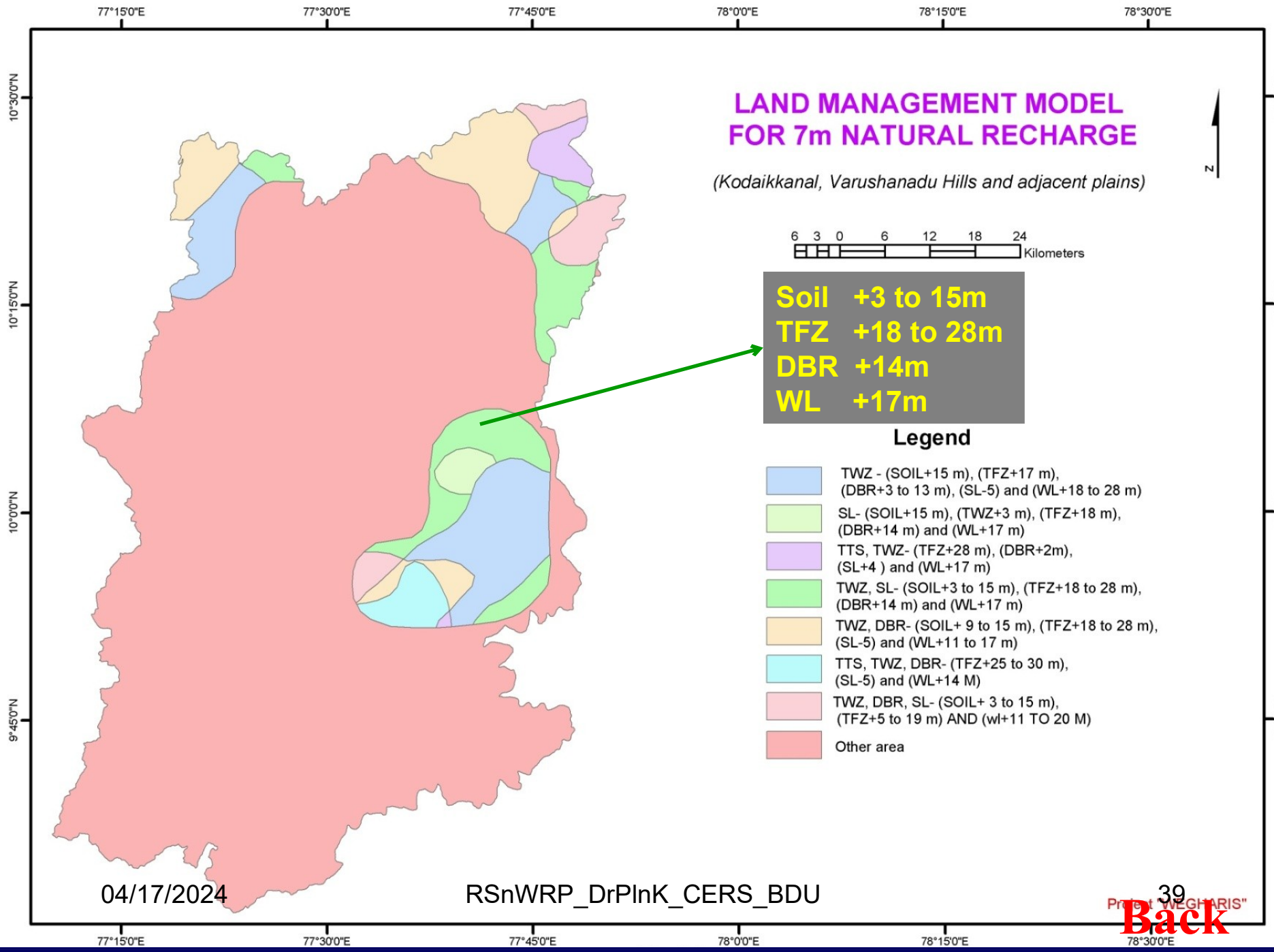

77°15'0"E
77°30'0"E
77°45'0"E
78°0'0"E
78°15'0"E
78°30'0"E
10°30'0"N
10°15'0"N
10°0'0"N
9°45'0"N
9°30'0"N
LAND MANAGEMENT MODEL
FOR 7m NATURAL RECHARGE
(Kodaikkanal, Varushanadu Hills and adjacent plains)
N
6 3 0 6 12 18 24
Kilometers
Legend
Areas suitable areas for natural recharge
Other areas
Project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

Fig. 4.1



Back

STUDY –14

ARTIFICIAL RECHARGE

Back

ARTIFICIAL RECHARGE:

- To push maximum flood water into the aquifer system through appropriate site specific mechanism
- By constructing various structures, the storage and the infiltration increased which in turn recharge the ground water.

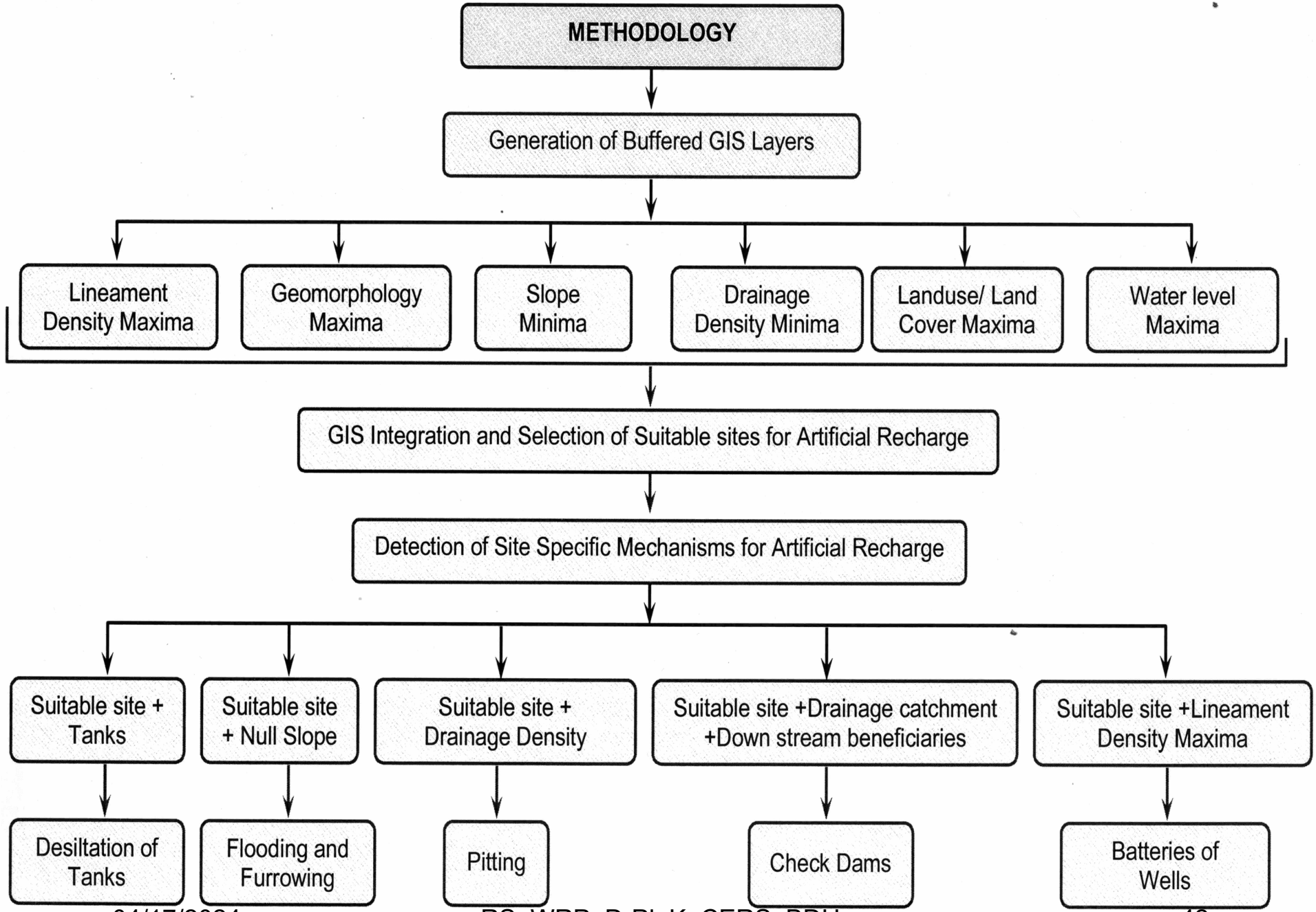
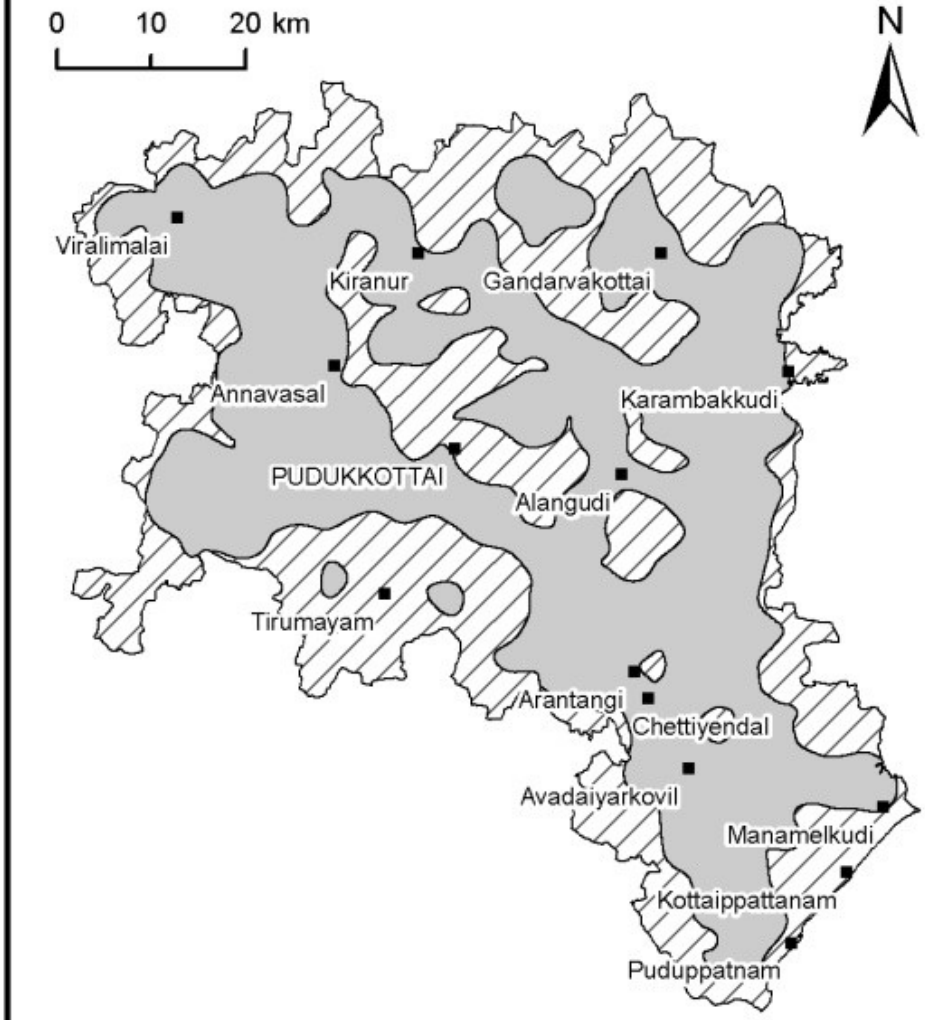


Fig. 6.36 Methodology – Site Selection and Mechanism Detection for Artificial Recharge



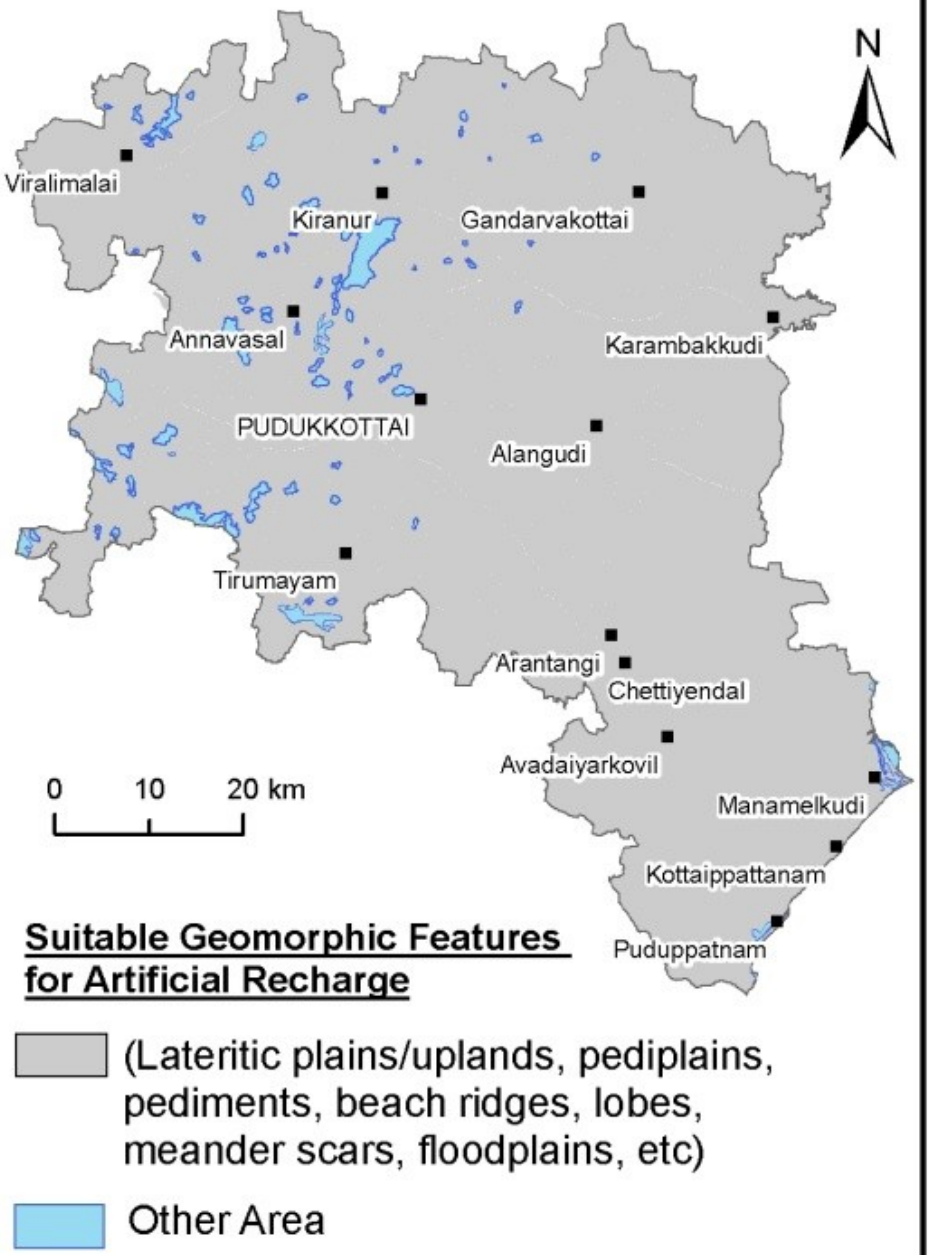


Fig.6.37 Lineament Density

Fig.6.38 Geomorphology

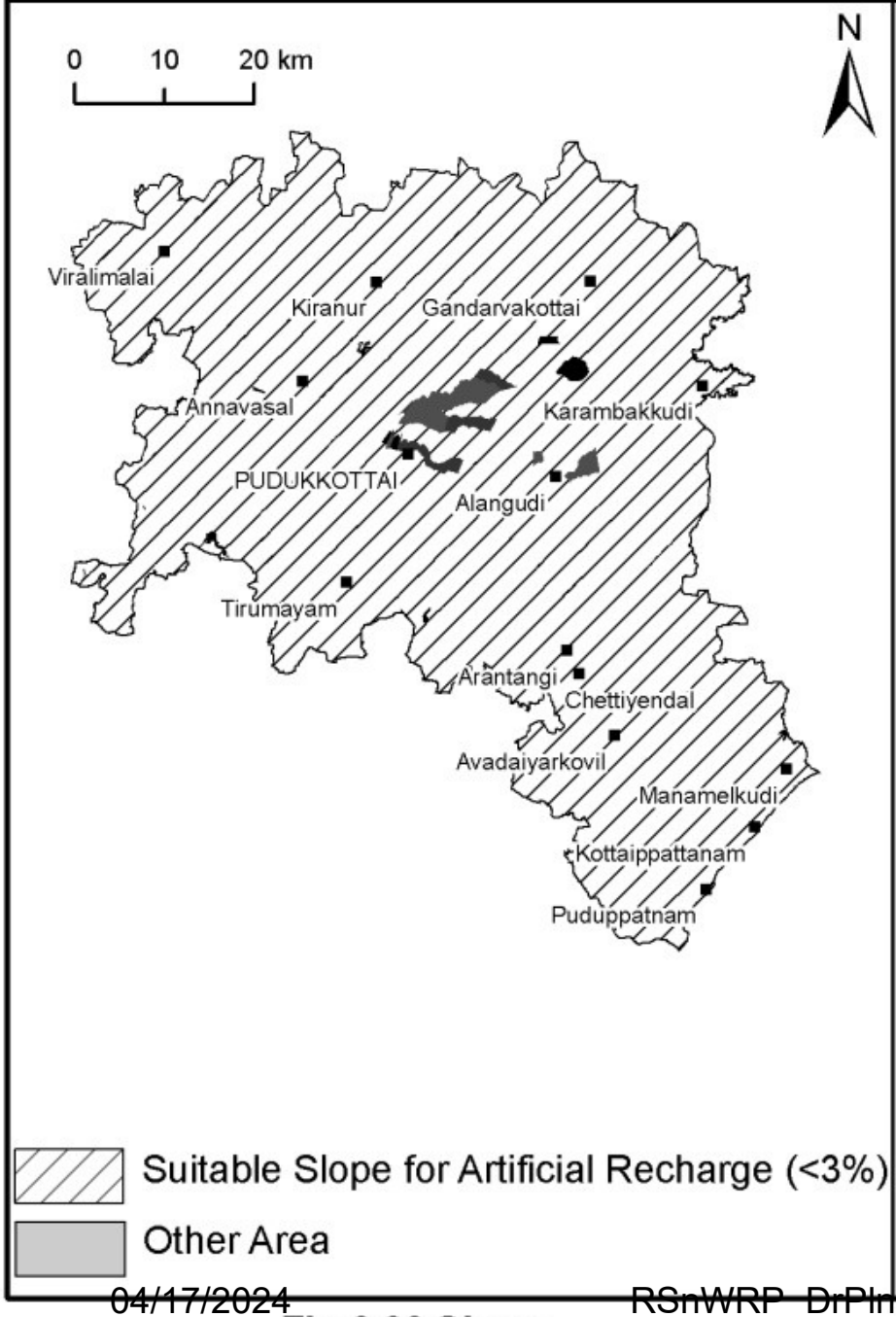
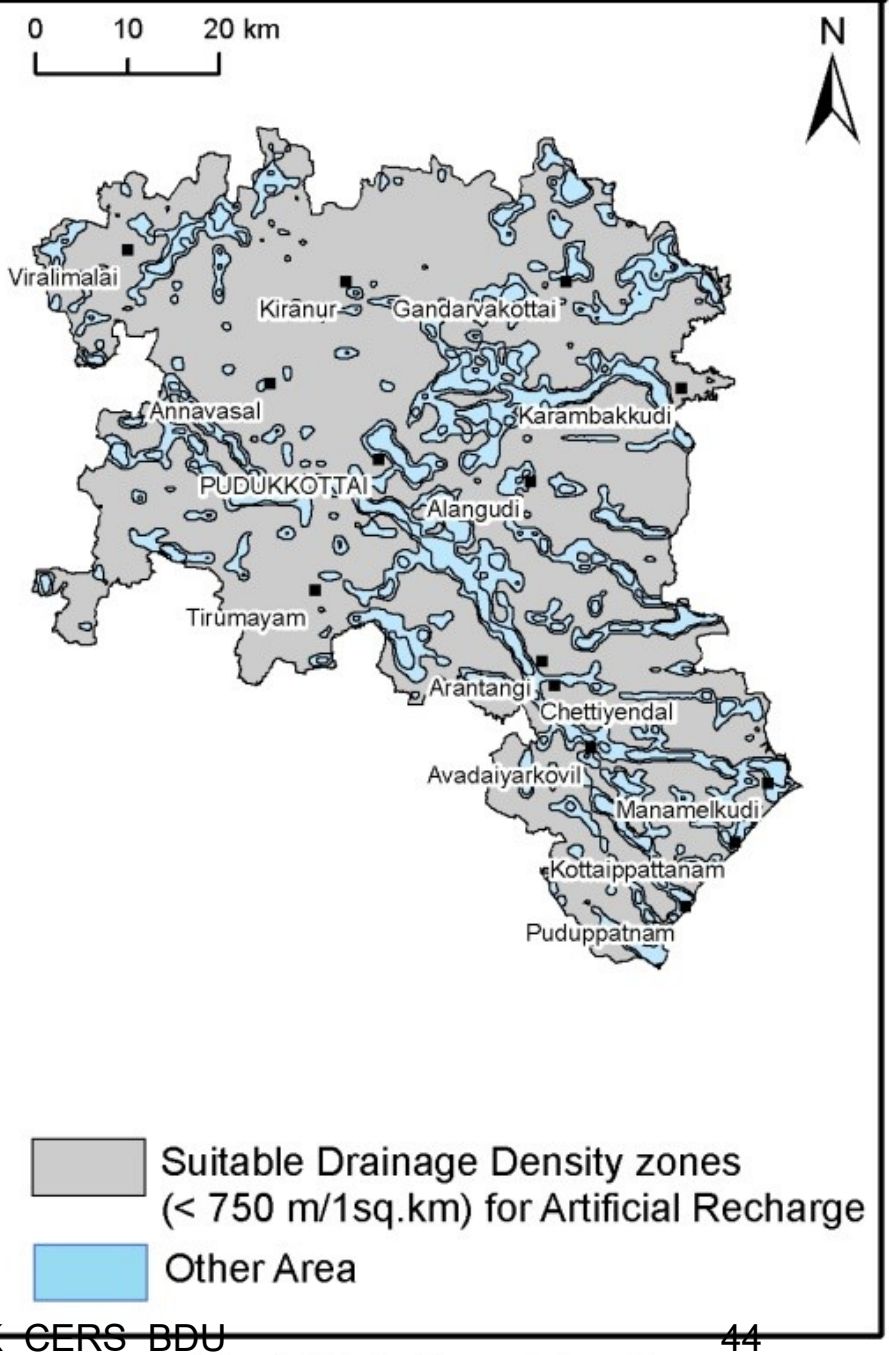


Fig.6.39 Slope



Flg.6.40 Drainage Density

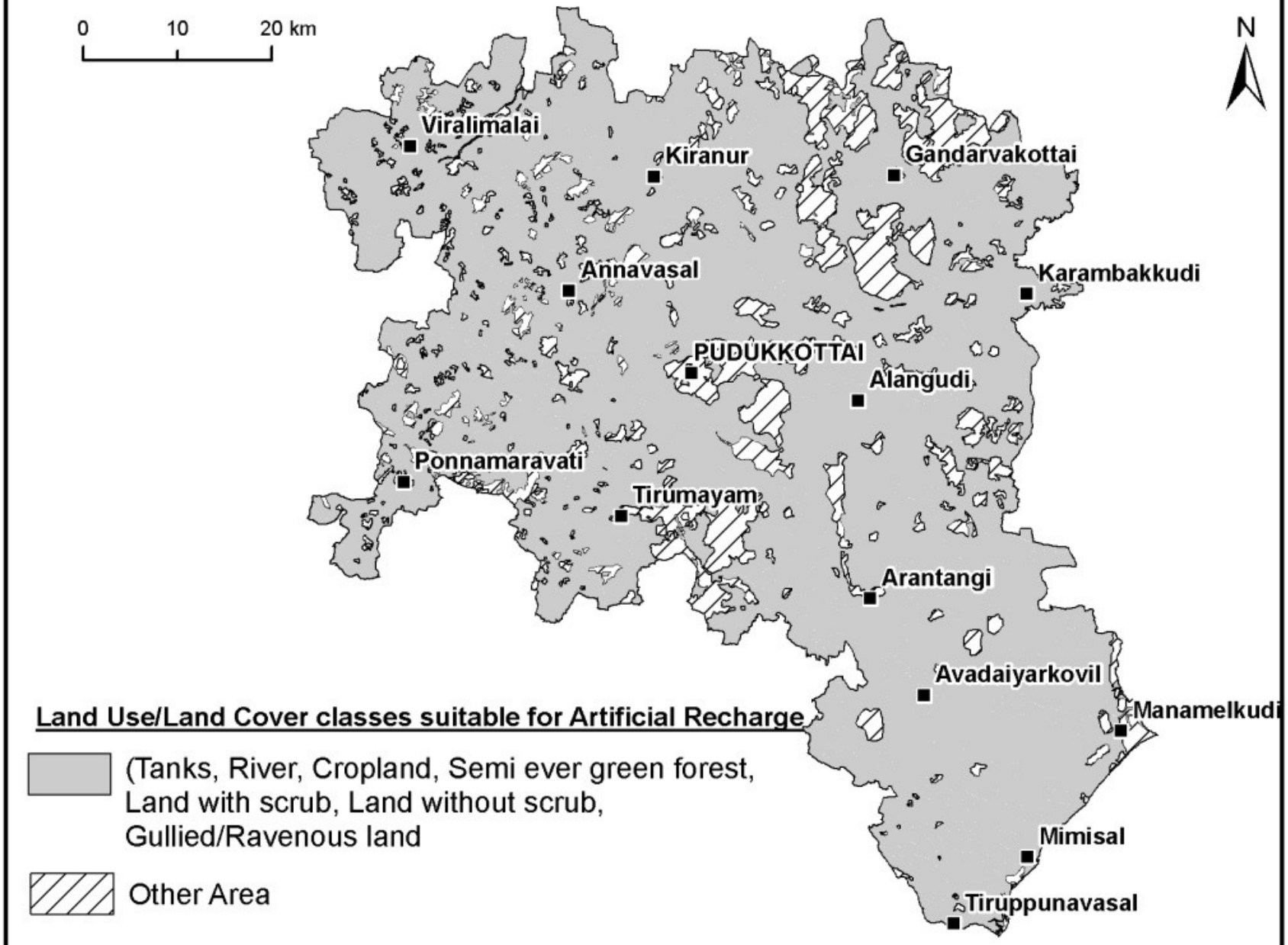


Fig.6.41 Land Use/Land Cover

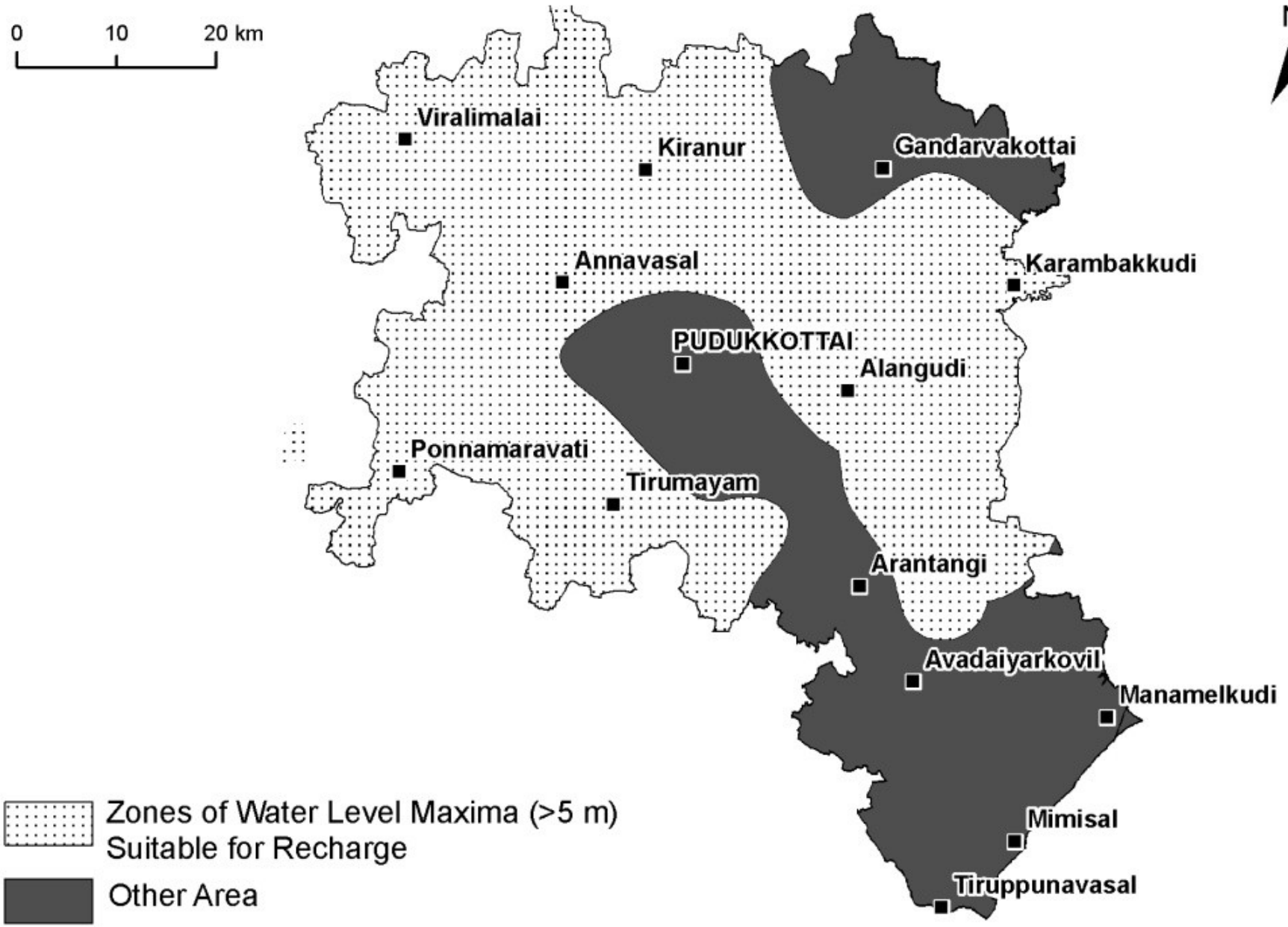


Fig. 6.42 Water Level

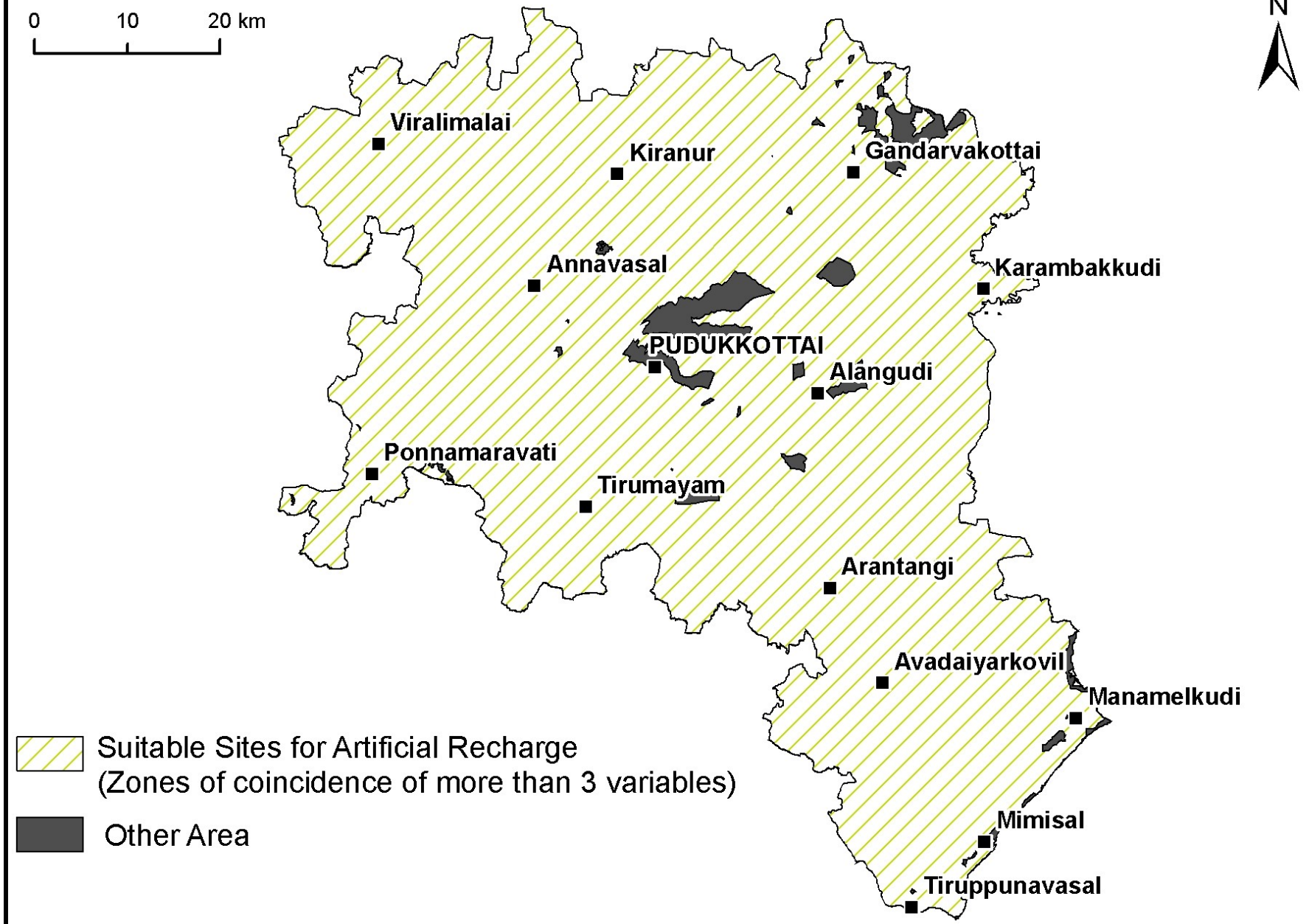


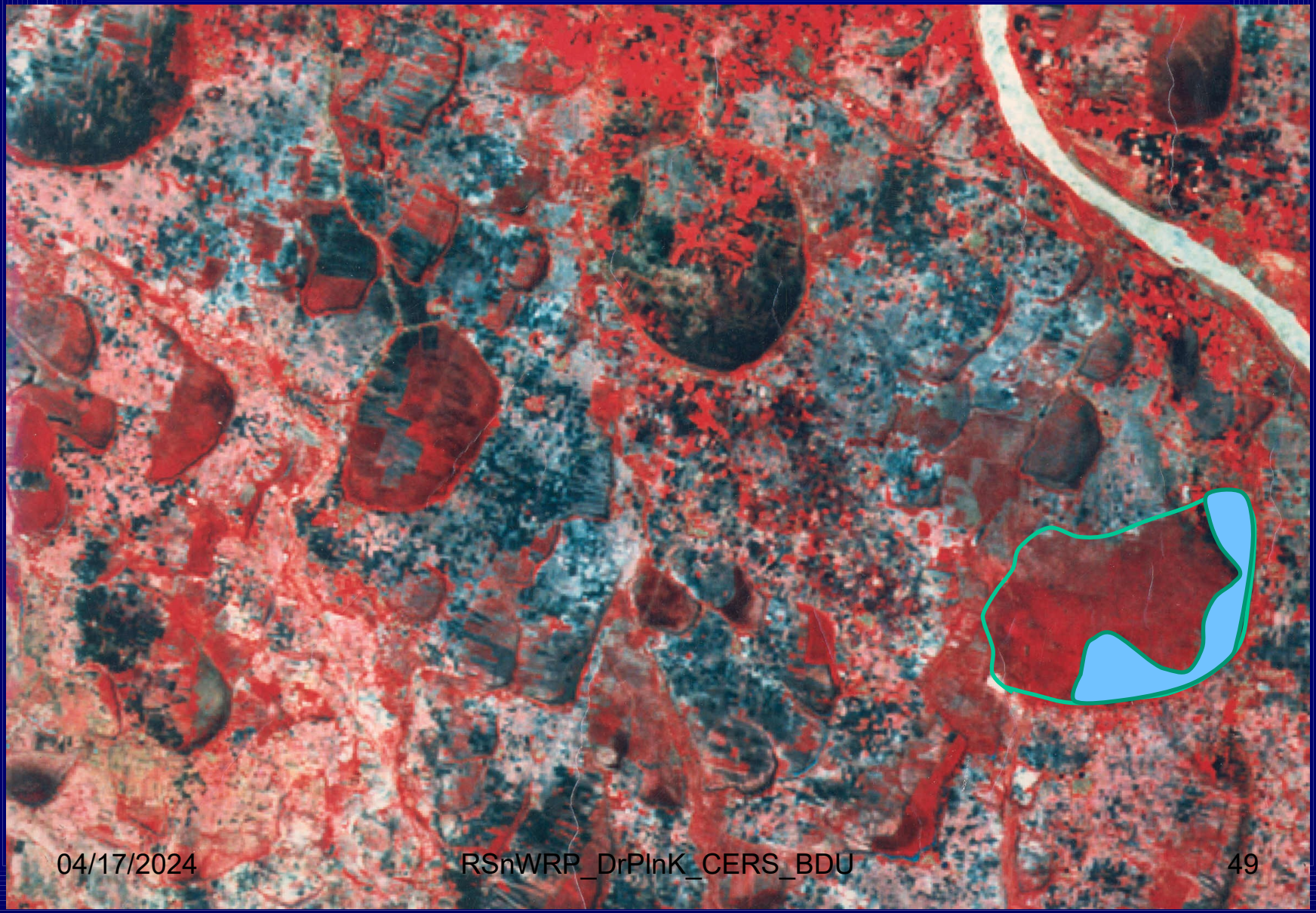
Fig.6.43 Suitable Sites for Artificial Recharge

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

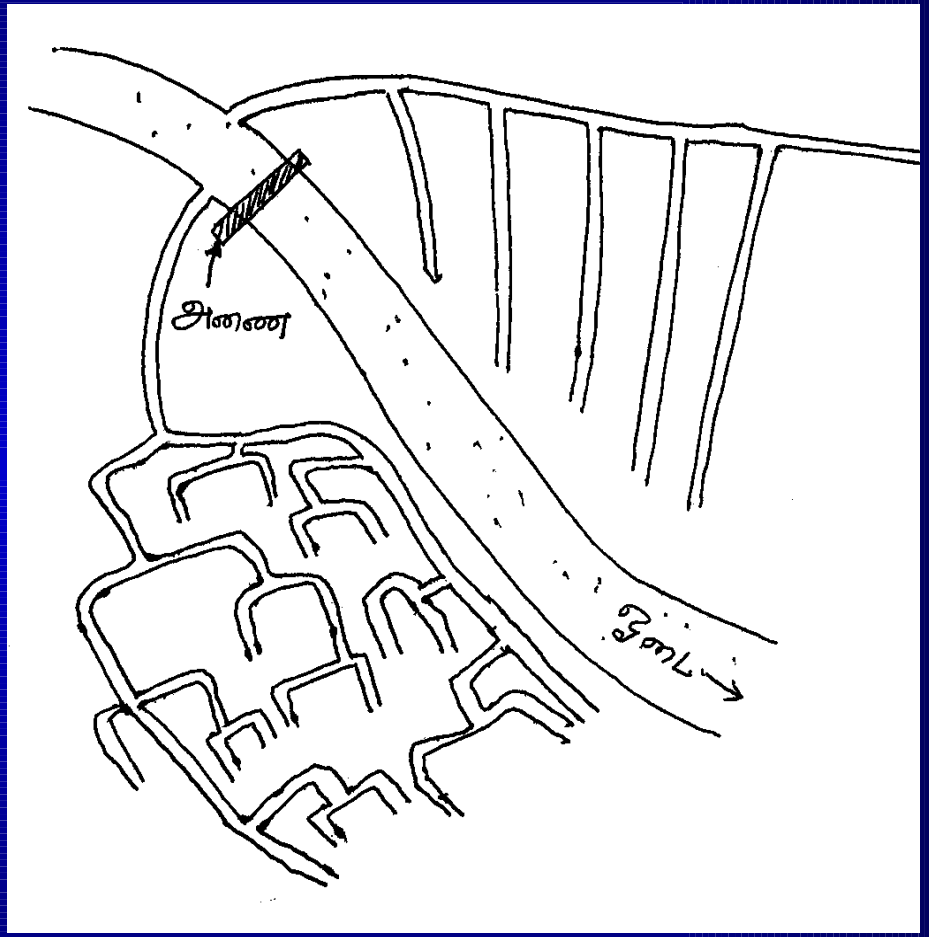


Flooding & Furrowing

Suitable area:

- Null slope
- Pervious soil at the surface

In the areas of high recharge zone

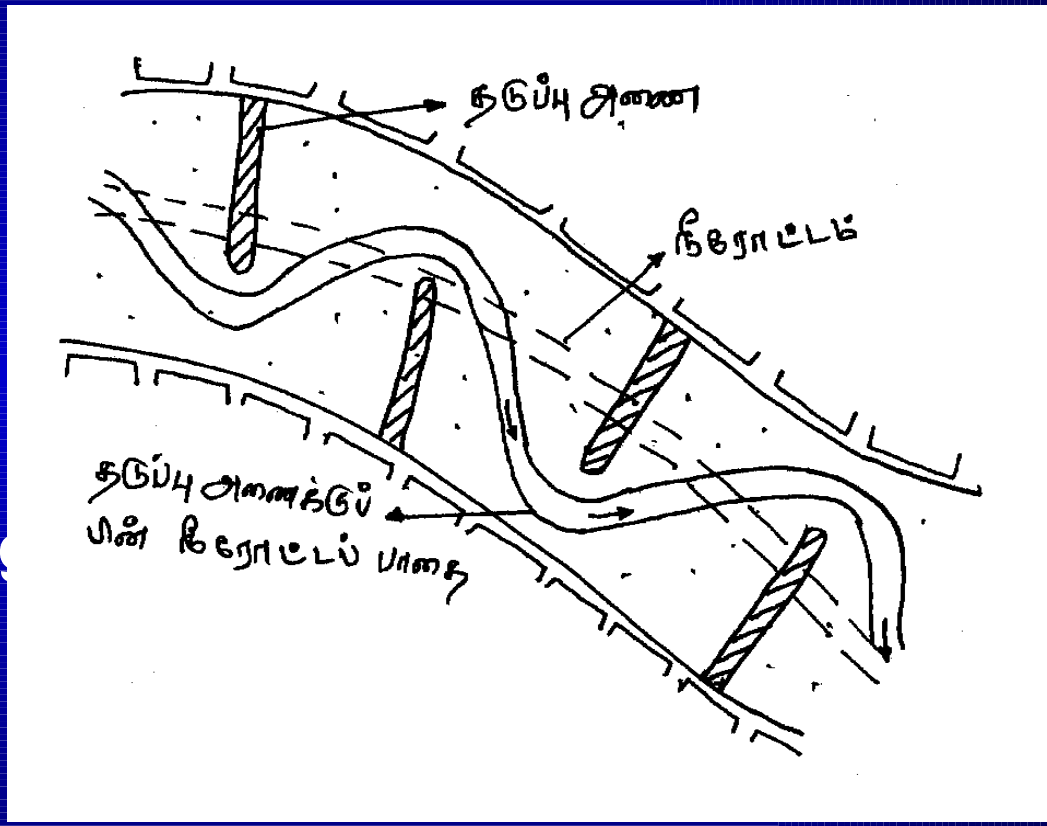


Flooding and Furrowing

EN-ECHELON DAMS:

Suitable areas:

- Straight drainag
- Wide span

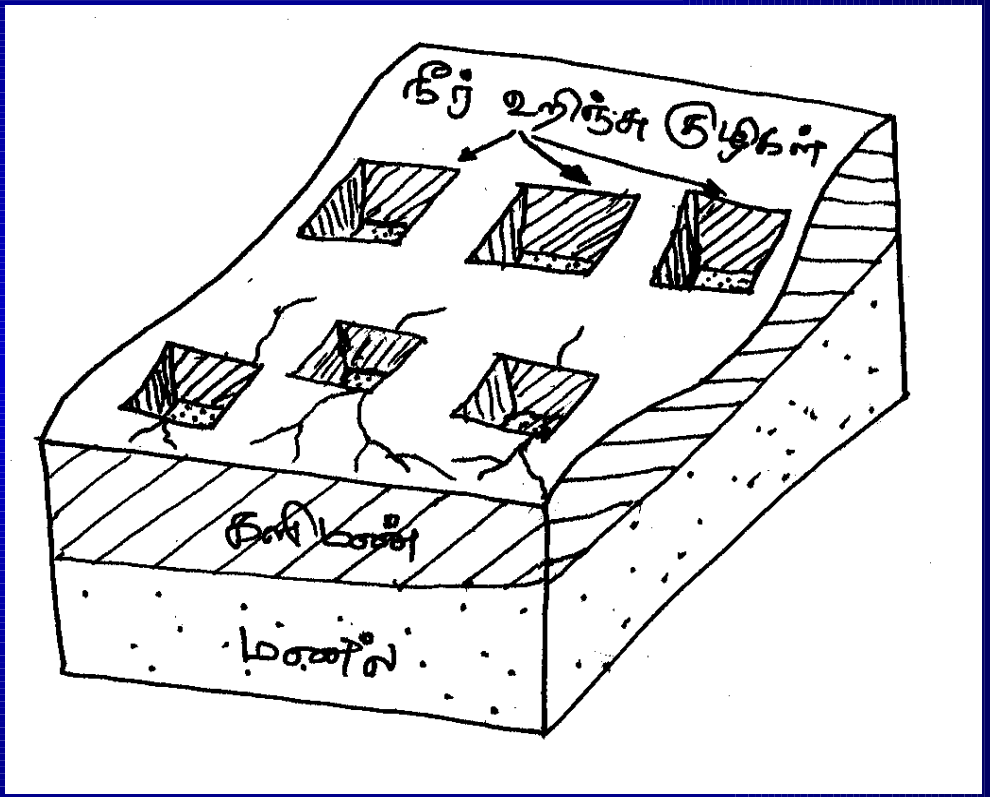


In the areas of high recharge zone

RECHARGE PITTING

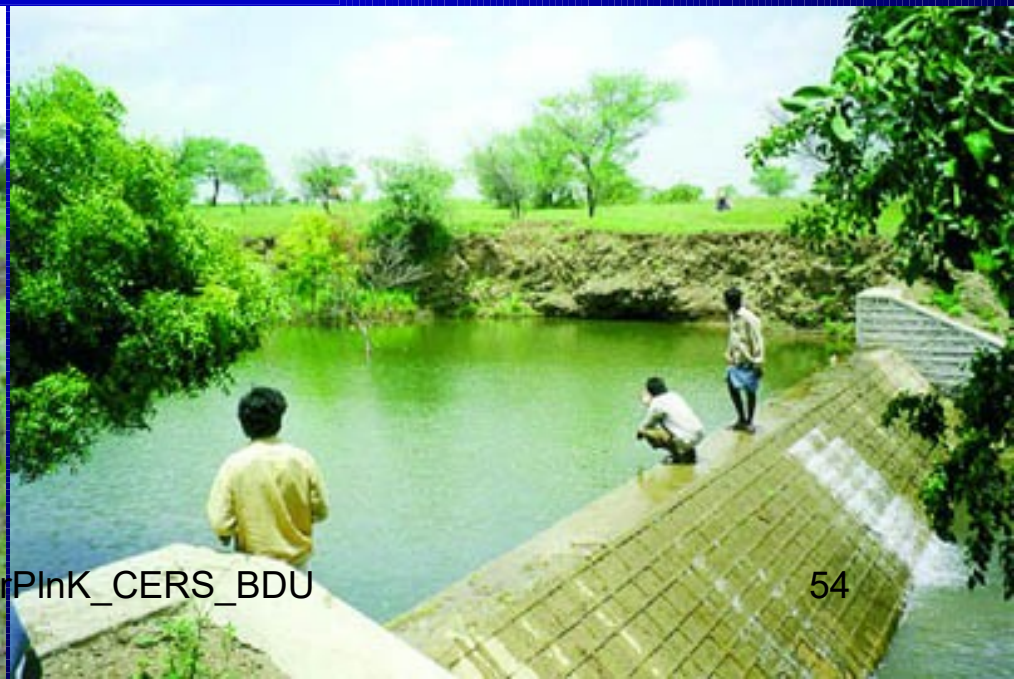
In the areas where,

- 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:

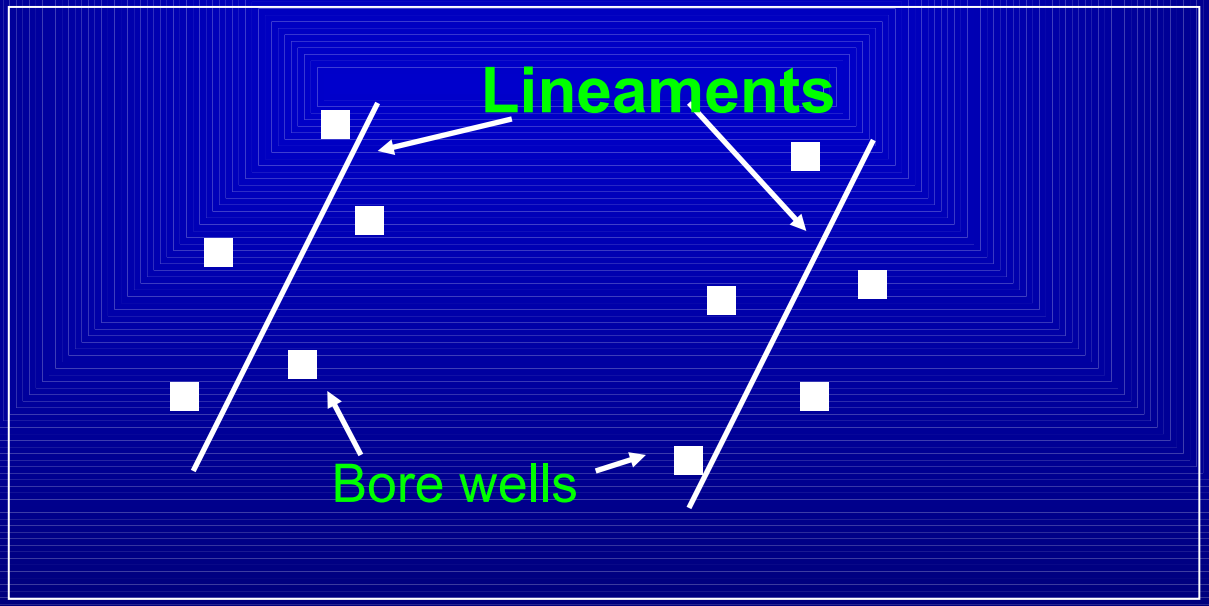
- **Water level minima Zone**
- **Drainage density maxima Zone**

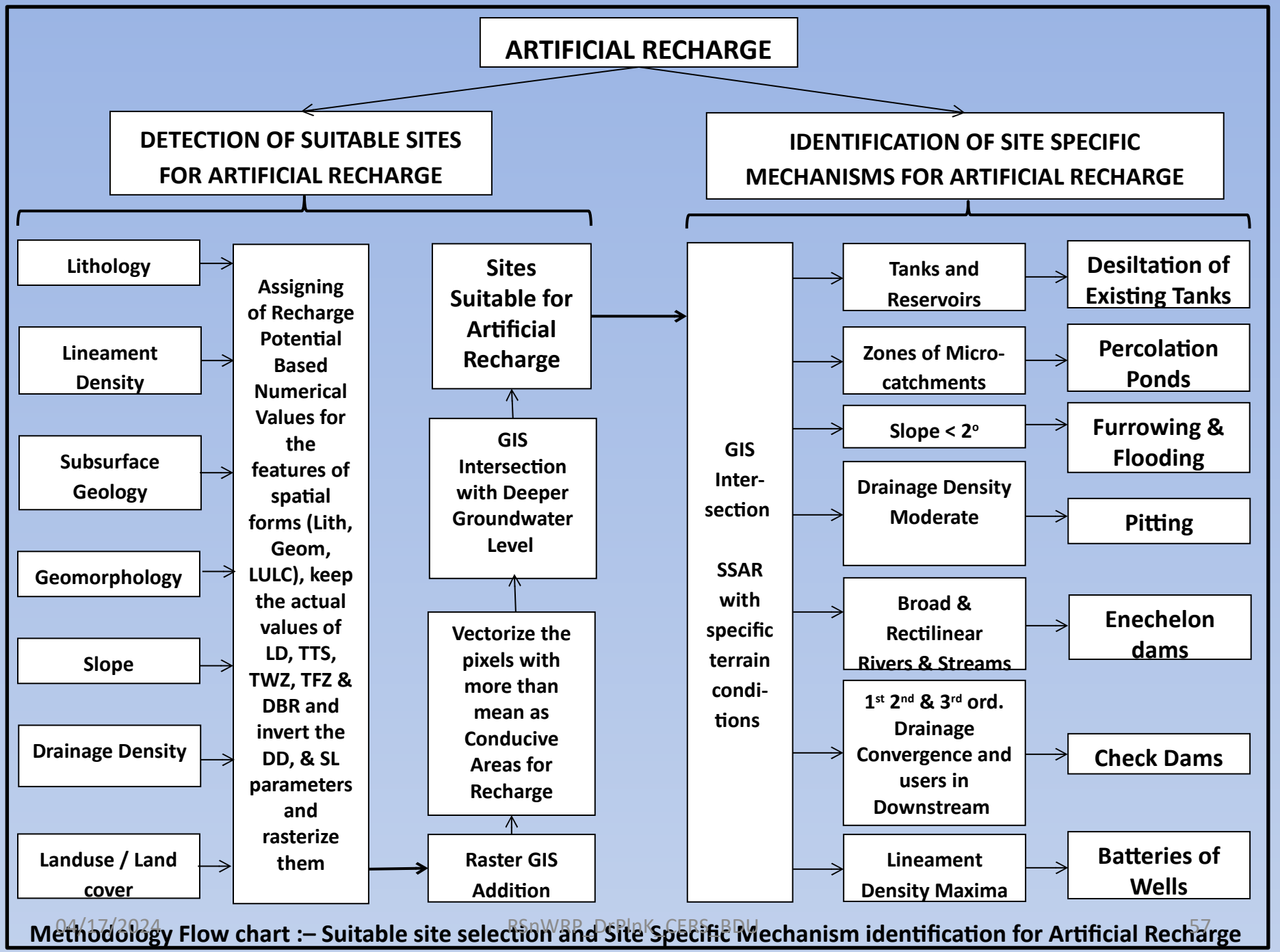
In these zones pump the water through bore wells.

BATTERIES OF WELLS

In the areas of lineament density maxima zones

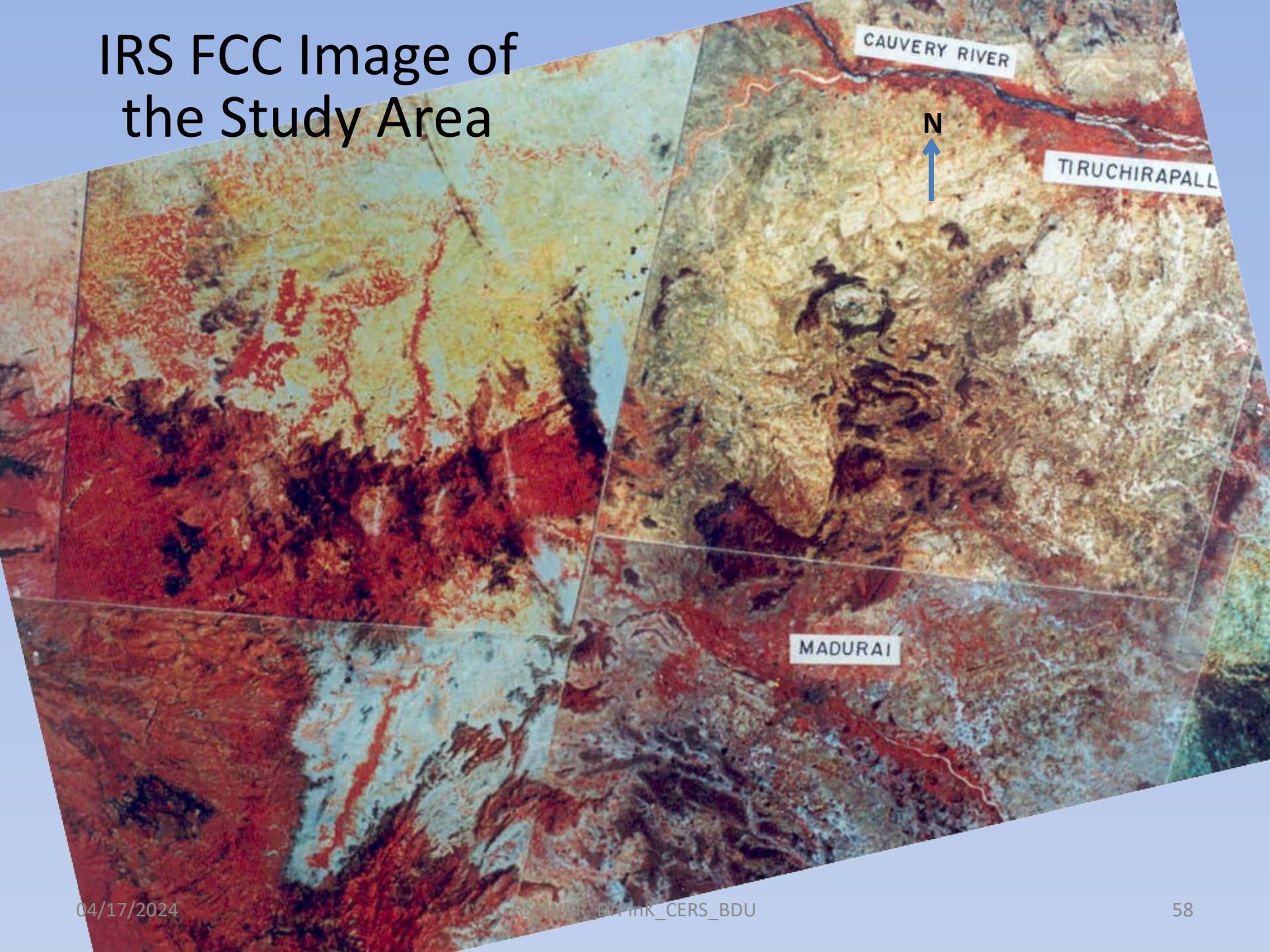
Bore wells on both sides of the fracture density maxima axes / major fractures





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

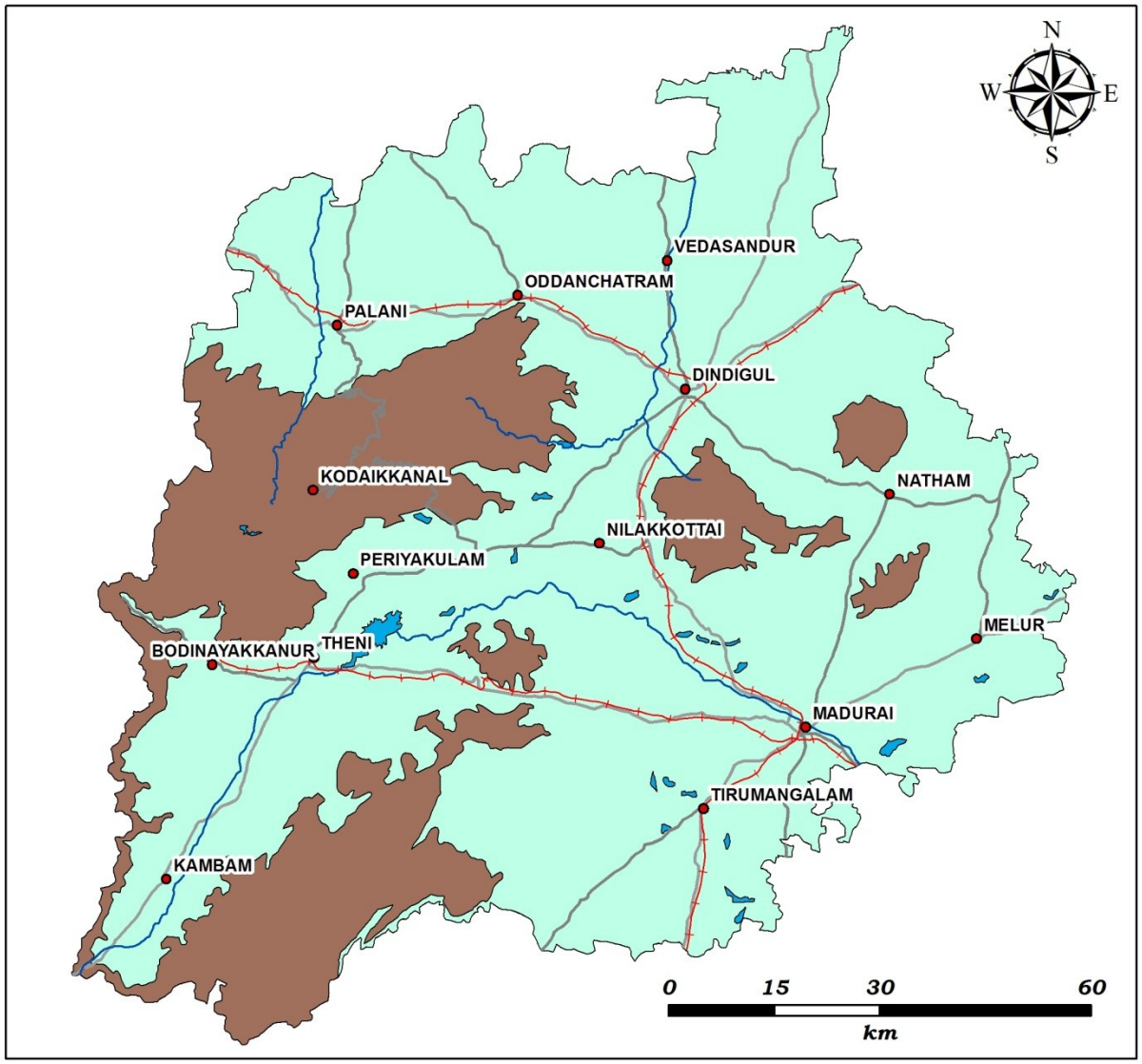
IRS FCC Image of the Study Area



Geosystem maps prepared for this study

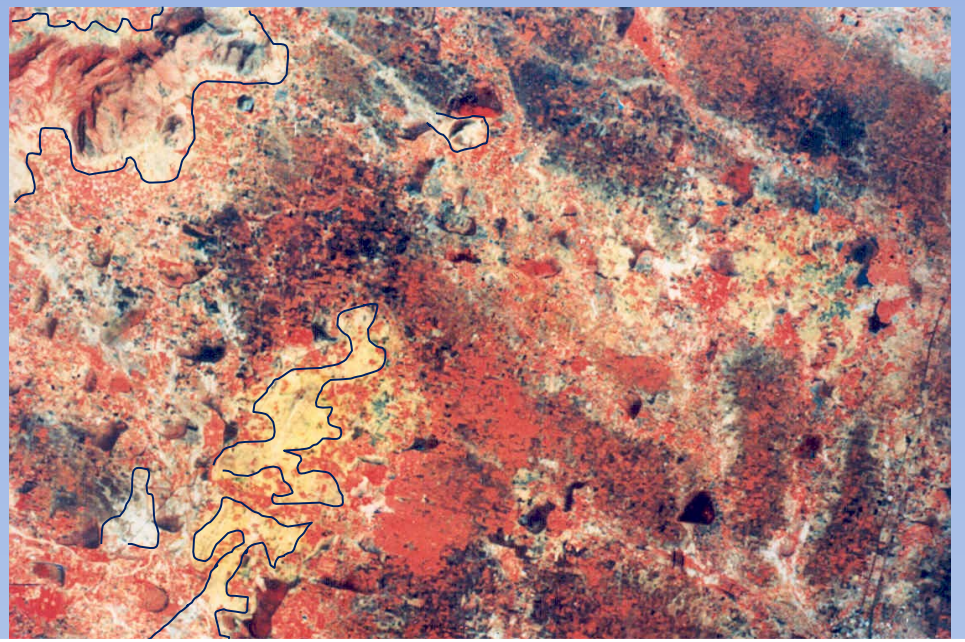
- Base map
- Lithology
- Structure – Fault, Lineament and Fracture systems & Lineament density
- Geomorphology
- Subsurface Lithology – Depth to Bed Rock
- Slope
- Micro-catchments (1st order streams emanating from plains) and other Drainages
- Drainage Density
- Groundwater level

BASE MAP
Parts of Western Ghats, Tamil Nadu

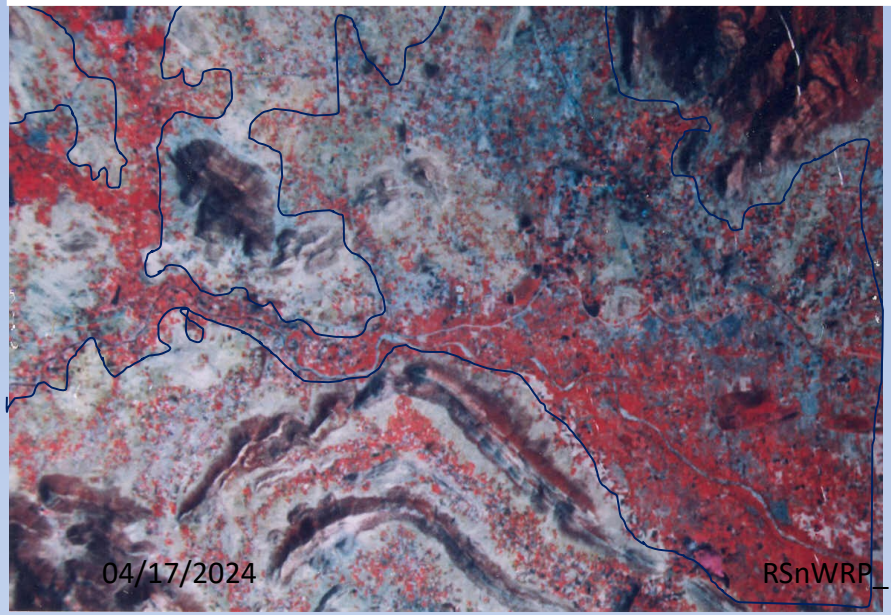


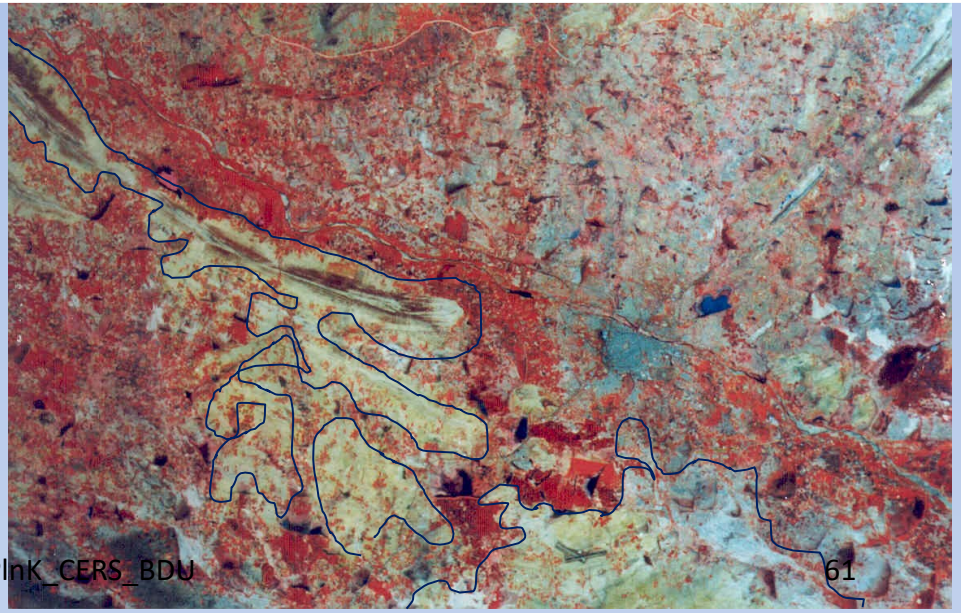
Legend

- Major Settlements
- Rail Network
- Major Road Network
- River
- Reservoirs / Major Tanks
- Major Hills
- Plain

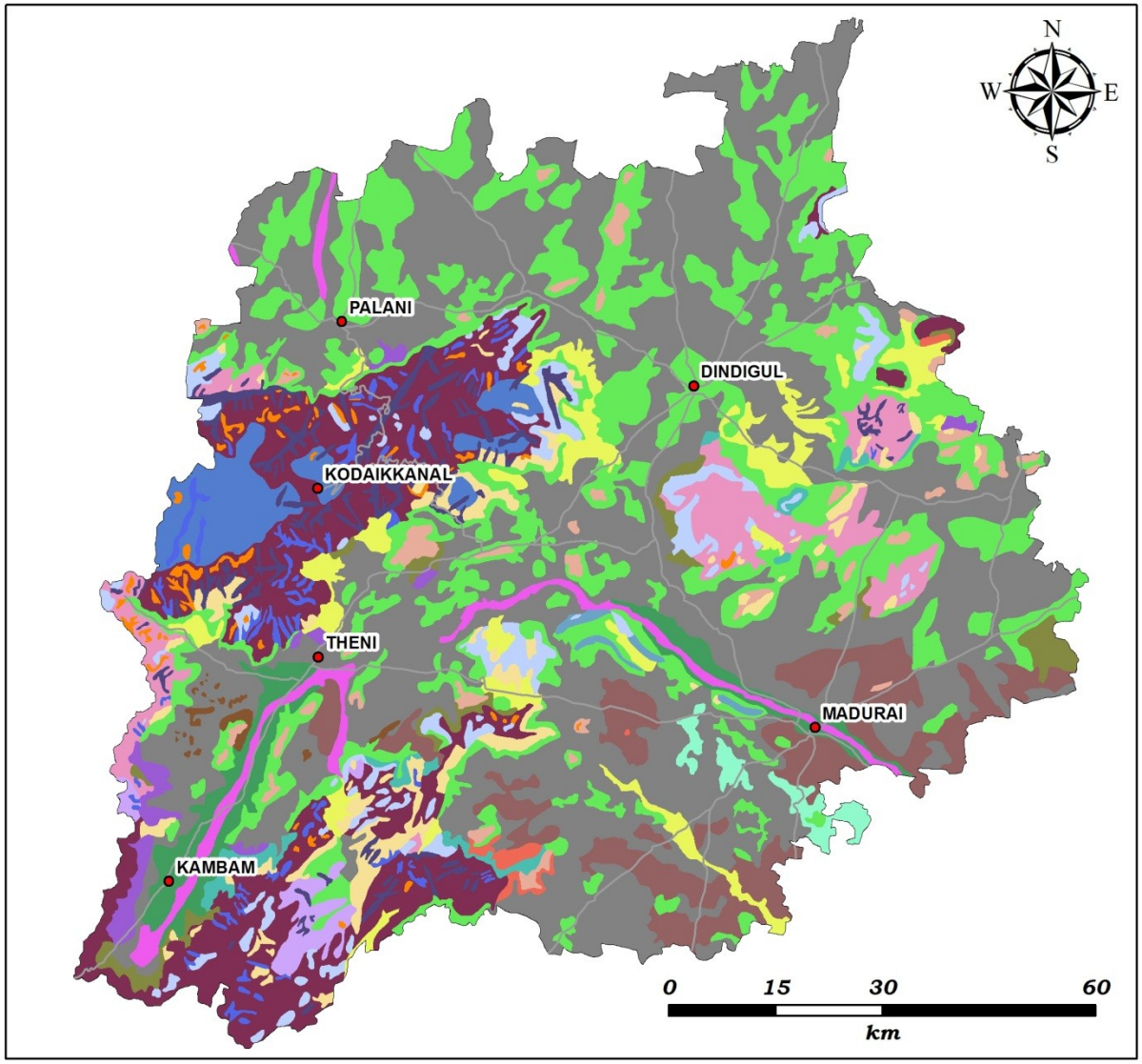


IRS satellite FCC Images showing favourable Lithological, Structural, Geomorphological and Landuse/land cover features of the study area





GEOMORPHOLOGY



Legend

- Settlement
- Road Network
- Denudational Hill
- Residual Hill
- Structural Hill
- Inselberg
- Dissected Erosional Plateau
- Linear Ridge
- Rock Fall Zone
- Active Convex and Concave Slopes
- Barren Valley
- Valley Fill
- Fractured Valley
- Gully
- Bajada
- Piedmont zone
- Pediment - Rocky
- Debris wash Plain
- Burried Pediment - Shalow
- Burried Pediment - Deep
- Colluvial fill
- Upland
- Floodplain - Older
- Floodplain - Younger
- Sand Dune

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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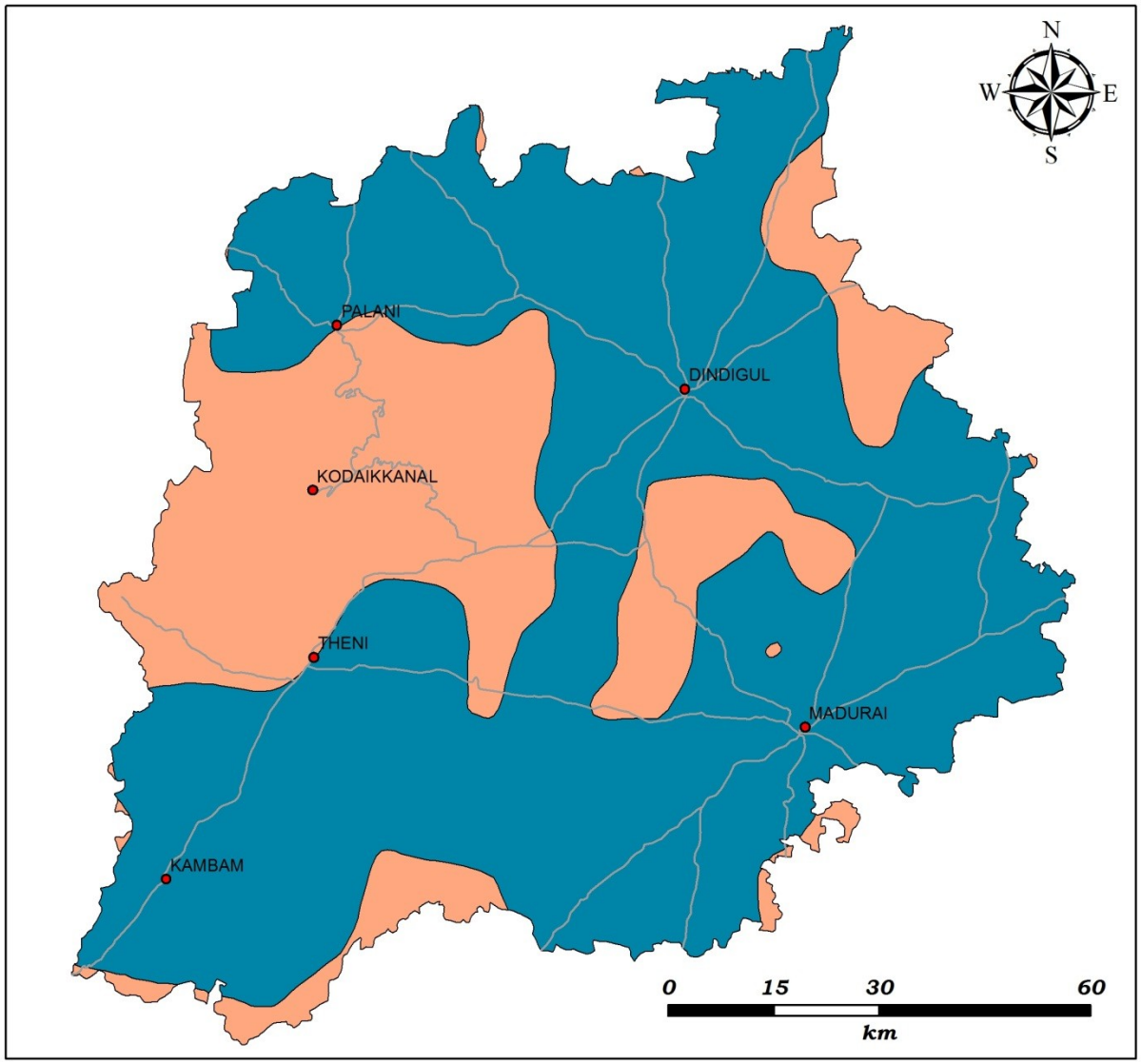
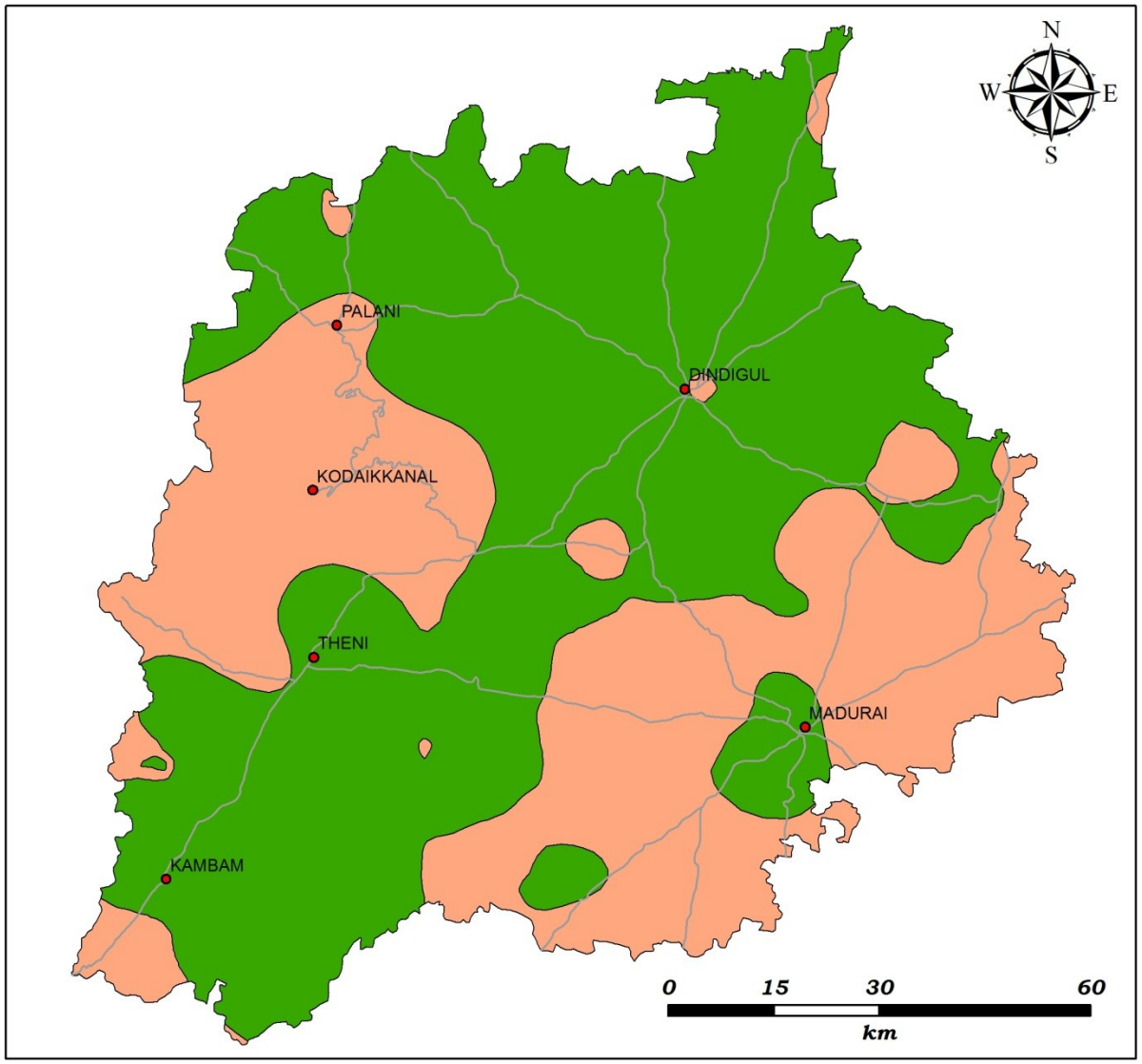
CONDUCIVE AREAS FOR RECHARGE



Legend

- Settlement
- Road Network
- Conducive Areas for Recharge
- Other Area

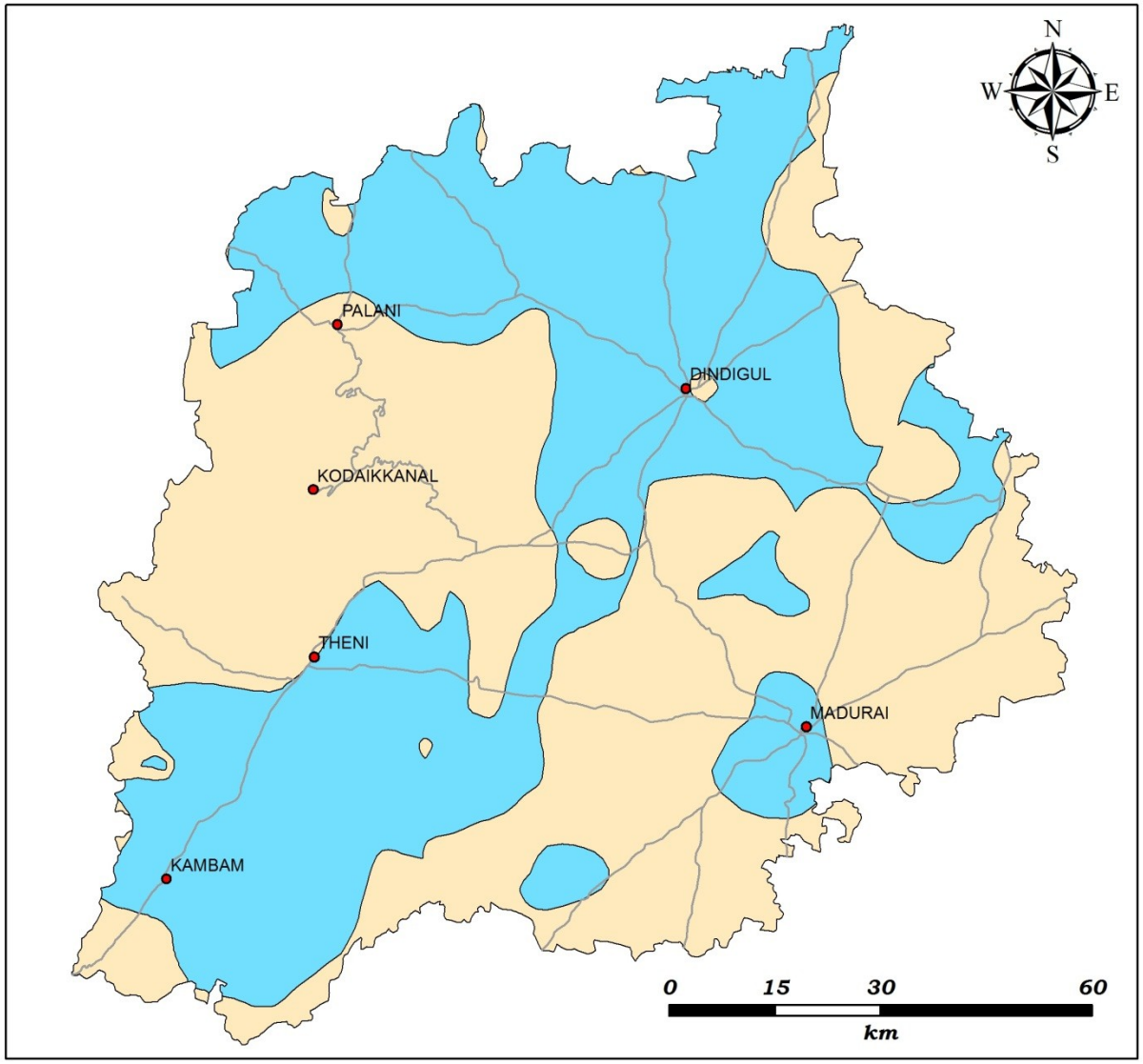
WATER LEVEL MAXIMA



Legend

- Settlement
- Road Network
- Areas of Water Level Maxima
- Other Area

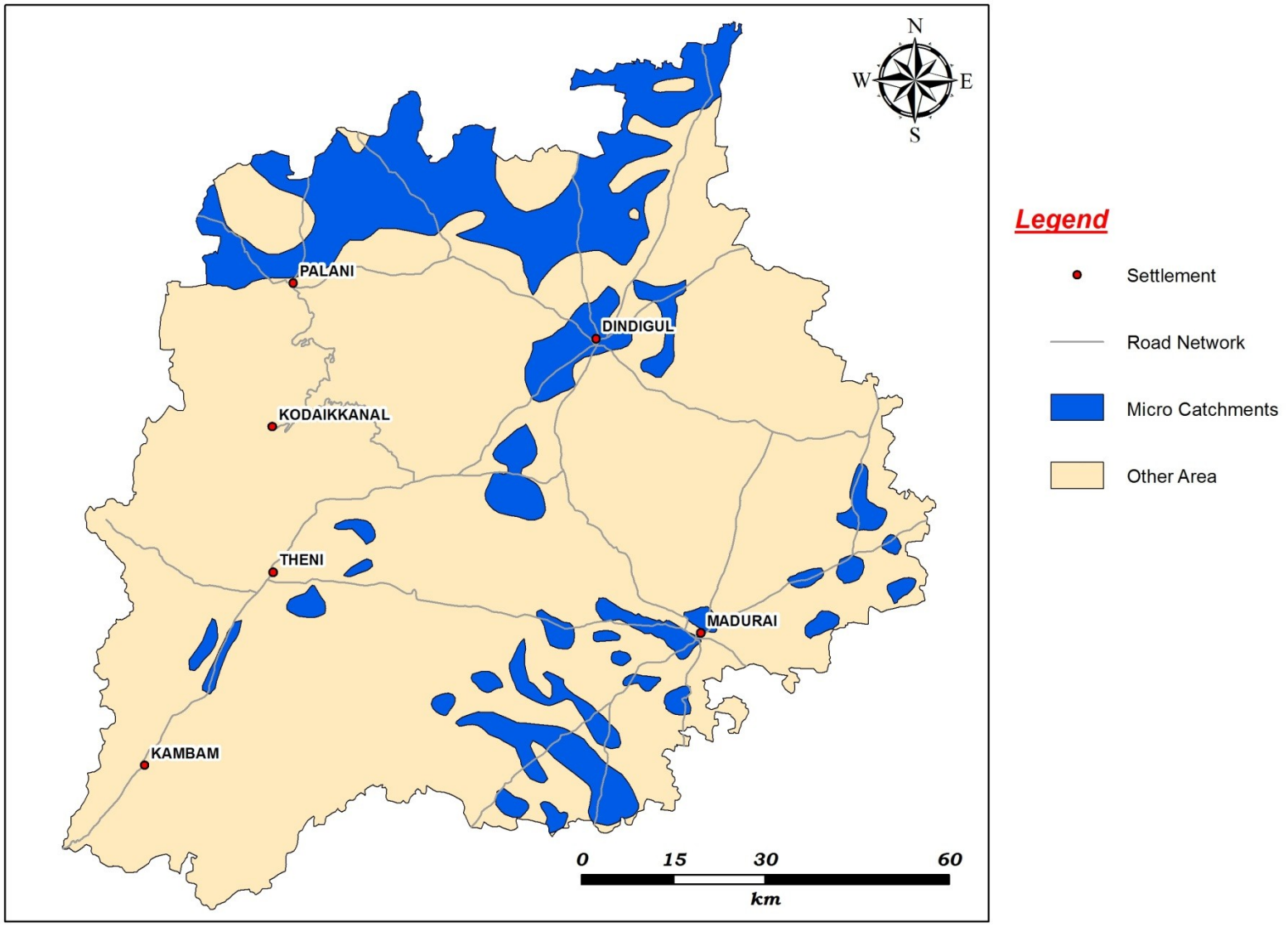
SUITABLE SITES FOR ARTIFICIAL RECHARGE



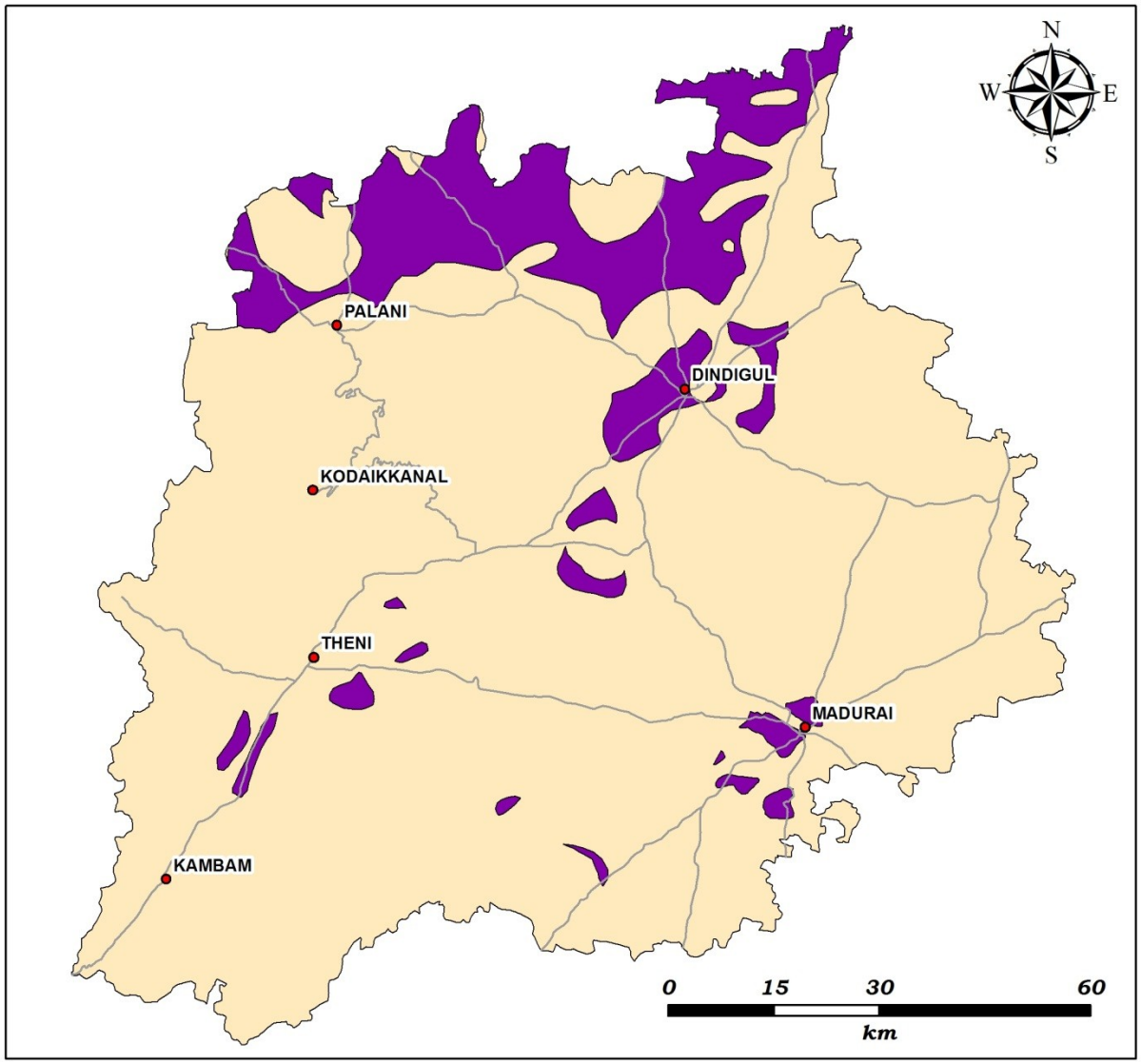
Legend

- Settlement
- Road Network
- Suitable site for Artificial Recharge
- Other Area

ZONES OF MICRO CATCHMENTS



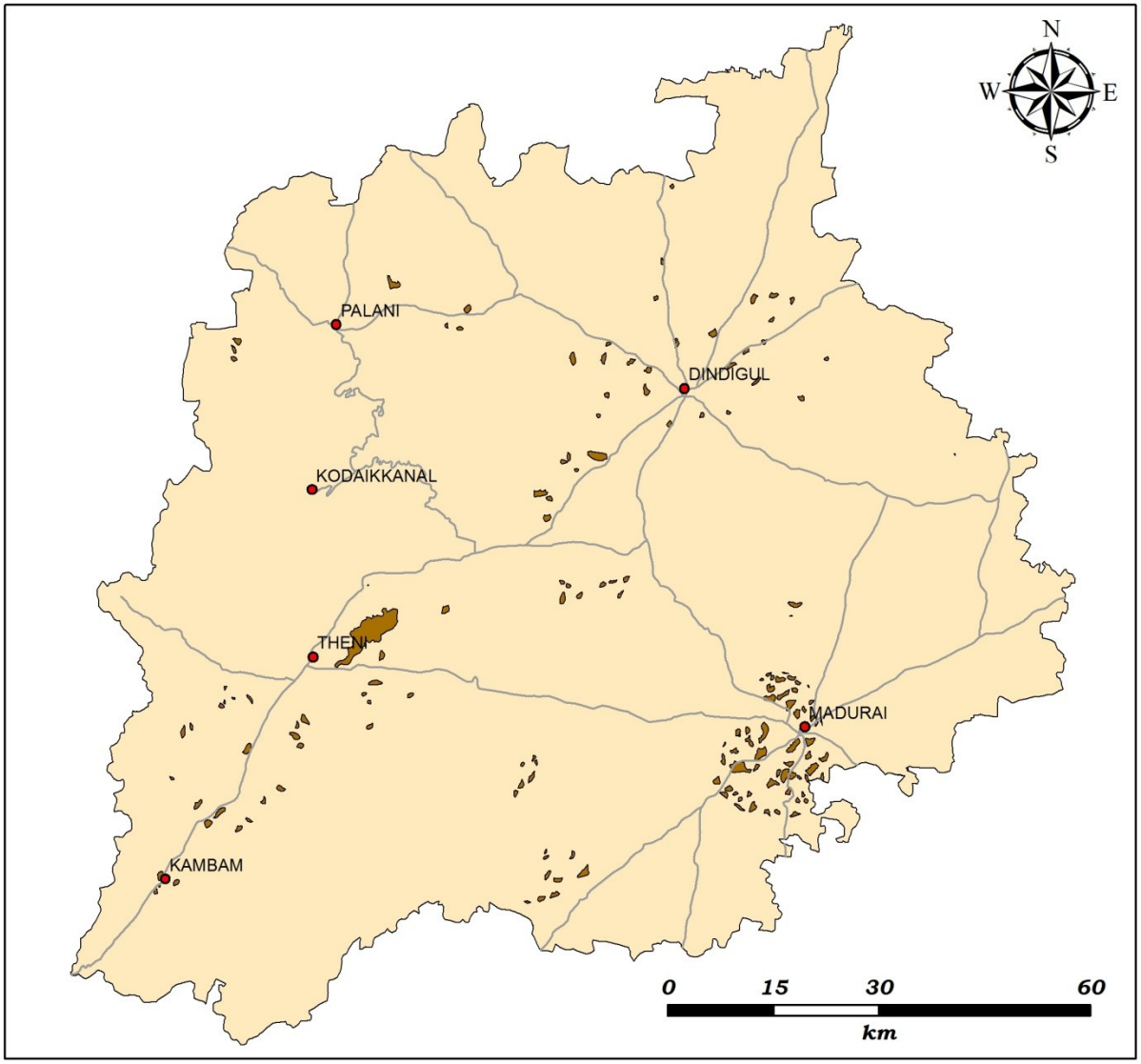
SUITABLE SITES FOR PERCOLATION PONDS



Legend

- Settlement
- Road Network
- Site Suitable for Percolation Pond
- Other Area

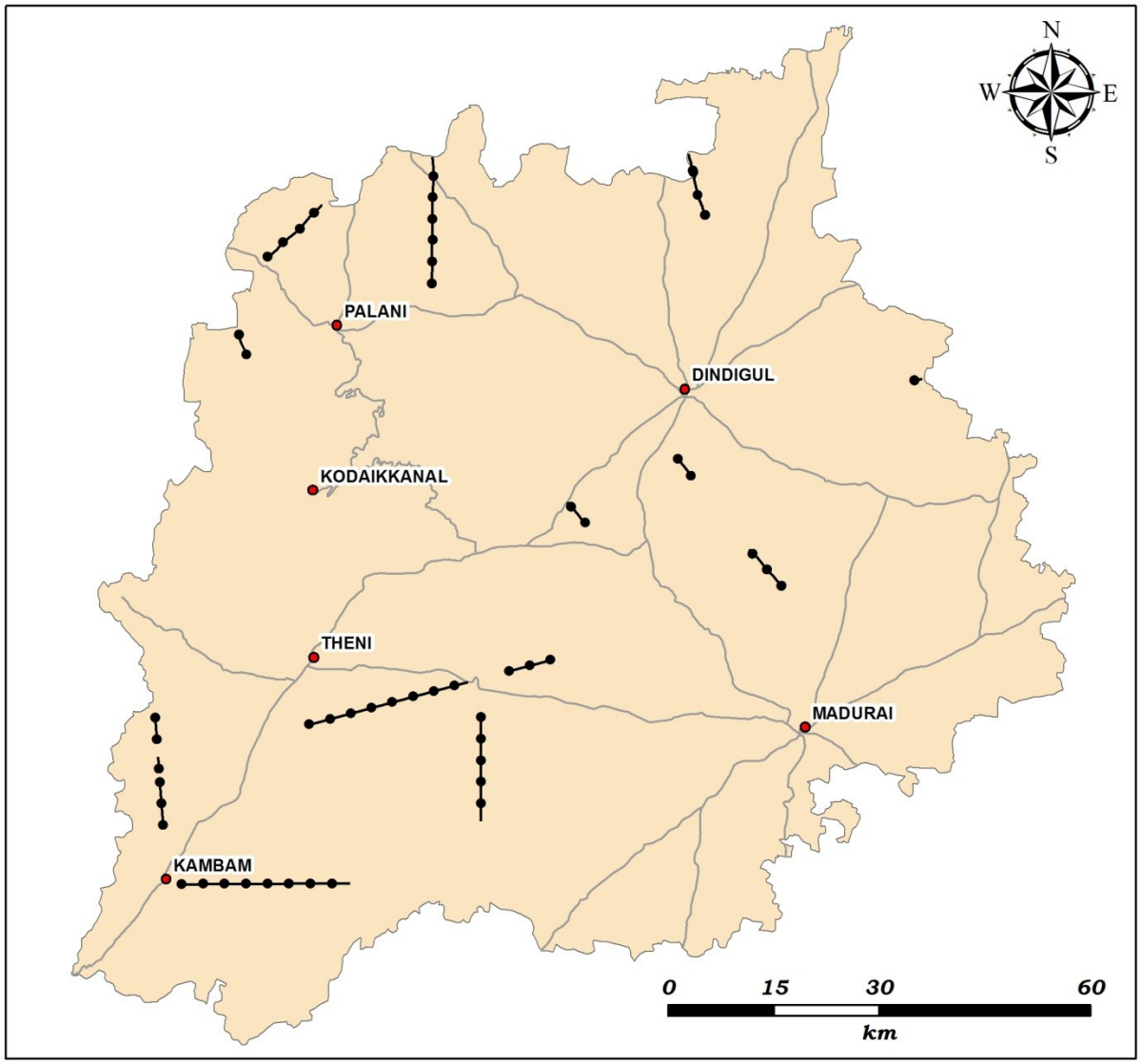
SITES SUITABLE FOR DESILTATION OF EXISTING TANKS



Legend

- Settlement
- Road Network
- Tanks / Reservoirs suitable for Desiltation
- Other Area

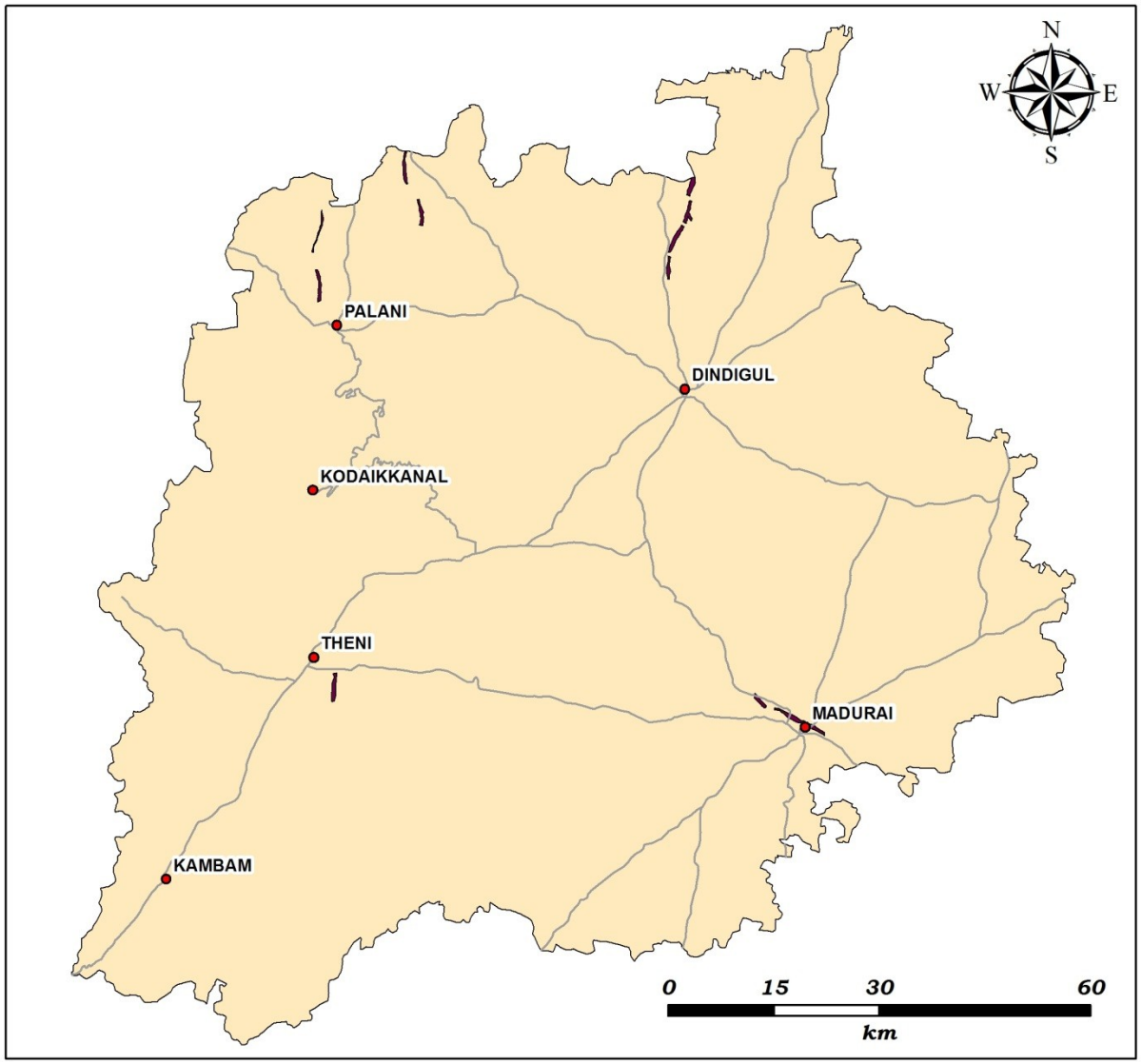
SITE SUITABLE FOR BATTERIES OF WELLS



Legend

- Settlement
- Road Network
- Site Suitable for Batteries of Wells
- Other Area

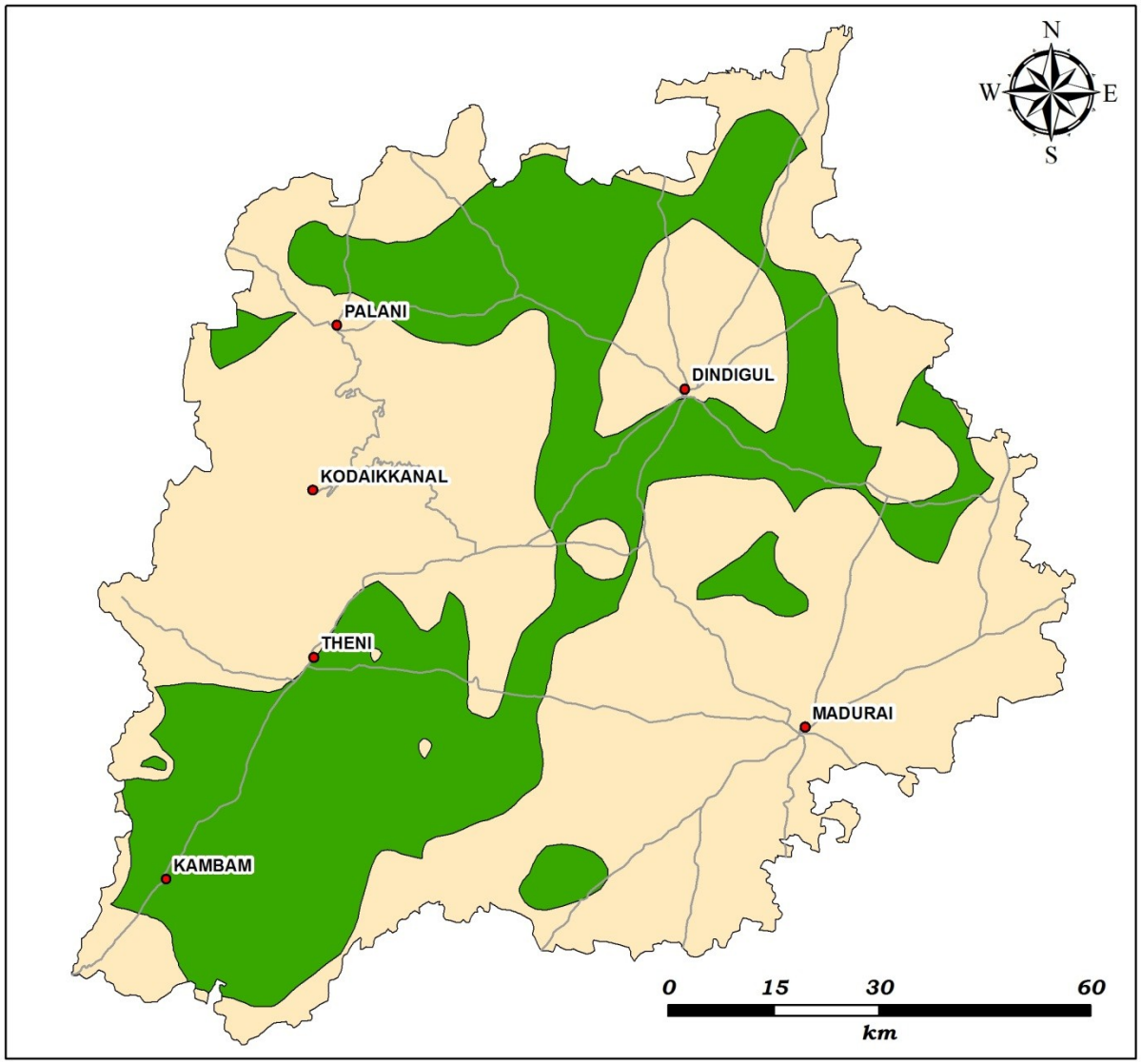
SITE SUITABLE FOR CONSTRUCTION OF ENECHELON DAMS



Legend

- Settlement
- Road Network
- Site Suitable for Construction of Enechelon Dams
- Other Area

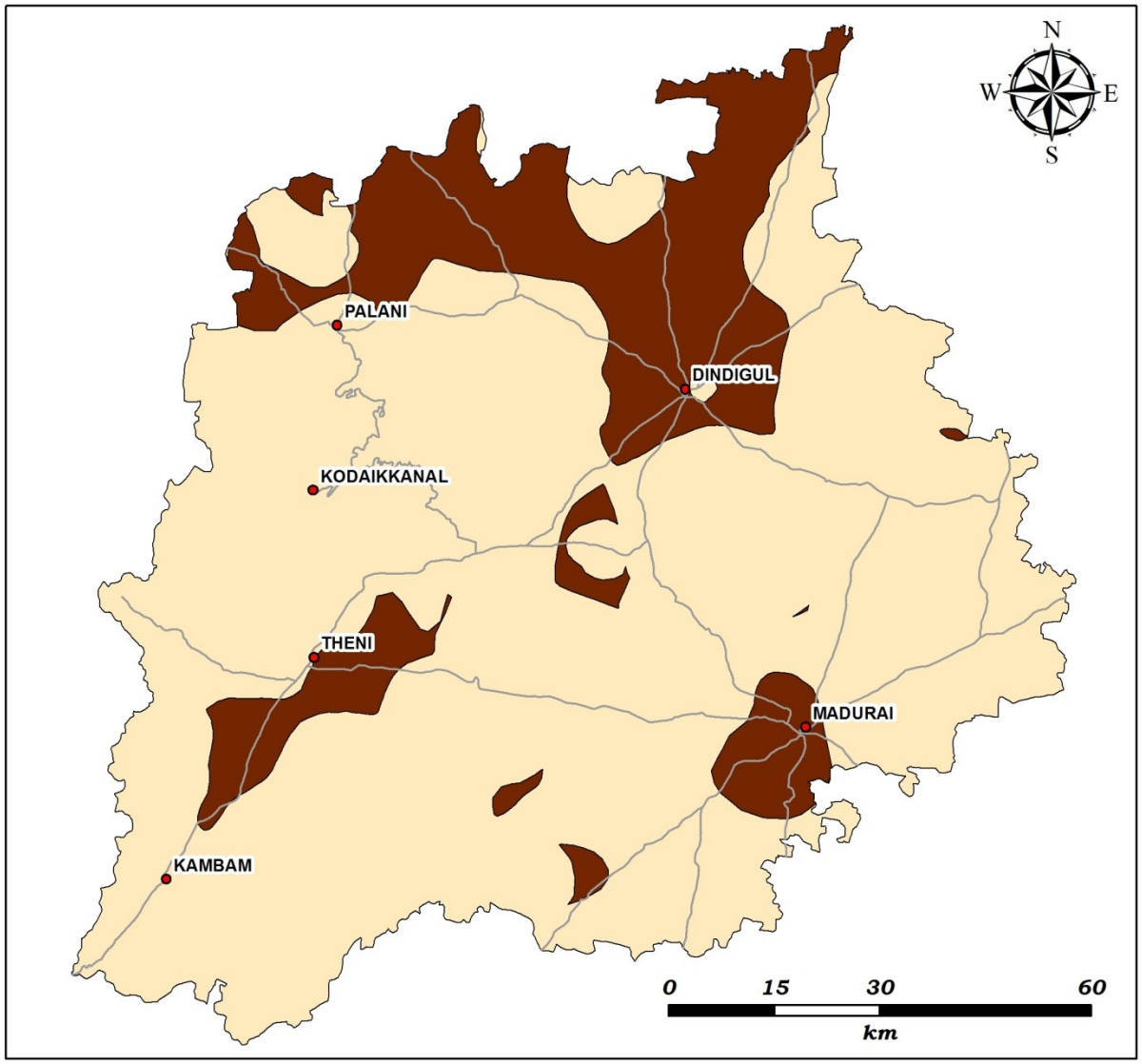
SUITABLE SITES FOR PITTING



Legend

- Settlement
- Road Network
- Site Suitable for Pitting
- Other Area

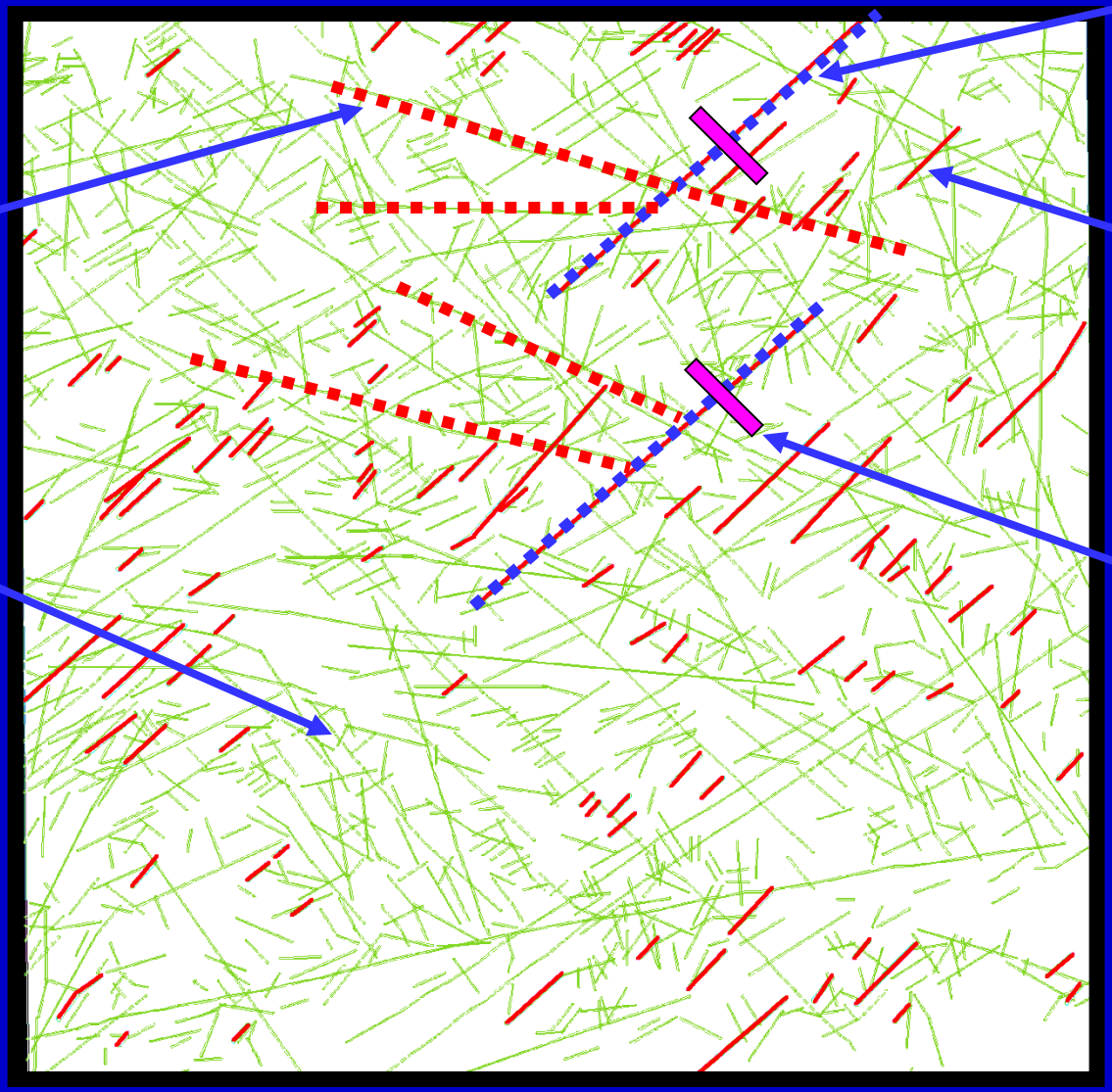
SUITABLE SITES FOR FURROWING & FLOODING



Legend

- Settlement
- Road Network
- Site Suitable for Furrowing and Flooding
- Other Area

RECHARGE THROUGH FRACTURES



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STUDY –15

Other studies on Water Resources Management

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STUDY –15

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.

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STUDY –16

Groundwater flow modeling in GIS

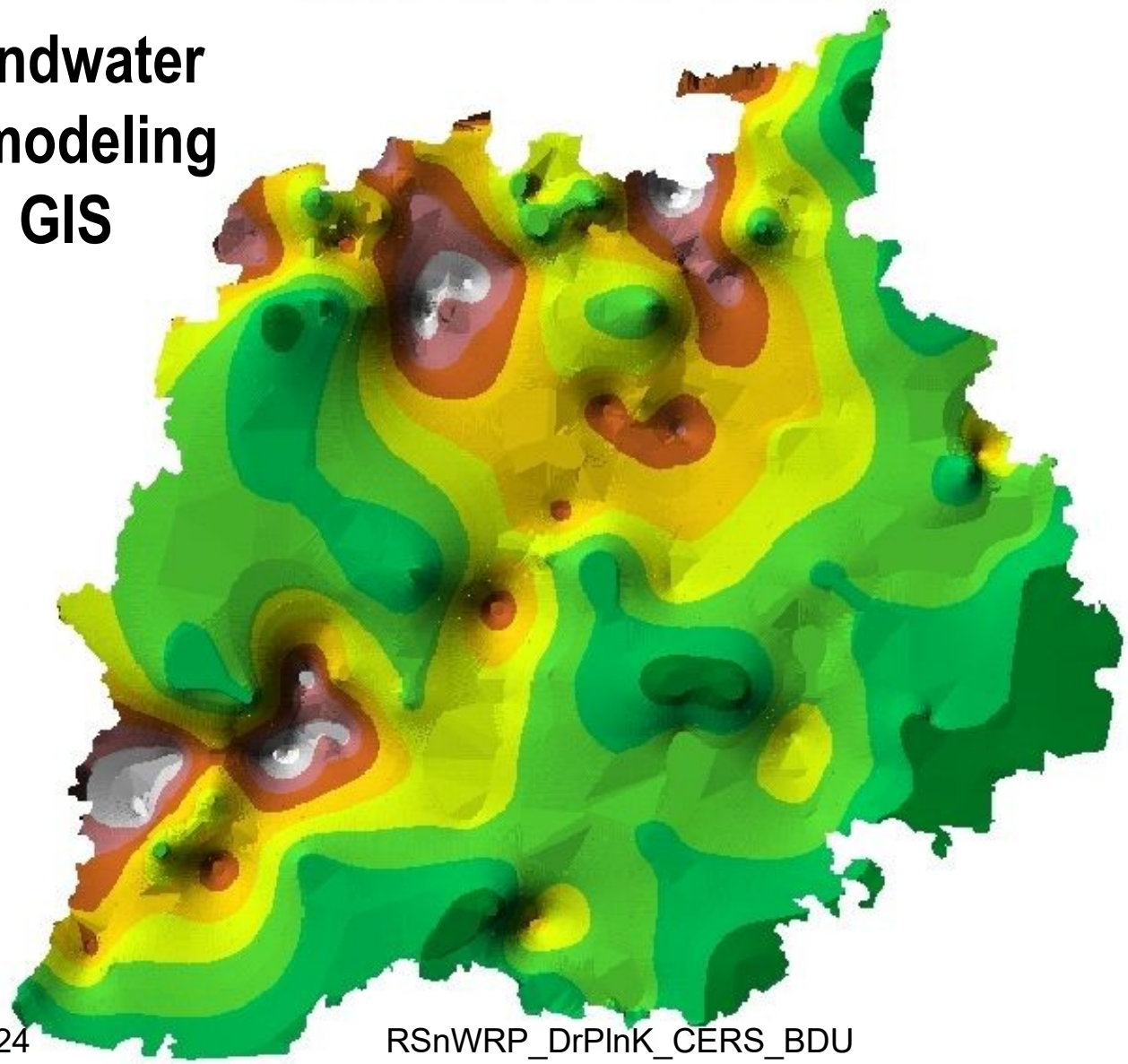

FIG. 1.8

DEM - WATER LEVEL (1985) OBLIQUE VIEW

MADURAI, DINDIGUL AND TENI DISTRICTS, TAMIL NADU

(PARTS OF TOPO SHEETS 58F, 58G, 58J & 58K)

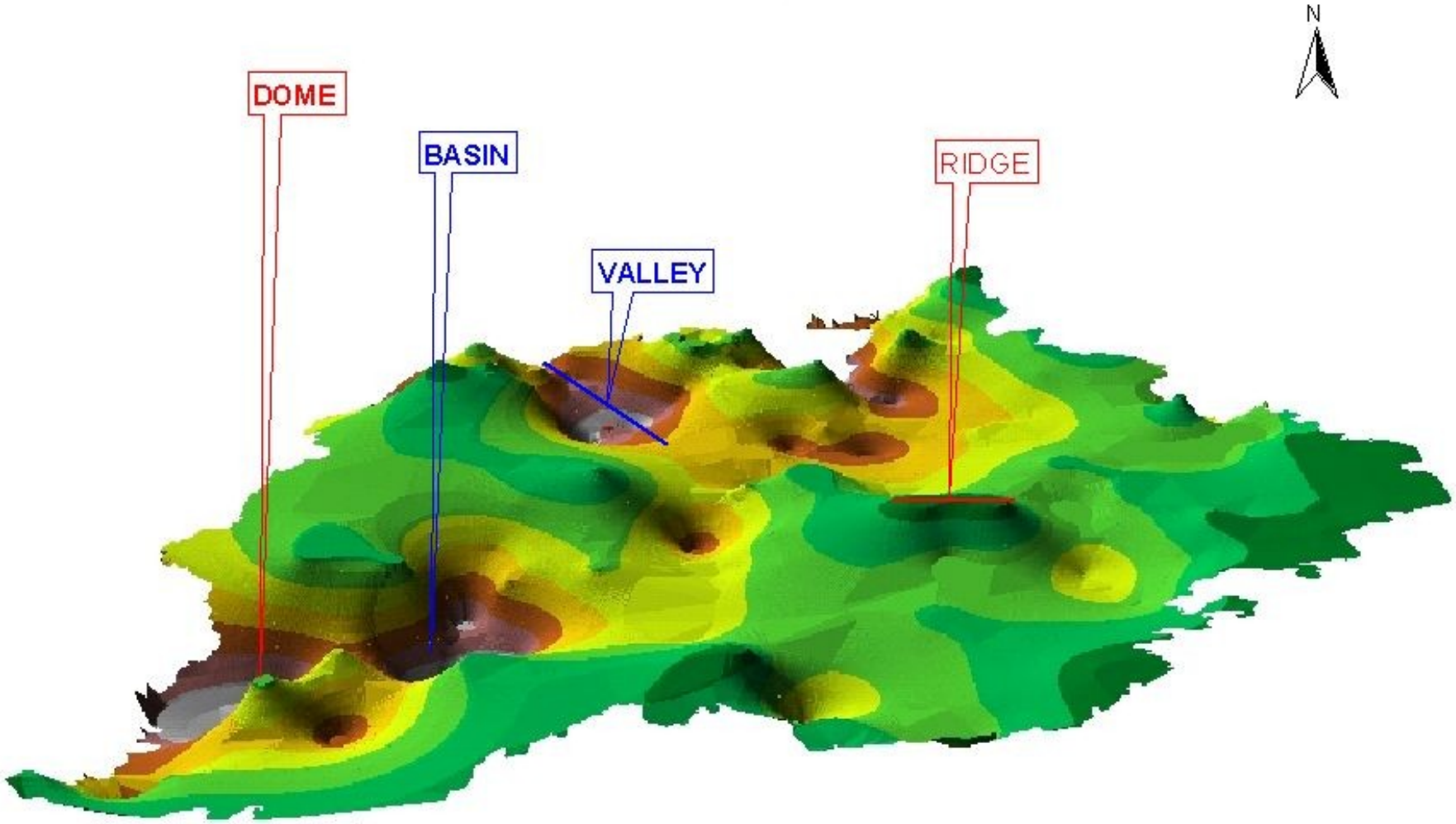

FIG. 1.9

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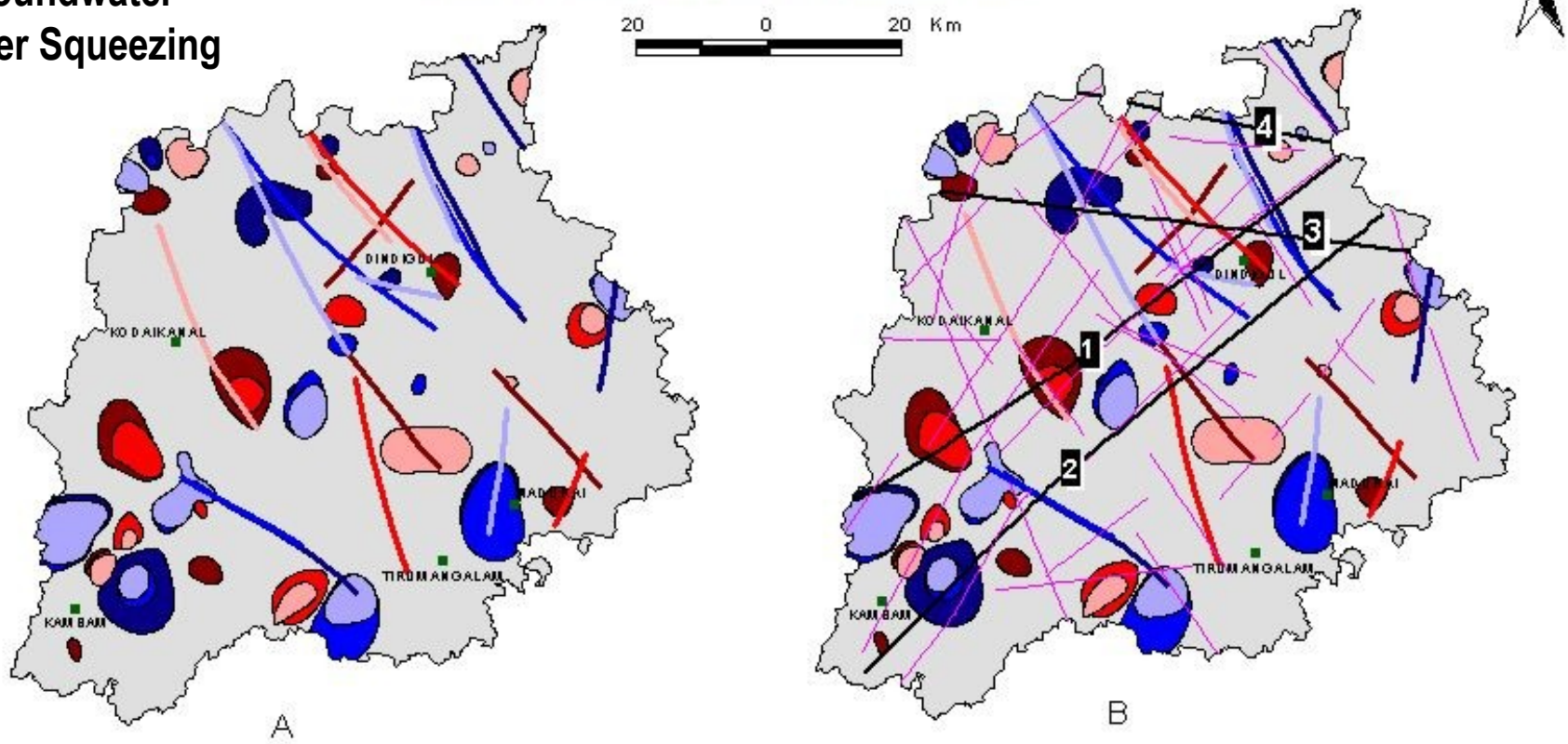
GIS IMAGE - WATER LEVEL VARIATIONS DURING (1985-90-95)

MADURAI, DINDIGUL AND TENI DISTRICTS, TAMIL NADU

(PARTS OF TOPO SHEETS 58F, 58G, 58J & 58K)

Groundwater Aquifer Squeezing



LEGEND

A - WATER LEVEL HIGHS AND LOWS

B - WATER LEVEL HIGHS AND LOWS AND LINEAMENTS

1. MARAKKANAM - THEVARAM FAULT
2. PONDICHERRY - KAMBAM FAULT
3. PONNANI - MANAMELGUDI FAULT
4. [illegible]RE - VADARANNIYAM FAULT

MAJOR LINEAMENTS

SETTLEMENTS

WATER LEVEL - 1985
- WATER LEVEL - BASIN
- WATER LEVEL - DOME
- WATER LEVEL - VALLEY
- WATER LEVEL - RIDGE

WATER LEVEL - 1990
- WATER LEVEL - BASIN
- WATER LEVEL - DOME
- WATER LEVEL - VALLEY
- WATER LEVEL - RIDGE

WATER LEVEL - 1995
- WATER LEVEL - BASIN
- WATER LEVEL - DOME
- WATER LEVEL - VALLEY
- WATER LEVEL - RIDGE

FIG. 2.4

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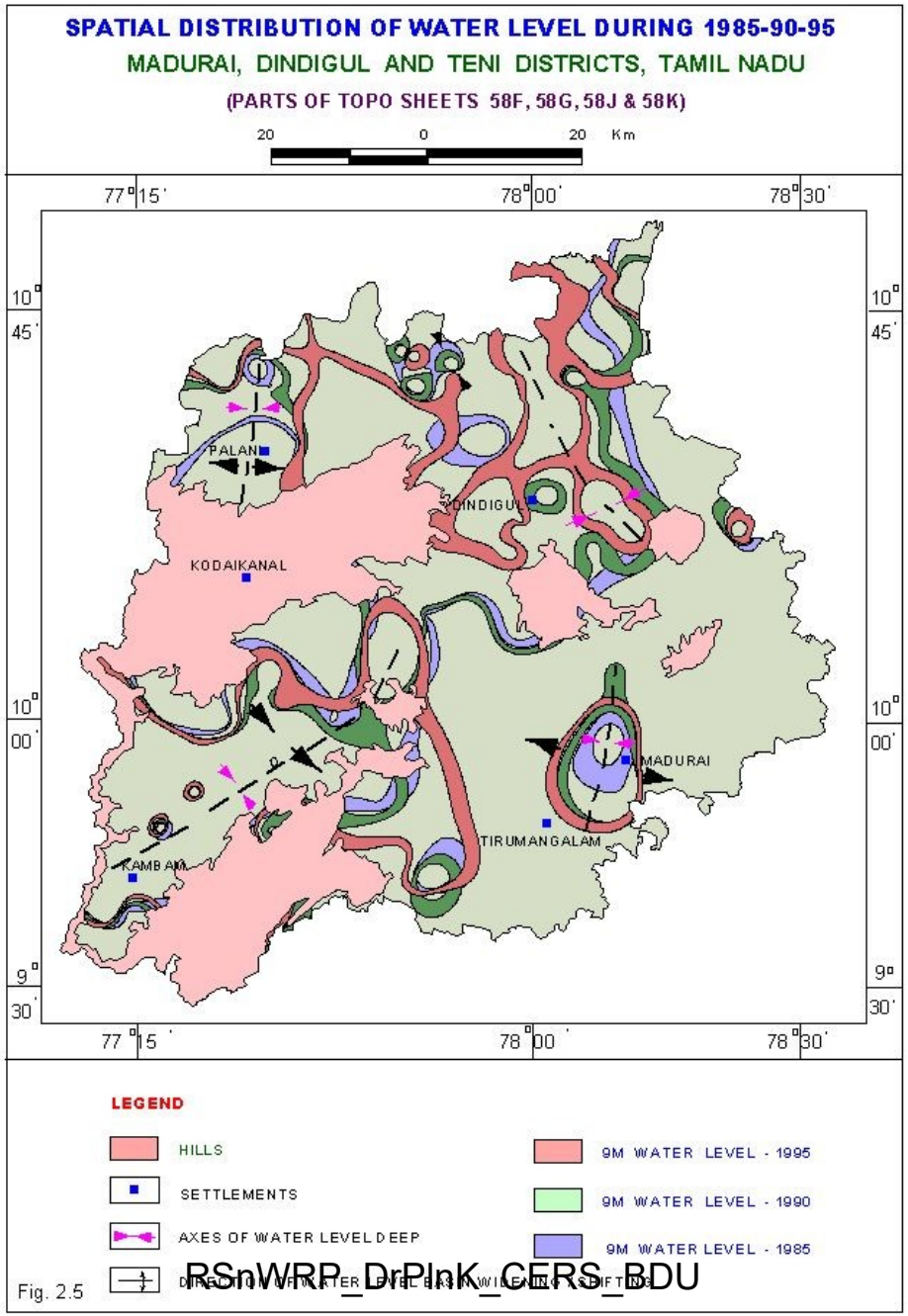
SPATIAL DISTRIBUTION OF WATER LEVEL DURING 1985-90-95
MADURAI, DINDIGUL AND TENI DISTRICTS, TAMIL NADU
(PARTS OF TOPO SHEETS 58F, 58G, 58J & 58K)
20 0 20 Km
77°15'
78°00'
78°30'
10°45'
10°00'
9°30'
PALANI
DINDIGUL
KODAIKANAL
MADURAI
TIRUMANGALAM
KAMBAM
LEGEND
HILLS
SETTLEMENTS
AXES OF WATER LEVEL DEEP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

Fig. 2.5

STUDY –17

WATER RESOURCES INFORMATION SYSTEM

SPATIAL DECISION SUPPORT SYSTEM - SDSS

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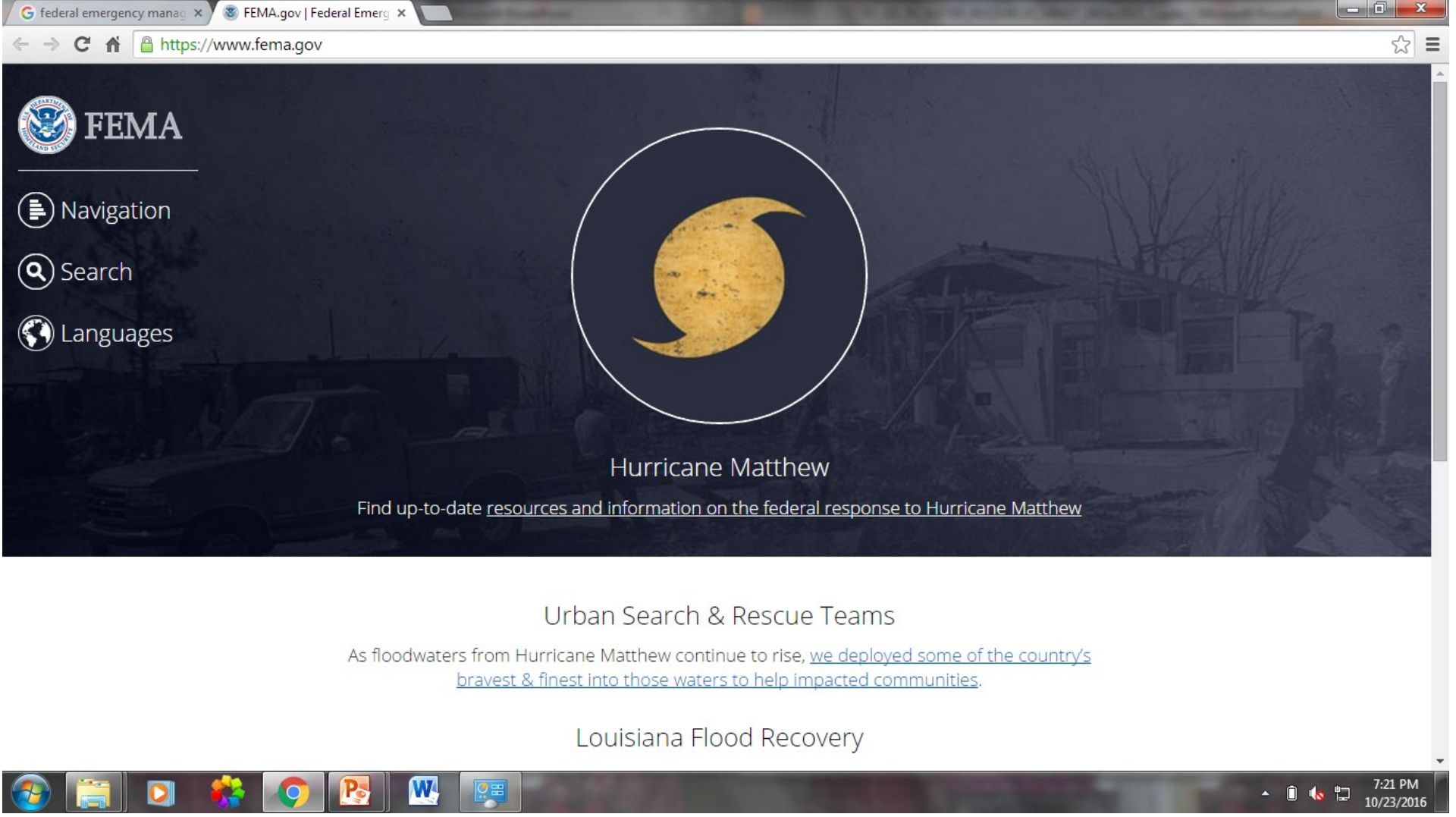
Credibility of WRIS

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
https://www.fema.gov
FEMA
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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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7:23 PM
10/23/2016

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CONCLUSIONS:

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

- **Surface and Ground water resources targetting,**
- **Runoff and Aquifer Volume estimation,**
- **Aquifer function modelling**
- **Surface water 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, Water Resources Information System using Geoinformatics Technology.

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