SURFACE AND GROUNDWATER HYDROLOGY AND MANAGEMENT

UNIT-2

Dr. K. Palanivel
Assistant Professor

Centre for Remote Sensing, Bharathidasan University

Tiruchirappalli.

28 15:47

MTIGT0604: SURFACE AND GROUNDWATER HYDROLOGY AND 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. 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.**

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.**

UNIT - 2

GEOINFORMATICS IN SURFACE WATER RESOURCES

Unit - 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.**

Remote Sensing and GIS for Water Resources – Certain Principles

- Maximum absorption in Visible range of EMR, i.e., **EMR Reflectance of Surface Water is Very Little**
- Total absorption in IR range
- Suspended sediments, shallow bottom topography, smooth flow of running water bodies will have reflectance to some extent
- Elements dissolved in water may also change the reflectance property of water
- Microwave will have smooth and coarse texture

Remote Sensing and GIS for Water Resources – Certain Principles

- Ice caps reflects very high and appears bright in visible region
- Reflectance vary depends on depth to the bottom of water body – reflectance from river bed, tank bed, coast, etc., gives little brighter signature
- Polluted waters will reflect little high and differently than the normal water bodies
- There are very good vistas for water resources management using fast emerging Geotechnology.

Microwave / RADAR Data

- Surface water targetting
- Surface water quantification
- Flood inundation mapping
- Flood forecasting
- Structural features mapping for GW targets.
- Fluvial Geomorphic landform mapping particularly, Floodplains, Alluvial plains, Palaeochannels, Deltaic plains, and
- Coastal aquifers like Beach Ridges and Dune Complexes for GW Targets.

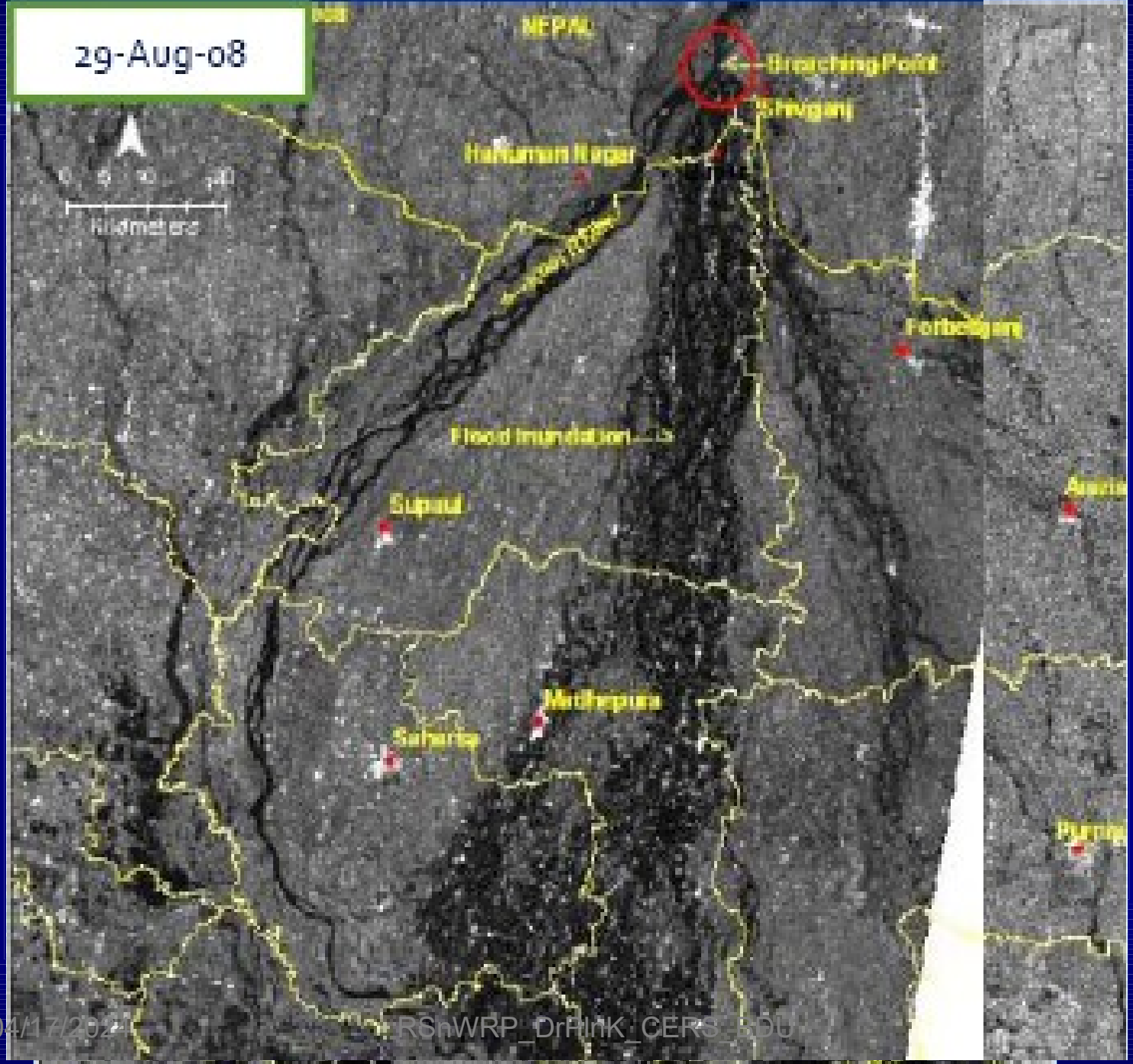
Surface water budgeting & quantification

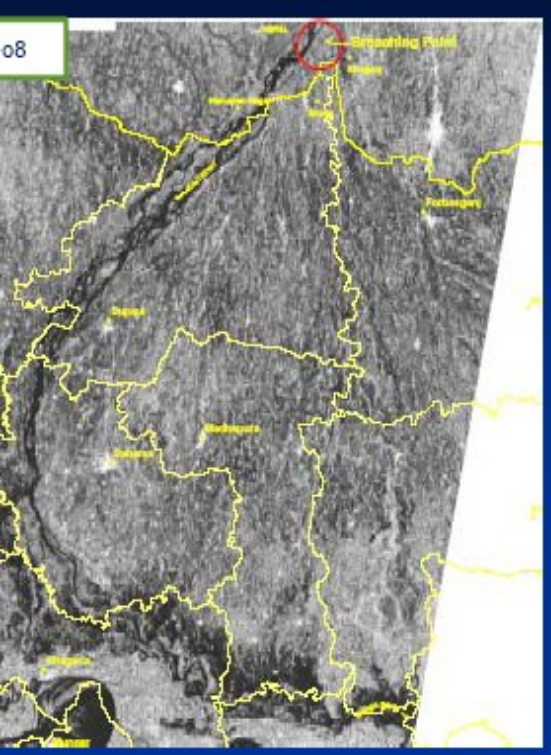
- Agricultural land type mapping and water requirement estimation
- Habitation area and type mapping and water requirement estimation
- Industrial area and type mapping and water requirement estimation
- Surface water quantification using bottom topography of water bodies and water spread area and
- Surface water budgetting

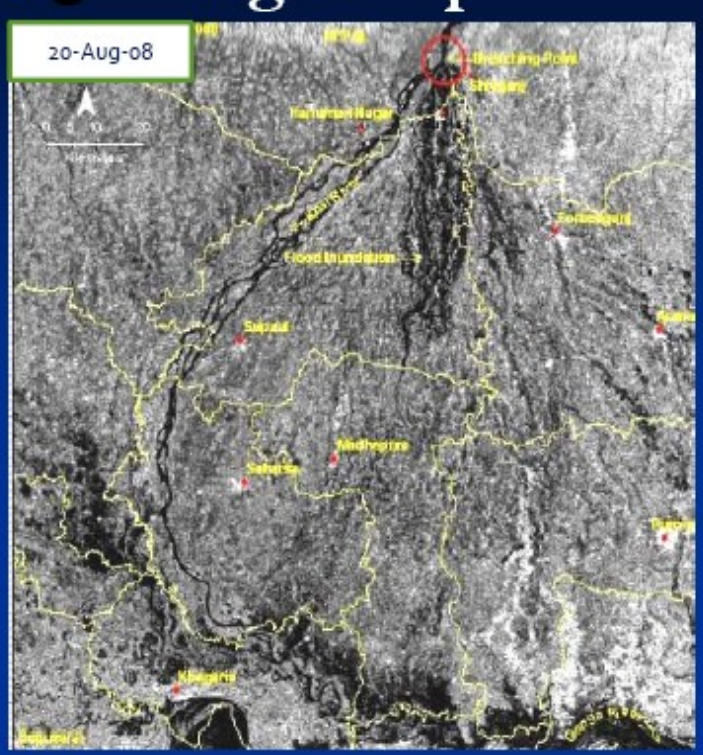
RS and GIS for WRC

- **Surface Water – Running and Static**
  - Mapping
    - Drainages, Canals, Rivers, Reservoirs, Lakes, Tanks
    - Watershed Delineation, Density maps….
  - Periodic / Daily Estimation of SW quantity
  - Budgeting (Available resources vs Usage)
  - Flood Hazard Zonation & Forewarning
  - Prioritization of watersheds using Drainage Morphometric Analysis
  - Surface water Quality Estimation
  - Soil erosion control and Siltation Mapping

Central Pivot irrigation system in Kansas using Ogallala Aquifer – Circular crop fields are covering 100s of sq.km


29-Aug-08
NEPAL
Breaching Point
Shivgarj
Hanuman Nagar
Kilometers
Forbesganj
Flood Inundation
Supaul
Araria
Madhepura
Saharsa
Purnia
Begusarai


Breaching Point
Supaul
Madhepura
Saharsa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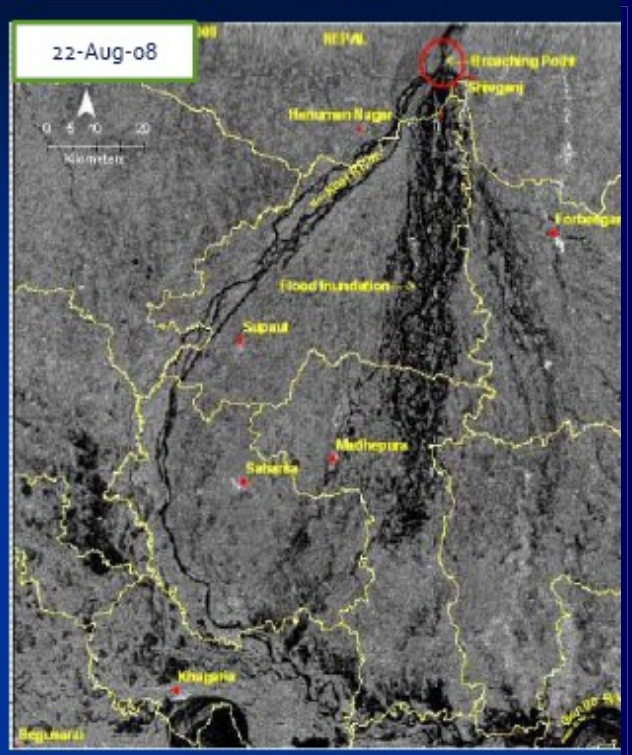
NEPAL
Breaching Point
Sheogarh
Hanuman Nagar
Forbesganj
Flood Inundation
Supaul
Madhepura
Saharsa
Khagaria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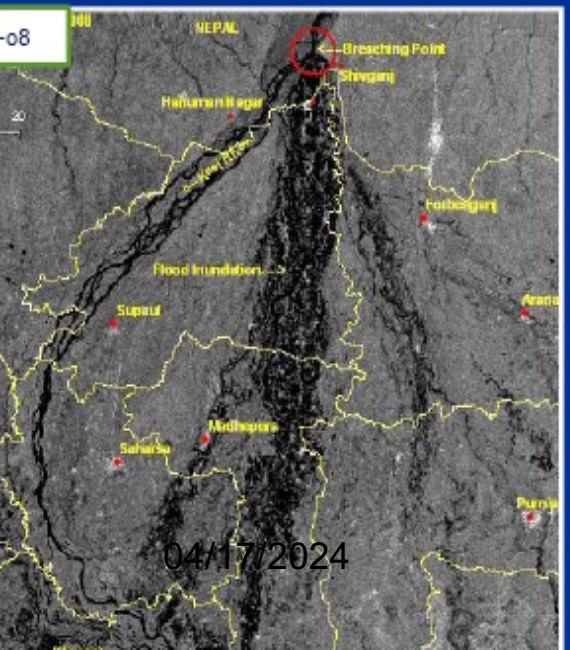
Hanuman Nagar
Forbesganj
Flood Inundation
Supaul
Madhepura
Saharsa
Khagaria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Flood Inundation
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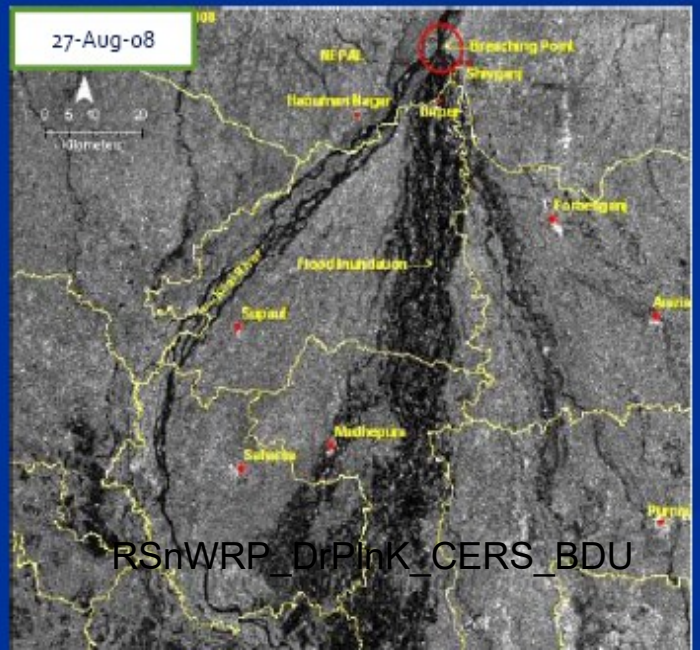
Saharsa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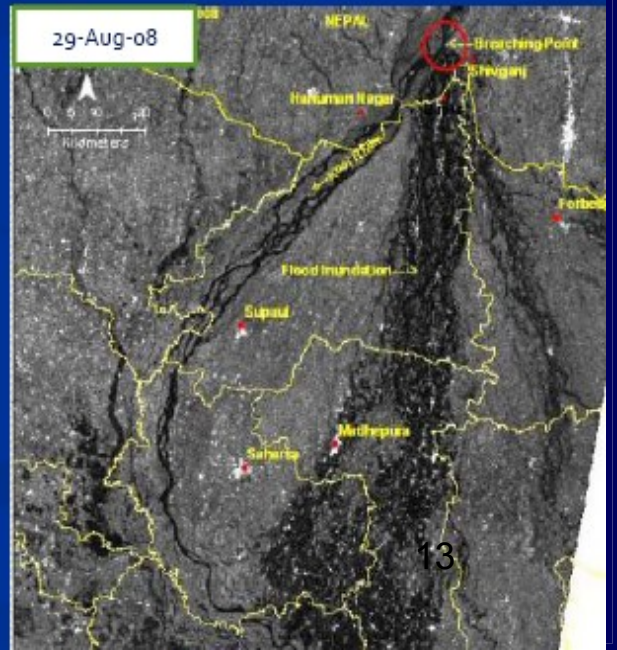
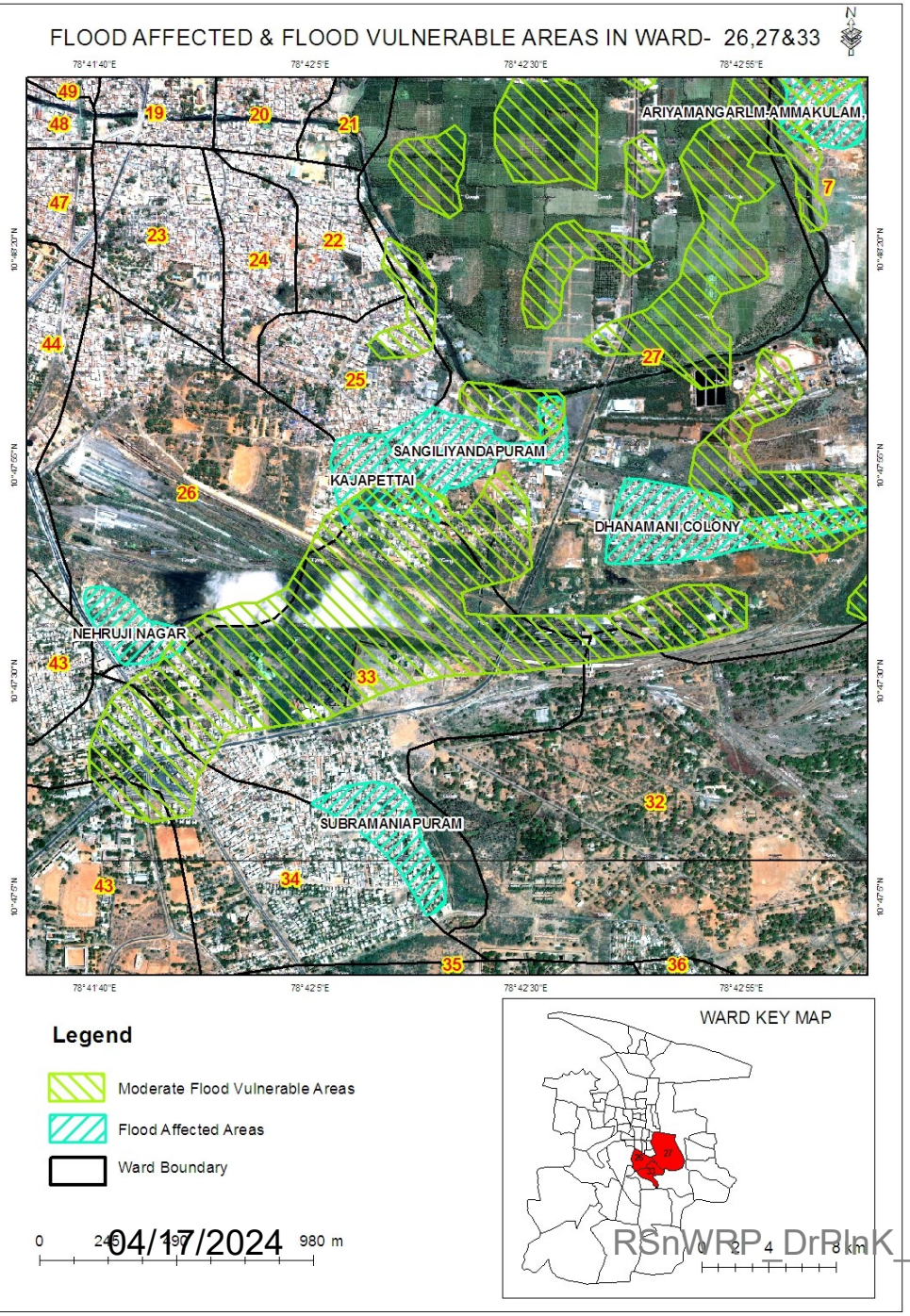
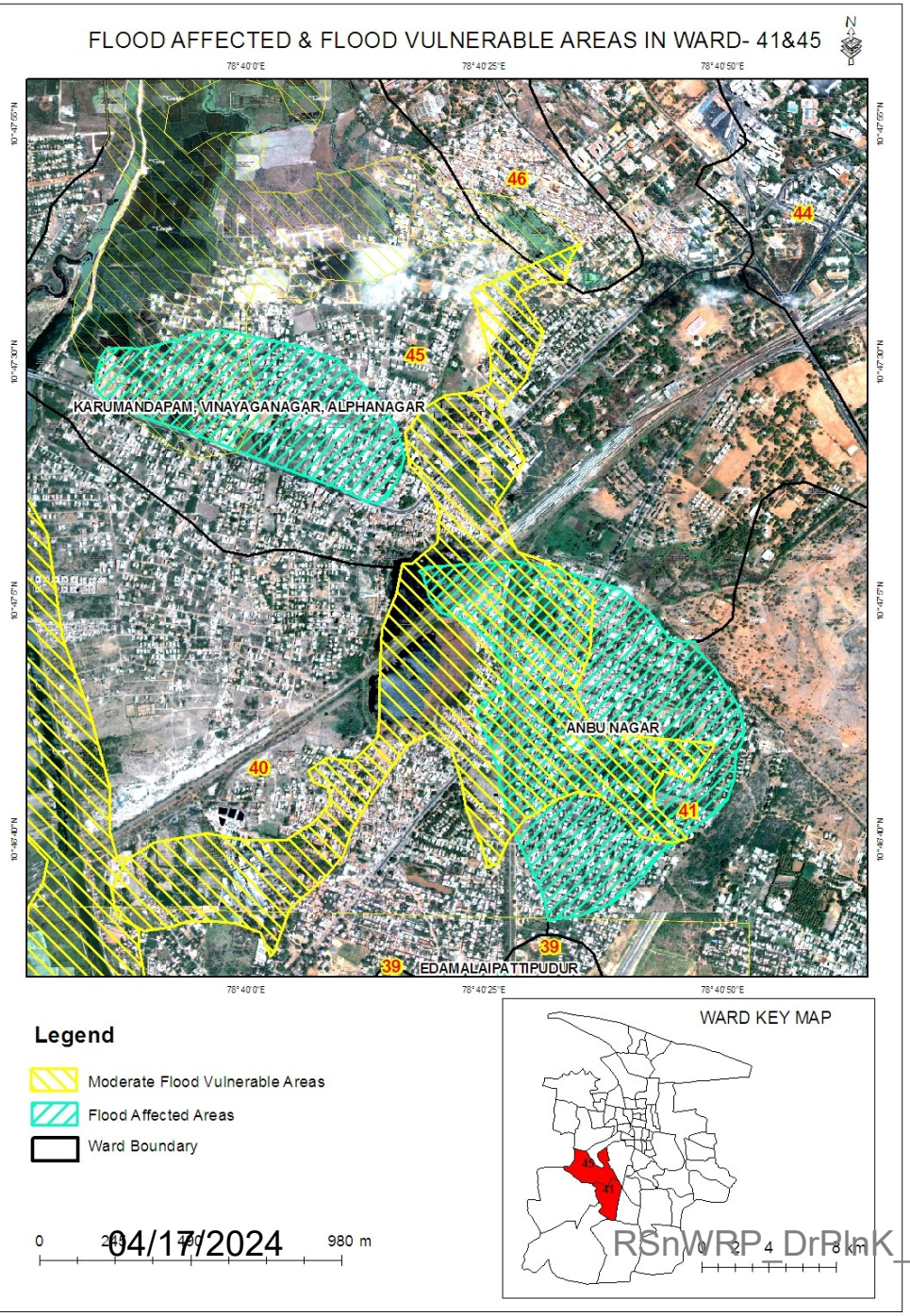
Hanuman Nagar
Forbesganj
Flood Inundation
Supaul
Madhepura
Saharsa

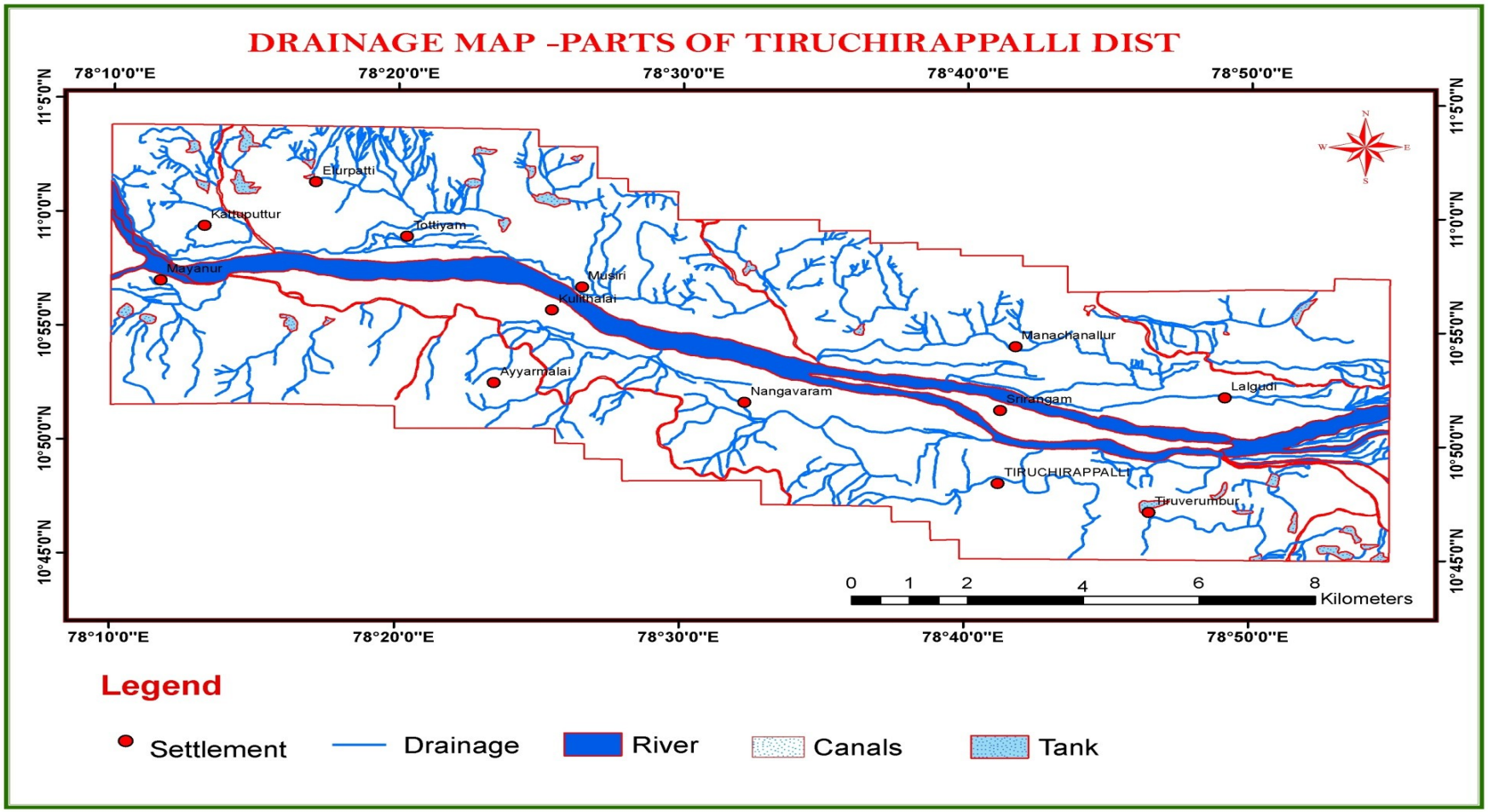

29-Aug-08
NEPAL
Breaching Point
Sheogarh
Hanuman Nagar
Flood Inundation
Supaul
Madhepura
Saharsa



Flood vulnerable areas and affected areas in Wards 26, 27&33, Tiruchirappalli Corporation

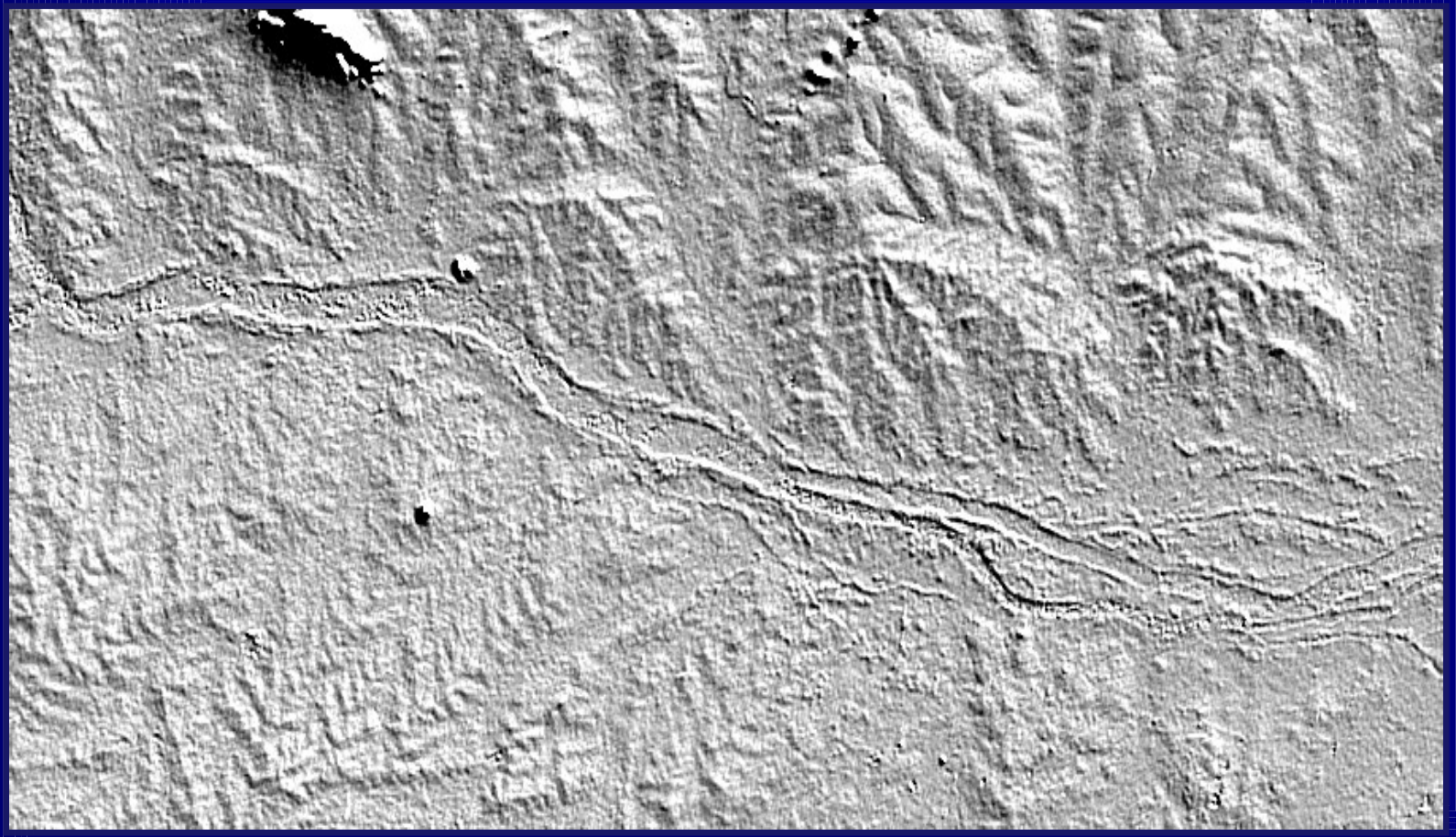


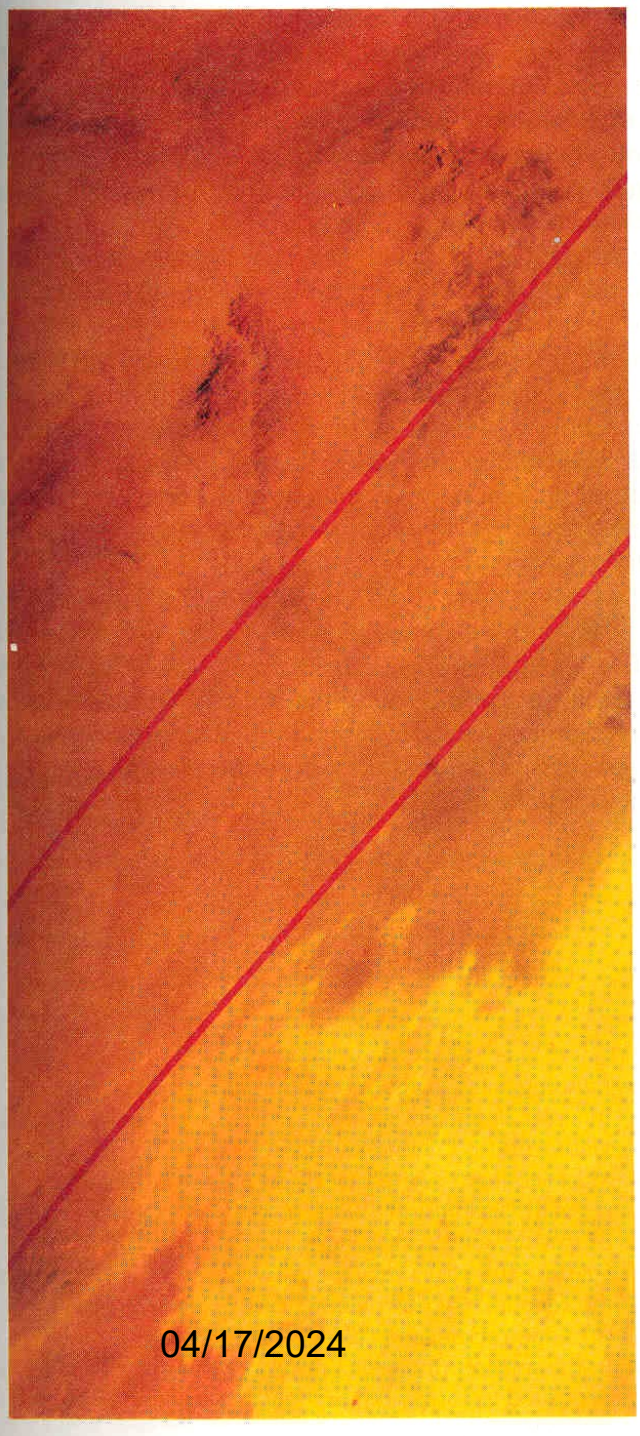
Flood vulnerable areas and affected areas in Ward 41&45, Tiruchirappalli Corporation



- Drainage map was prepared from the SOI Toposheet (58.I/1, 5, 9, 13, 58I/4, 5).
- Here all the possible rivers, streams and tanks were digitized.
- Cauvery and Kolidam Rivers are flowing in the area.
- Most of the tanks are present in the upper and lower parts of the NW & SE part.

SHADED RELIEF MAP





Buried channels of mighty river Sarasvathi

Eolian plain – Thar Desert

Back

Research & Development studies conducted and Pilot Models developed, validated & implemented with success in several places, on various aspects of Water Resources Conservation and Management at Centre for Remote Sensing, Bharathidasan University are:

1. Watershed wise Runoff Modelling
2. 2A. Tank – Reservoir Water Storage Forecasting
3. 2B. Surface Water Quantification
4. 3. Surface Water Targetting
5. 4. Surface Water Quality from Satellite data
6. 5. Soil Erosion – Reservoir Siltation and Remedial Measures
7. 6. Inter-watershed water transfer
8. 7. Flood water Harvesting
9. 8. GIS based Drainage Morphometric Analyses & Runoff Estimation

STUDY - 1

WATER SHEDWISE RUNOFF MODELLING

Back

STUDY 1

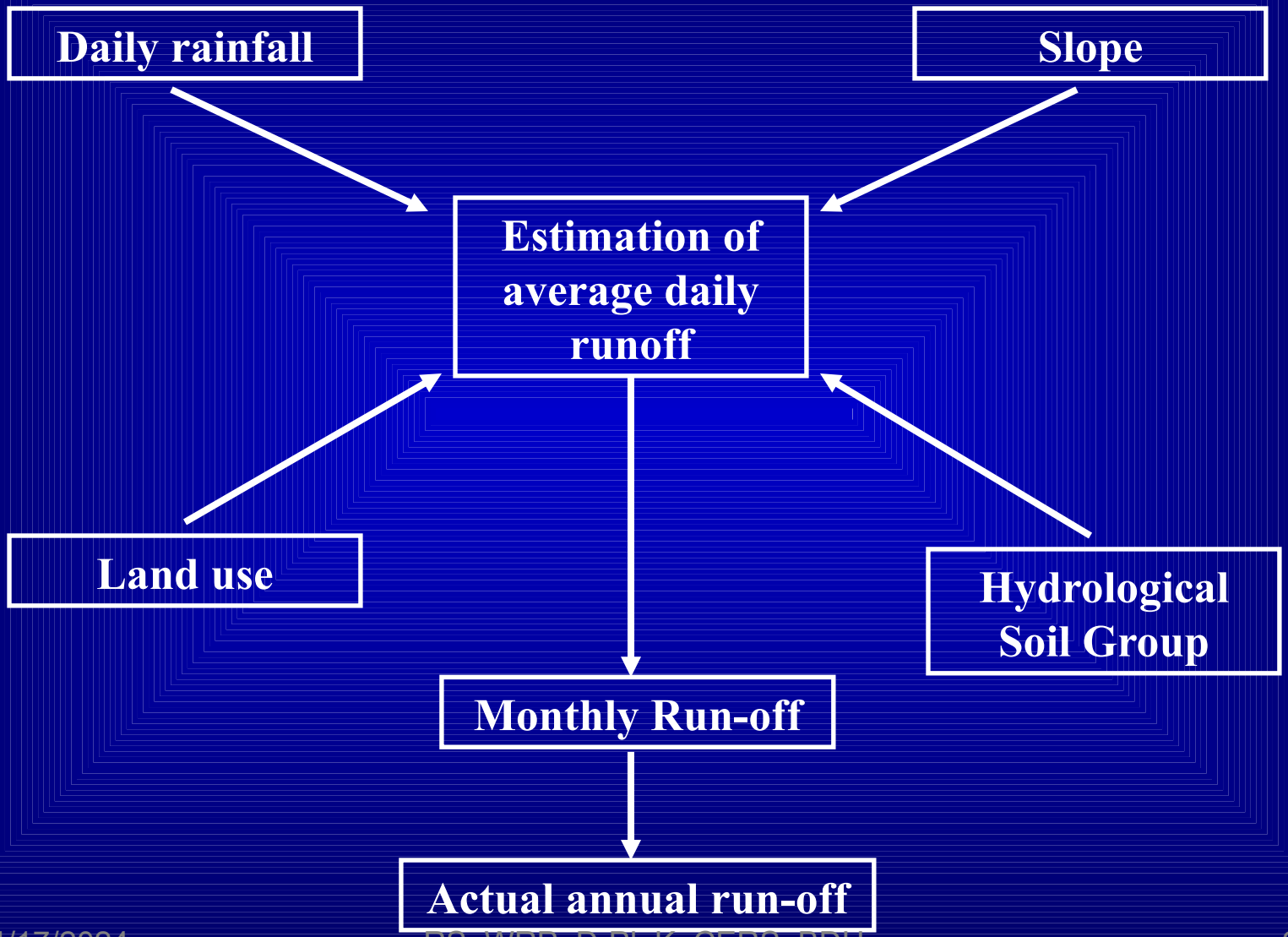
WATER SHEDWISE RUNOFF MODELLING

- **INPUT DATA**
  - **Daily Rain Fall**
  - **Slope**
  - **Hydrological Soil Group**
  - **Land Use and Land Cover**
- **OUTPUT DATA**
  - Monthly **Run off**
  - **Annual Run Off**

IRS 1A BAND – 4 (NIR) DATA
(Raiapalayam – Sankarankovil area)

Surface Water

ESTIMATION OF SURFACE WATER POTENTIAL / RUNOFF ESTIMATION



The Surface water potential on watershed basis, DRY-DAMP-WET method
For Example,

Karur District was divided into 33 sub watershed

Subsequently other data bases were generated on

- **Daily Rainfall for 30 Years (from 23 rain gauge stations)**
- **Mean Slope for each Watershed**
- **Hydrological Soil Group and**
- **Landuse and Land Cover**

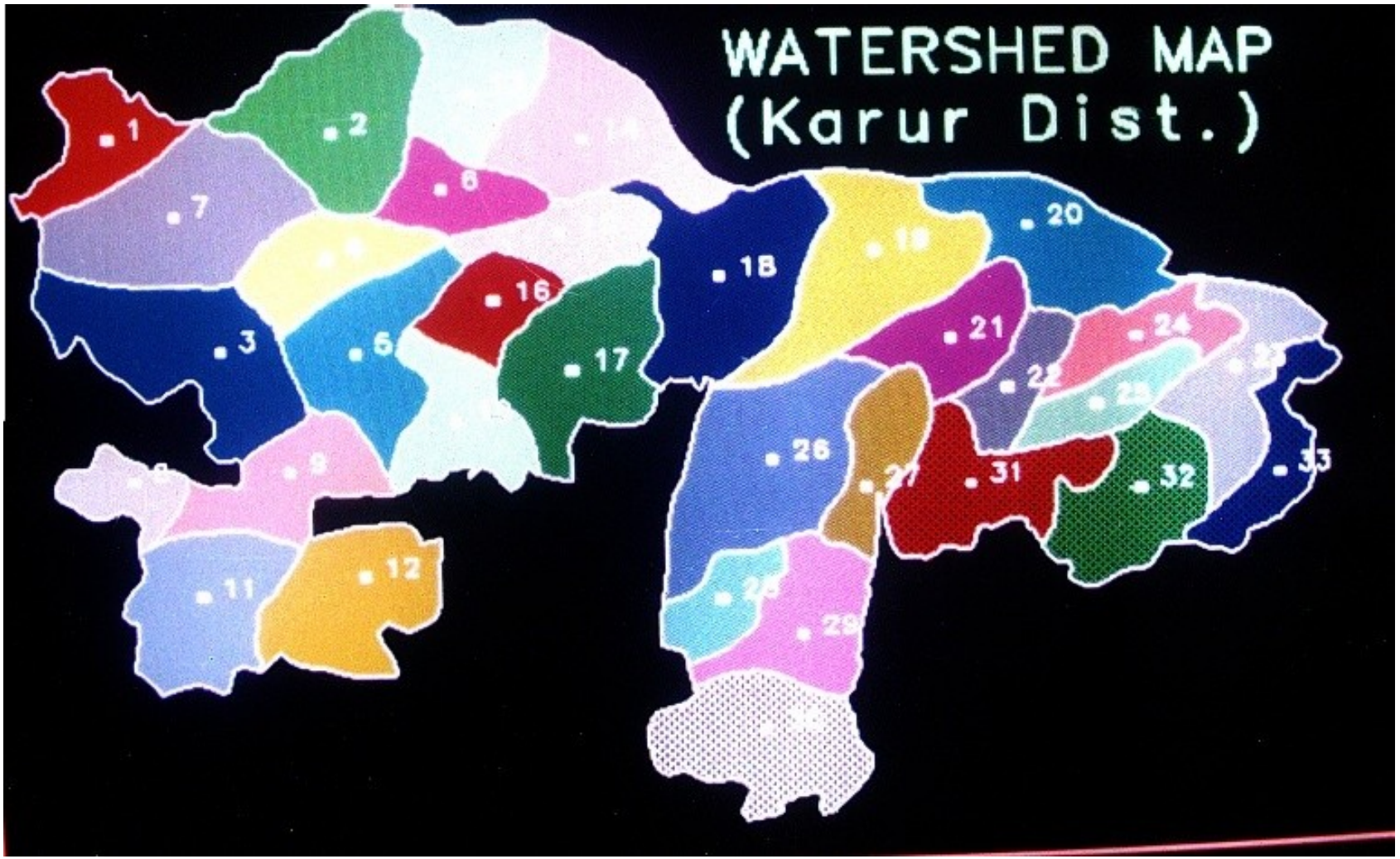

WATERSHED MAP
(Karur Dist.)
1
2
6
7
16
18
20
3
6
17
21
24
26
31
32
33
11
12

TABLE 1

SLOPE DATA

SL.NO.	WATERSHED NO.	SLOPE IN RADIANCE
1	1	0.02616
2	2	0.27610
3	3	0.02035
4	4	0.02442
5	5	0.01744
6	6	0.01744
7	7	0.03198
8	8	0.01453
9	9	0.02035
10	10	0.15180
11	11	0.04797
12	12	0.06154
13	13	0.01744
14	14	0.01744
15	15	0.02350
16	16	0.01599
17	17	0.01686
18	18	0.01744
19	19	0.01279
20	20	0.01221
21	21	0.01162
22	22	0.01279
23	23	0.01628
24	24	0.01762
25	25	0.16280
26	26	0.01162
27	27	0.01744
28	28	0.12210
29	29	0.01192
30	30	0.22677
31	31	0.04797
32	32	0.03488
33	33	0.03458

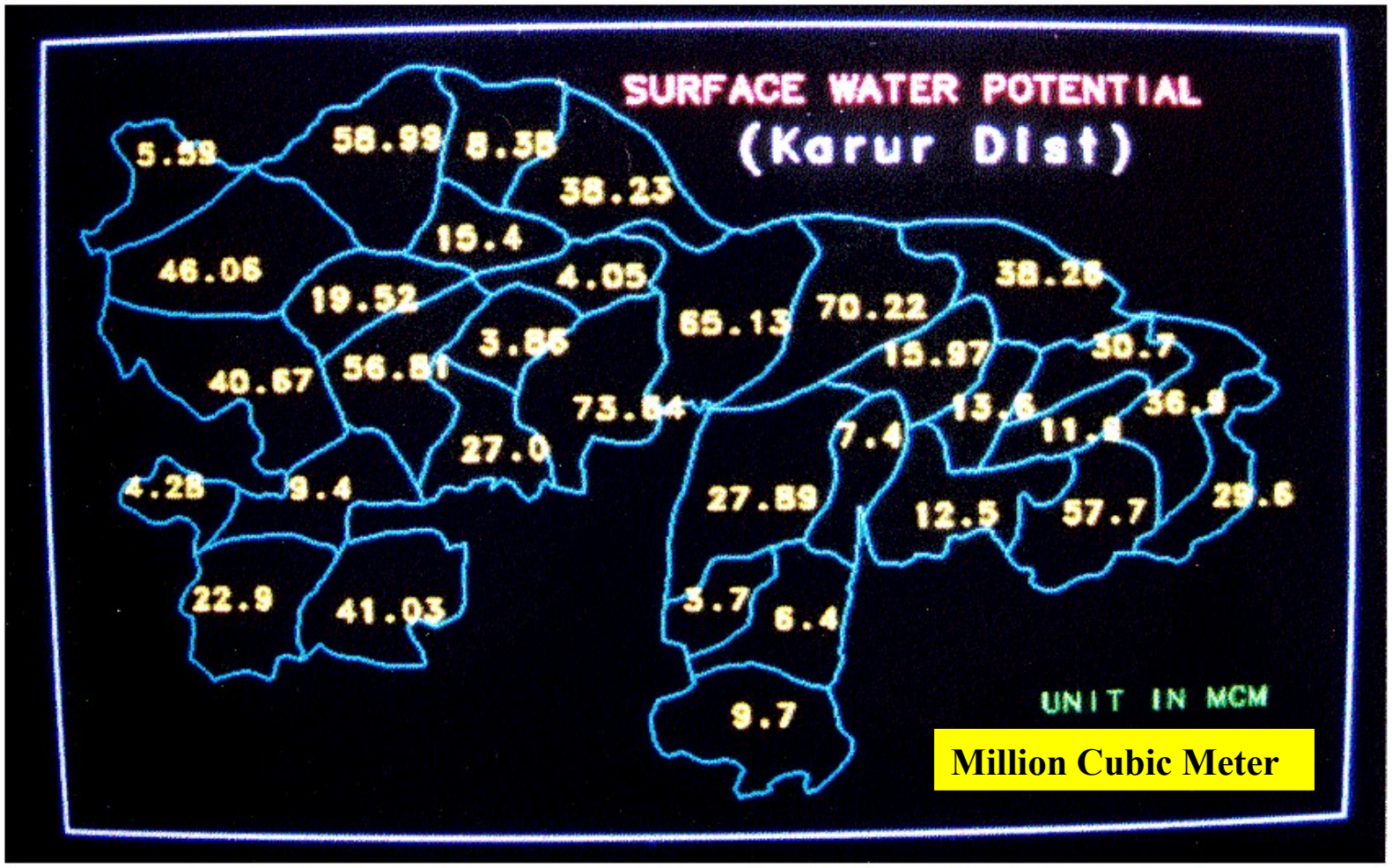
TABLE 2

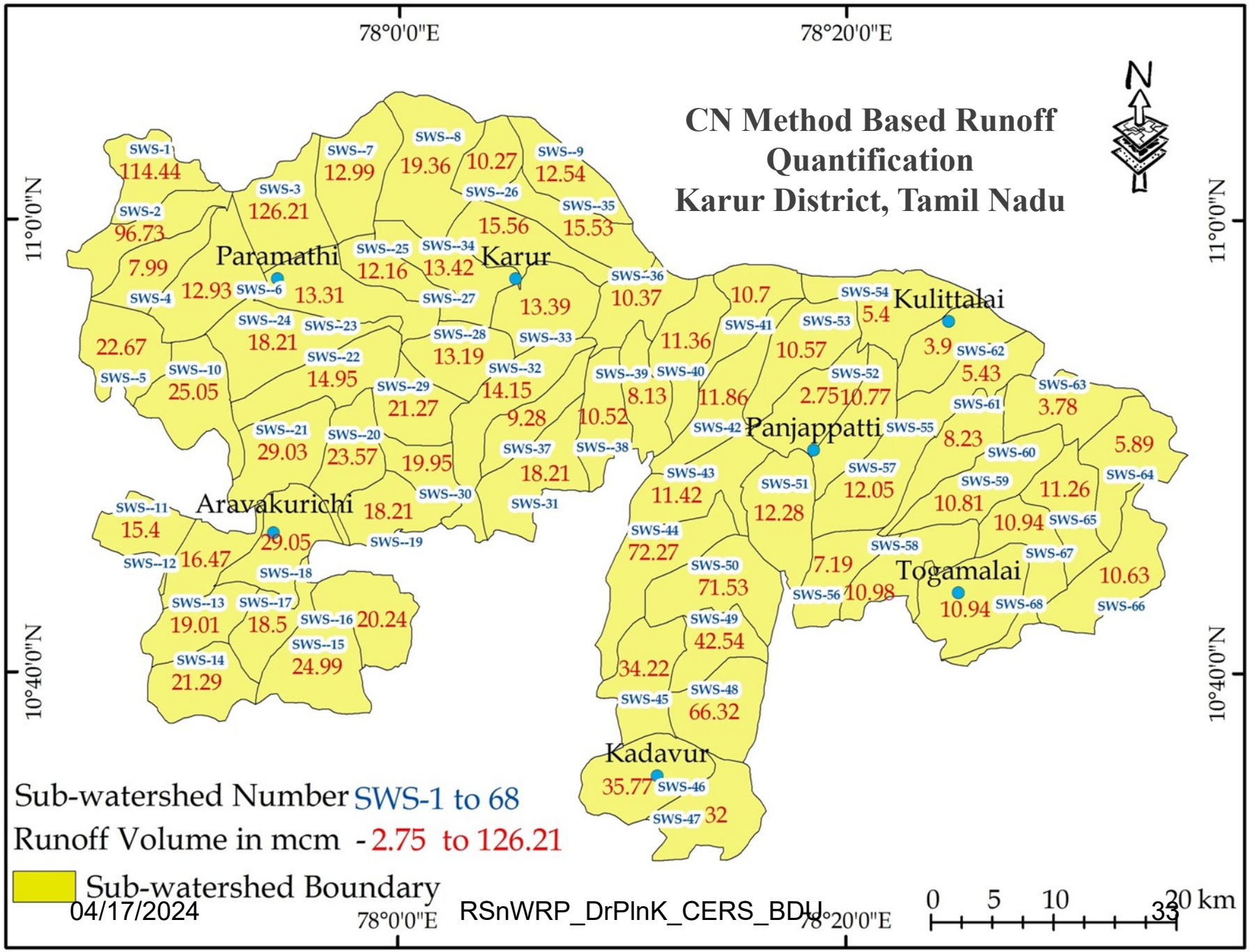
HYDROLOGICAL SOIL GROUP DATA

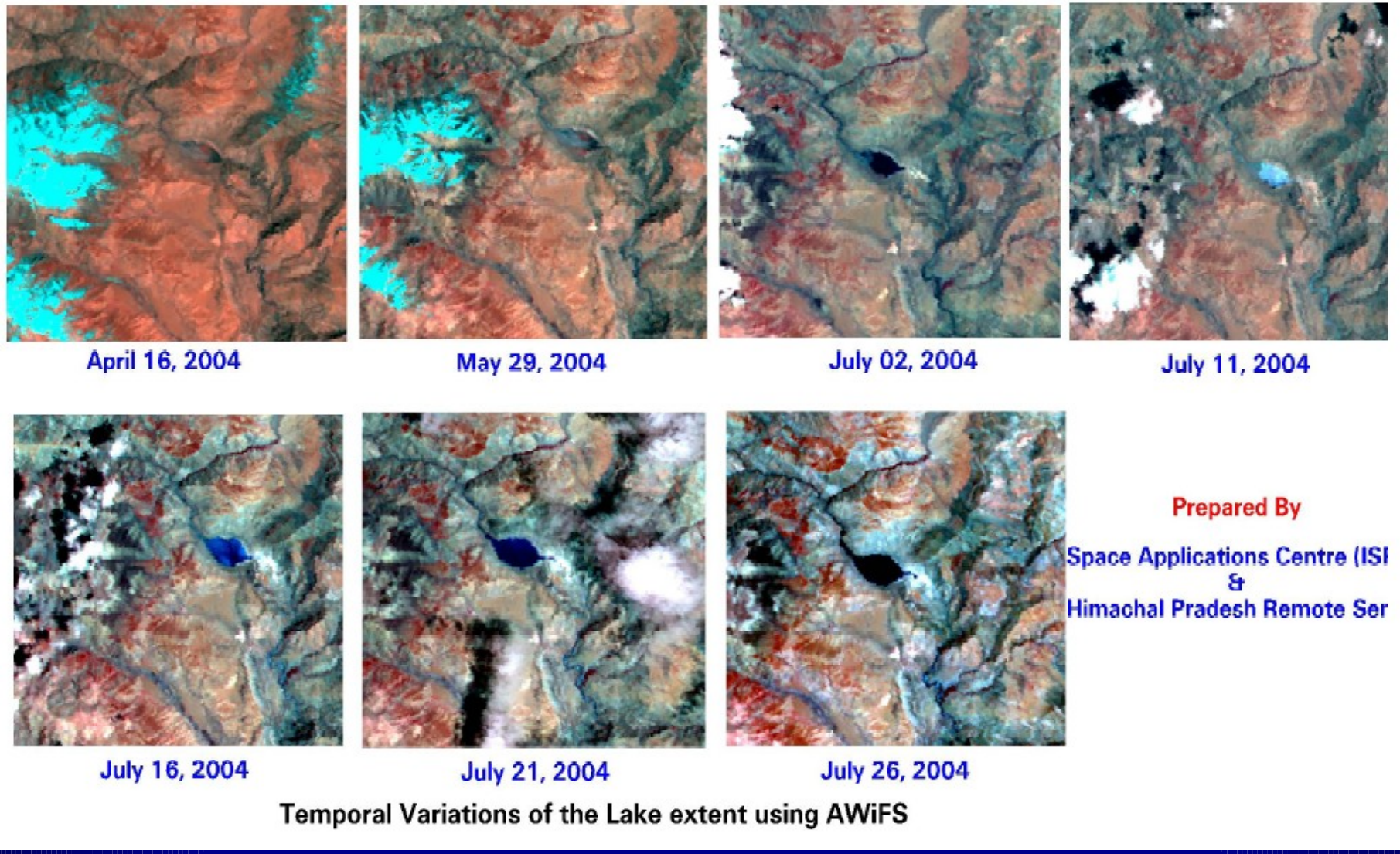
SL.NO.	WATERSHED NO.	AREA IN Sq.Km.			
		A	B	C	D
1	1	0.30	69.96	0.00	0.00
2	2	0.00	127.00	3.08	0.00
3	3	0.50	148.17	0.64	0.00
4	4	2.30	64.55	0.04	0.00
5	5	0.00	96.77	2.22	0.00
6	6	1.06	50.41	0.87	0.00
7	7	0.03	150.80	3.14	0.00
8	8	0.00	38.67	0.00	0.00
9	9	0.02	80.16	0.14	0.00
10	10	2.73	64.95	1.07	0.00
11	11	0.34	107.25	0.00	0.00
12	12	0.11	106.71	0.23	0.00
13	13	0.00	69.79	2.31	0.00
14	14	0.00	105.00	2.73	0.00
15	15	0.00	50.58	0.99	0.00
16	16	0.00	47.06	2.37	0.00
17	17	0.84	110.35	0.78	0.00
18	18	0.83	122.82	4.61	0.00
19	19	0.00	130.31	7.99	0.00
20	20	0.03	103.94	3.84	0.00
21	21	0.00	65.63	0.86	0.00
22	22	0.00	43.66	0.19	0.00
23	23	0.13	82.71	3.85	0.00
24	24	0.00	55.22	0.33	0.00
25	25	0.00	44.77	0.25	0.00
26	26	0.18	138.03	8.66	0.00
27	27	0.00	56.37	0.12	0.00
28	28	0.10	41.86	0.58	0.00
29	29	2.96	79.14	0.00	0.00
30	30	2.47	90.65	17.94	0.00
31	31	0.11	93.21	6.61	0.00
32	32	0.00	87.88	0.00	0.00
33	33	0.00	62.57	0.00	0.00

TABLE 3
LANDUSE AND LANDCOVER DATA

SL.NO.	WATERSHED NO.	AREA IN Sq.Km.			
		WETCROP	DRYCROP	NATURAL VEGETATION	BARREN LAND
1	1	5.56	4.12	0.00	61.07
2	2	19.25	7.25	0.00	106.96
3	3	14.75	3.43	0.00	111.95
4	4	1.81	2.06	0.00	67.63
5	5	12.65	3.87	0.00	72.85
6	6	15.62	10.06	0.00	33.44
7	7	3.75	1.43	0.00	145.20
8	8	31.30	5.75	0.00	14.95
9	9	6.25	13.87	0.00	69.56
10	10	6.47	7.81	0.00	68.95
11	11	5.50	3.93	0.00	98.82
12	12	7.43	8.75	3.25	94.07
13	13	96.06	7.60	0.00	44.38
14	14	45.56	10.62	0.00	58.32
15	15	15.93	3.00	0.00	33.05
16	16	7.25	13.50	0.00	39.50
17	17	9.94	23.62	0.00	95.01
18	18	29.93	5.75	0.00	87.94
19	19	12.62	38.12	0.00	79.60
20	20	82.87	2.00	0.50	27.16
21	21	6.27	8.39	0.25	29.53
22	22	8.06	17.75	0.00	42.35
23	23	27.50	0.25	0.00	64.88
24	24	28.00	7.00	0.00	18.50
25	25	7.13	9.25	0.00	31.00
26	26	13.08	7.82	1.00	106.35
27	27	11.24	6.25	0.00	42.35
28	28	6.00	1.50	6.75	22.15
29	29	12.93	2.00	16.00	57.57
30	30	7.50	1.80	38.50	45.80
31	31	11.30	12.68	0.00	70.70
32	32	16.50	15.87	0.00	52.78
33	33	22.31	3.00	0.00	42.31


SURFACE WATER POTENTIAL
(Karur Dist)
5.59
58.99
8.35
38.23
15.4
46.06
19.52
4.05
38.28
65.13
70.22
3.86
15.97
30.7
40.67
56.81
73.84
13.6
36.9
11.8
7.4
27.0
4.28
9.4
27.89
12.5
57.7
29.6
22.9
41.03
3.7
6.4
9.7
UNIT IN MCM
Million Cubic Meter


CN Method Based Runoff Quantification
Karur District, Tamil Nadu
N
78°0'0"E
78°20'0"E
11°0'0"N
10°40'0"N
Paramathi
Karur
Kulittalai
Panjappatti
Aravakurichi
Togamalai
Kadavur
SWS-1 114.44
SWS-2 96.73
SWS-3 126.21
SWS-4 7.99
SWS-5 22.67
SWS--6 12.93
SWS--7 12.99
SWS--8 19.36
SWS--9 10.27
SWS--10 25.05
SWS--11 15.4
SWS--12 16.47
SWS--13 19.01
SWS--14 21.29
SWS--15 24.99
SWS--16 18.5
SWS--17 20.24
SWS--18 29.05
SWS--19 18.21
SWS--20 23.57
SWS--21 29.03
SWS--22 18.21
SWS--23 14.95
SWS--24 25.05
SWS--25 12.16
SWS--26 13.31
SWS--27 21.27
SWS--28 13.19
SWS--29 14.15
SWS--30 9.28
SWS--31 18.21
SWS--32 19.95
SWS--33 13.39
SWS--34 13.42
SWS--35 15.56
SWS--36 15.53
SWS-37 10.37
SWS--38 10.52
SWS--39 8.13
SWS-40 11.86
SWS-41 11.36
SWS-42 10.7
SWS-43 11.42
SWS-44 72.27
SWS-45 34.22
SWS-46 35.77
SWS-47 32
SWS-48 66.32
SWS-49 42.54
SWS-50 71.53
SWS-51 12.28
SWS-52 2.75
SWS-53 10.57
SWS-54 5.4
SWS-55 10.77
SWS-56 7.19
SWS-57 12.05
SWS-58 10.98
SWS-59 8.23
SWS-60 10.81
SWS-61 5.43
SWS-62 3.9
SWS-63 3.78
SWS-64 11.26
SWS-65 10.94
SWS-66 5.89
SWS-67 10.63
SWS-68 10.94
Sub-watershed Number SWS-1 to 68
Runoff Volume in mcm - 2.75 to 126.21
Sub-watershed Boundary
0 5 10 20 km



Temporal Variations of the Lake extent using AWiFS

The quantum of blocked water stored in this temporary reservoir was estimated later to understand the danger and the official were trained by the SAC, Ahmedabad on this methodology & how to safeguard the people in its downstream.

14th Aug. 2004

Back

STUDY – 2A

TANK - RESERVOIR STORAGE

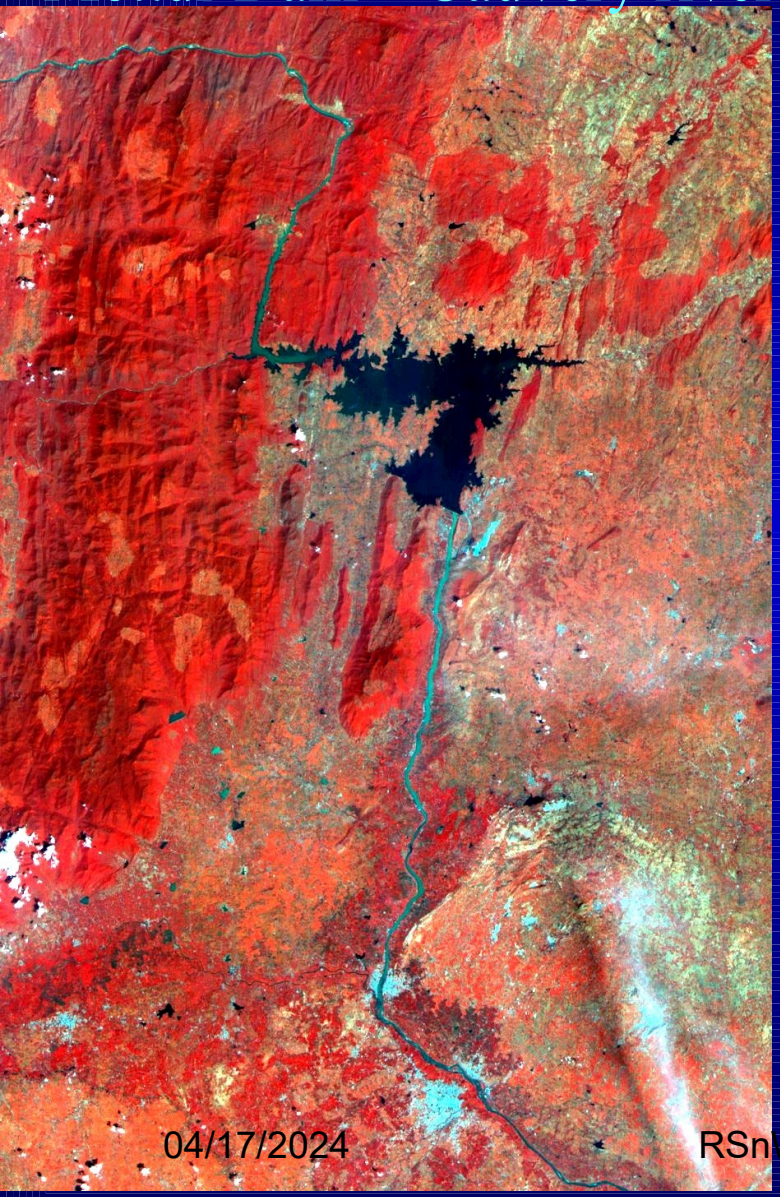
FORE CASTING

☛ USING SATELLITE IR DATA

Back

SURFACE WATER RESOURCES

Mettur Dam – Cauvery river



Mississippi River

3 July 1996

16 March 1997

METHODOLOGY(in Brief)

Identification of 30 Surface Water Bodies each in Small, Medium and Major Categories

- Work out the Perimeter of Water Spread area from Satellite IR Data
- Work out bottom topography & Average Depth of Tanks
- Estimate Volume of Water in 30 Water bodies
- Establish the relation between WSA and WV

IRS 1A BAND – 4 (NIR) DATA

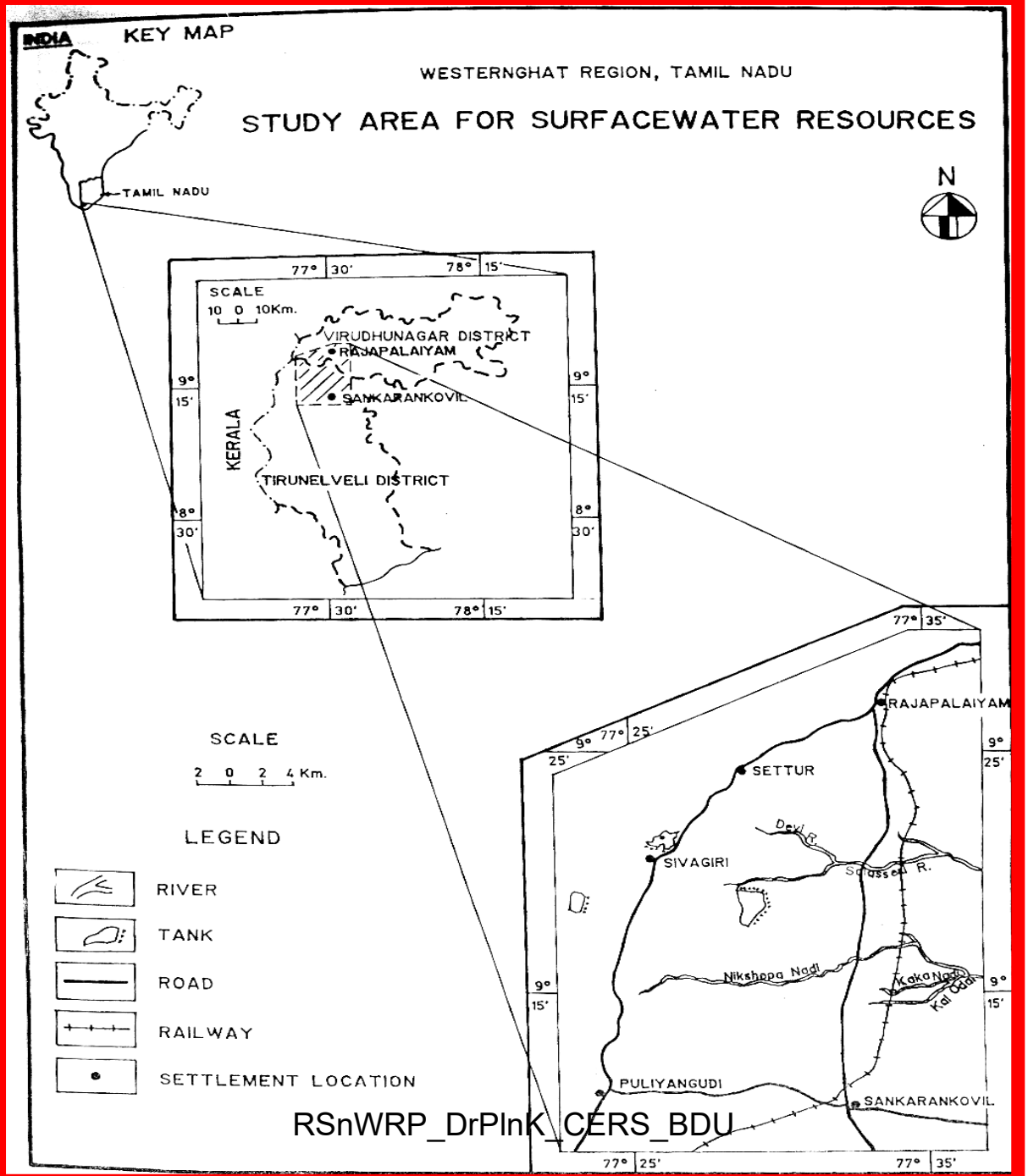
(Raiapalayam – Sankarankovil area)

Surface Water

- Carry out Regression Analysis Between Water Volume Data of 30 tanks (Dependent Variable) and Perimeter of Water Spread area (Independent Variable) and Build up a Model

Water Volume = Coefficient A + (Coefficient B X Water Spread Area)

- Validate the model
- Feed the WSA data from temporal satellite data in the model and we can forecast the Water quantity


INDIA
KEY MAP
TAMIL NADU
WESTERNGHAT REGION, TAMIL NADU
STUDY AREA FOR SURFACEWATER RESOURCES
N
77° 30'
78° 15'
SCALE
10 0 10Km.
VIRUDHUNAGAR DISTRICT
RAJAPALAIYAM
SANKARANKOVIL
KERALA
TIRUNELVELI DISTRICT
9° 15'
8° 30'
SCALE
2 0 2 4 Km.
LEGEND
RIVER
TANK
ROAD
RAILWAY
SETTLEMENT LOCATION
77° 35'
77° 25'
9° 25'
RAJAPALAIYAM
SETTUR
SIVAGIRI
Nikshepa Nadi
PULIYANGUDI
SANKARANKOVIL
9° 15'

SURFACEWATER QUANTIFICATION

Sl.No.	Tank No.	Water Spread Area (in sq.mts)	Average Depth (in mts)	Water Volume (in cubic mts)
1	M-1	700000	1.50	1050000
2	M-2	640000	0.75	480000
3	M-3	700000	1.50	1050000
4	M-4	560000	2.50	1400000
5	M-5	470000	1.50	705000
6	M-6	420000	2.00	840000
7	M-7	480000	1.50	720000
8	M-8	200000	2.50	500000
9	M-9	140000	1.50	210000
10	M-10	100000	1.25	125000
11	I-1	160000	1.25	200000
12	I-2	60000	0.75	45000
13	I-3	150000	1.50	225000
14	I-4	250000	1.50	375000
15	I-5	120000	1.00	120000
16	I-6	250000	3.50	875000
17	I-7	280000	3.00	840000
18	I-8	180000	2.00	360000
19	I-9	150000	2.50	375000
20	I-10	100000	2.50	250000
21	I-11	130000	1.50	195000
22	I-12	150000	2.50	375000
23	I-13	170000	2.00	340000
24	I-14	180000	2.00	360000
25	I-15	260000	3.00	780000
26	I-16	80000	1.50	120000
27	I-17	120000	1.00	120000
28	I-18	100000	1.00	100000
29	I-19	80000	1.00	80000
30	I-20	230000	1.50	345000

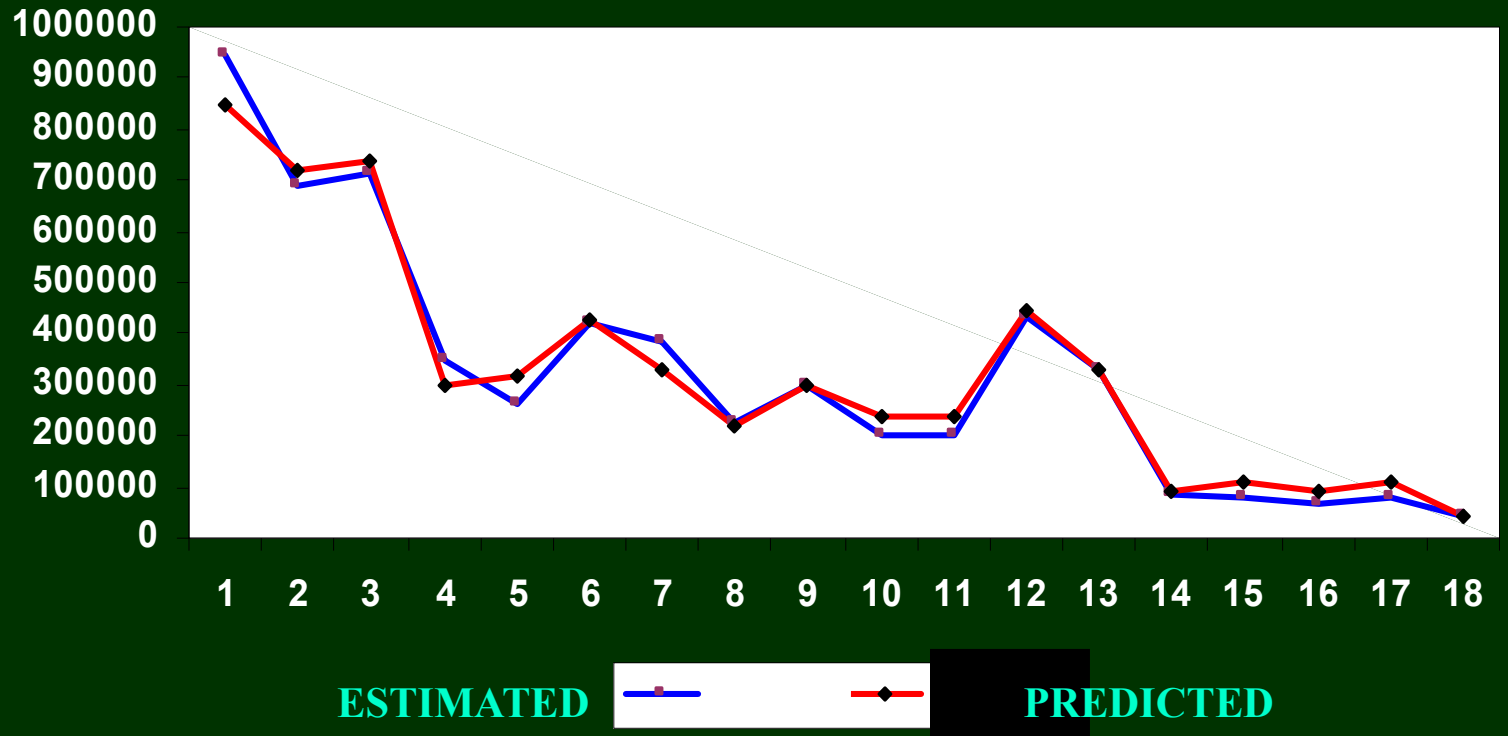
M - Major Tank; I - Intermediate Tank; m - Minor Tanks

SURFACEWATER - PERIODICAL ASSESSMENT MODEL VALIDATION

Sl.No.	Tank No.	Water Spread Area (WSA) (in sq.mts)	Water Volume Calculated (in Cubic mts)	Water Volume by model Coef.A+(Coef.BxWSA) (in Cubic mts)
(1)	(2)	(3)	(4)	(5)
1	VM-1	540000	945000	847466
2	VM-2	460000	690000	718666
3	VM-3	475000	712500	738066
4	VI-1	200000	350000	300066
5	VI-2	210000	262500	316166
6	VI-3	280000	420000	428866
7	VI-4	220000	385000	332266
8	VI-5	150000	225000	219566
9	VI-6	200000	300000	300066
10	VI-7	160000	200000	235666
11	VI-8	160000	200000	235666
12	VI-9	290000	435000	444966
13	Vm-1	220000	330000	332266
14	Vm-2	70000	87500	90766
15	Vm-3	80000	80000	106866
16	Vm-4	70000	70000	90766
17	Vm-5	80000	80000	106866
18	Vm-6	40000	40001	42466

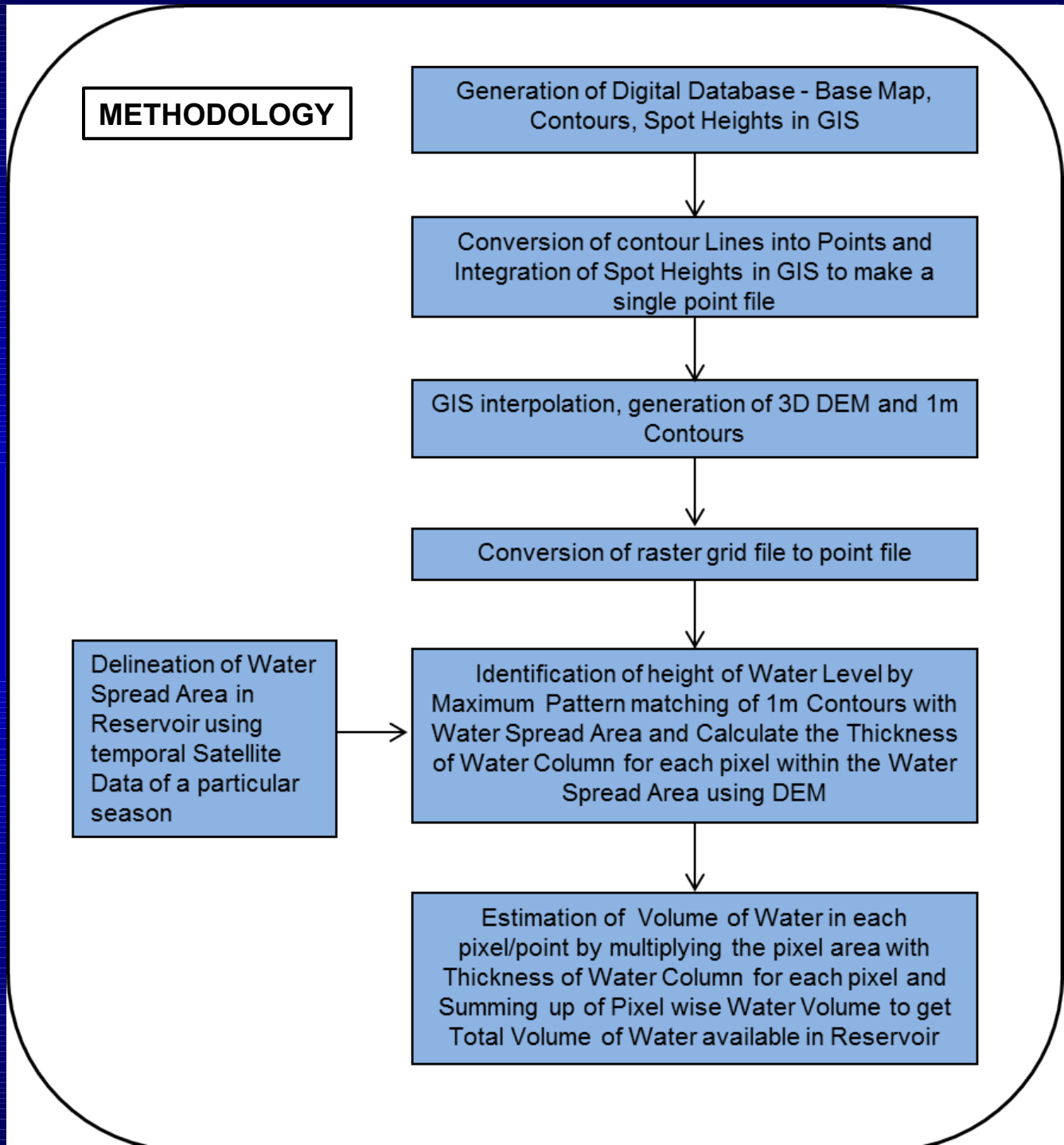
VM - Validation Tank - Major
VI - Validation Tank - Intermediate
Vm - Validation Tank - Minor

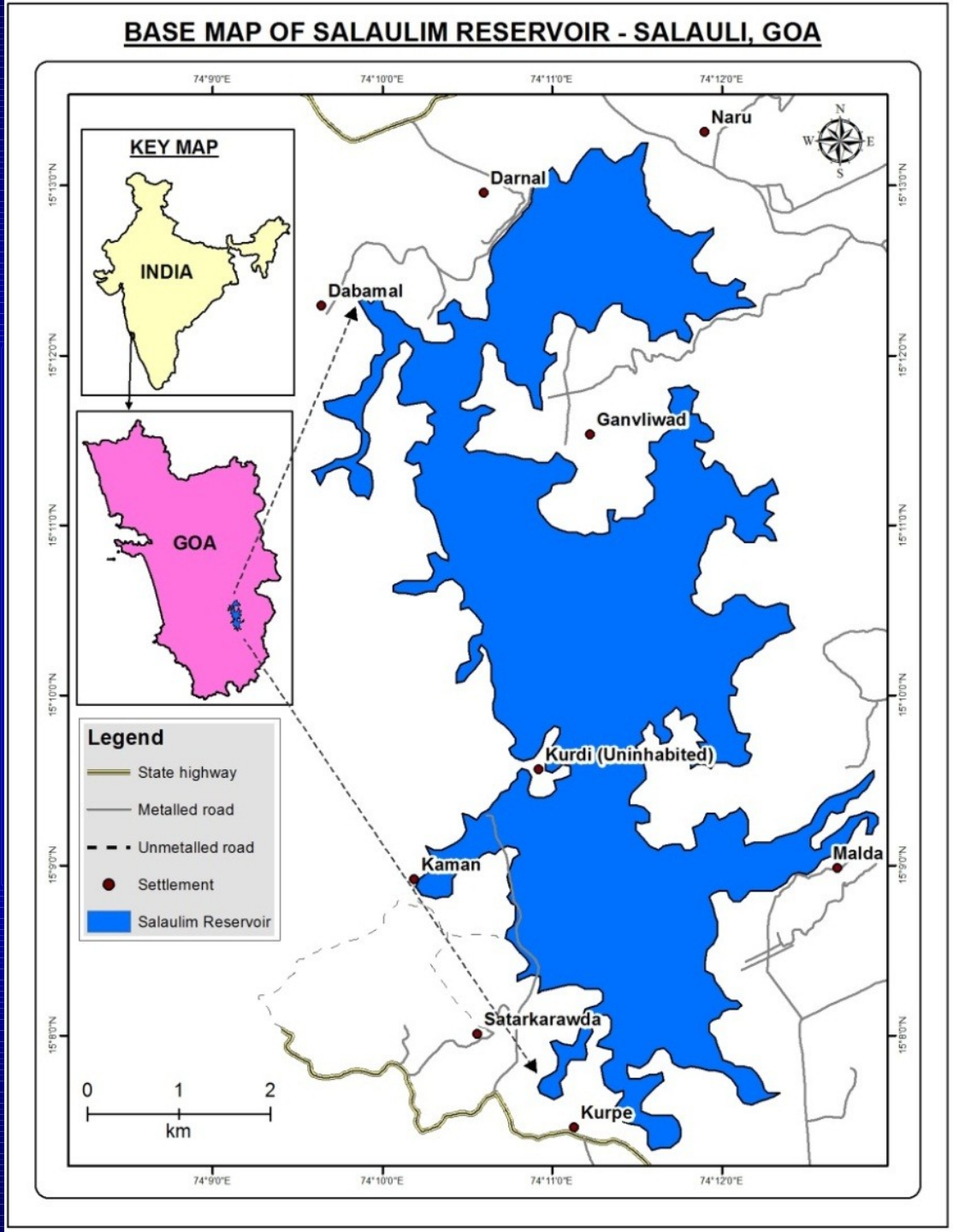
GRAPH BETWEEN ESTIMATED AND PREDICTED

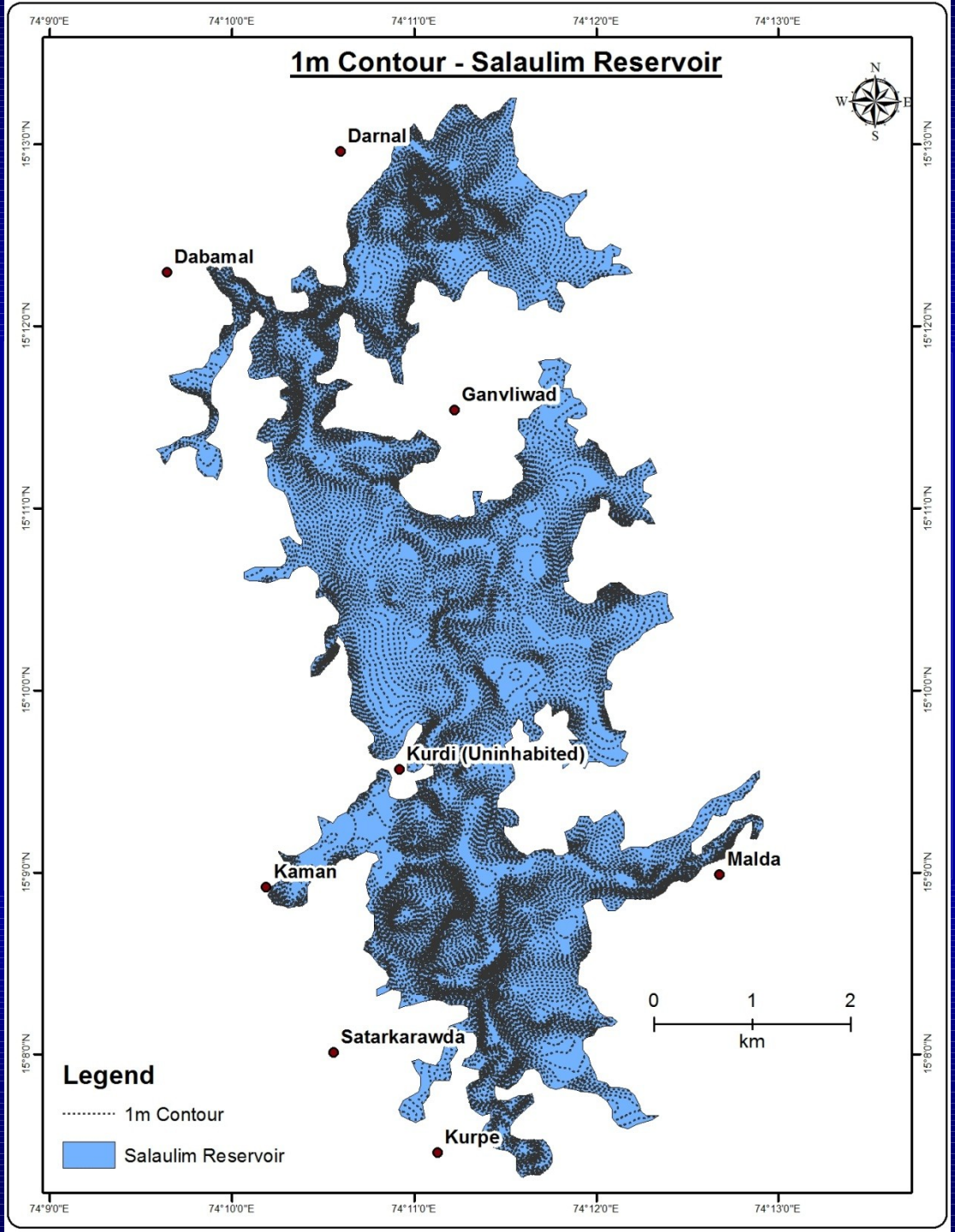


CASE STUDY-2B

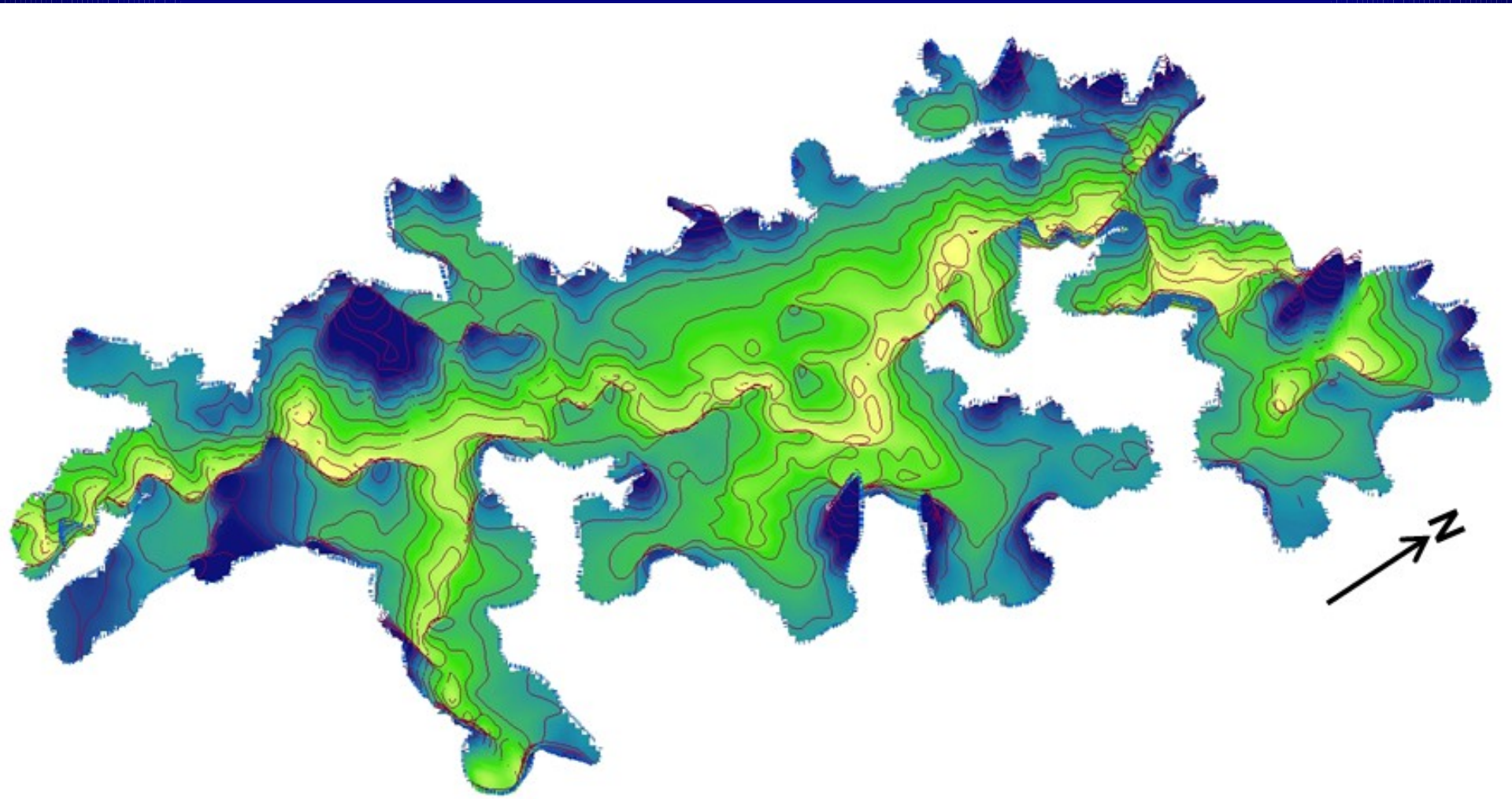
Geospatial Technology in Quantifying Seasonal Availability of Water Stored in Salaulim Reservoir Salauli, Goa State, India




BASE MAP OF SALAULIM RESERVOIR - SALAULI, GOA
KEY MAP
INDIA
GOA
Legend
State highway
Metalled road
Unmetalled road
Settlement
Salaulim Reservoir
Naru
Darnal
Dabamal
Ganvliwad
Kurdi (Uninhabited)
Kaman
Malda
Satarkarawda
Kurpe
0
1
2
km
74°9'0"E
74°10'0"E
74°11'0"E
74°12'0"E
15°13'0"N
15°12'0"N
15°11'0"N
15°10'0"N
15°9'0"N
15°8'0"N
N
S
E
W

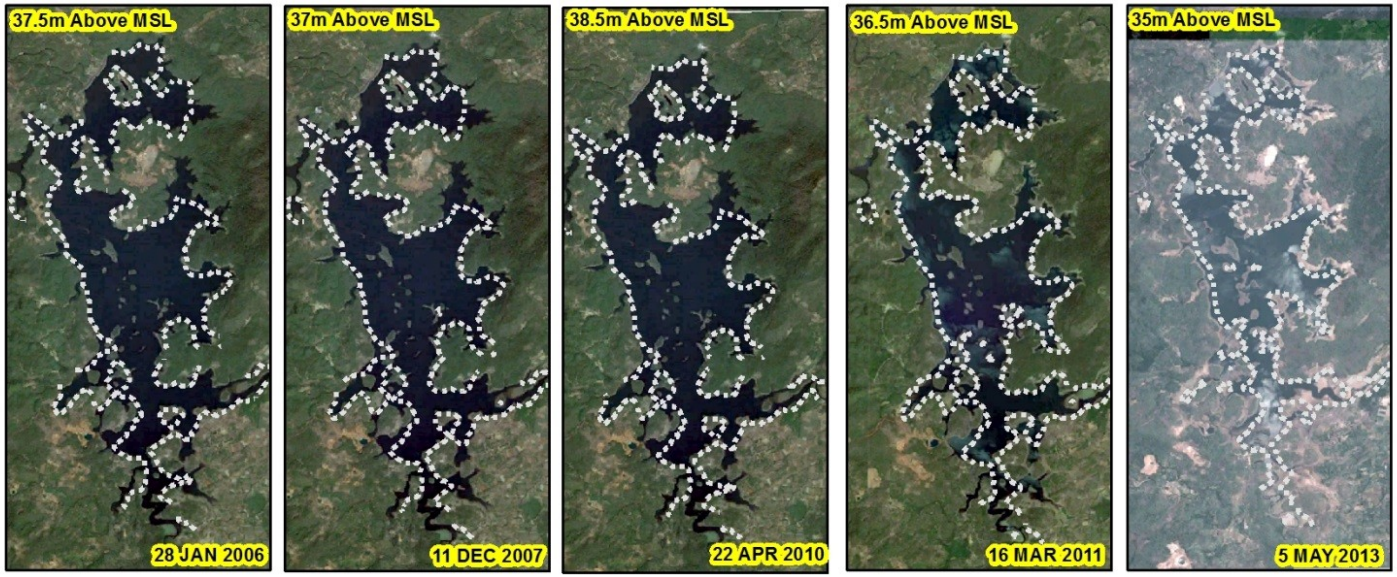

1m Contour - Salaulim Reservoir
74°9'0"E
74°10'0"E
74°11'0"E
74°12'0"E
74°13'0"E
15°13'0"N
15°12'0"N
15°11'0"N
15°10'0"N
15°9'0"N
15°8'0"N
N
S
E
W
Darnal
Dabamal
Ganvliwad
Kurdi (Uninhabited)
Kaman
Malda
Satarkarawda
Kurpe
0
1
2
km
Legend
1m Contour
Salaulim Reservoir

3D MODEL OF SALAULIM RESERVOIR BED AND BOTTOM TOPOGRAPHY

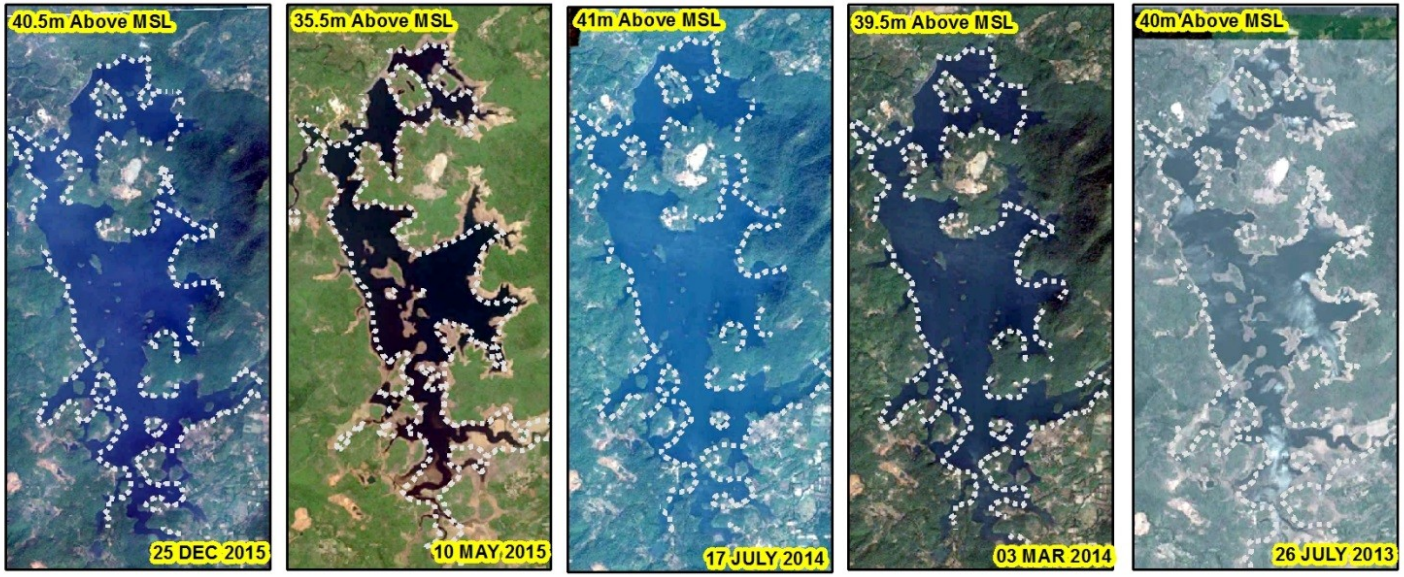


STANDING WATER LEVELS OF SALAULIM RESERVOIR DETERMINED IN SEASONAL GEOEYE DATA BY WRAPPING CONTOUR MAP OF 1M INTERVAL

Images Acquired during Post Monsoon



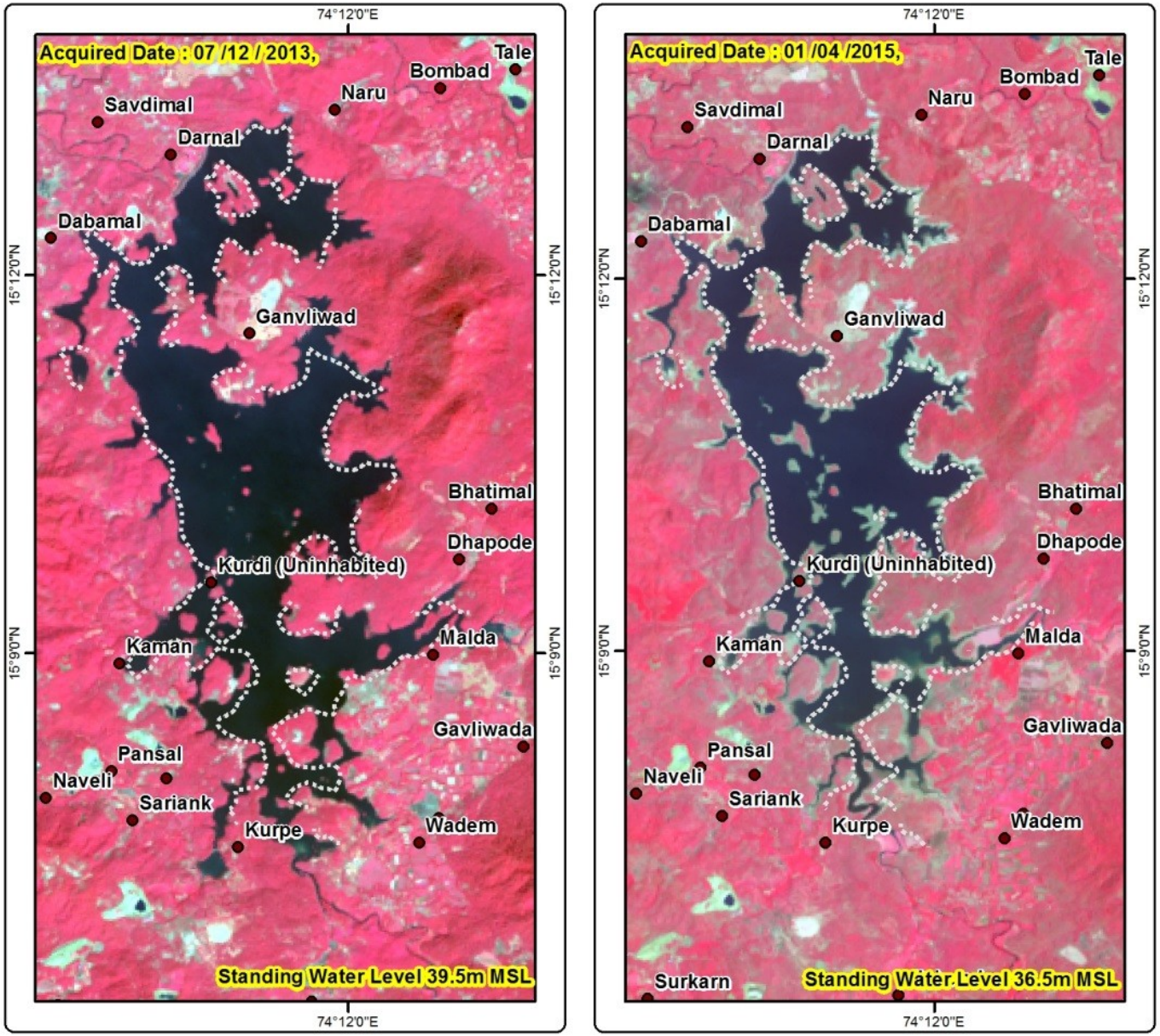
Images Acquired during Pre Monsoon



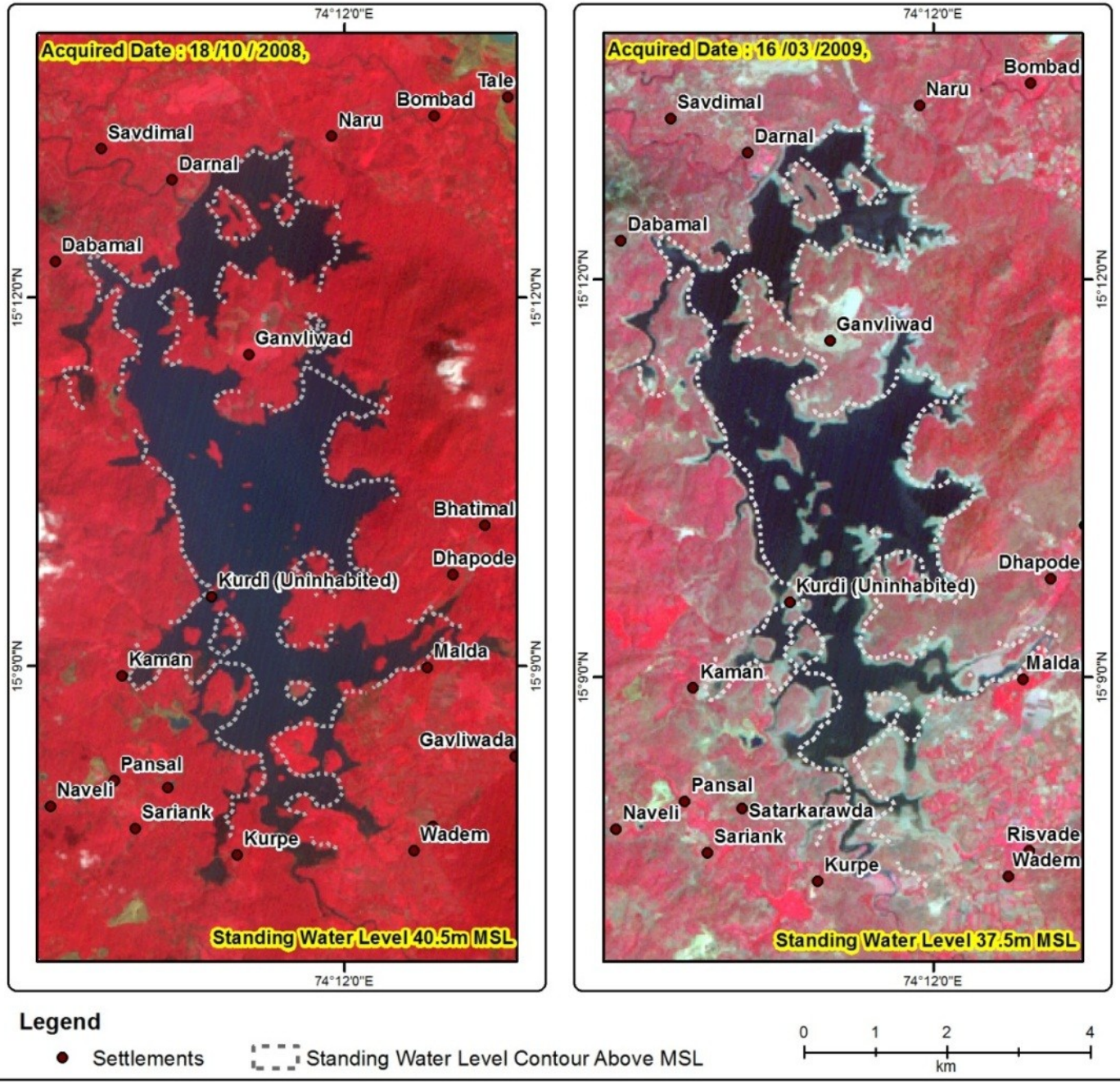
Standing Water Level Contour Above MSL

Data Source : Google Earth

STANDING WATER LEVELS OF SALAULIM RESERVOIR DETERMINED IN SEASONAL LANDSAT8 SATELLITE DATA BY WRAPPING CONTOUR MAP OF 1M INTERVAL



STANDING WATER LEVELS OF SALAULIM RESERVOIR DETERMINED IN SEASONAL IRS-P6 SATELLITE DATA BY WRAPPING CONTOUR MAP OF 1M INTERVAL



Pixel-ID	Location data		GeoEye_10th May, 2015		GeoEye_25th Dec. 2015	
	X-Location	Y-Location	Thickness of Water Column	Pixel wise Water Volume	Thickness of Water Column	Pixel wise Water Volume
1	413264	1683032	0	0	0	0
2	413274	1683032	0	0	0	0
3	413284	1683032	0	0	0	0
4	413294	1683032	0	0	0	0
5	413214	1683022	0	0	0	0
….	…..	…..	….	…..	…..	…..
….	…..	…..	….	…..	…..	…..
….	…..	…..	….	…..	…..	…..
1870	413094	1682732	0	0	0.708	70.8
1871	413104	1682732	0	0	1.3981	139.81
1872	413114	1682732	0	0	2.0131	201.31
1873	413124	1682732	0	0	2.536	253.6
1874	413134	1682732	0	0	2.9608	296.08
….	…..	…..	….	…..	…..	…..
….	…..	…..	….	…..	…..	…..
….	…..	…..	….	…..	…..	…..
291012	413254	1671902	12.4897	1248.97	19.4897	1948.97
291013	413264	1671902	12.6999	1269.99	19.6999	1969.99
291014	413274	1671902	12.8768	1287.68	19.8768	1987.68
291015	413284	1671902	13.011	1301.1	20.011	2001.1
291016	413294	1671902	13.0731	1307.31	20.0731	2007.31
Total Volume of Water in Salaulim Reservoir				111.0978678 MCM		222.339146 MCM

S.No.	Satellite Image Used	Acquired Date Of Seasonal Satellite Image	Standing Water Level of Salaulim Reservoir	Date wise Estimated Volume of Water In Salaulim Reservoir (In Mcm)
1.	GEOEYE (Satellite Data Source : Google Earth)	28/01/2006	37.5	165.0
2.		11/12/2007	37	156.4
3.		22/04/2010	38.5	183.1
4.		16/03/2011	36.5	148.0
5.		05/05/2013	35	117.8
6.		26/07/2013	40	212.0
7.		07/03/2014	39.5	202.1
8.		17/07/2014	41**	232.9**
9.		10/05/2015	35.5*	111.0*
10.		25/12/2015	40.5	222.3
11.	LANDSAT-8	07/12/2013	39.5	202.1
12.		01/04/2015	36.5	148.0
13.	IRS P6 LISSIII	18/10/2008	40.5	222.3
14.		16/03/2009	37.5	165.0

VALIDATION OF THE MODEL

- In the web page, www.WeatherinGoa.Blogspot.com, written by Atul Naik (2014), the water levels in Salaulim Reservoir were reported for the dates 26th, July 2013 and 17th July 2014, as 41.15m and 42.42m respectively.
- The differences in water levels determined through this research study are: -1.15m and -1.42m respectively on these dates.

This paper is available online @ https:// www.ijariit.com/manuscrips/v3i2/v3l2-1535.pdf

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STUDY - 3

SURFACE WATER TARGETTING - A SPATIAL DESIGN

Back

METHODOLOGY IN BRIEF

- GIS Image Creation Showing Water Bodies Deduced from
  - Topo Sheets
  - Satellite FCC Data
  - Satellite IR Data
  - GIS Integration & Detection of Target Areas

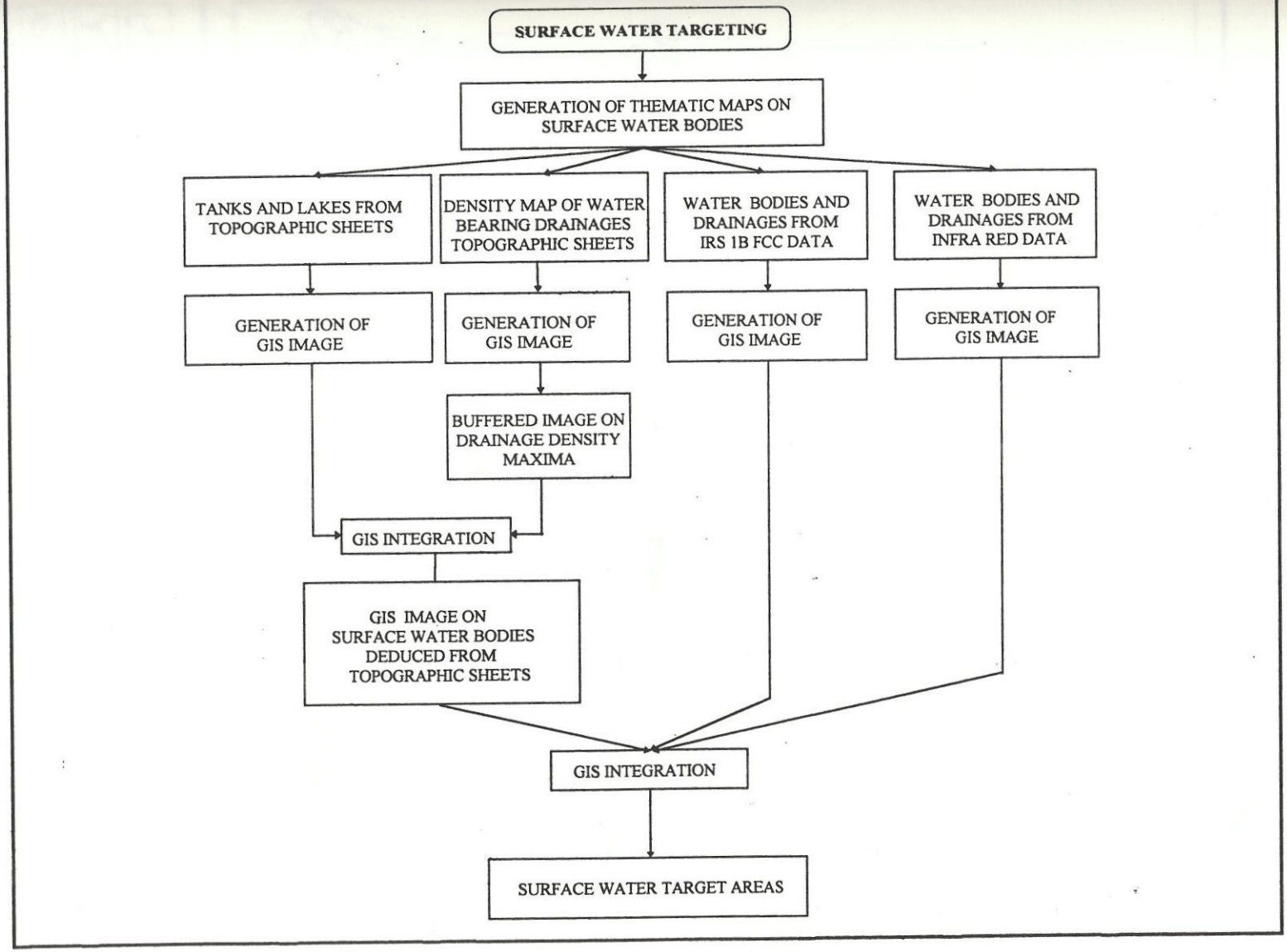
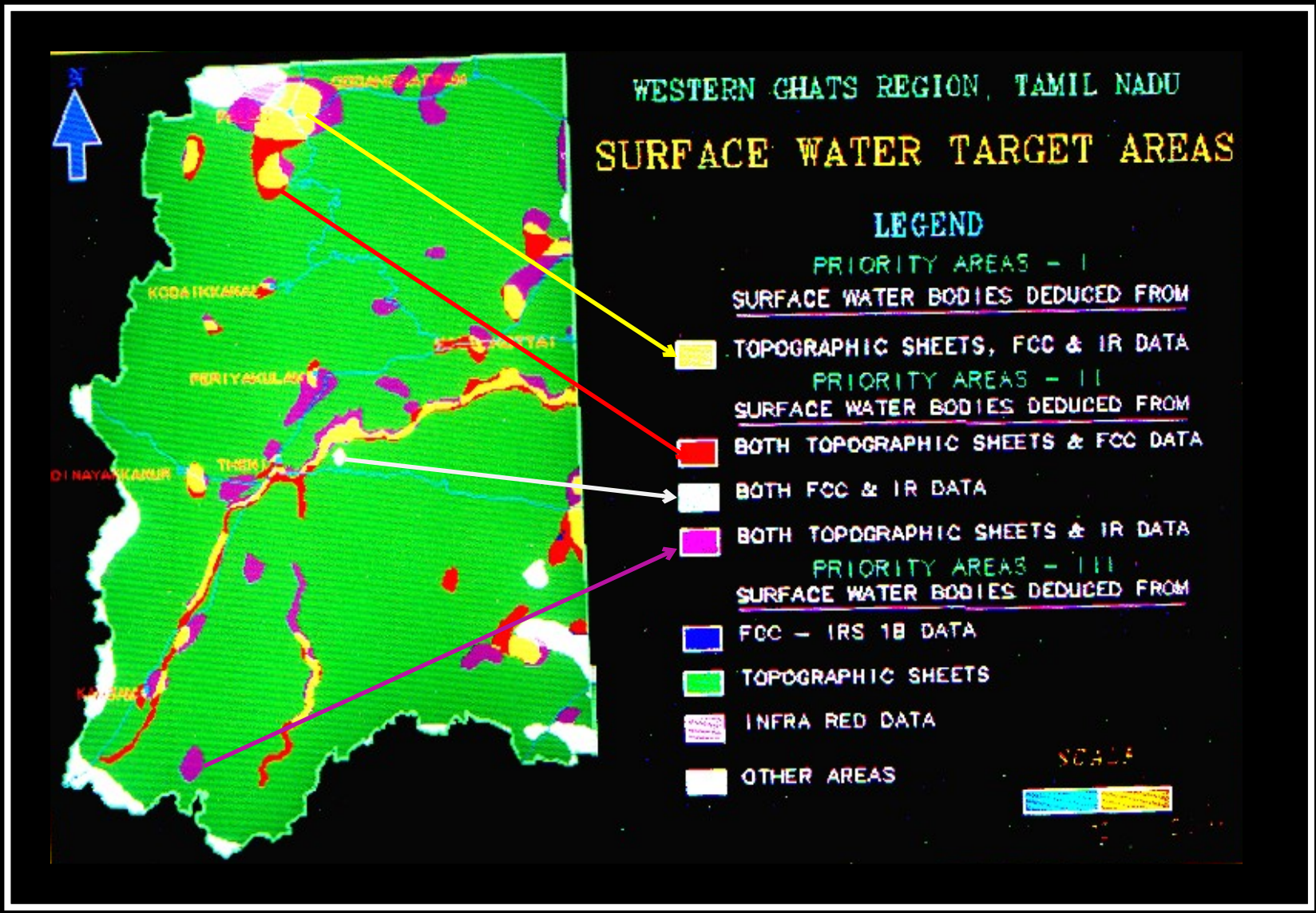


FIGURE 3.1 METHODOLOGY FLOW CHART


WESTERN GHATS REGION, TAMIL NADU
SURFACE WATER TARGET AREAS
LEGEND
PRIORITY AREAS - I
SURFACE WATER BODIES DEDUCED FROM
TOPOGRAPHIC SHEETS, FCC & IR DATA
PRIORITY AREAS - II
SURFACE WATER BODIES DEDUCED FROM
BOTH TOPOGRAPHIC SHEETS & FCC DATA
BOTH FCC & IR DATA
BOTH TOPOGRAPHIC SHEETS & IR DATA
PRIORITY AREAS - III
SURFACE WATER BODIES DEDUCED FROM
FCC - IRS 1B DATA
TOPOGRAPHIC SHEETS
INFRA RED DATA
OTHER AREAS
SCALE
N
KODAIKKANAL
PERIYAKULAM

Back

STUDY 4

SURFACE WATER QUALITY FROM SATELLITE DATA

- **A Model from Cauvery River**

Back

METHODOLOGY IN BRIEF

- Spectro-Radiometric Survey in **Six** Pollution Points in Cauvery for **5** Days
- Thus, generation of 30 Data Bases on TM **4** bands, IRS **4** bands and SPOT **3** bands (30 x11)
- Water Sample Collection and Quality Analysis of 30 Samples on Temperature, Turbidity, B.O.D, C.O.D, Total Hardness, Nitrate, pH, Silica, Fluoride, etc.
- Carry out Graphical Correlation
- Carry out Bivariate Regression Analysis and
- Generate Pollution Monitoring Model Directly from Satellite Data.

CHINTHAMANI AREA

Physico - Chemical Parametes	*TM bands*				*Chinthamani IRS bands*				*Spot bands*		
	1	2	3	4	1	2	3	4	1	2	3
Temperature	F	N	N	N	N	N	N	N	N	N	N
Turbidity	–	–	–	–	–	–	–	–	–	–	–
Biological Oxygen Demand	F	⊖	F	F	F	⊖	N	⊕	N	⊕	⊖
Chemical Oxygen Demand	F	⊕	F	F	F	⊕	N	⊕	N	⊕	⊕
Total Hardness	F	⊕	F	F	F	⊕	N	⊕	N	⊕	⊕
Nitrate	N	⊕	N	F	F	⊖	N	⊕	N	⊕	N
pH	–	–	–	–	–	–	–	–	–	–	–
Silica	N	N	N	N	N	⊕	F	N	N	N	N
Flouride	–	–	–	–	–	–	–	–	–	–	–

\+ Positive correlation F Fair correlation

\- Negative correlation N No correlation

SARKARPALAYAM AREA

Physico - Chemical Parameters	*Sarkarpalayam*										
	TM bands				*IRS bands*				*Spot bands*		
	1	2	3	4	1	2	3	4	1	2	3
Temperature	F	F	F	F	F	⊕	⊕	F	⊕	F	F
Turbidity	–	–	–	–	–	–	–	–	–	–	–
Biological Oxygen Demand	F	⊕	F	F	F	F	F	F	F	F	F
Chemical Oxygen Demand	F	F	⊕	F	F	F	F	F	F	F	F
Total Hardness	F	F	⊕	F	F	F	F	F	F	F	F
Nitrate	F	⊕	⊕	F	F	⊕	F	⊕	F	F	F
pH	–	–	–	–	–	–	–	–	–	–	–
Silica	F	⊕	⊕	F	F	⊕	F	⊕	F	F	F
Flouride	F	⊕	⊕	F	F	⊕	F	⊕	F	F	F

+ **Positive correlation** **F Fair correlation**

- **Negative correlation** **N No correlation**

RESULTS

- Water Temperature can be Monitored from TM band2, IRS band2
- B.O.D – TM band3, IRS band3
- C.O.D – TM band2, IRS band2.

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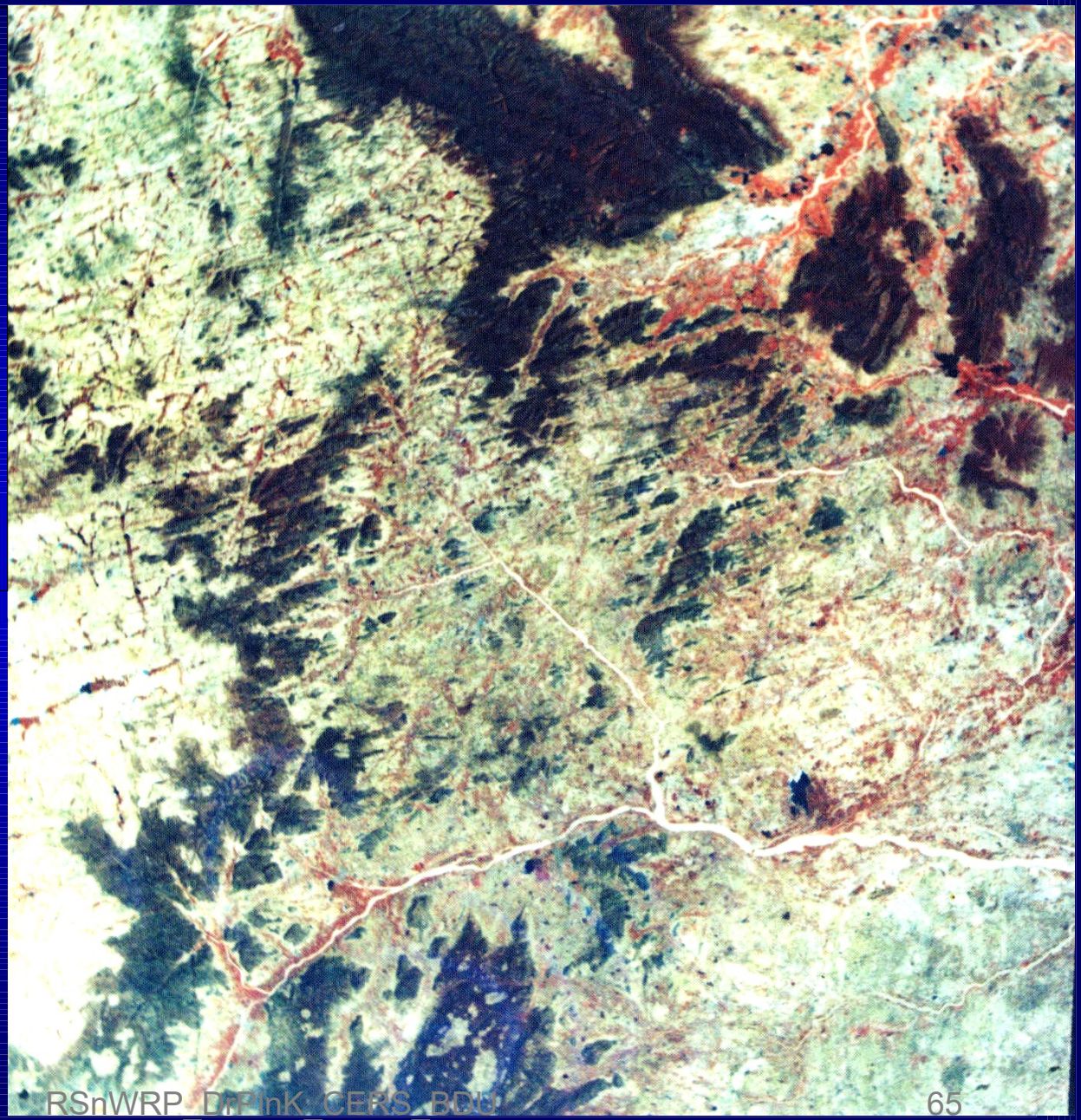
STUDY - 5

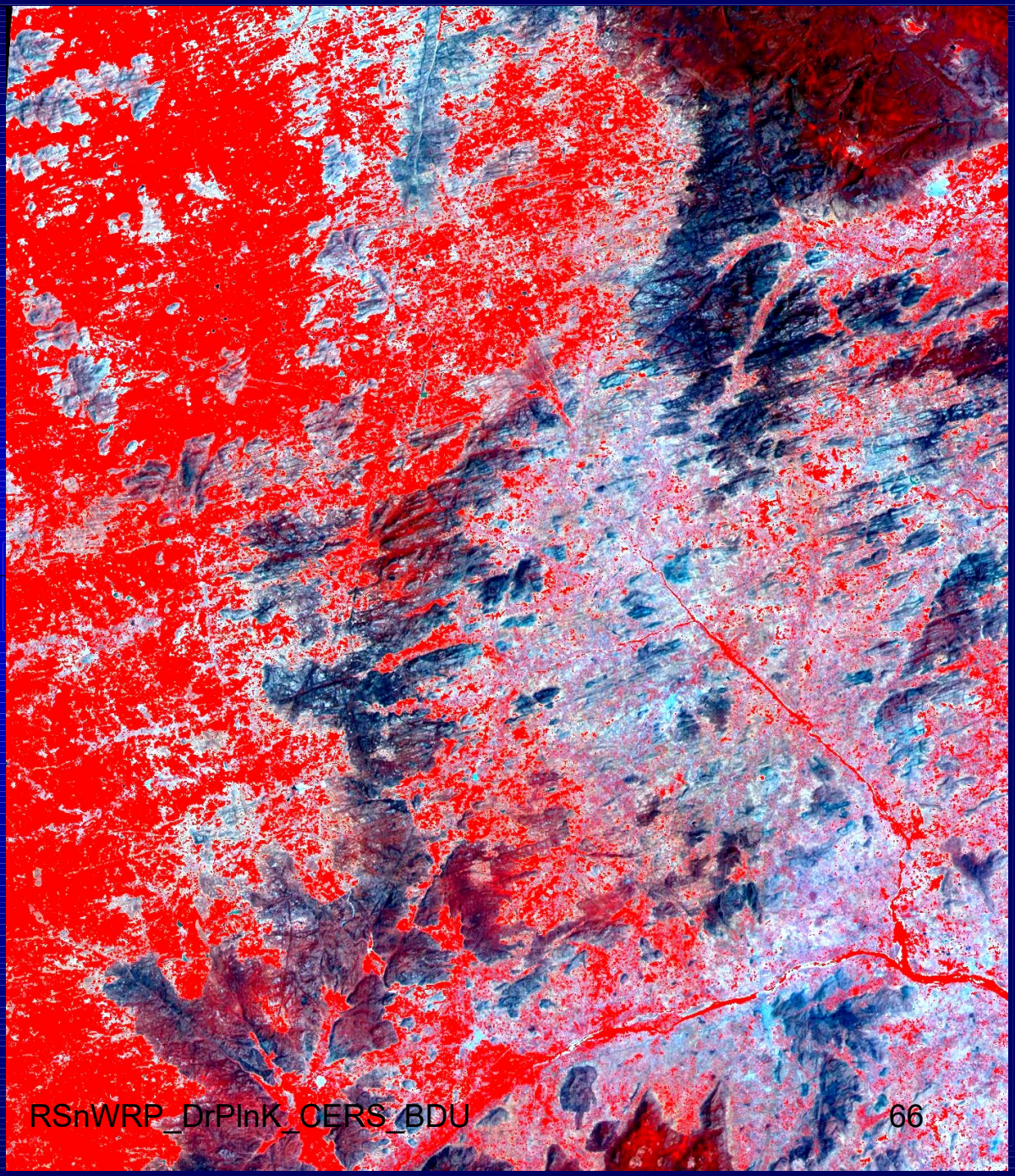
SOIL EROSION - RESERVOIR SILTATION AND REMEDIAL MEASURES

Back



SOIL EROSION – TIRUTTANI & TIRUMALA REGION

SOUTH INDIA



SOIL EROSION – TIRUTTANI & TIRUMALA REGION

PROCESSED IMAGE

Silted Water Bodies

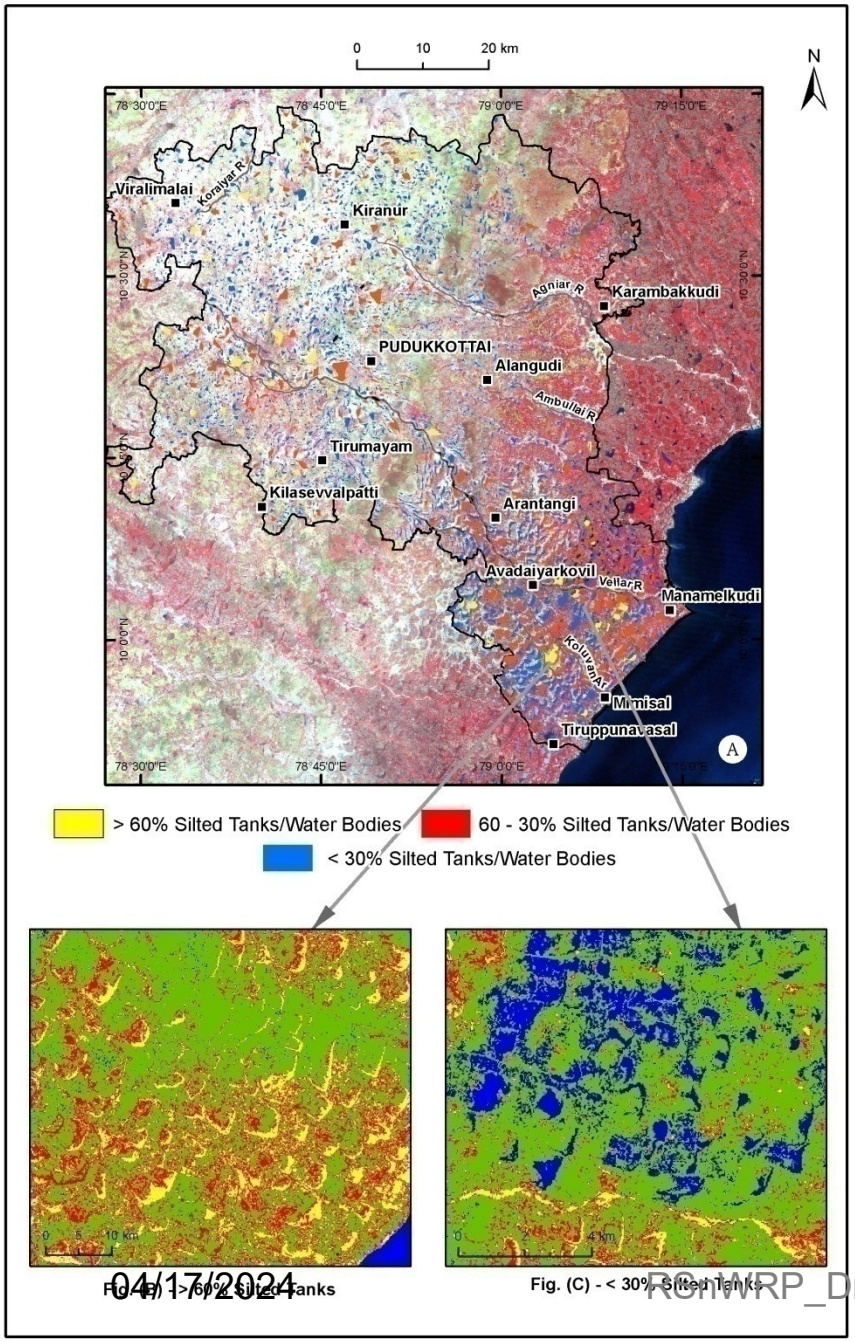


Fig. 5.2 IRS FCC (A) and Density Sliced (B and C) Images showing Silted Water Bodies

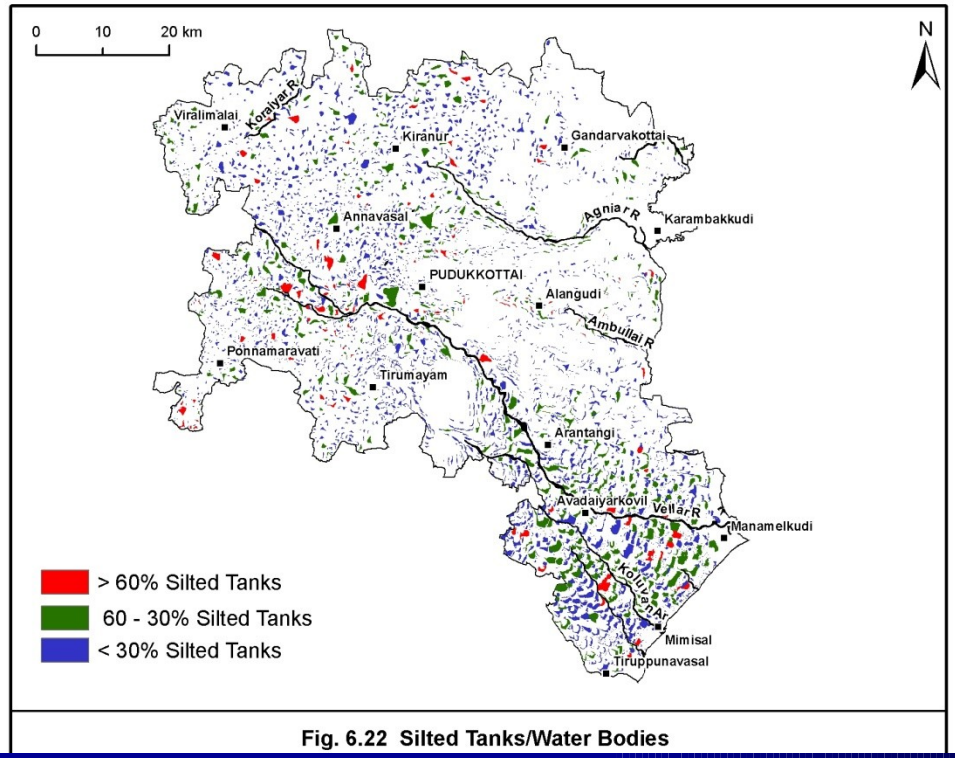


Fig. 6.22 Silted Tanks/Water Bodies

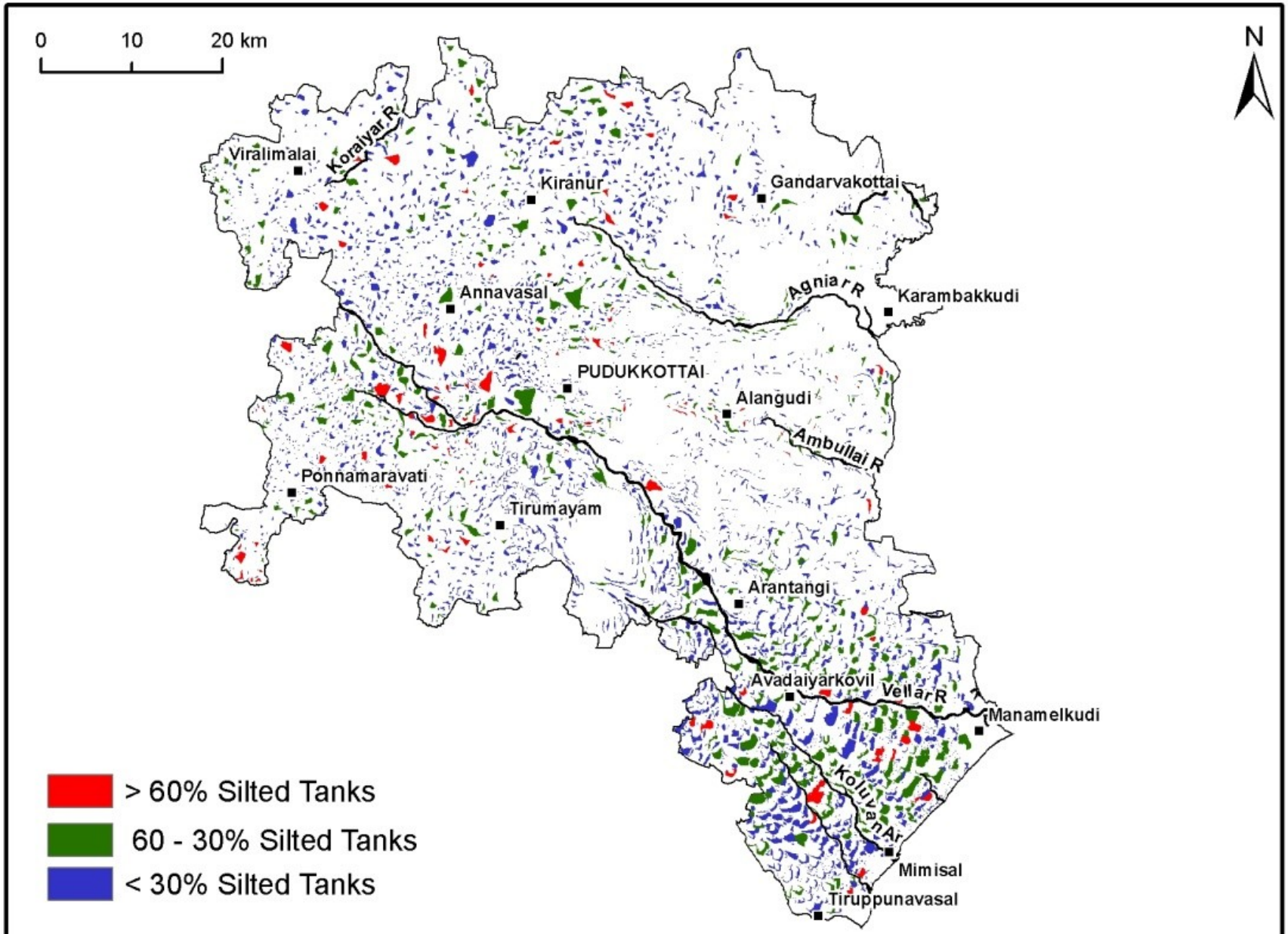
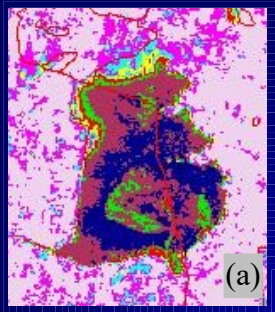
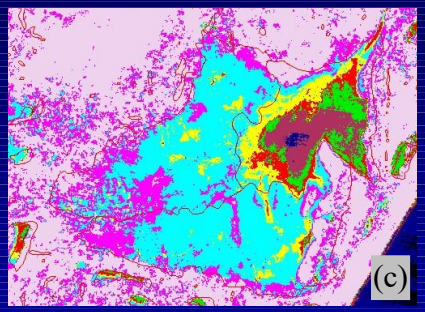
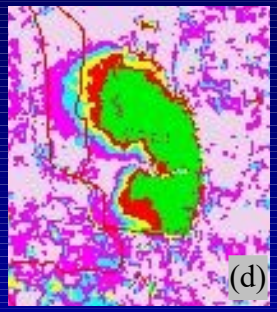
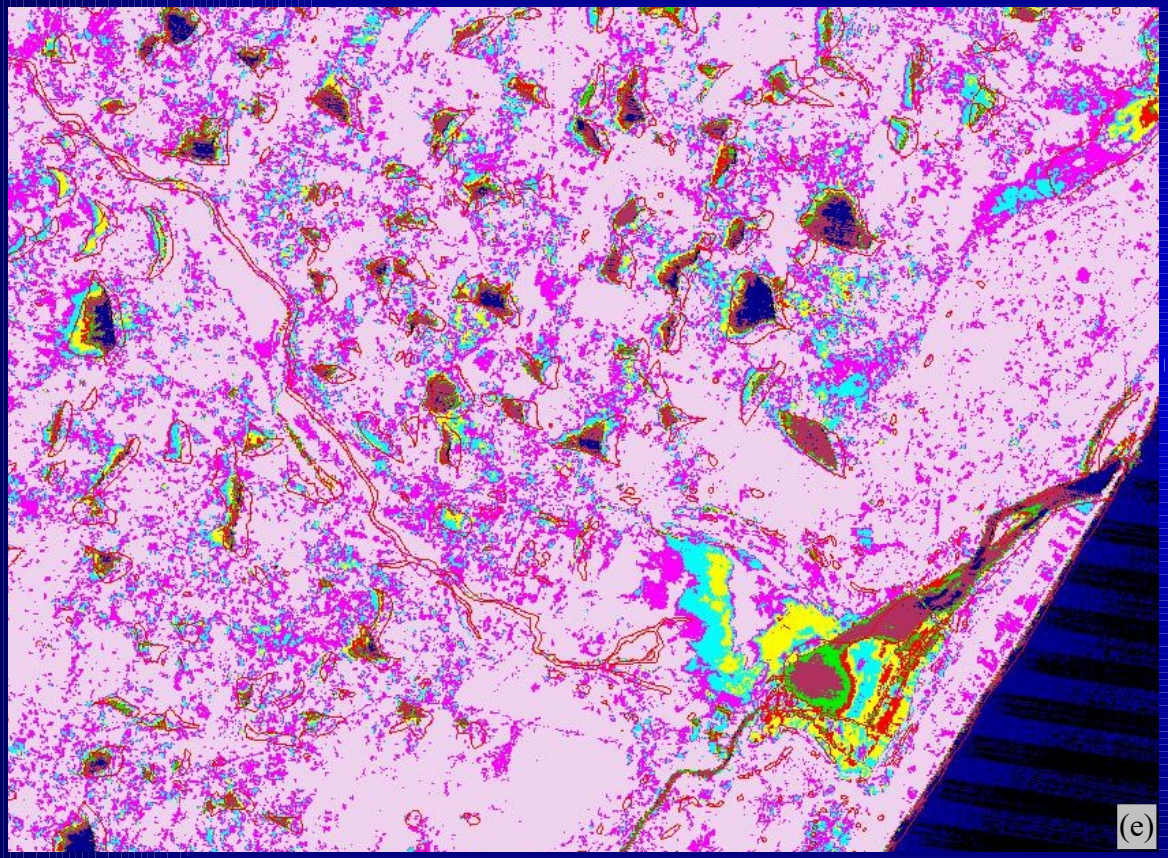


Fig. 6.22 Silted Tanks/Water Bodies

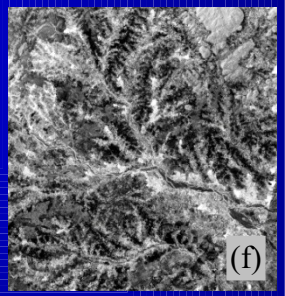


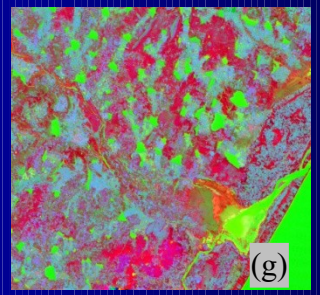


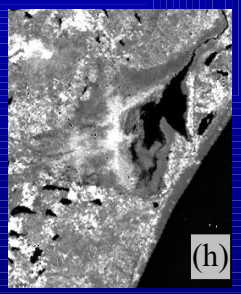


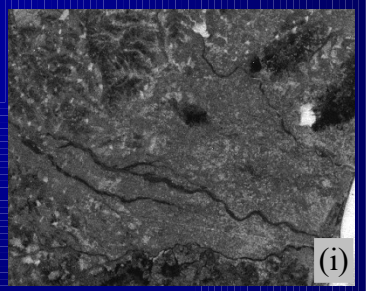


Density Sliced Images (a – e):
0-7 Black-Water
8-10 Blue-Muddy Water
11-15 Maroon-Less silted
16-20 Green-Moderately Silted
42-52 Cyan-Extinct Water Bodies
21-31 Red- Silted
32-41 Yellow-Heavily Silted
53-63 Magenda-Eroded/silted area
64-255 Thistle-Other Land areas





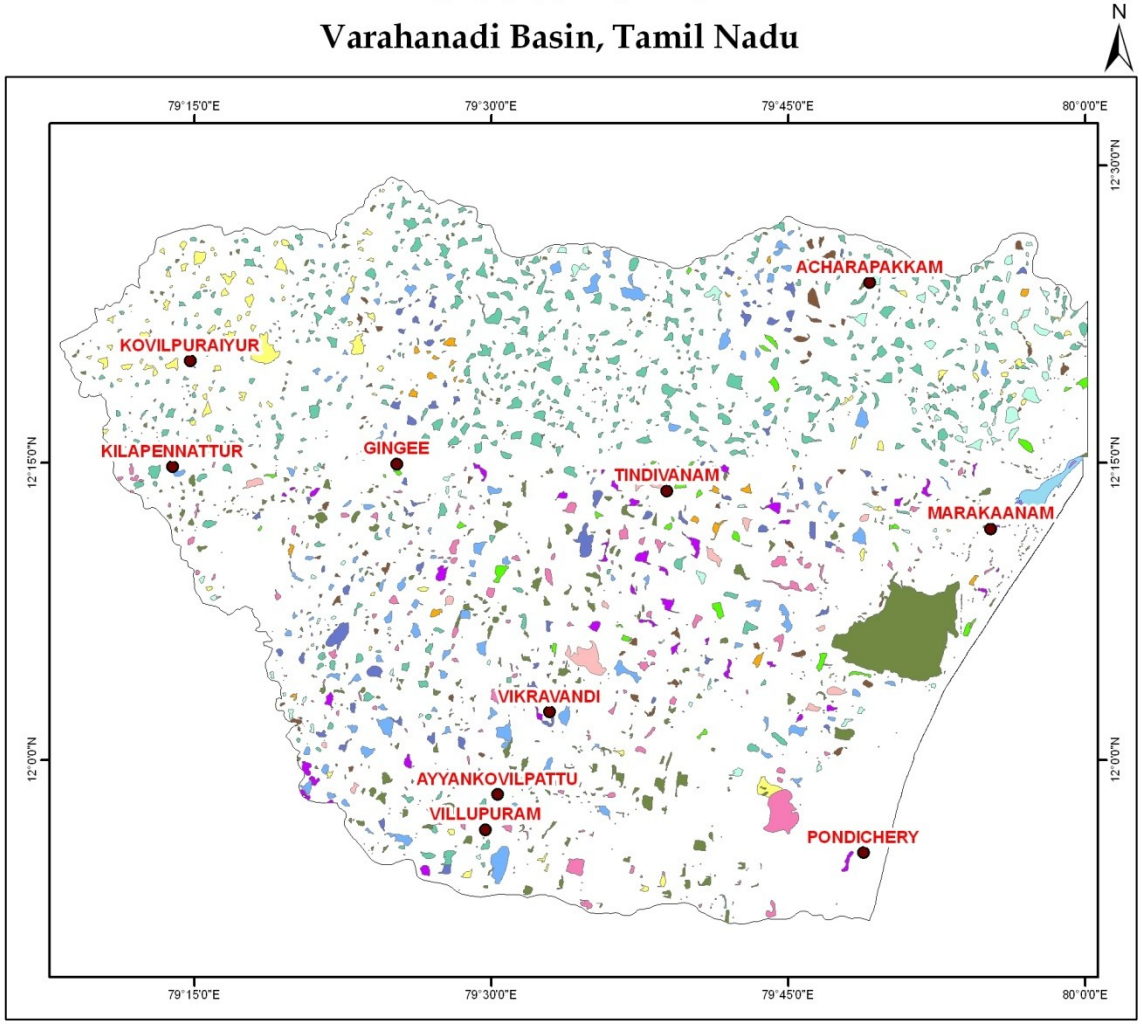




Principal Component Analyses: PC3 Image-Gullies(f), PC432 combination–Eroded upland(g),
Band Ratios: 1/3–Siltation levels(h), 4/3–Unpaired deltaic plain(i)

Graded Tanks

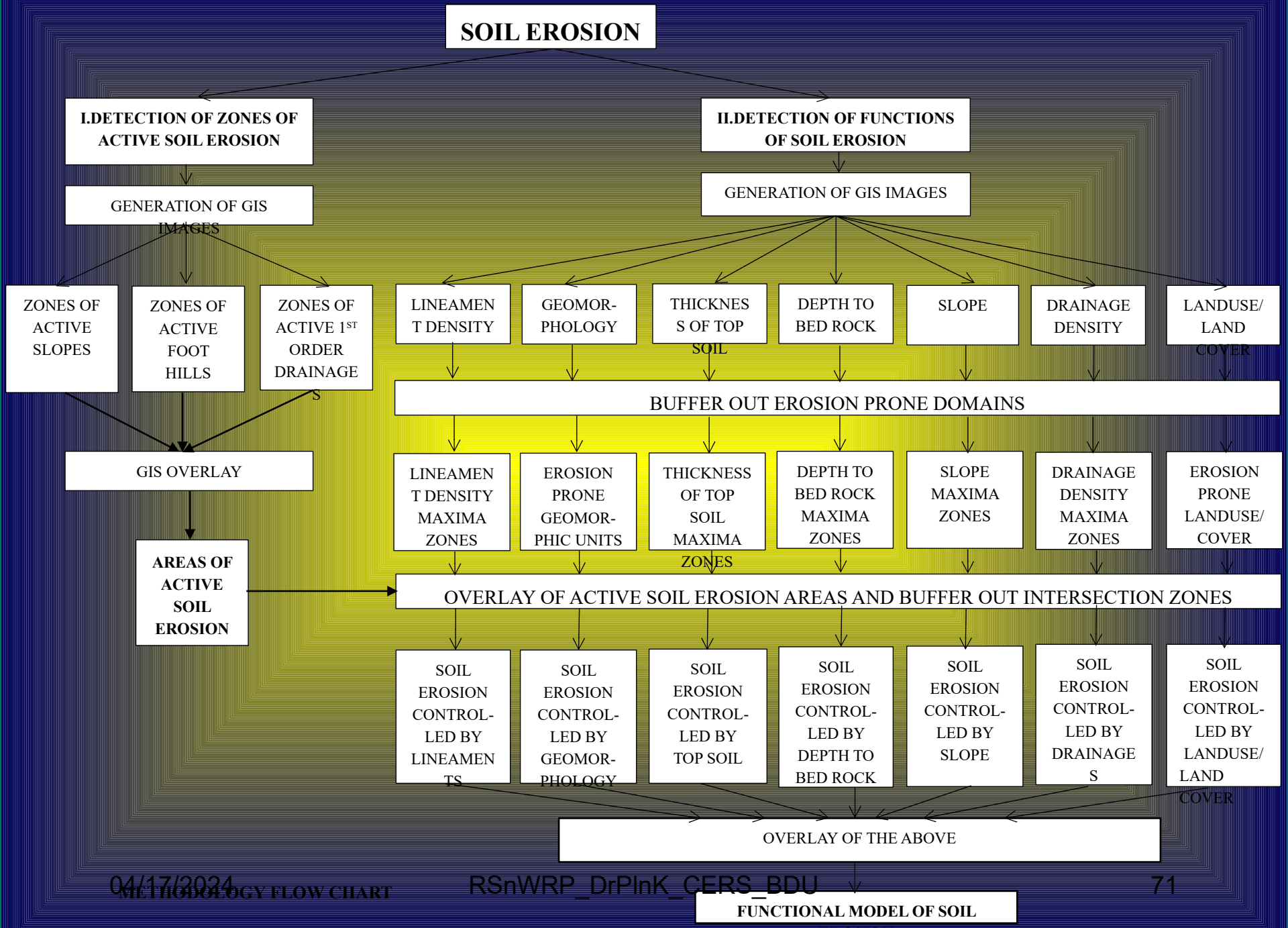
Varahanadi Basin, Tamil Nadu



LEGEND

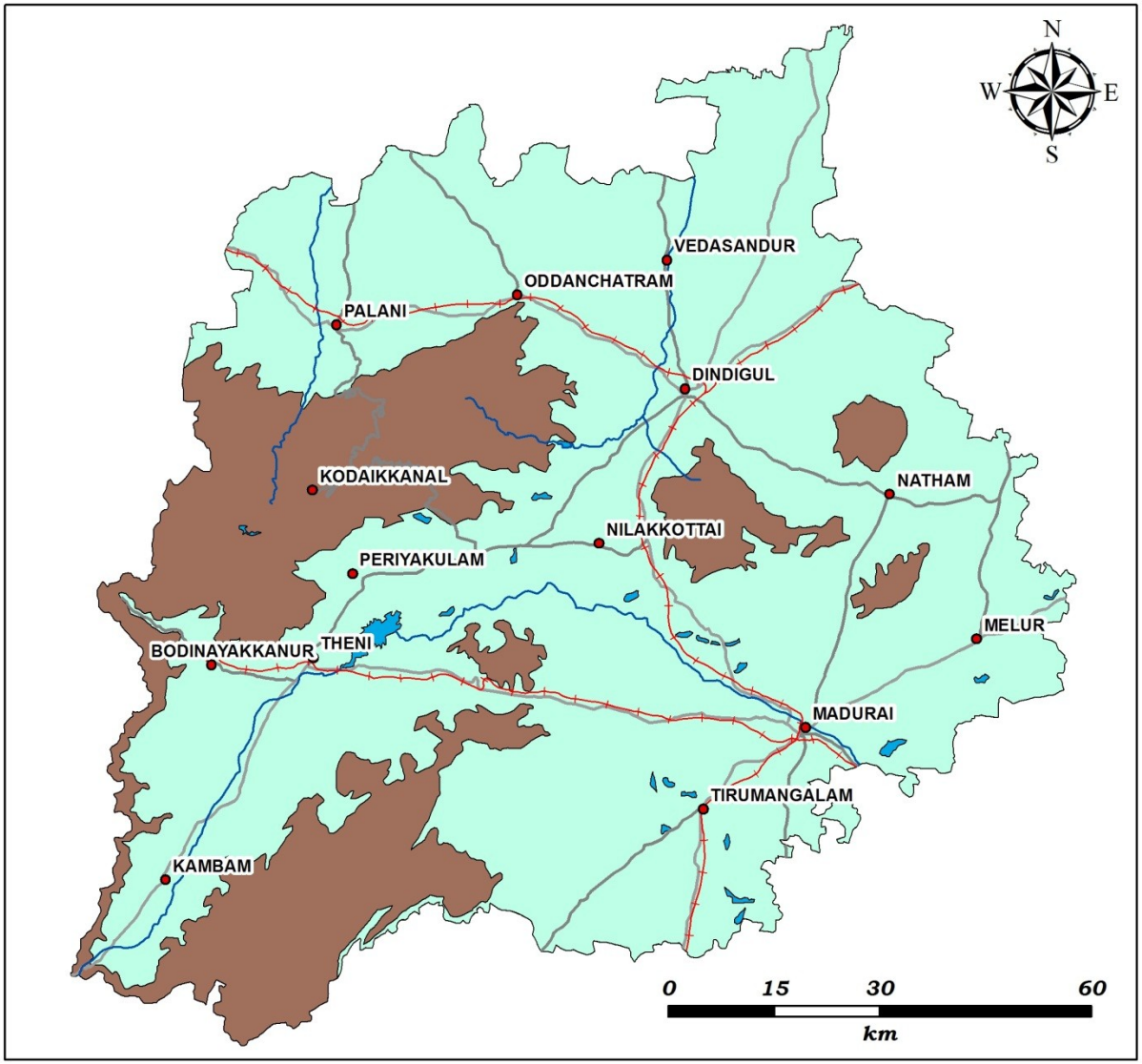
- SETTLEMENT
- 1 - DEFUNCT
- 1V - DEFUNCT + VEGETATED
- 2 - 80% SILTED
- 2V - 80% SILTED + VEGETATED
- 3 - 60 - 80% SILTED
- 3V - 60 - 80% SILTED + VEGETATED
- 4 - 40 - 60% SILTED
- 4V - 40 - 60% SILTED + VEGETATED
- 5 - 20 - 40 % SILTED
- 5V - 20 - 40% SILTED + VEGETATED
- 6 - < 20 % SILTED
- 6V - < 20 % SILTED + VEGETATED
- RIVER

RSnWRP_DrPlnK_CERS_BDU



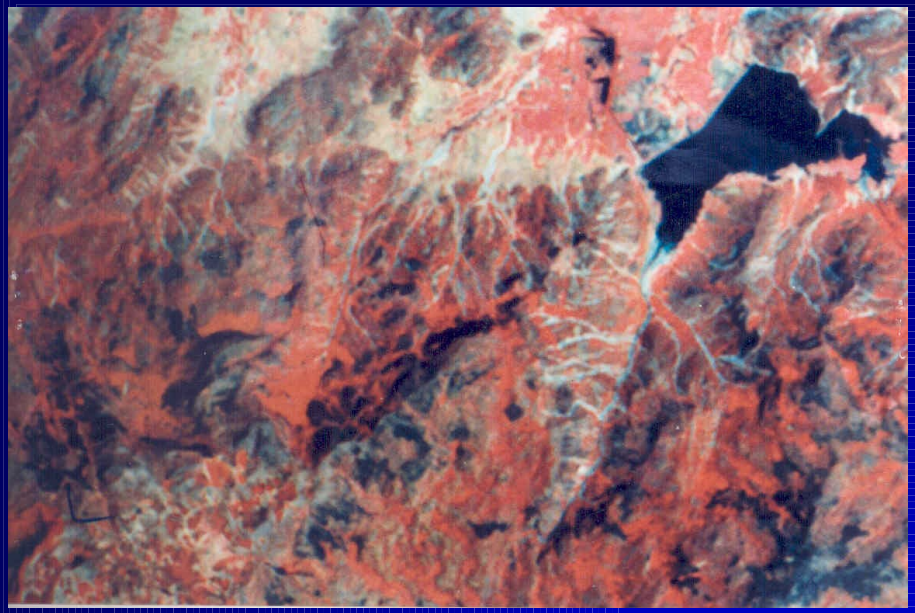
METHODOLOGY FLOW CHART

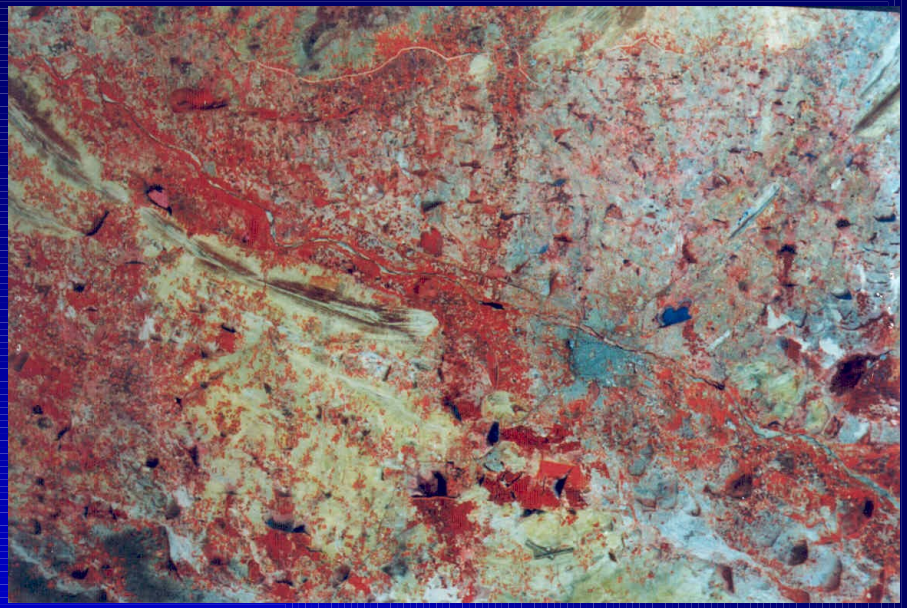
BASE MAP
Parts of Western Ghats, Tamil Nadu



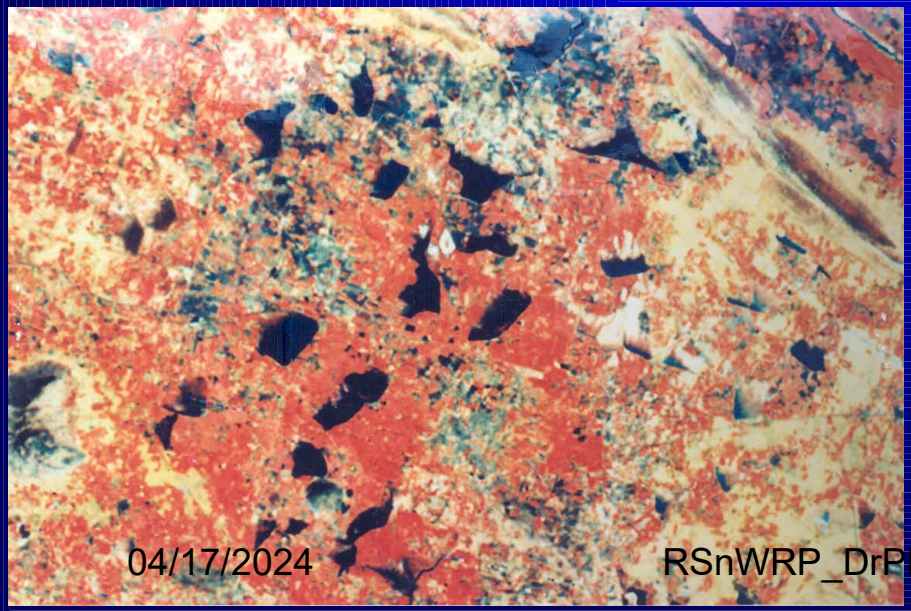
Legend

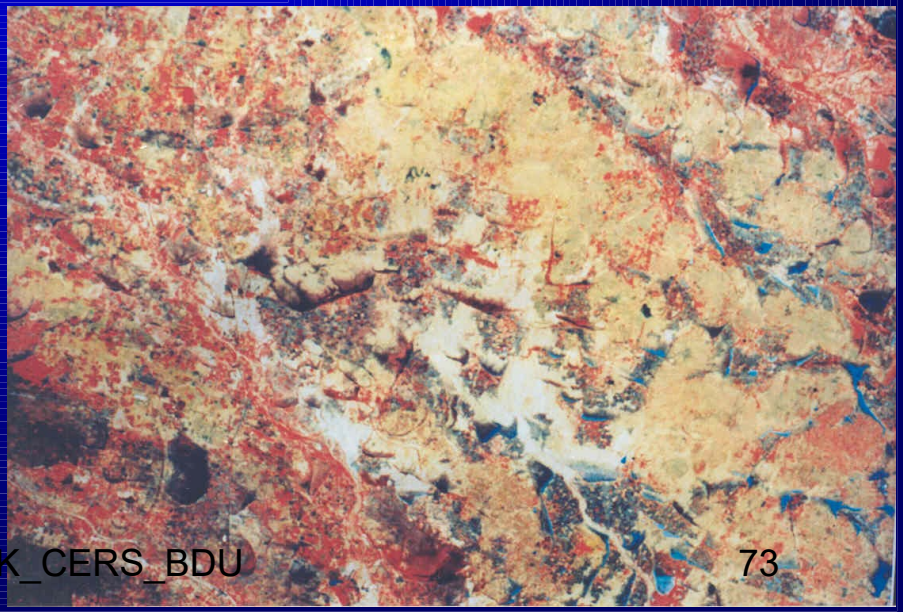
- Major Settlements
- Rail Network
- Major Road Network
- River
- Reservoirs / Major Tanks
- Major Hills
- Plain



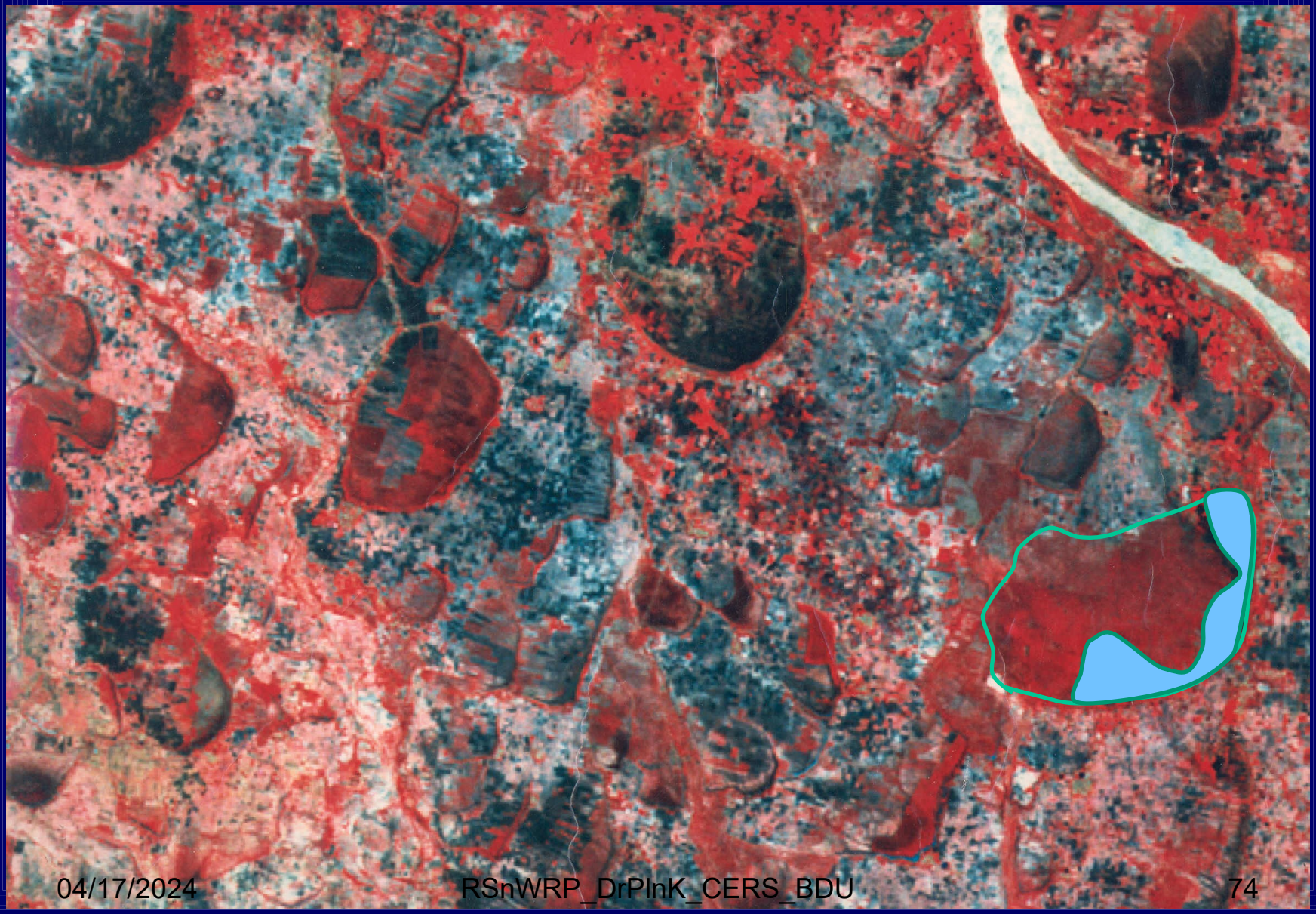


IRS satellite FCC images showing areas of soil erosion and silted water bodies





SILTATION OF TANKS



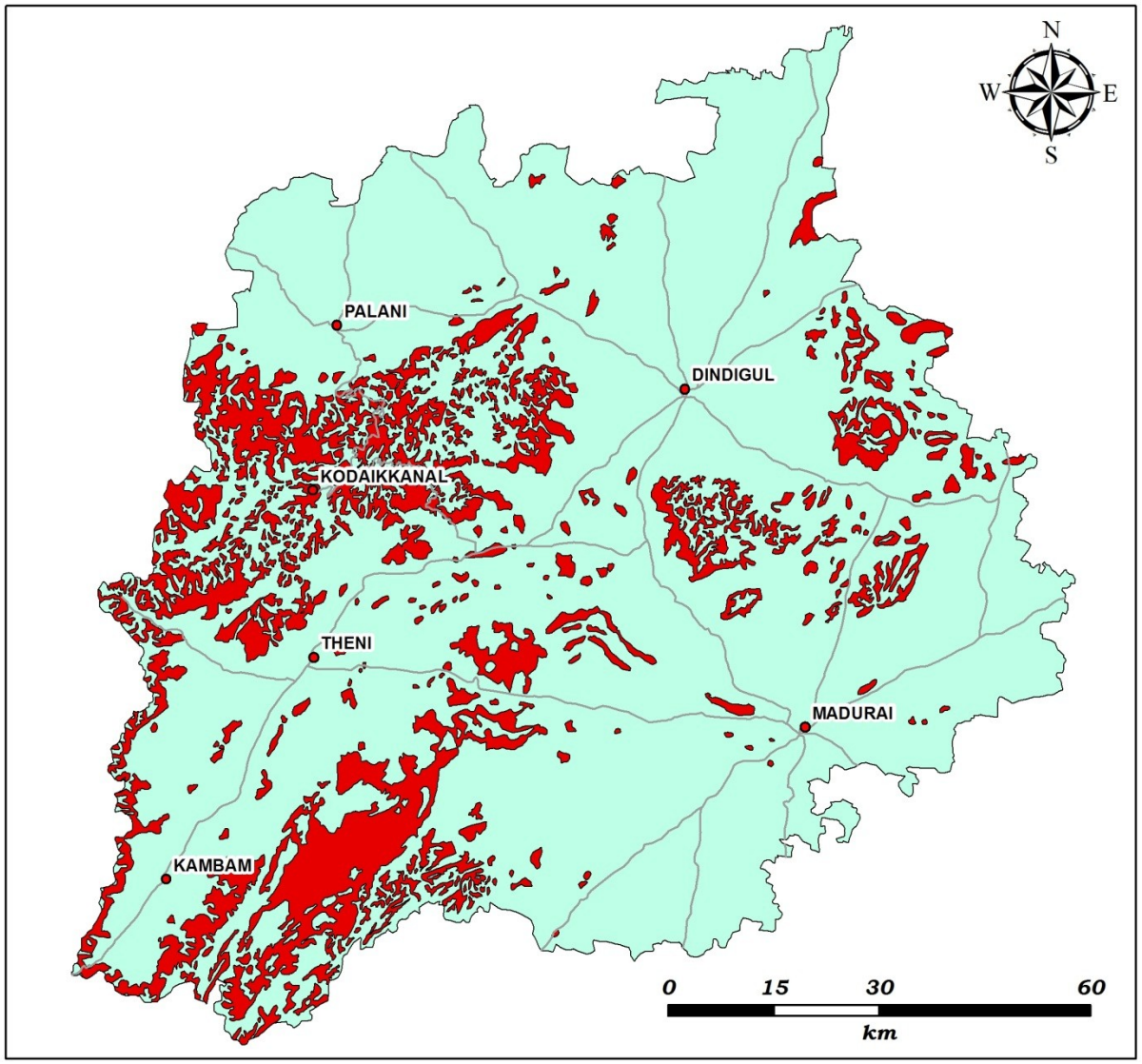

4
554


611


612


G
D
VF

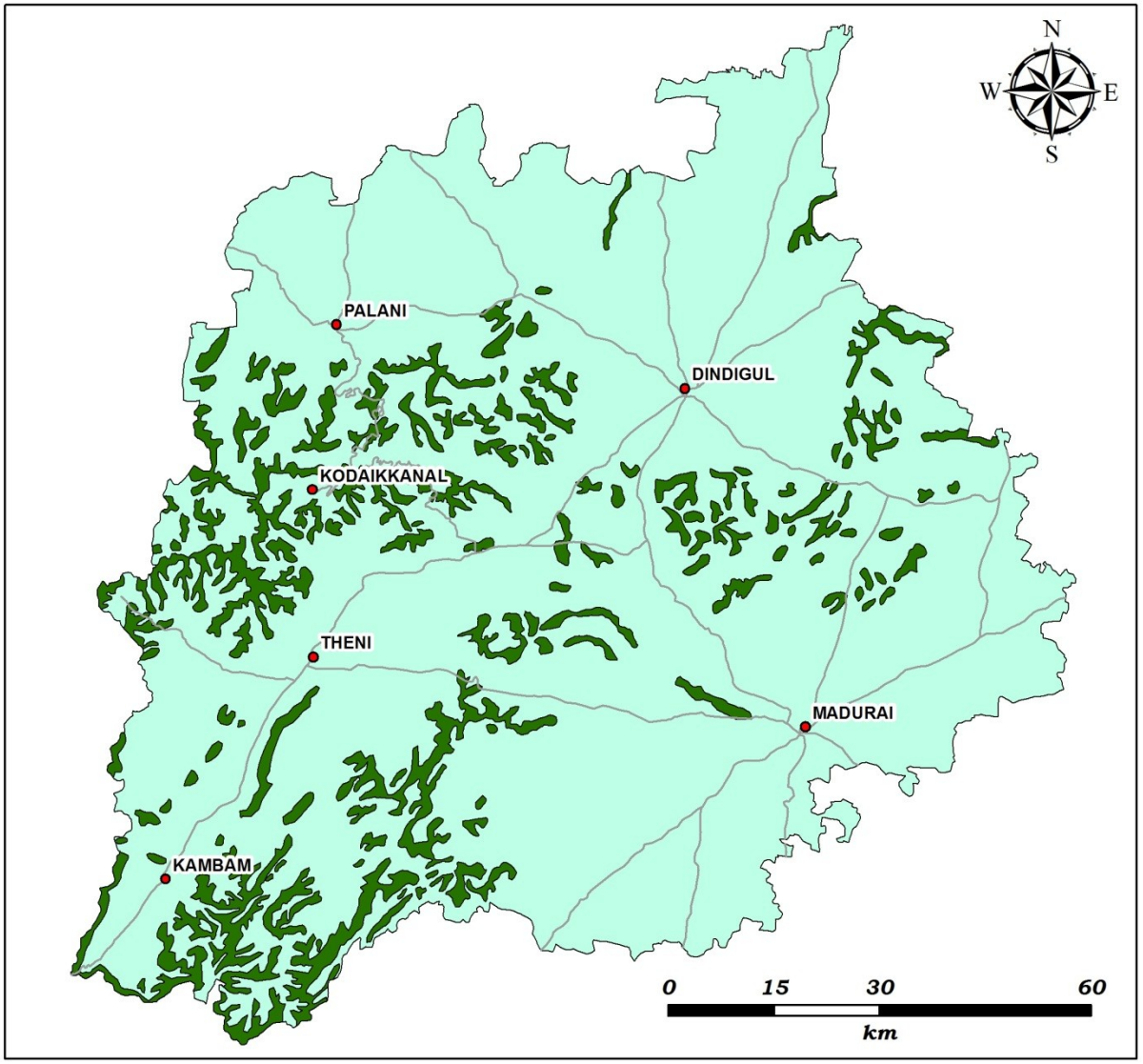
ACTIVE SLOPE AREAS



Legend

- Settlement
- Road Network
- Active Slope Areas
- Other Area

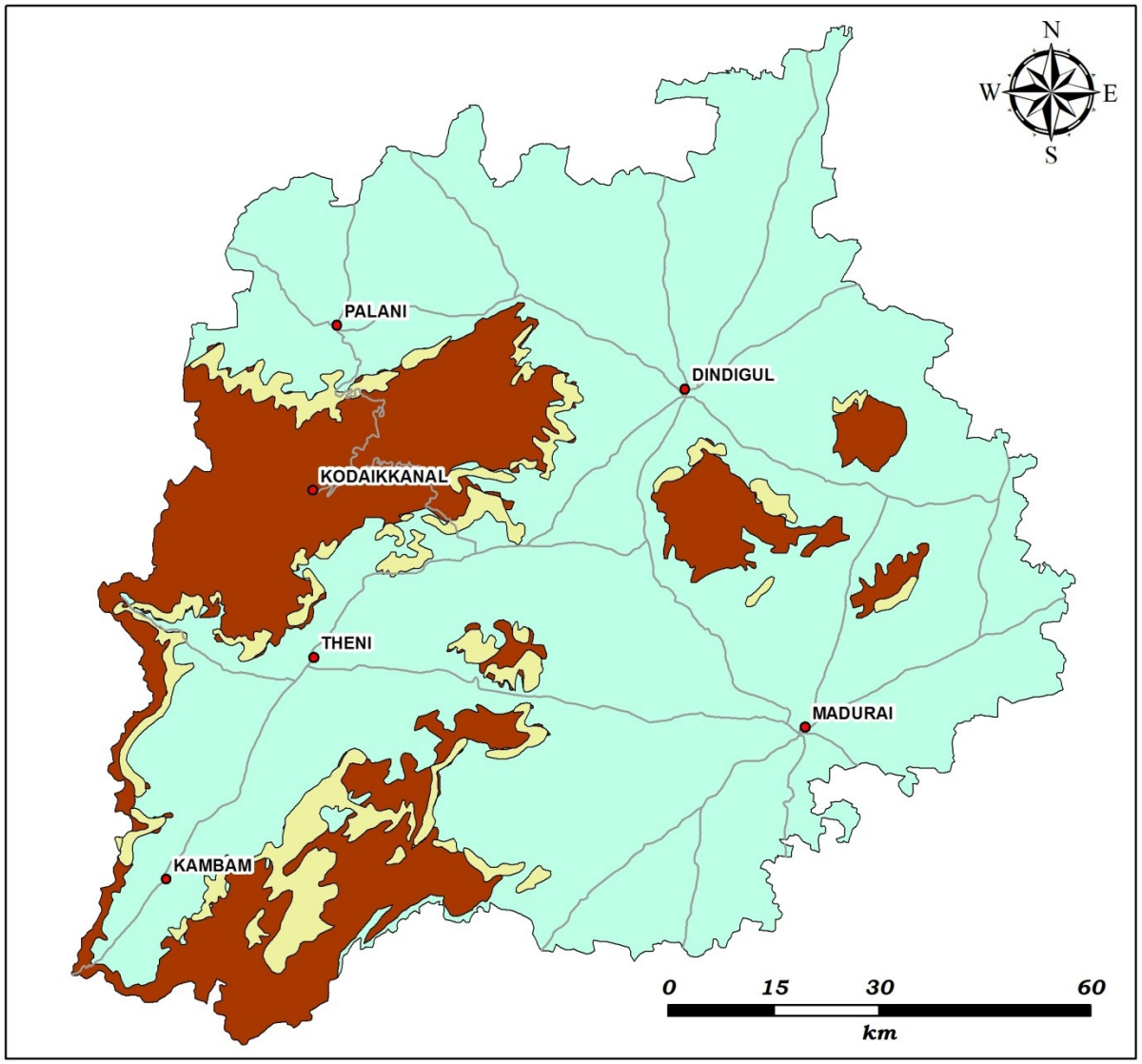
AREAS OF FIRST ORDER DRAINAGES



Legend

- Settlement
- Road Network
- Areas of First Order Drainages
- Other Area

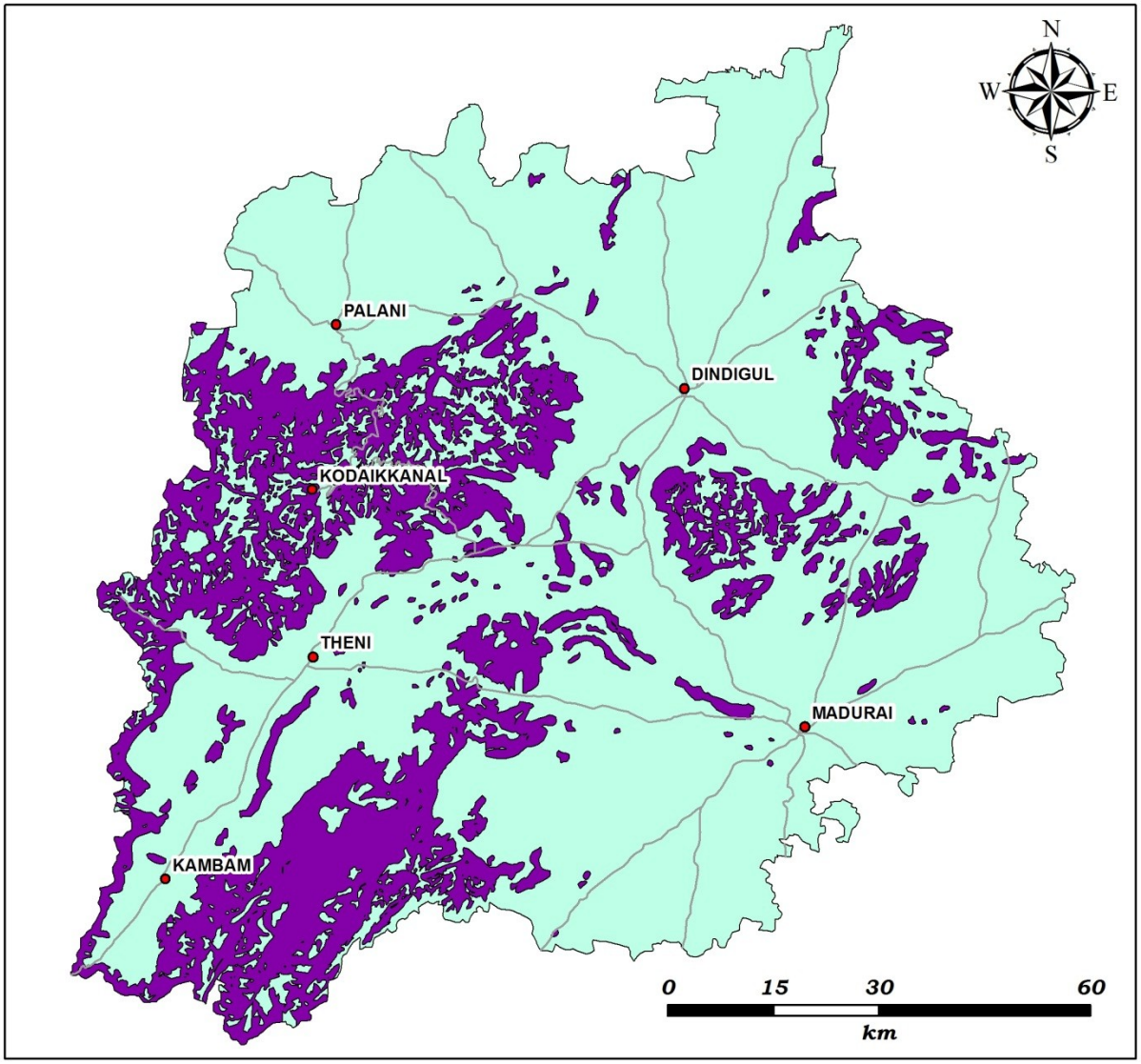
ACTIVE FOOT HILLS



Legend

- Settlement
- Road Network
- Active Foot Hills
- Hills
- Other Area

AREAS OF ACTIVE SOIL EROSION

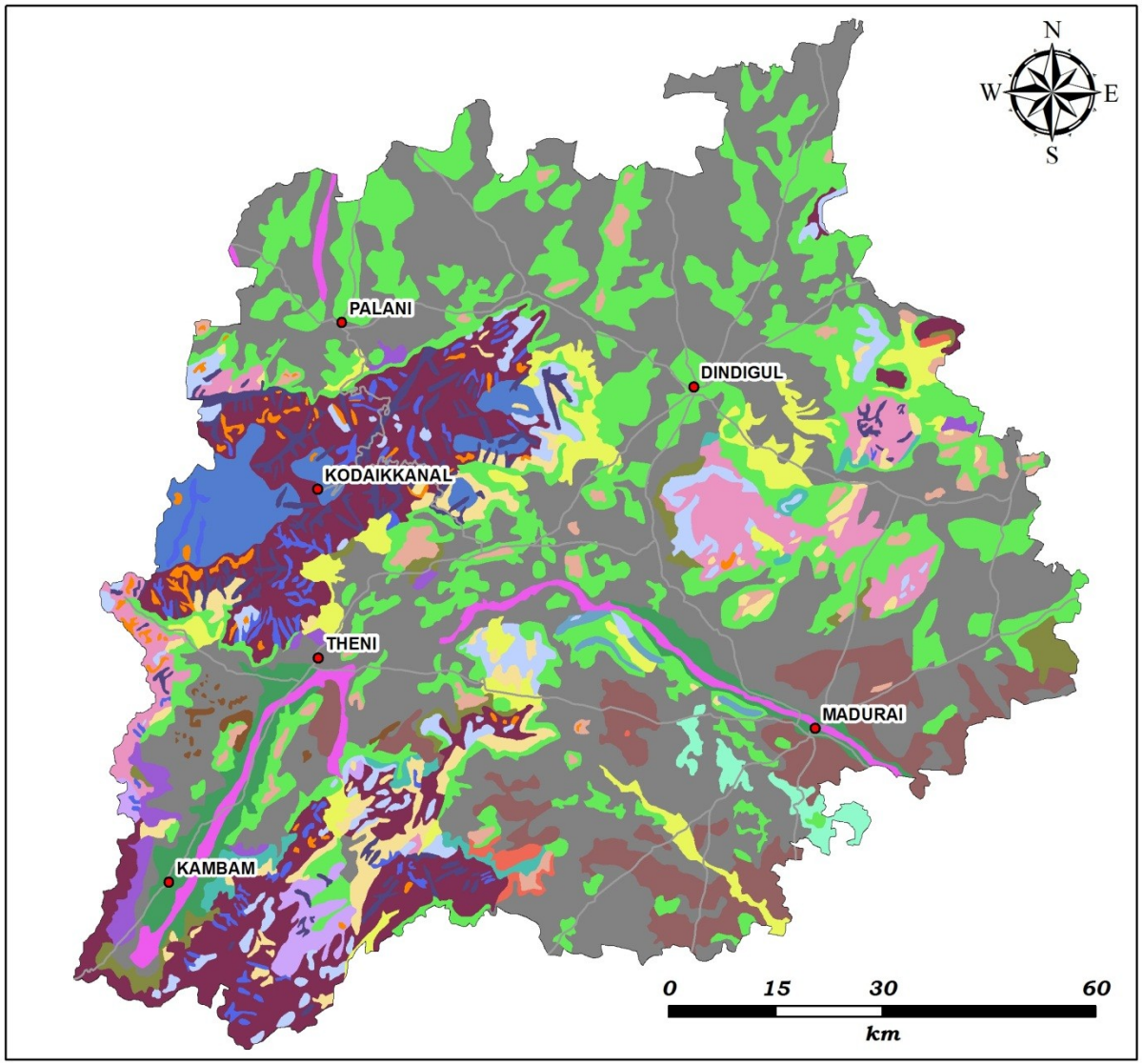


Legend

- Settlement
- Road Network
- Areas of Active Soil Erosion
- Other Area

(Combined Image of zones of
- Active Slopes
- Active Foot Hills and
- First Order Drainages)

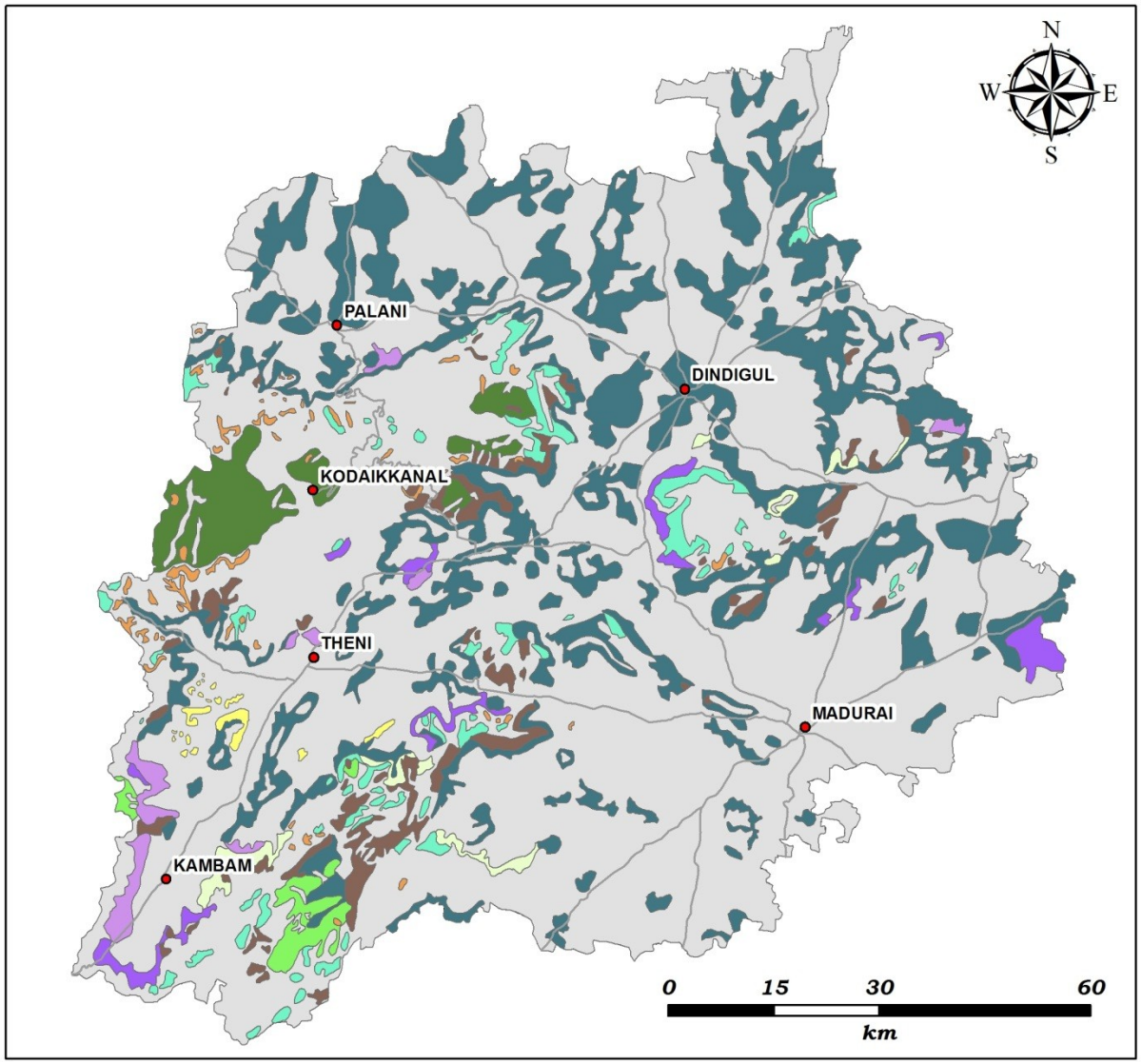
GEOMORPHOLOGY



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

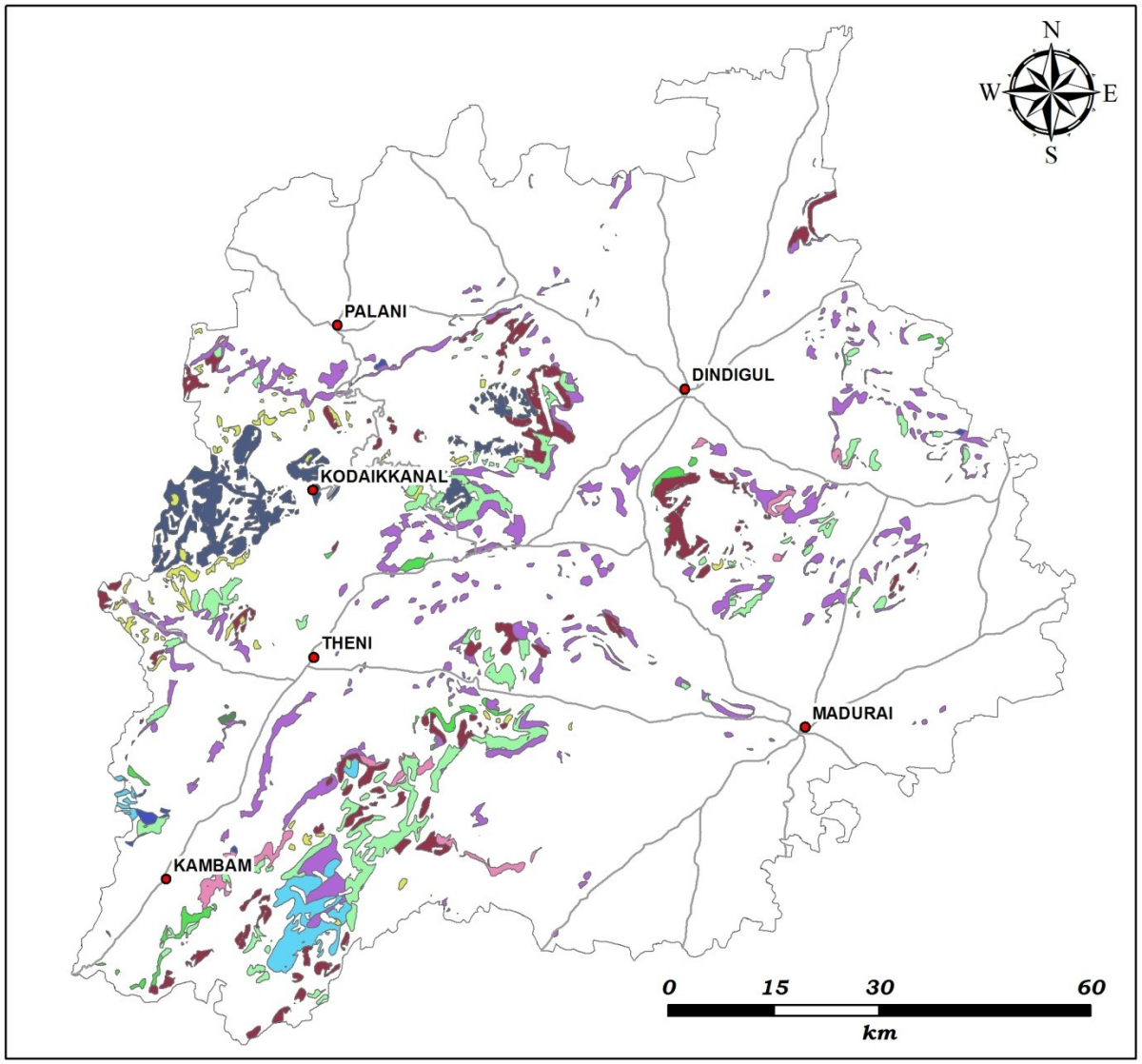
GEOMORPHOLOGY - EROSION PRONE



Legend

- Settlement
- Road Network
- Dissected Erosional Plateau
- Rock Fall Zone
- Active Convex and Concave Slopes
- Barren Valley
- Debris wash Plain
- Bajada
- Gully
- Piedmont zone
- Pediment - Rocky
- Sand Dune
- Other Area

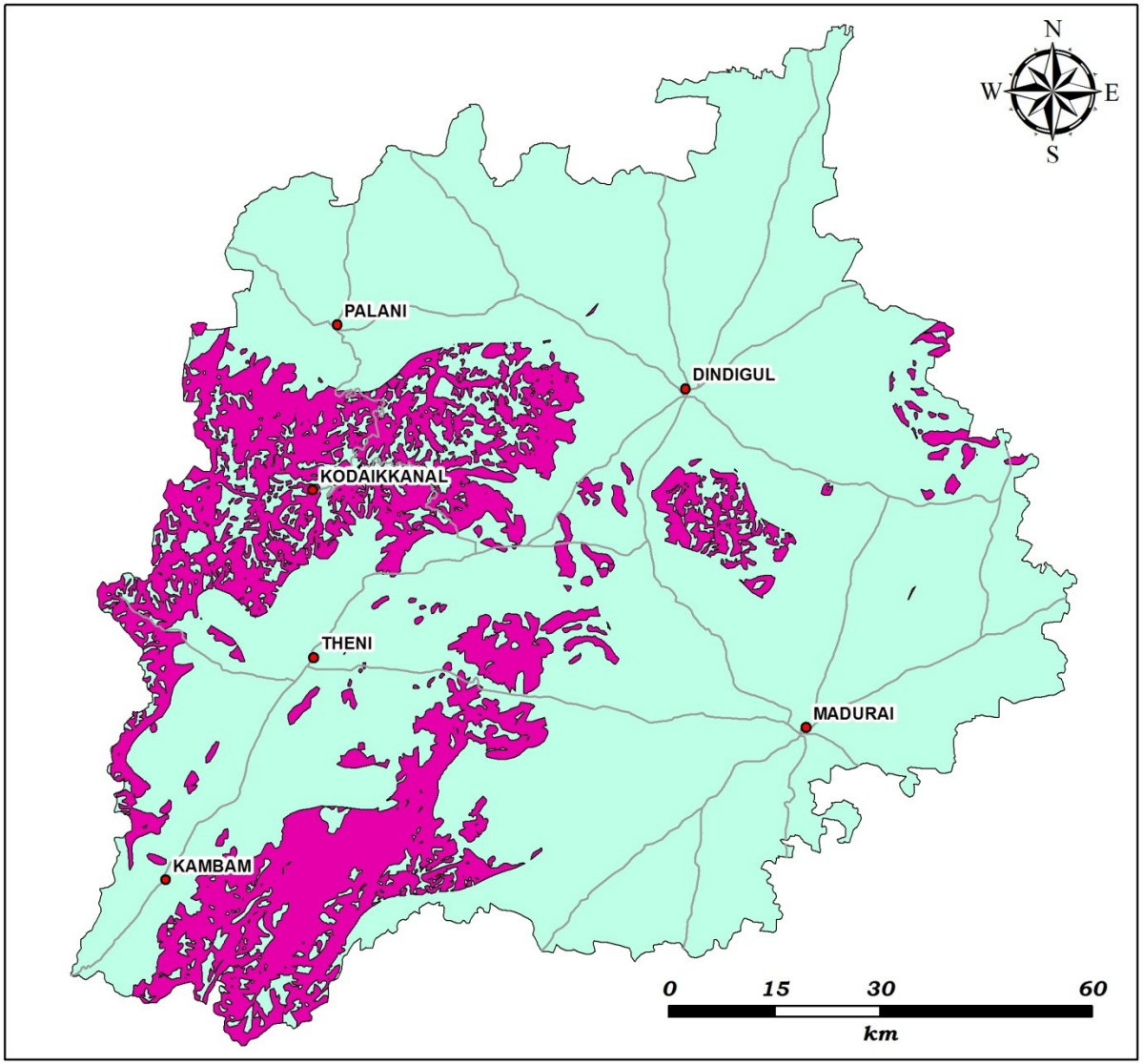
SOIL EROSION CONTROLLED BY GEOMORPHOLOGY



Legend

- Settlement
- Road Network
- Dissected Erosional Plateau
- Rock Fall Zone
- Barren Valley
- Active Convex and Concave Slopes
- Gully
- Piedmont zone
- Debris wash Plain
- Bajada
- Pediment - Rocky
- Sand Dune
- Other Areas

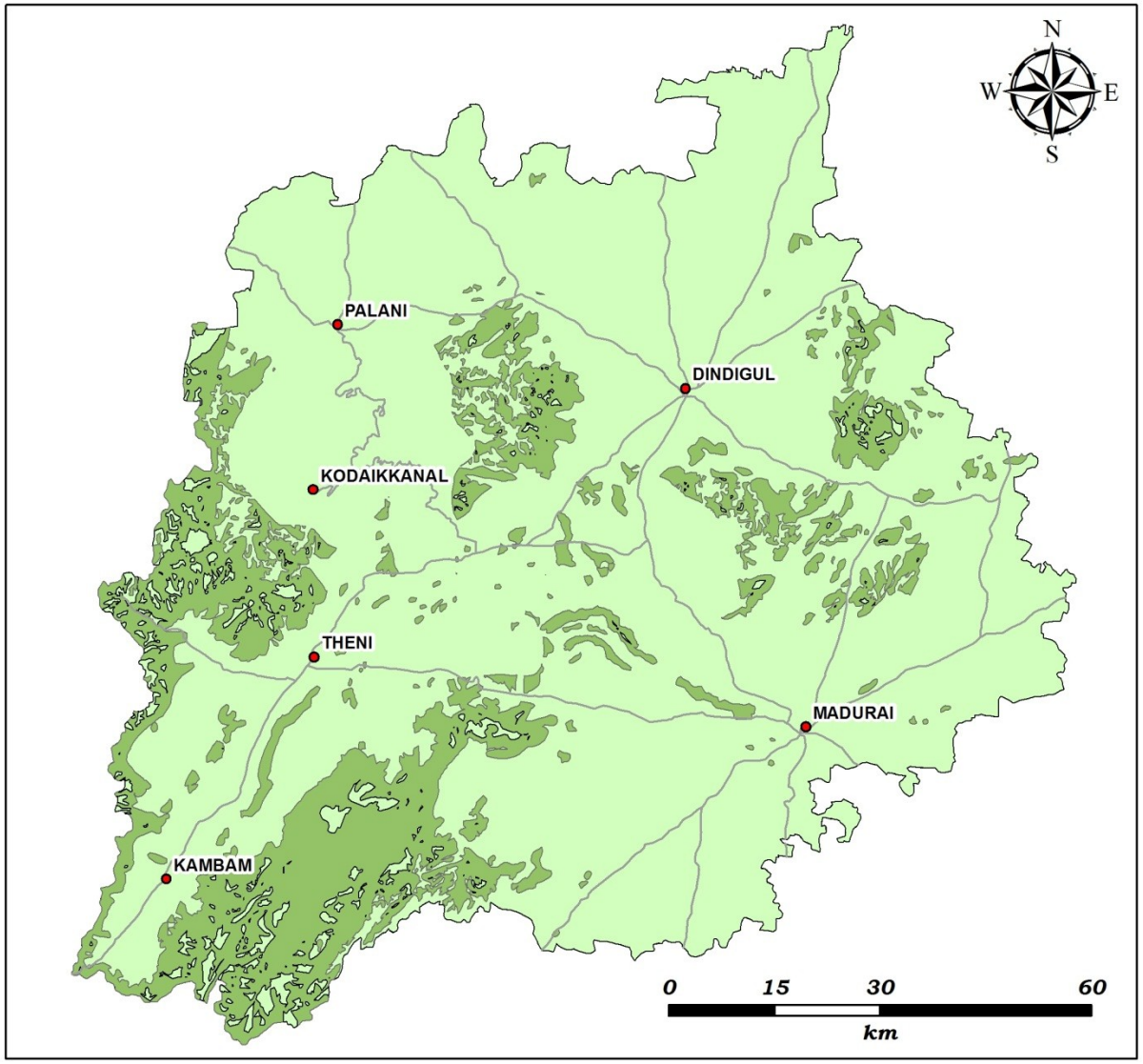
SOIL EROSION CONTROLLED BY LINEAMENT DENSITY



Legend

- Settlement
- Road Network
- Soil Erosion Controlled by Lineament Density
- Other Area

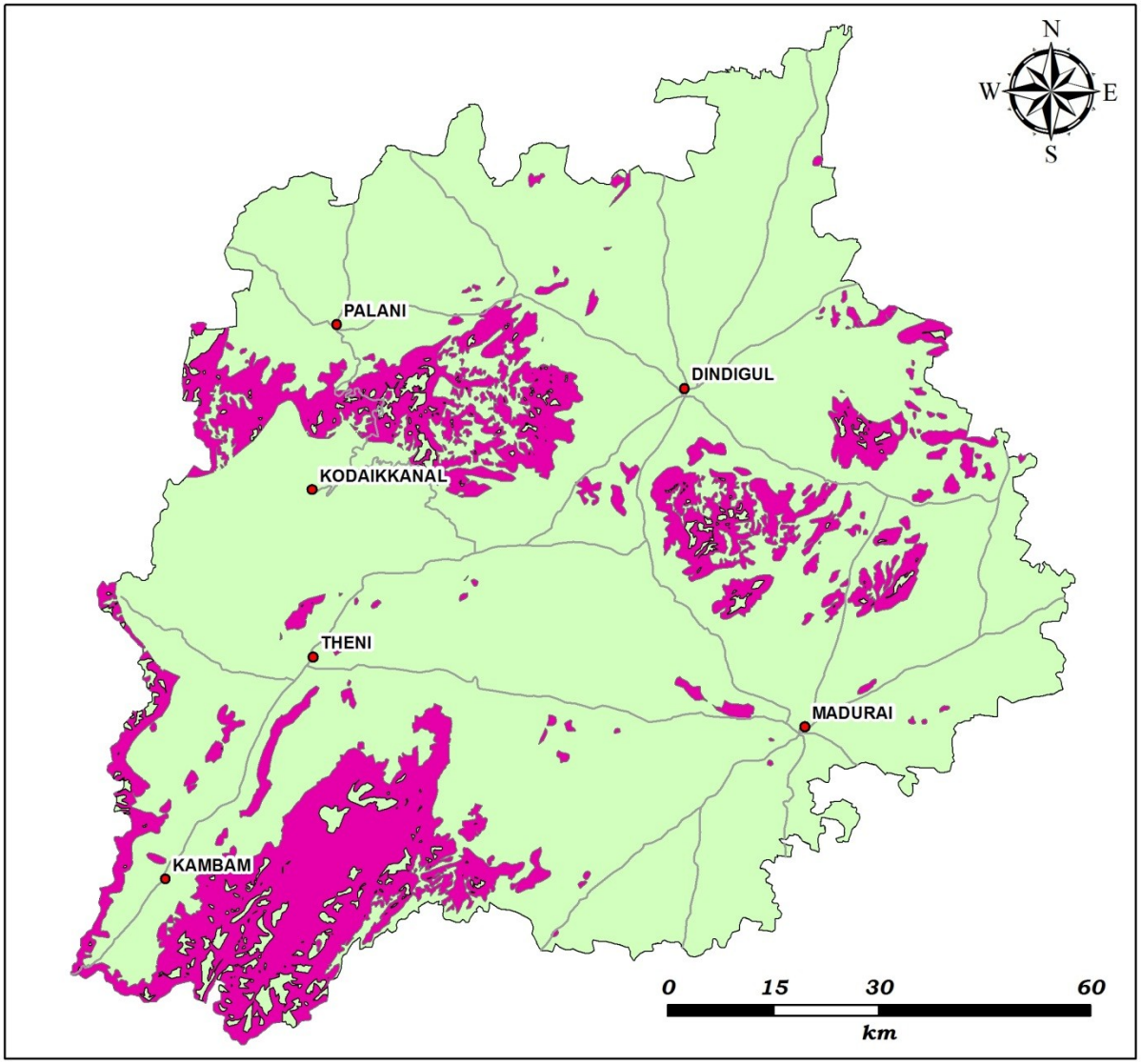
SOIL EROSION CONTROLLED BY THICKNESS OF TOP SOIL



Legend

- Settlement
- Road Network
- Soil Erosion Controlled by Thickness of Top Soil
- Other Area

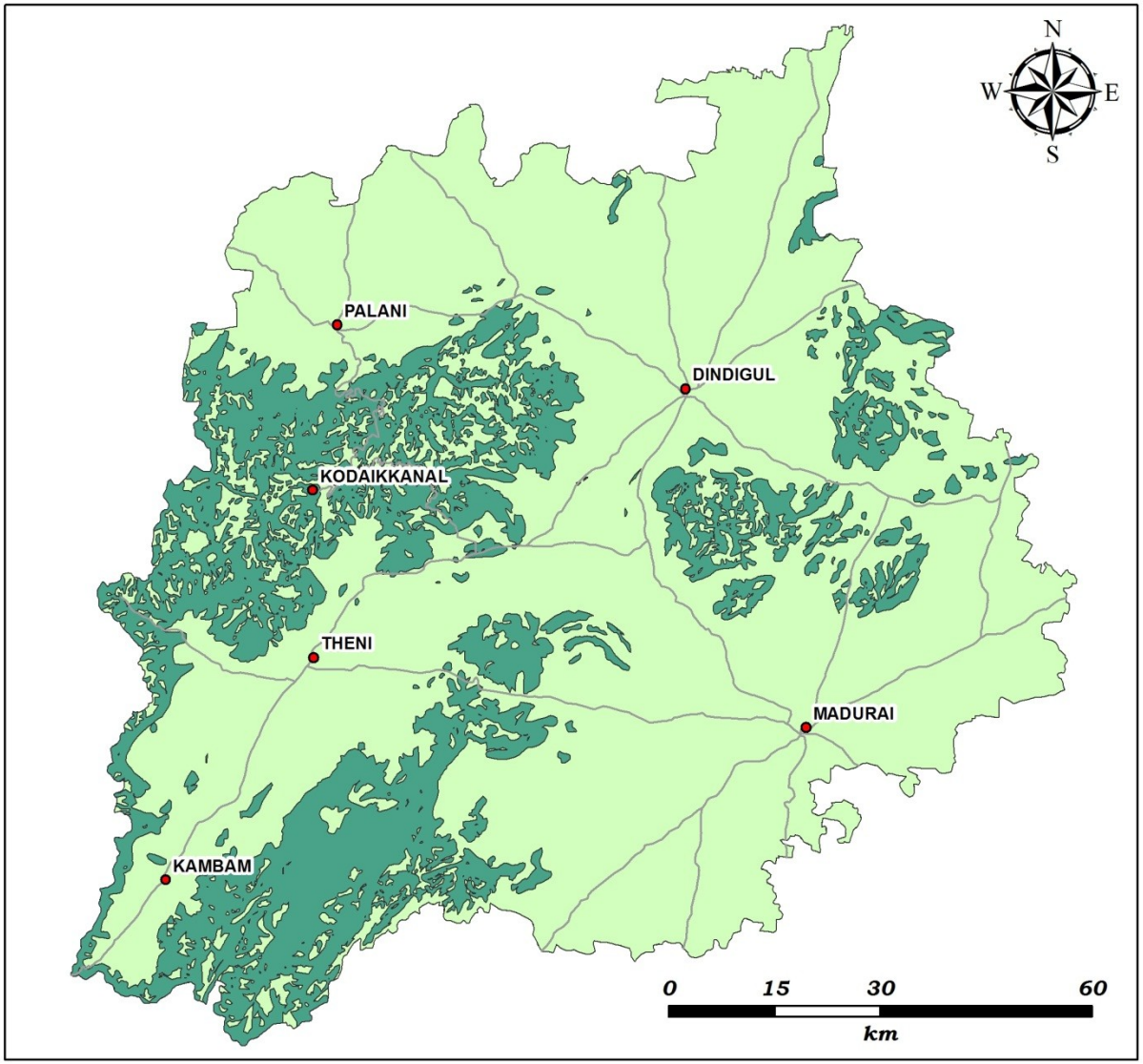
SOIL EROSION CONTROLLED BY DEPTH TO BED ROCK



Legend

- Settlement
- Road Network
- Soil Erosion Controlled by Depth to Bed Rock
- Other Area

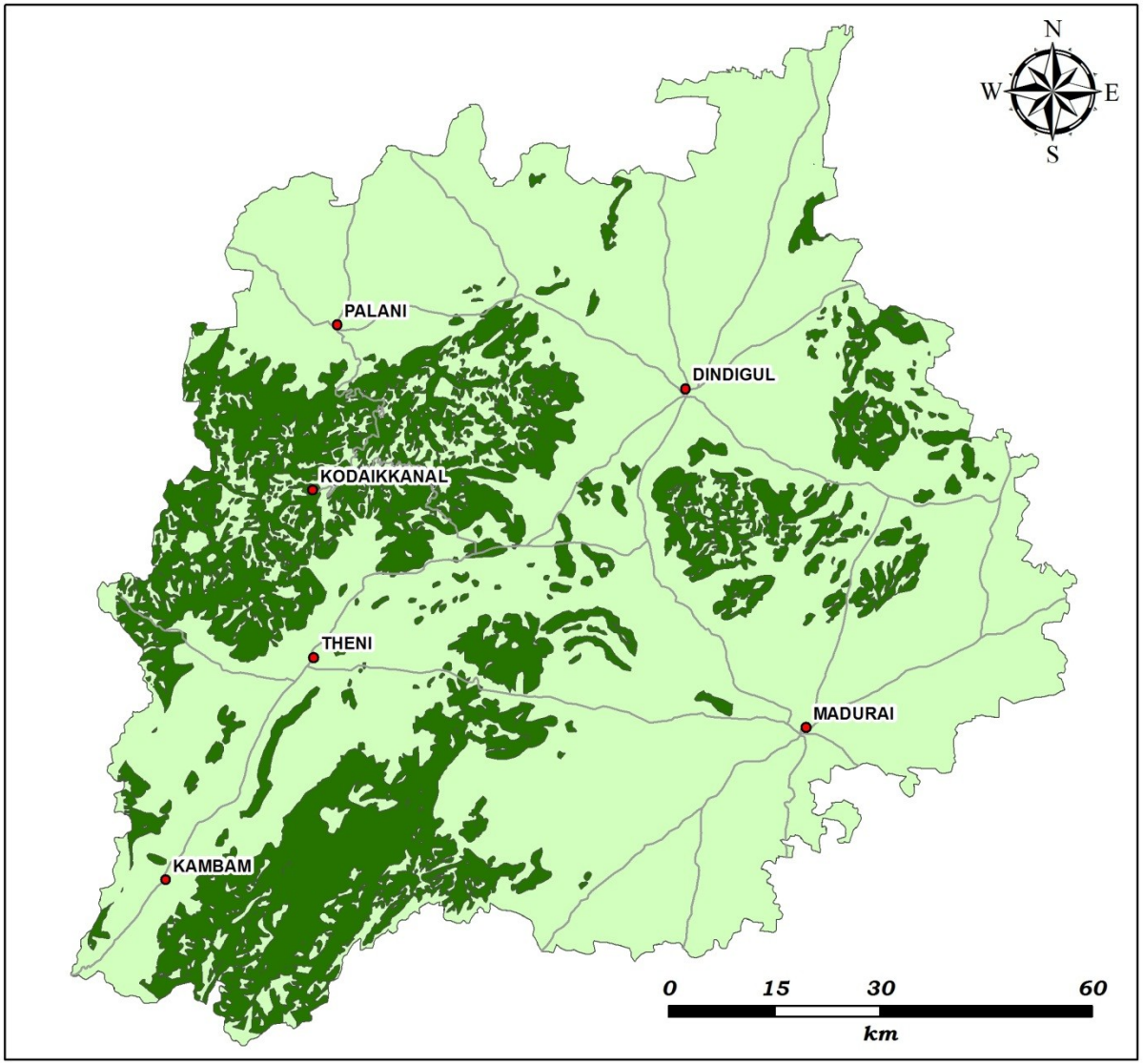
SOIL EROSION CONTROLLED BY SLOPE



Legend

- Settlement
- Road Network
- Soil Erosion Controlled by Slope
- Other Area

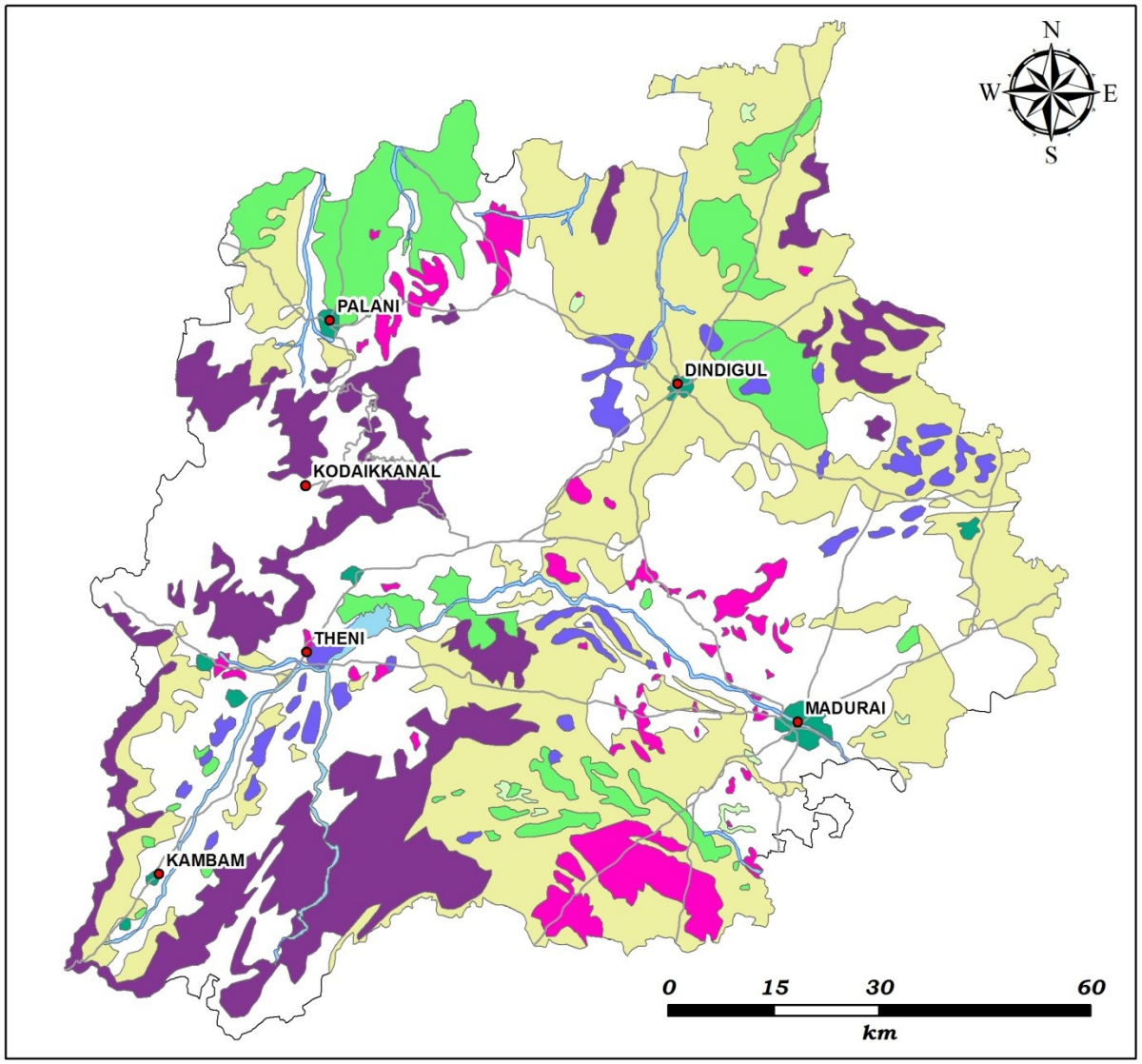
SOIL EROSION CONTROLLED BY DRAINAGE DENSITY



Legend

- Settlement
- Road Network
- Soil Erosion Controlled by Drainage Density
- Other Area

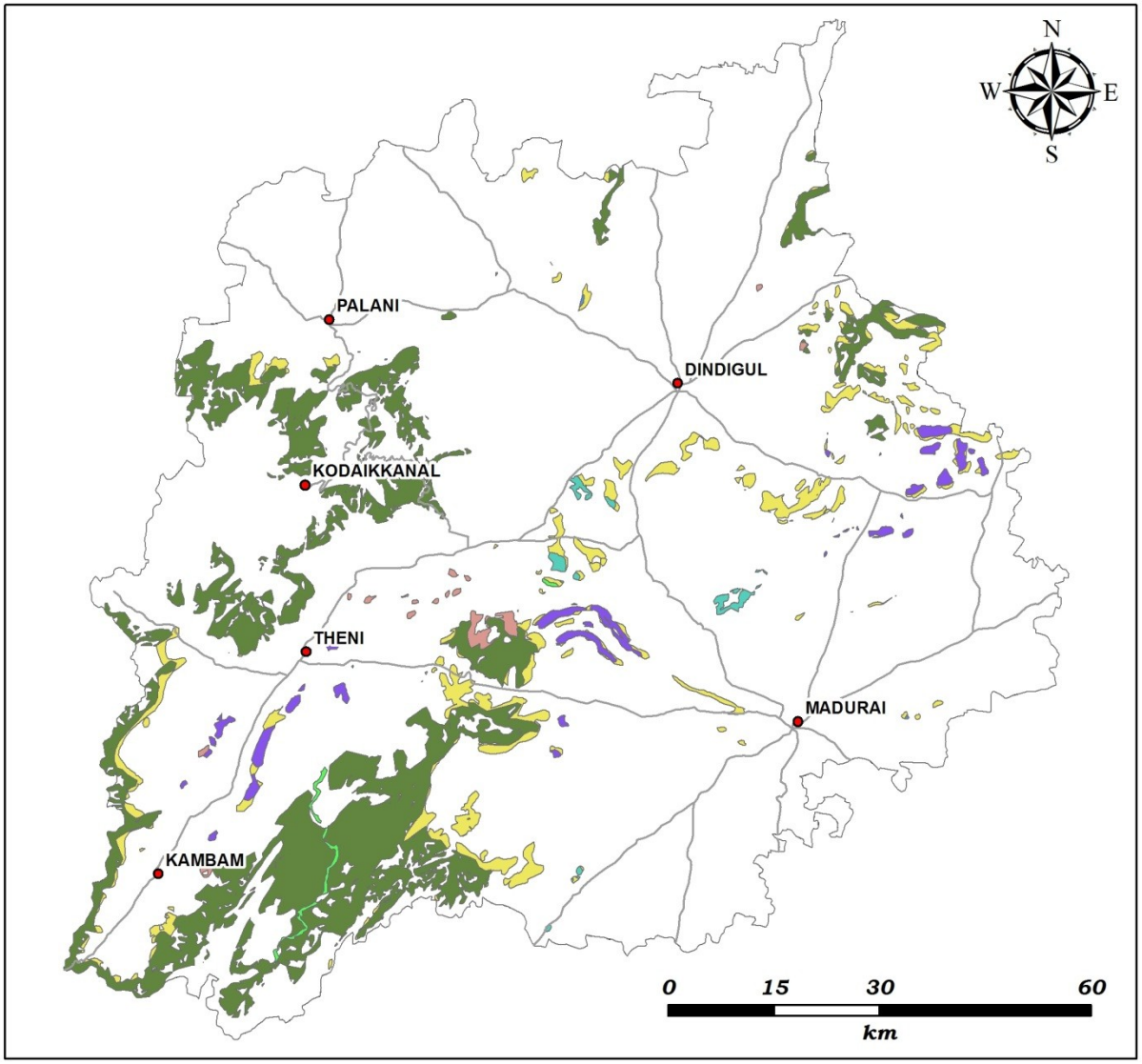
LANDUSE / LAND COVER - EROSION PRONE



Legend

- Settlement
- Road Network
- Builtup Area
- Open Forest / Forest Blank
- Fallow Land
- Land with Scrub
- Land without Scrub
- Miining Area
- Barren Rocky and Stony Waste
- River / Stream
- Other Area

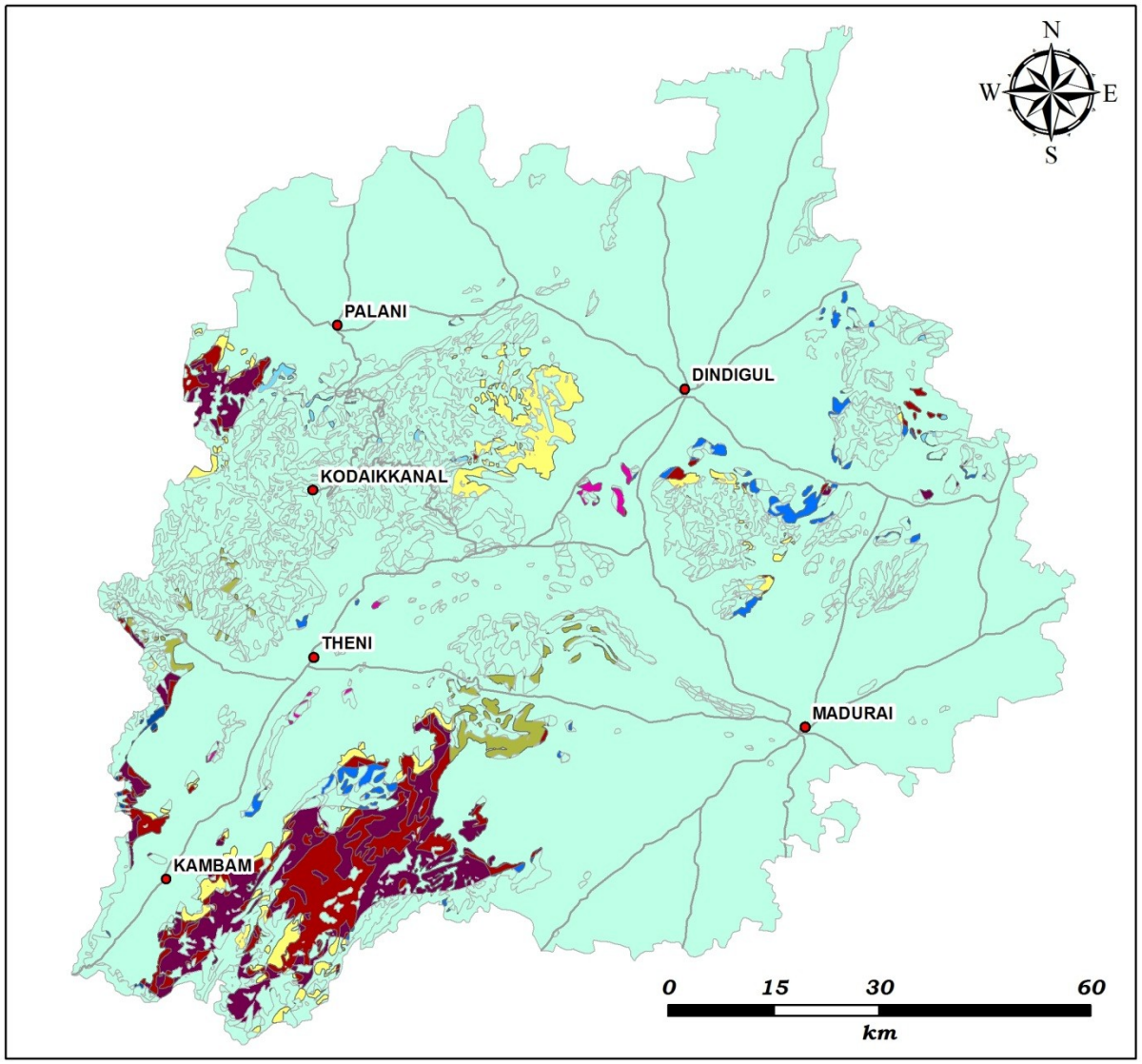
SOIL EROSION CONTROLLED BY LANDUSE / LAND COVER



Legend

- Settlement
- Road Network
- Open Forest / Forest Blank
- Fallow Land
- Land with Scrub
- Land without Scrub
- Miining Area
- Barren Rocky and Stony Waste
- River / Stream
- Other Area

FUNCTIONS OF SOIL EROSION (6 & 7 Parameters)



Legend

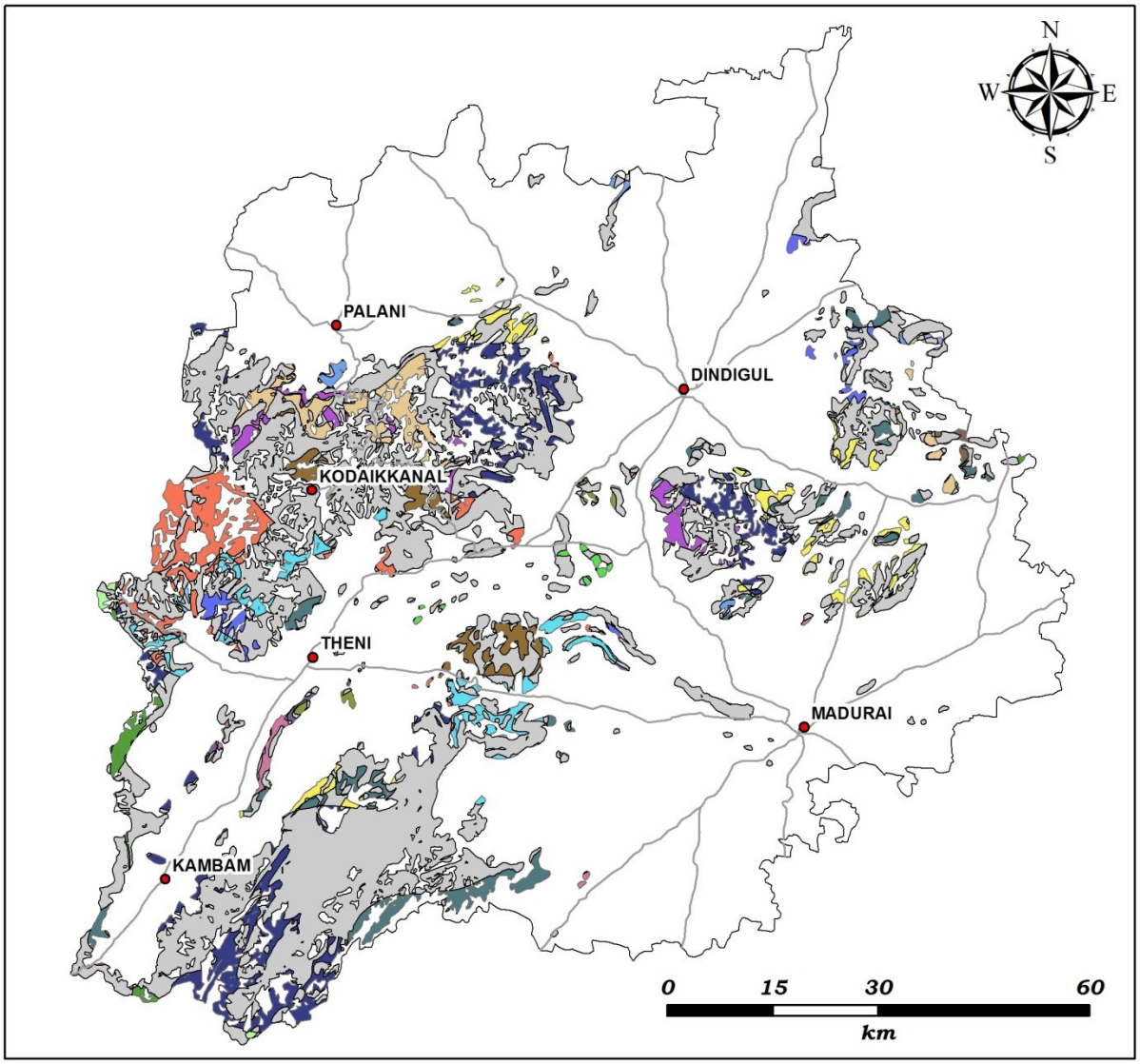
- Settlement
- Road Network

Soil Erosion Controlled by

- LD+TTS+DBR+GEOM+SL+DD+LU
- LD+TTS+DBR+GEOM+SL+DD
- LD+TTS+DBR+GEOM+SL+LU
- LD+TTS+DBR+GEOM+DD+LU
- LD+TTS+DBR+SL+DD+LU
- LD+TTS+GEOM+SL+DD+LU
- LD+DBR+GEOM+SL+DD+LU
- TTS+DBR+GEOM+SL+DD+LU
- Other Area

(Where,
LD - Lineament Density
TTS - Thickness of Top Soil
DBR - Depth to Bed Rock
GEOM - Geomorphology
SL - Slope
DD - Drainage Density
LU - Landuse / Land Cover)

FUNCTIONS OF SOIL EROSION (5 PARAMETERS)



Legend

- Settlement
- Road Network

Soil Erosion Controlled by

- DBR+GEOM+SL+DD+LU
- LD+DBR+GEOM+DD+LU
- LD+DBR+GEOM+SL+DD
- LD+DBR+GEOM+SL+LU
- LD+DBR+SL+DD+LU
- LD+GEOM+SL+DD+LU
- LD+TTS+DBR+DD+LU
- LD+TTS+DBR+GEOM+DD
- LD+TTS+DBR+GEOM+SL
- LD+TTS+DBR+SL+DD
- LD+TTS+DBR+SL+LU
- LD+TTS+GEOM+DD+LU
- LD+TTS+GEOM+SL+DD
- LD+TTS+GEOM+SL+LU
- LD+TTS+SL+DD+LU
- TTS+DBR+GEOM+DD+LU
- TTS+DBR+GEOM+SL+DD
- TTS+DBR+GEOM+SL+LU
- TTS+DBR+SL+DD+LU
- TTS+GEOM+SL+DD+LU
- Remaining Soil Erosion Prone Areas
- Other Area

(Where,
LD - Lineament Density
TTS - Thickness of Top Soil
DBR - Depth to Bed Rock
GEOM - Geomorphology
SL - Slope
DD - Drainage Density
LU - Landuse / Land Cover)

Remedial Measures

Areas of soil erosion controlled by		Controlling Parameter based Remedial Measures
1) Lineament density	⇑	Gully Filled Vegetation
2) Geomorphology	⇑	Afforestation, Gully Plugging, Check Dams, Pasture development
3) Thickness of top soil	⇑	Afforestation, Geotextiling, Nailing
4) Depth to bed rock	⇑	Intensive Afforestation
5) Slope	⇑	Bench Cultivation
6) Drainage density	⇑	Gully Plucking, Check Dams
7) Landuse/land cover	⇑	Afforestation, etc.

SOIL RESOURCES

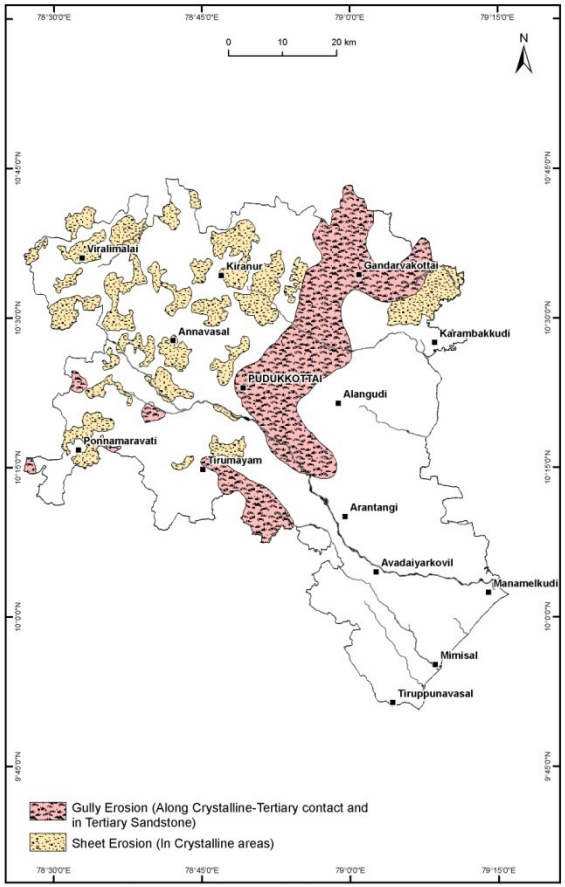


Fig.6.16 Areas of Soil Erosion - Pudukkottai District

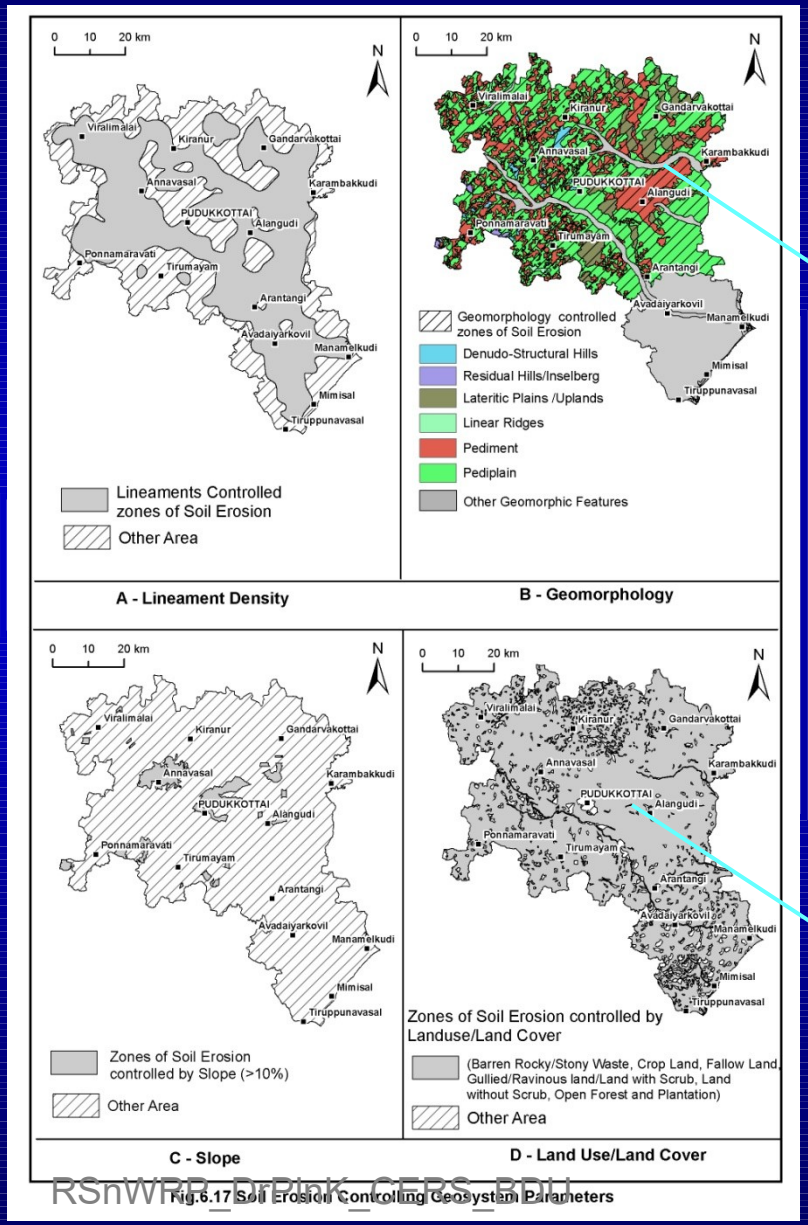


Fig.6.17 Soil Erosion Controlling Geosystem Parameters

Soil erosion prone Geomorphic features

Soil erosion prone LU/LC

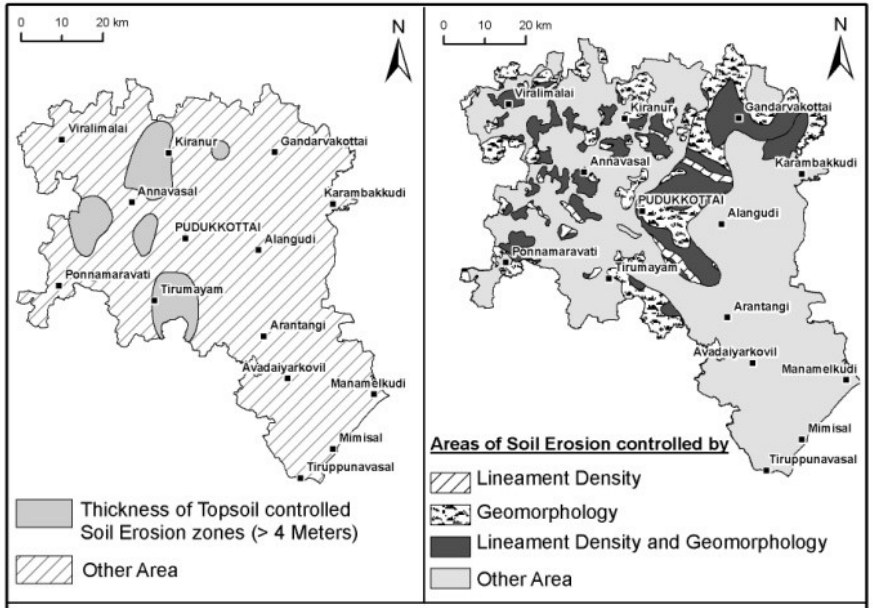


Fig.6.18 Thickness of Topsoil

Fig.6.19 Level - I GIS Integration (Lineament Density Vs Geomorphology)

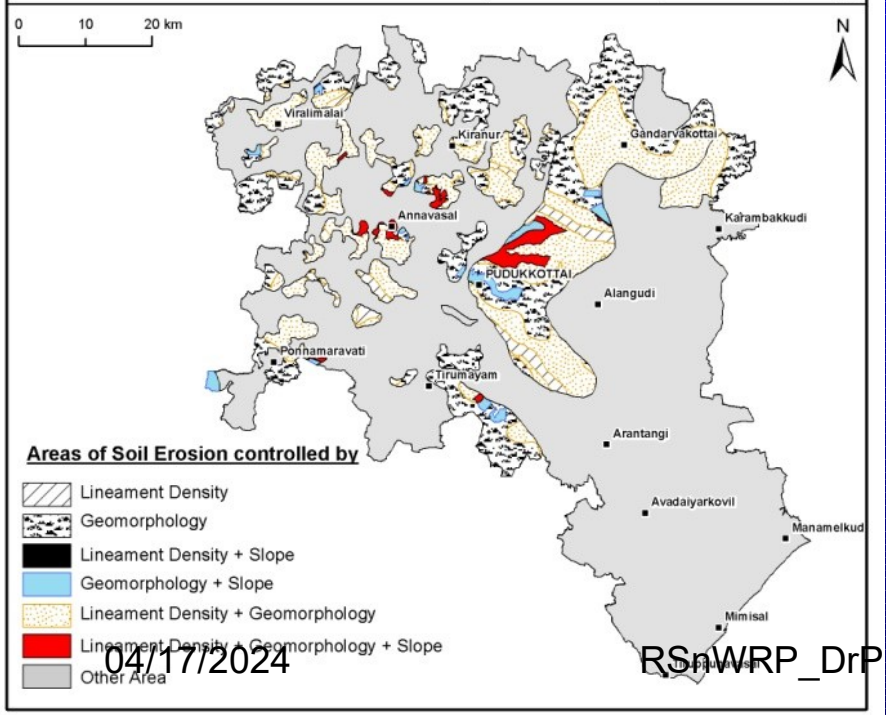


Fig.6.20 Level - II GIS Integration (Level - I + Slope)

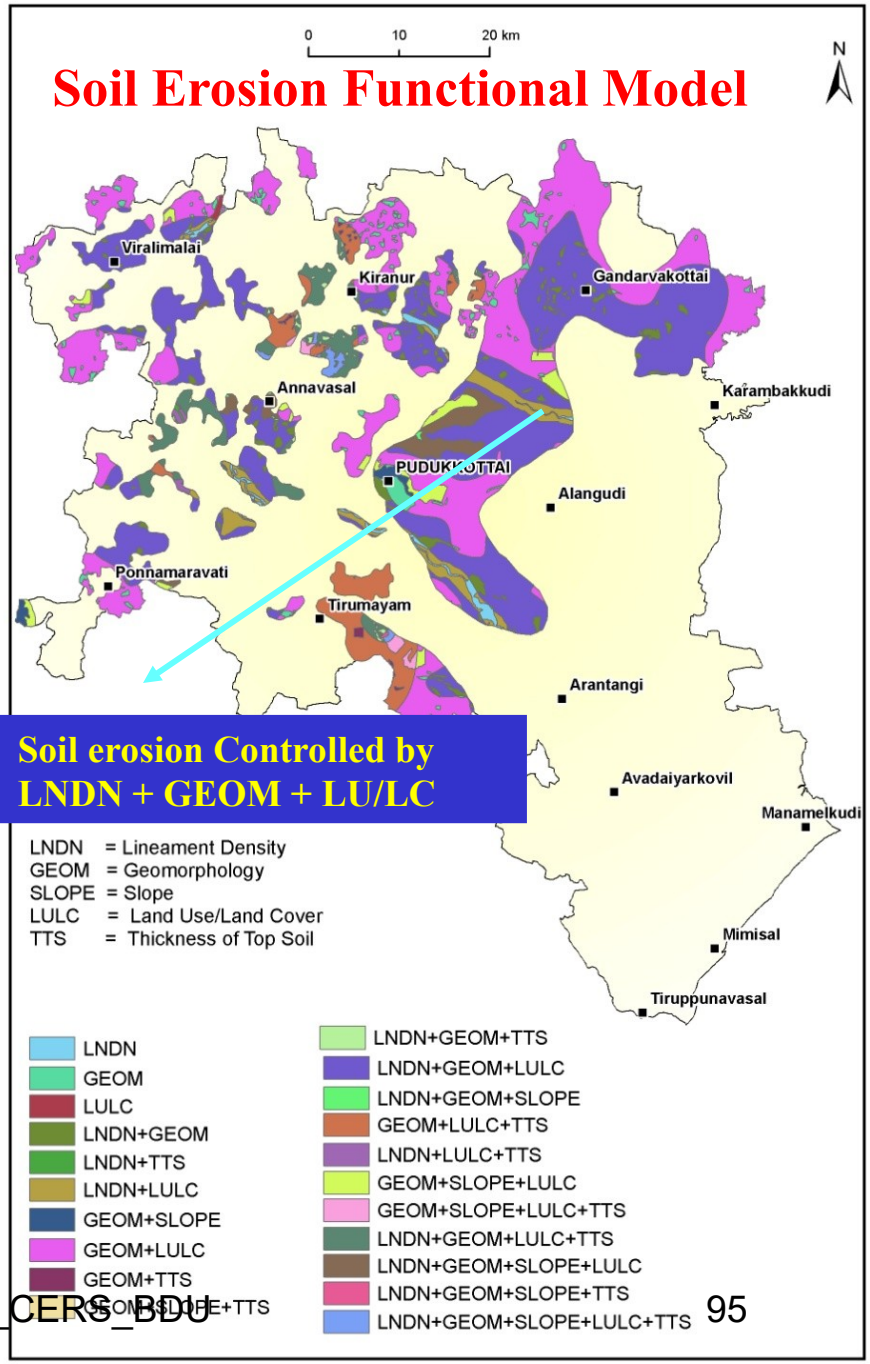


Fig.6.21 Soil Erosion Functional Model - Pudukkottai District

Sl. No.	Controlling Geo-system Parameters	Remedial Measures
1	Lineament Density	Gully Plugging, Gully Filled Vegetation
2	<u>Erosion prone Geomorphology</u> 2.1 Residual hills/Inselberg, Denudo-Structural hills	Afforestation, Contour bounding
	2.2 Lateritic Plains/Uplands	Plantations, Dry land Irrigation, Horticulture
	2.3 Pediment/Pediplains	Agriculture, Horticulture, Mixed Plantation, etc
3	Slope	Contour bounding, Bench Cultivation, Check Dam, Silt trapping
4	<u>Landuse/Land Cover</u> 4.1 Barren Rocky/Stony Waste	Afforestation, Horticulture
	4.2 Fallow Land	Cultivation, Deep penetrating rooted Plants
	4.3 Gullied land/Ravenous land	Gully Plugging, Gully filed Vegetation
	4.4 Open Forest and Plantation	Intensive Afforestation
5	Thickness of Topsoil	Afforestation,Geotextiling, Irrigation

Back

RUNOFF AND SOIL EROSION ESTIMATION USING REMOTE SENSING AND GIS OF SOLANI WATERSHED – A CASE STUDY-YEAR 2008

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NNRMS TRAINEES-2010
WATER RESOURCES DIVISION
INDIAN INSTITUTE OF REMOTE SENSING
DEHRADUN

Aims

AIMS

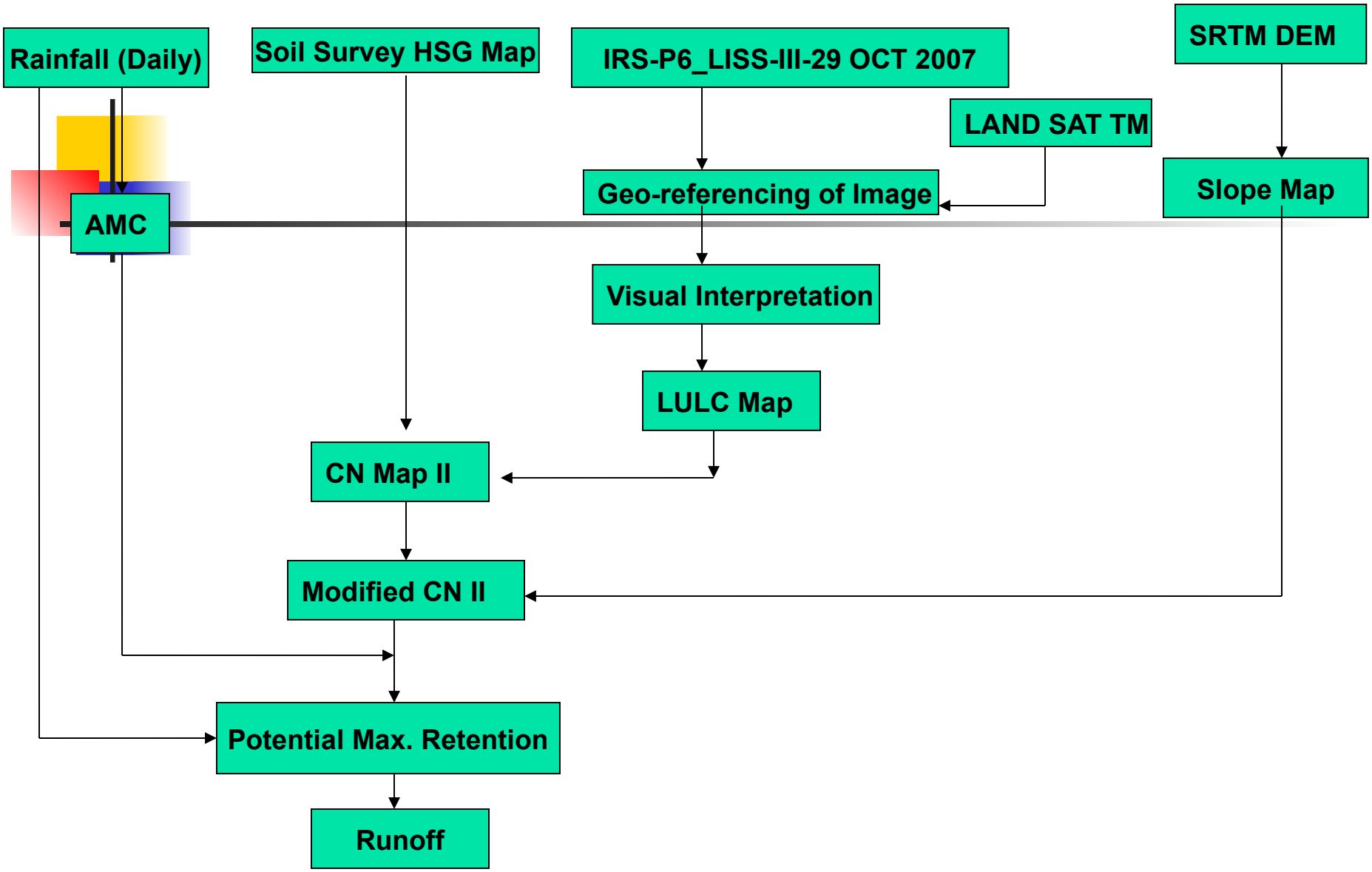
Aims of this present study is to Estimate,

- Runoff
- Soil erosion and
- Sediment yield
- using Remote Sensing and GIS for Solani watershed.

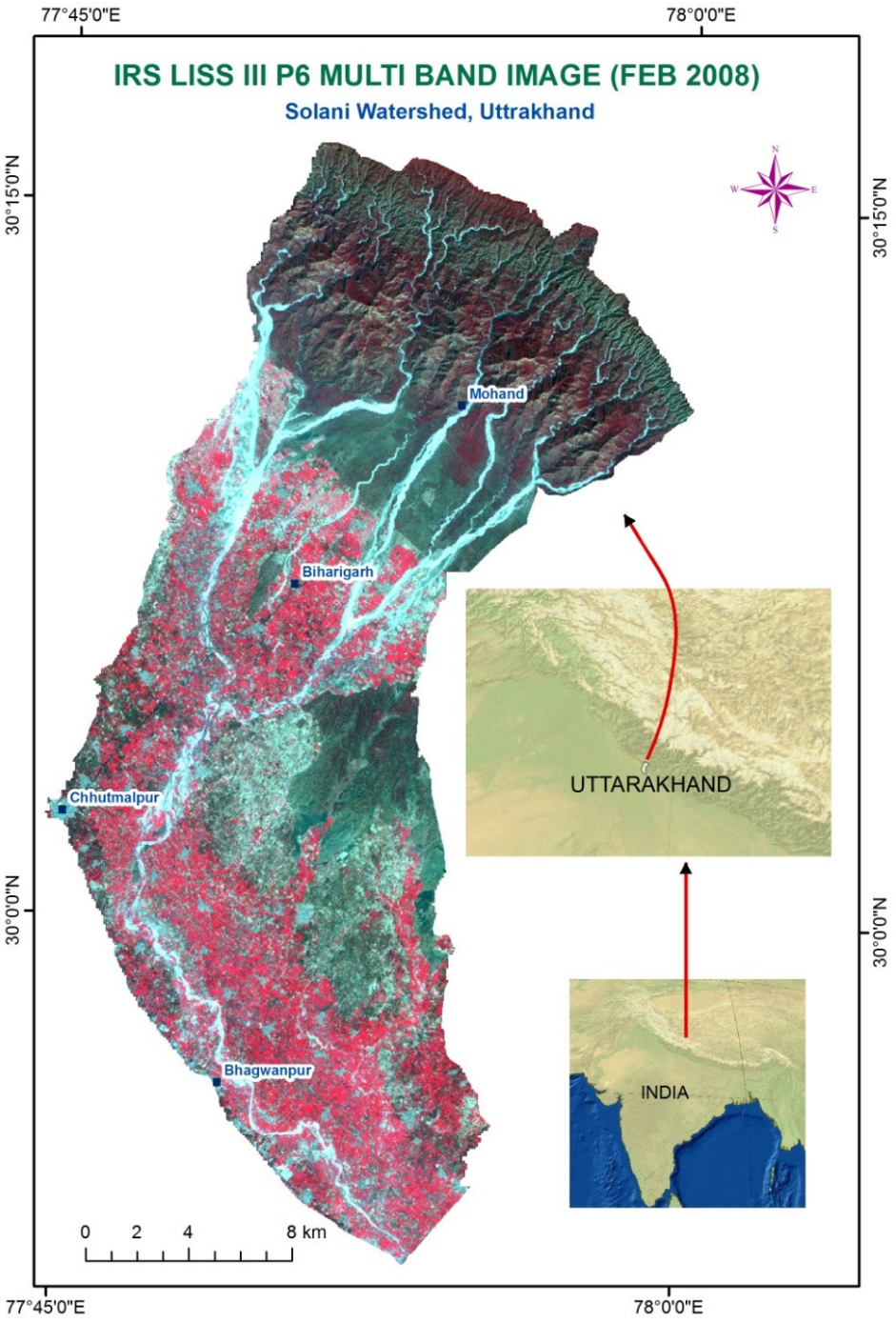
OBJECTIVES

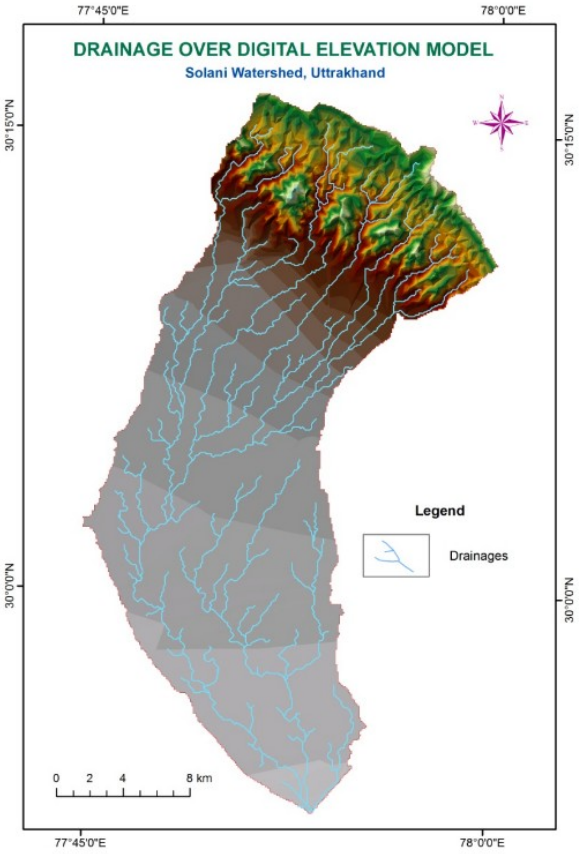
- Estimation of runoff for Solani watershed through Curve Number method using Remote sensing data and GIS for the year 2008 and
- Estimation of soil erosion and sediment yield for Solani watershed using RUSLE, Remote sensing data and GIS for the year 2008.

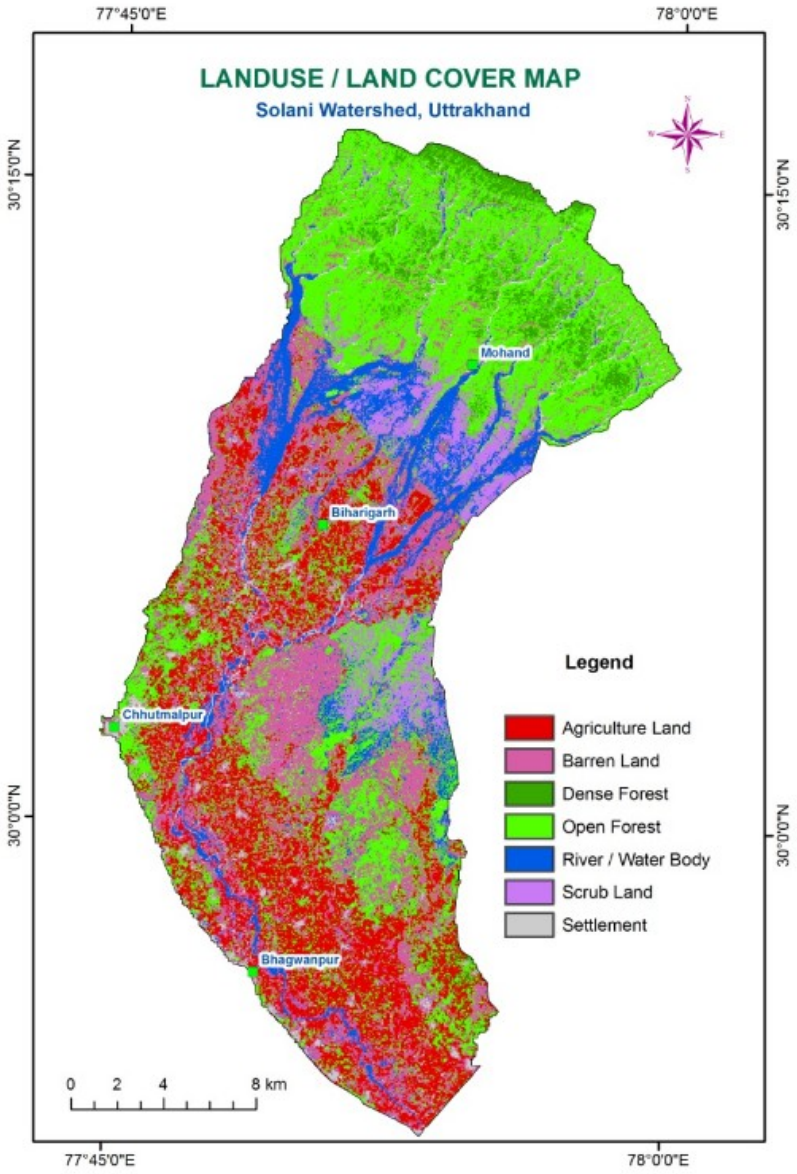
1. RUNOFF ESTIMATION



Flow Chart for Runoff Estimation

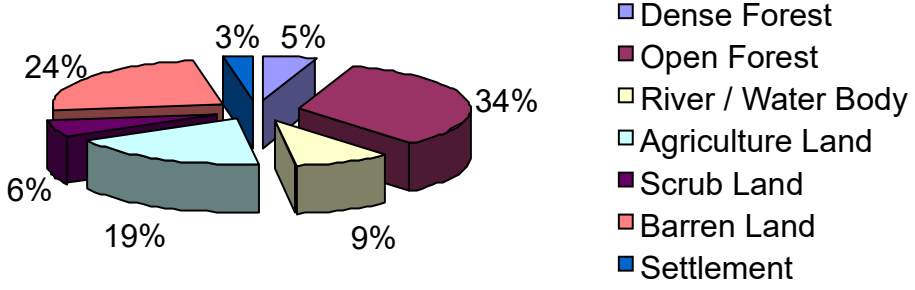

77°45'0"E
78°0'0"E
IRS LISS III P6 MULTI BAND IMAGE (FEB 2008)
Solani Watershed, Uttrakhand
30°15'0"N
30°0'0"N
Mohand
Biharigarh
Chhutmalpur
Bhagwanpur
UTTARAKHAND
INDIA
0 2 4 8 km

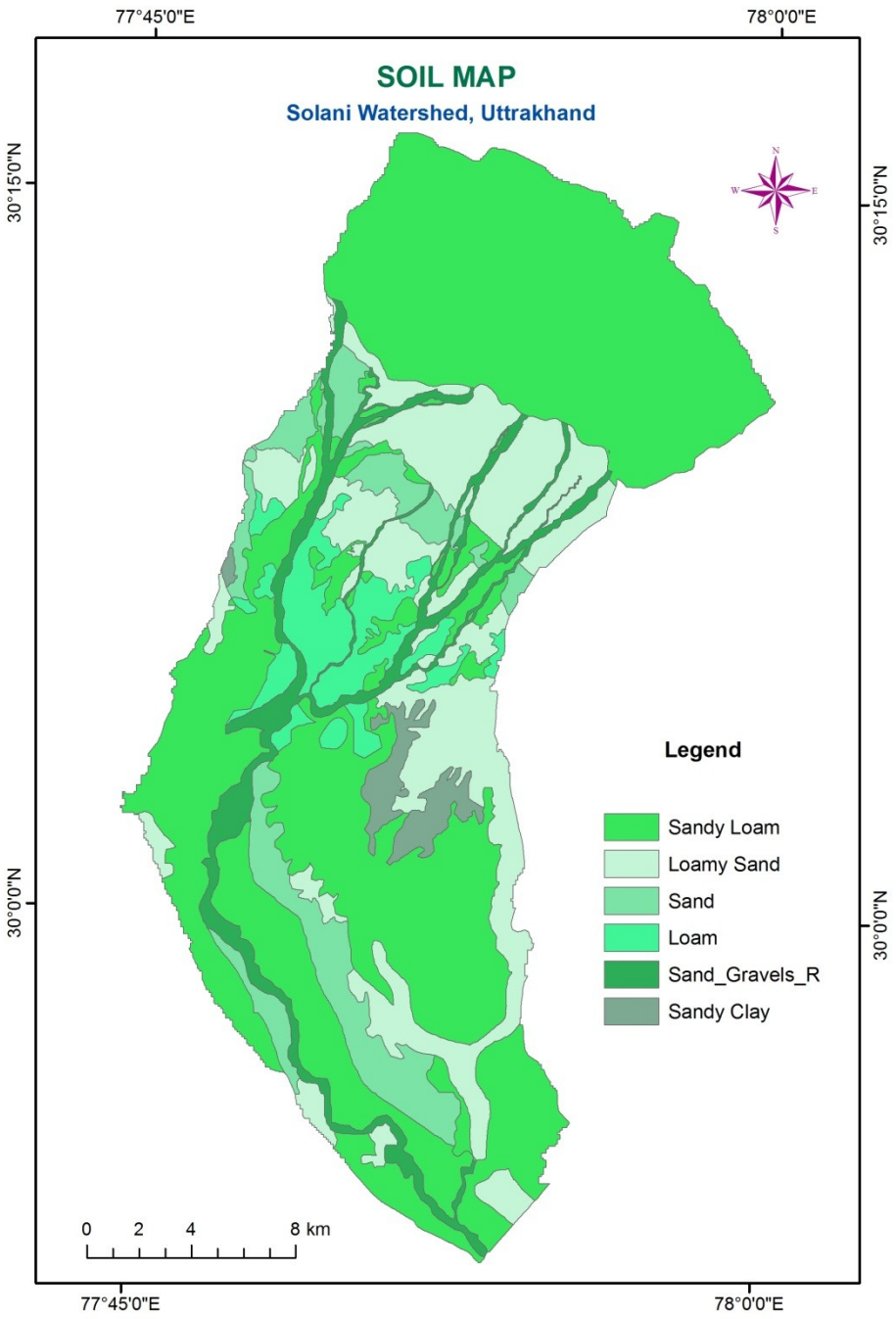

77°45'0"E
78°0'0"E
DRAINAGE OVER DIGITAL ELEVATION MODEL
Solani Watershed, Uttrakhand
30°15'0"N
30°0'0"N
Legend
Drainages
0 2 4 8 km

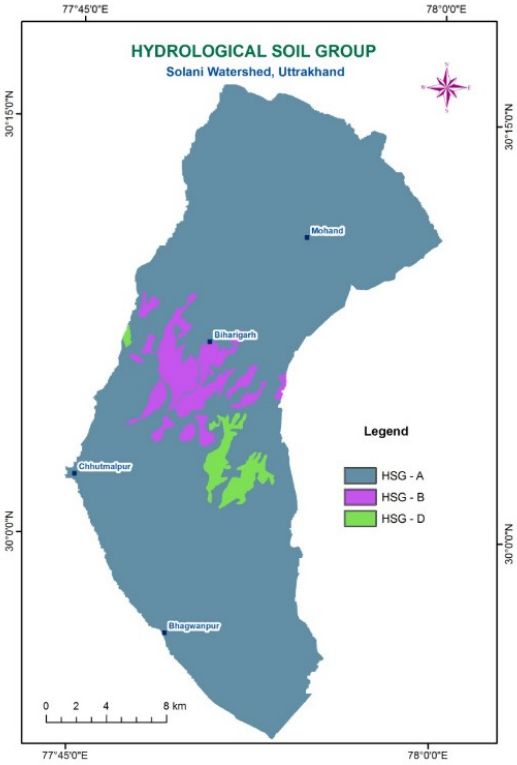


Sl. No.	Landuse / Land cover Categories	Area (sq.km)	Area in %
1	Dense Forest	25.92	5
2	Open Forest	181.33	34
3	River / Water Body	48.38	9
4	Agriculture Land	101.02	19
5	Scrub Land	31.56	6
6	Barren Land	128.18	24
7	Settlement	14.86	3

Landuse / Land cover – Percentage share in Solani Watershed




SOIL MAP
Solani Watershed, Uttrakhand
77°45'0"E
78°0'0"E
30°15'0"N
30°0'0"N
Legend
Sandy Loam
Loamy Sand
Sand
Loam
Sand_Gravels_R
Sandy Clay
0 2 4 8 km


HYDROLOGICAL SOIL GROUP
Solani Watershed, Uttrakhand
77°45'0"E
78°0'0"E
30°15'0"N
30°0'0"N
Mohand
Biharigarh
Chhutmalpur
Bhagwanpur
Legend
HSG - A
HSG - B
HSG - D
0 2 4 8 km

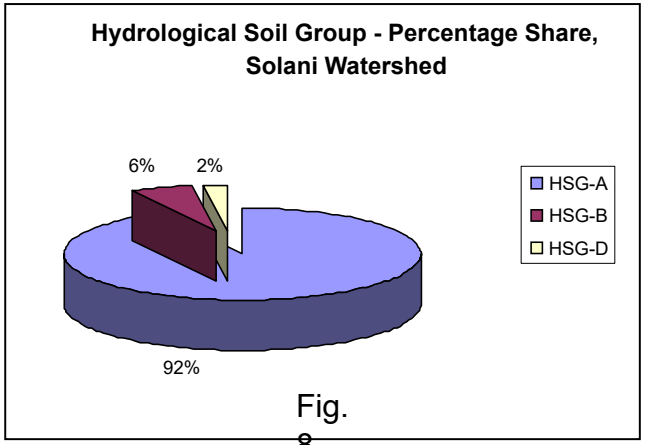
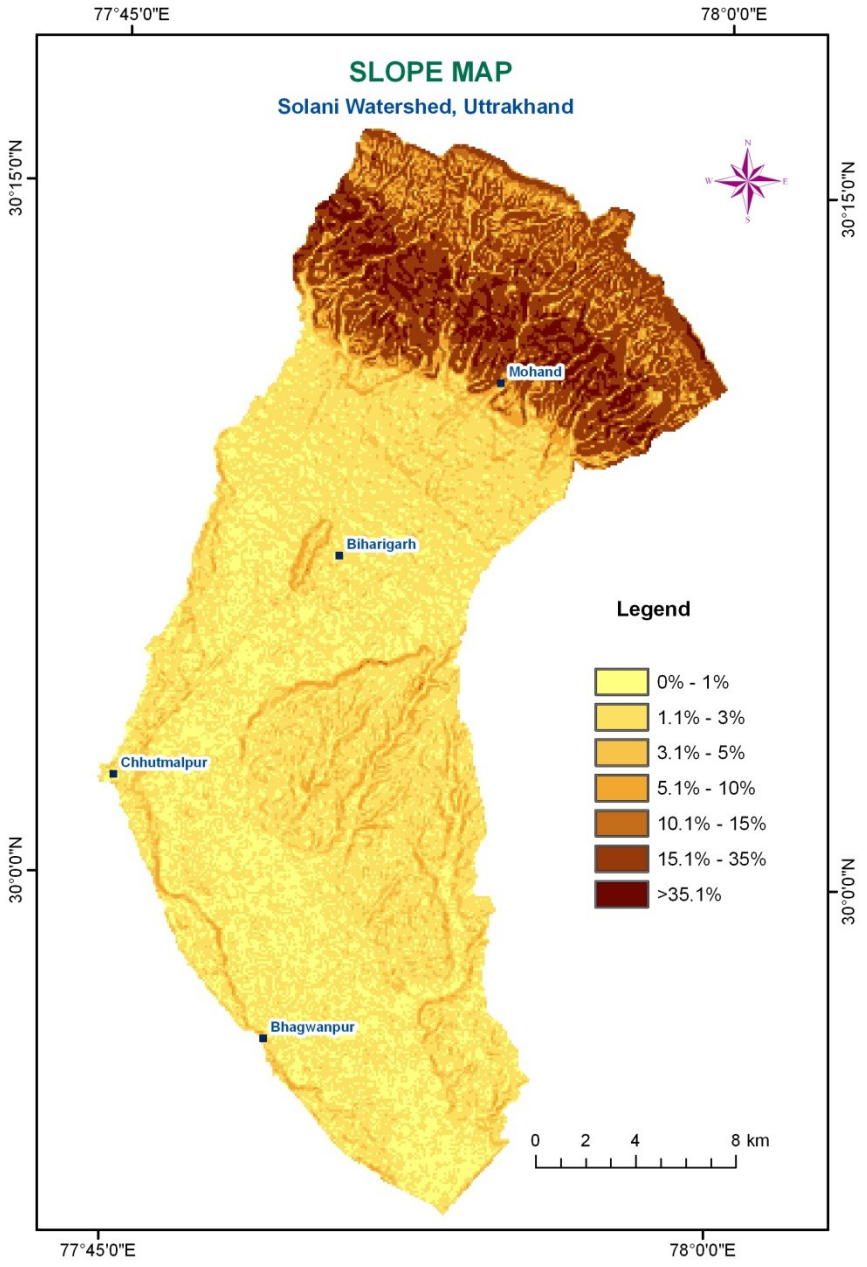
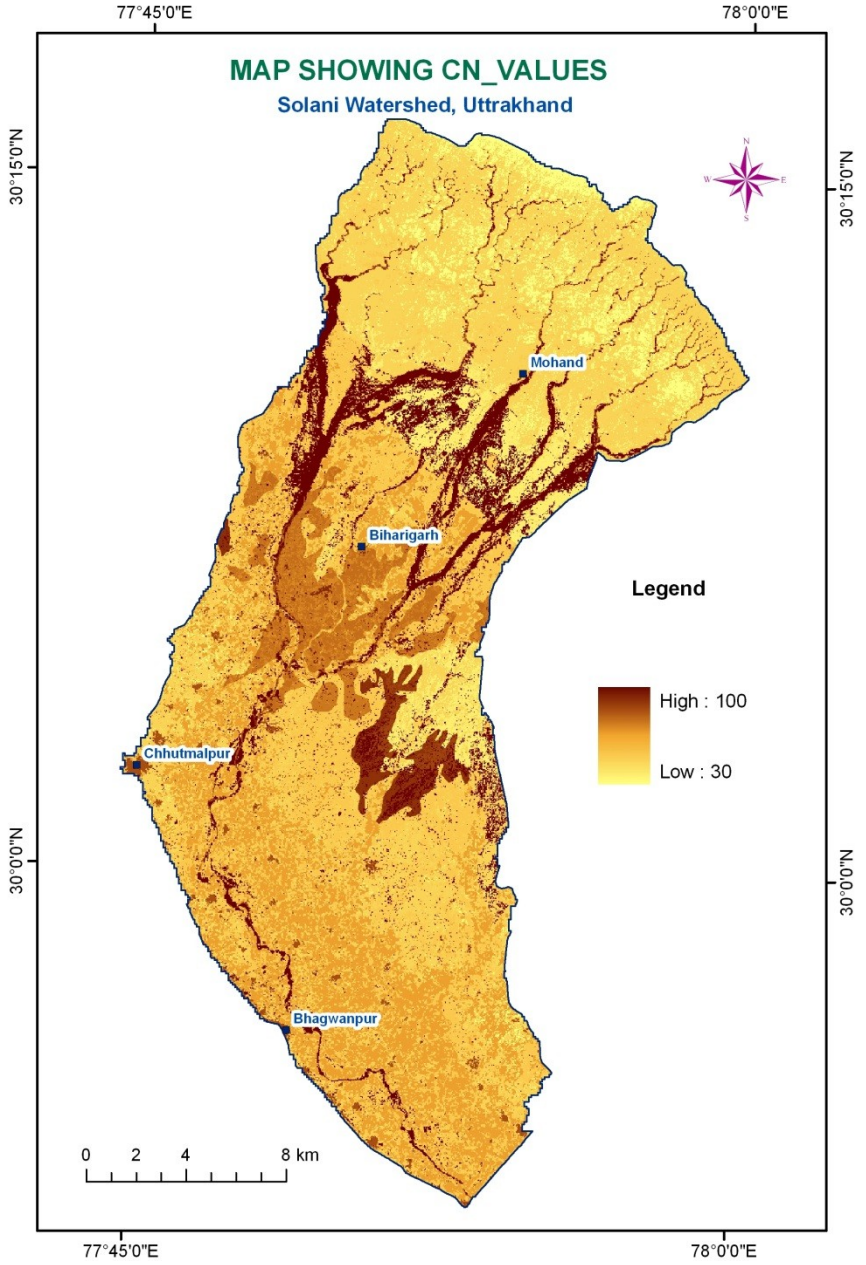
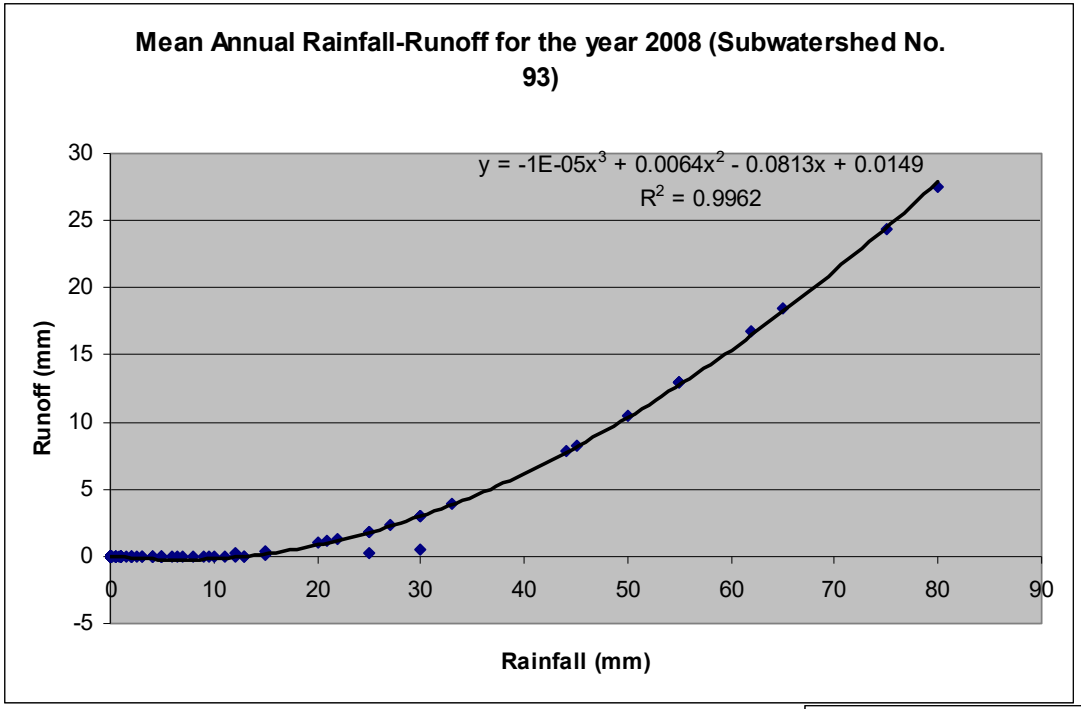
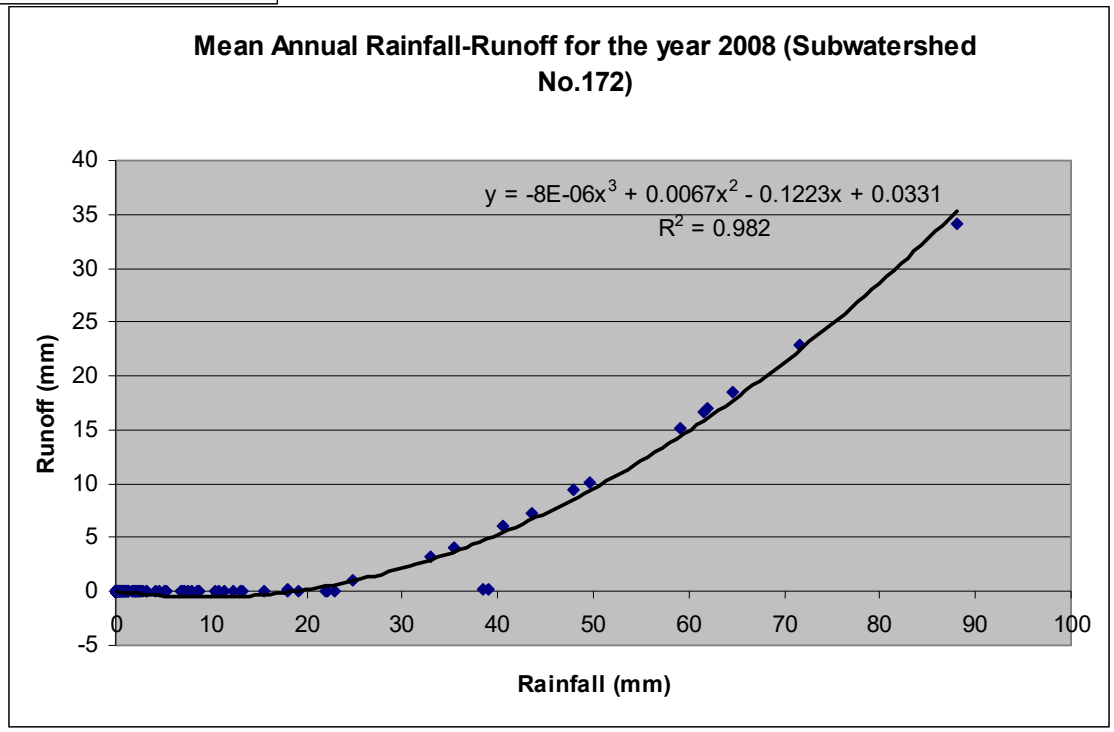

Hydrological Soil Group - Percentage Share, Solani Watershed
6%
2%
92%
HSG-A
HSG-B
HSG-D

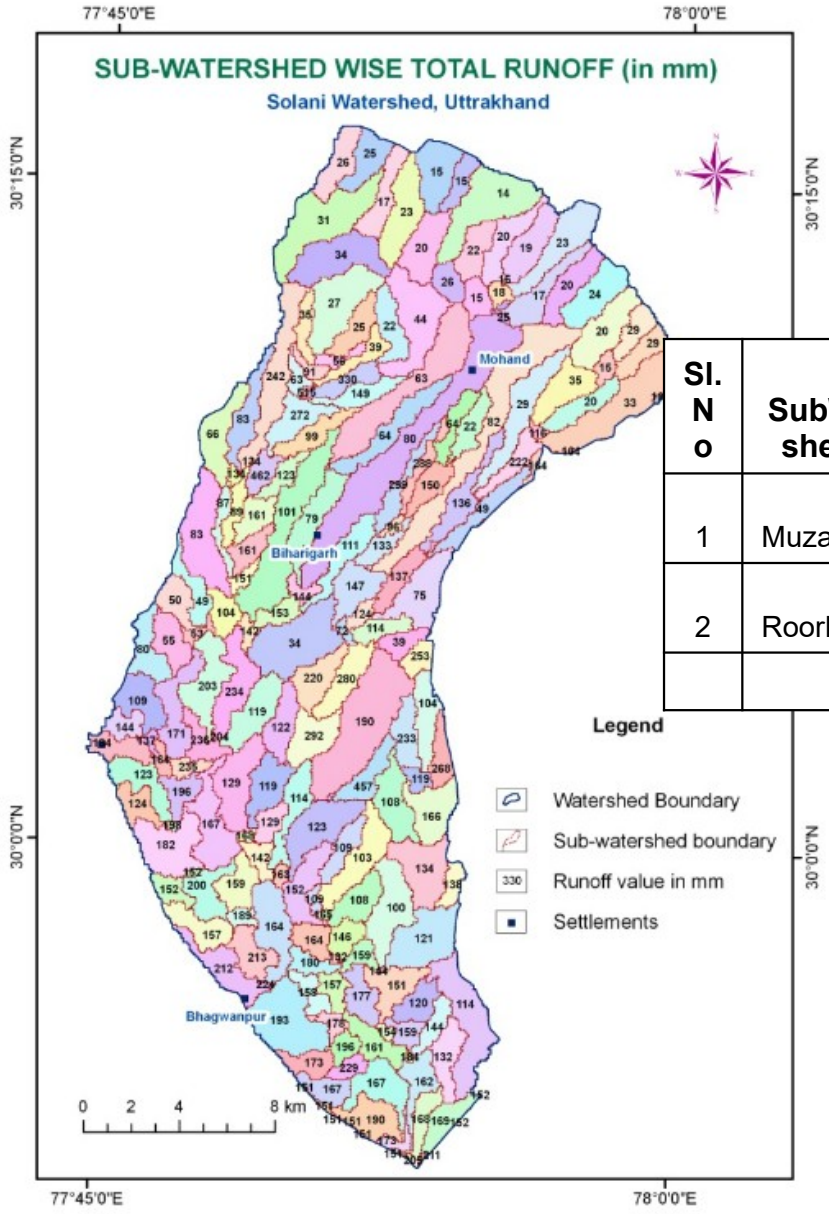
Fig. 8


77°45'0"E
78°0'0"E
SLOPE MAP
Solani Watershed, Uttrakhand
30°15'0"N
30°0'0"N
Mohand
Biharigarh
Chhutmalpur
Bhagwanpur
Legend
0% - 1%
1.1% - 3%
3.1% - 5%
5.1% - 10%
10.1% - 15%
15.1% - 35%
>35.1%
0 2 4 8 km


77°45'0"E
78°0'0"E
MAP SHOWING CN_VALUES
Solani Watershed, Uttrakhand
30°15'0"N
30°0'0"N
Mohand
Biharigarh
Chhutmalpur
Bhagwanpur
Legend
High : 100
Low : 30
0 2 4 8 km


Mean Annual Rainfall-Runoff for the year 2008 (Subwatershed No. 93)
y = -1E-05x3 + 0.0064x2 - 0.0813x + 0.0149
R2 = 0.9962
Runoff (mm)
Rainfall (mm)
30
25
20
15
10
5
0
-5
0
10
20
30
40
50
60
70
80
90


Mean Annual Rainfall-Runoff for the year 2008 (Subwatershed No.172)
y = -8E-06x3 + 0.0067x2 - 0.1223x + 0.0331
R2 = 0.982
Runoff (mm)
Rainfall (mm)
40
35
30
25
20
15
10
5
0
-5
0
10
20
30
40
50
60
70
80
90
100

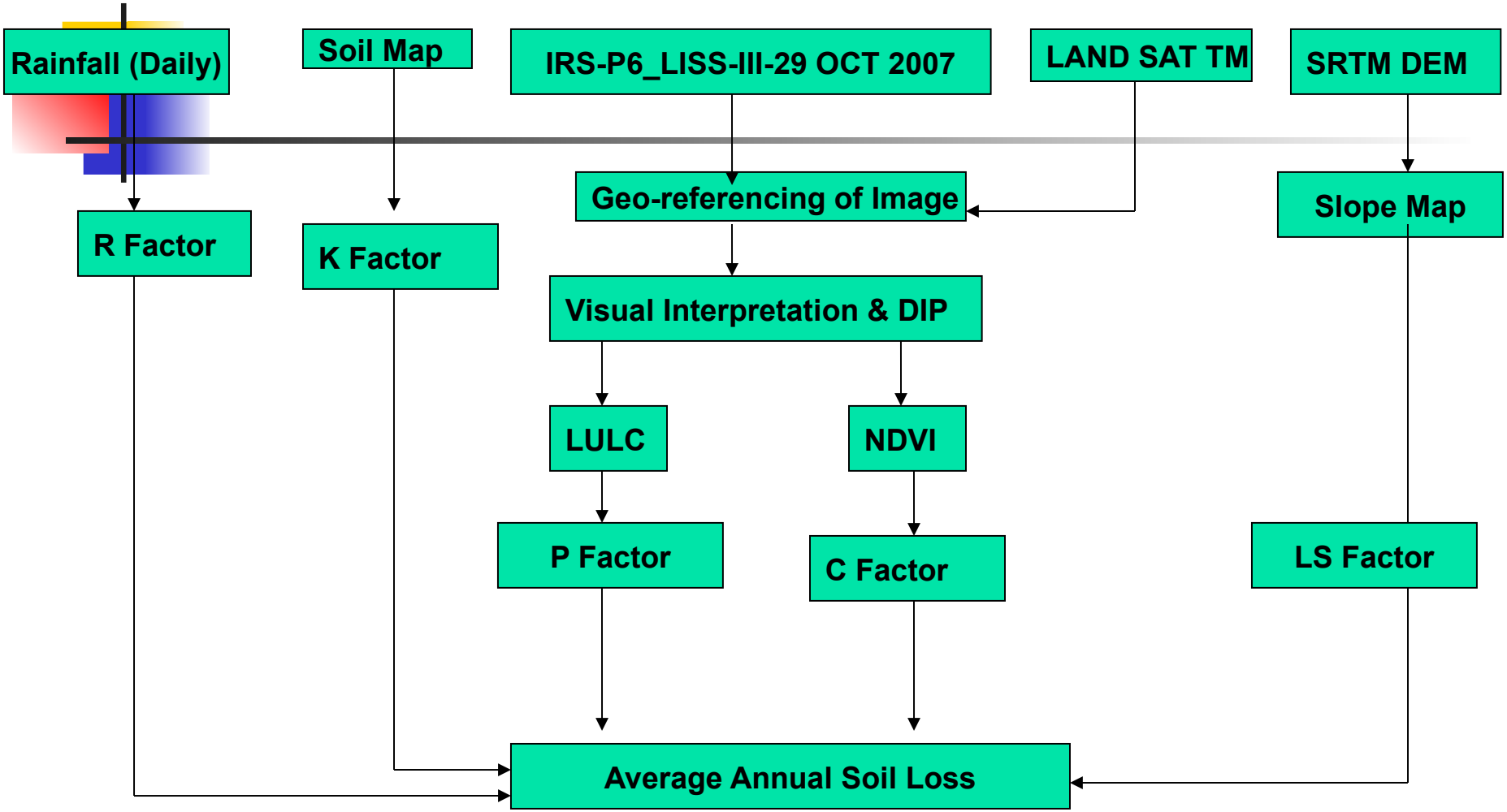


Sl. No	SubWater-sheds of	No. of Rainy Days	Rainfall (mm)	Runoff (mm)	Area(sq. m)	Volume (m^3)
1	Muzafferpur	72	1126.00	16089.0	289.8×10^6	4662.8×10^6
2	Roorkee	86	1105.85	15811.4	233.3×10^6	3689.1×10^6
				Total	523.1×10^6	8351.9×10^6

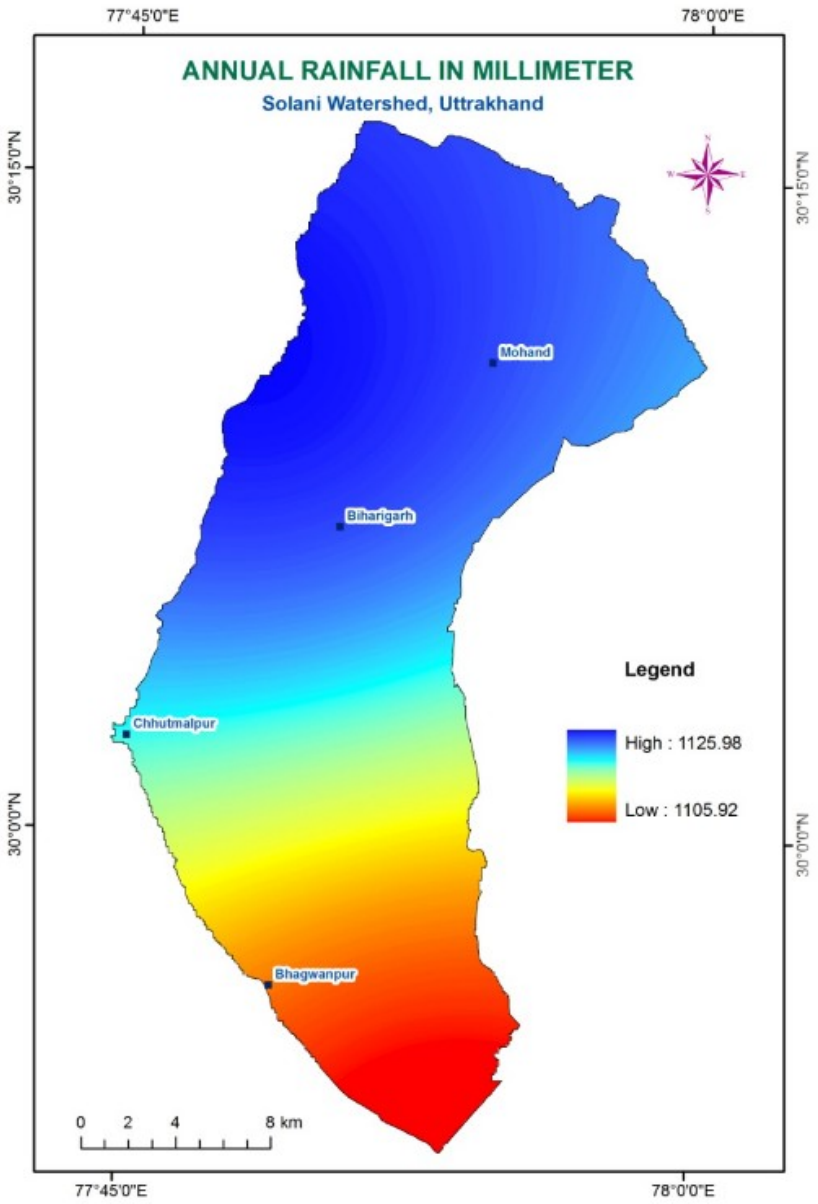
CONCLUSIONS

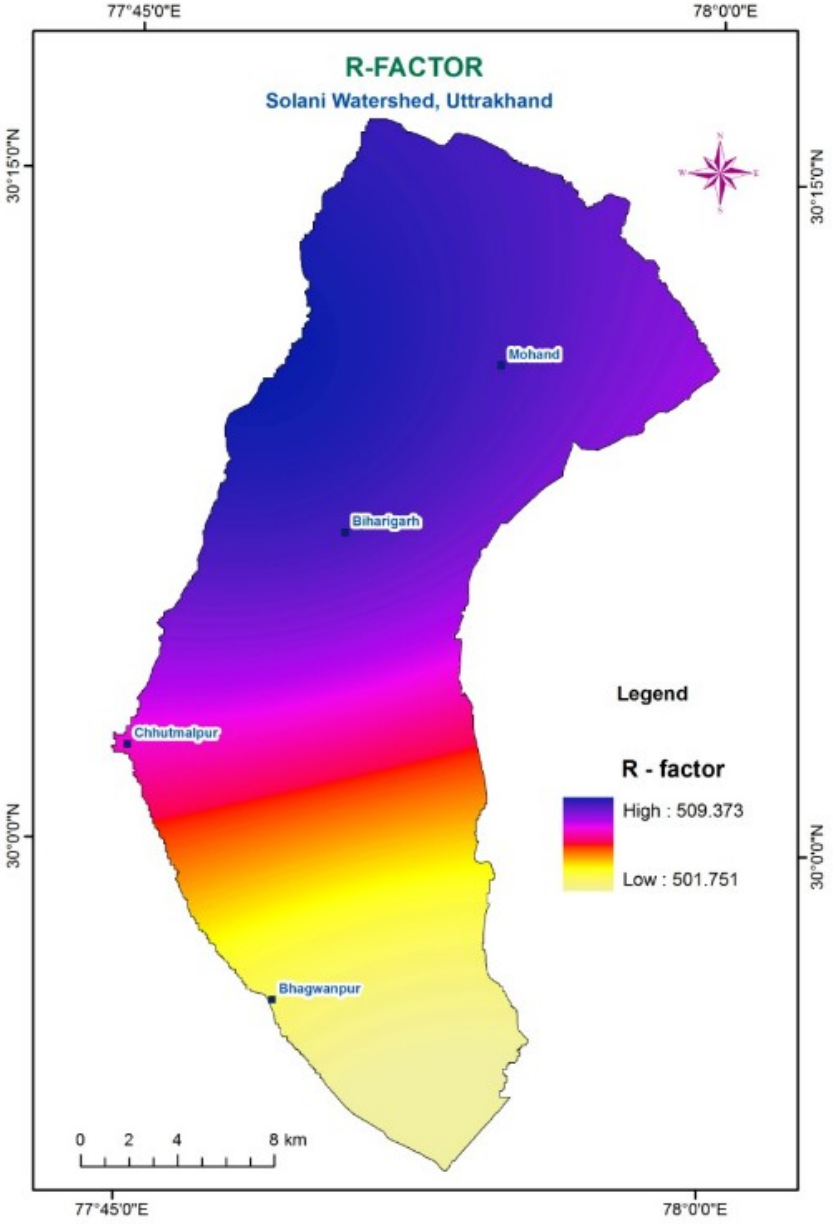
- The average annual runoff is 170.7 mm against the average rainfall of 1116mm for the year 2008 in Solani watershed.
- The use of Remote Sensing data with collateral data and the efficiency of GIS platform has been well documented for runoff estimation.
- This approach could be applied easily for other watersheds for efficient and effective planning and implementation.

2. SOIL LOSS ESTIMATION



Flow Chart for Estimation of Annual Soil Loss





R-Factor = 81.5 + (0.380 * [rain.img])

$$LS = (As/22.13)^n \times (\sin \beta/0.0896)^m$$

Where,

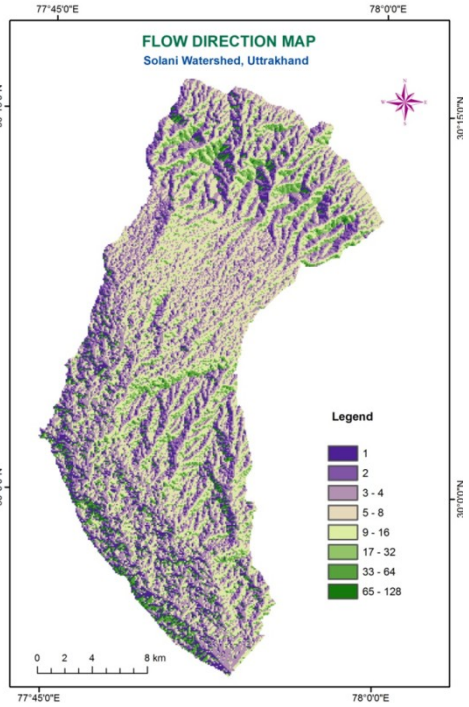
As = specific area *(=A/b),* defined as the upslope contributing area for an overland cell (A) per unit width normal to the flow direction *(b);*

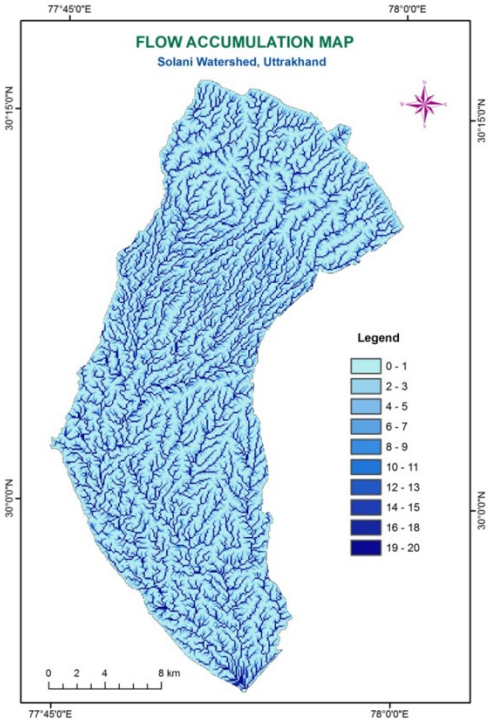
β = the slope gradient in degrees;

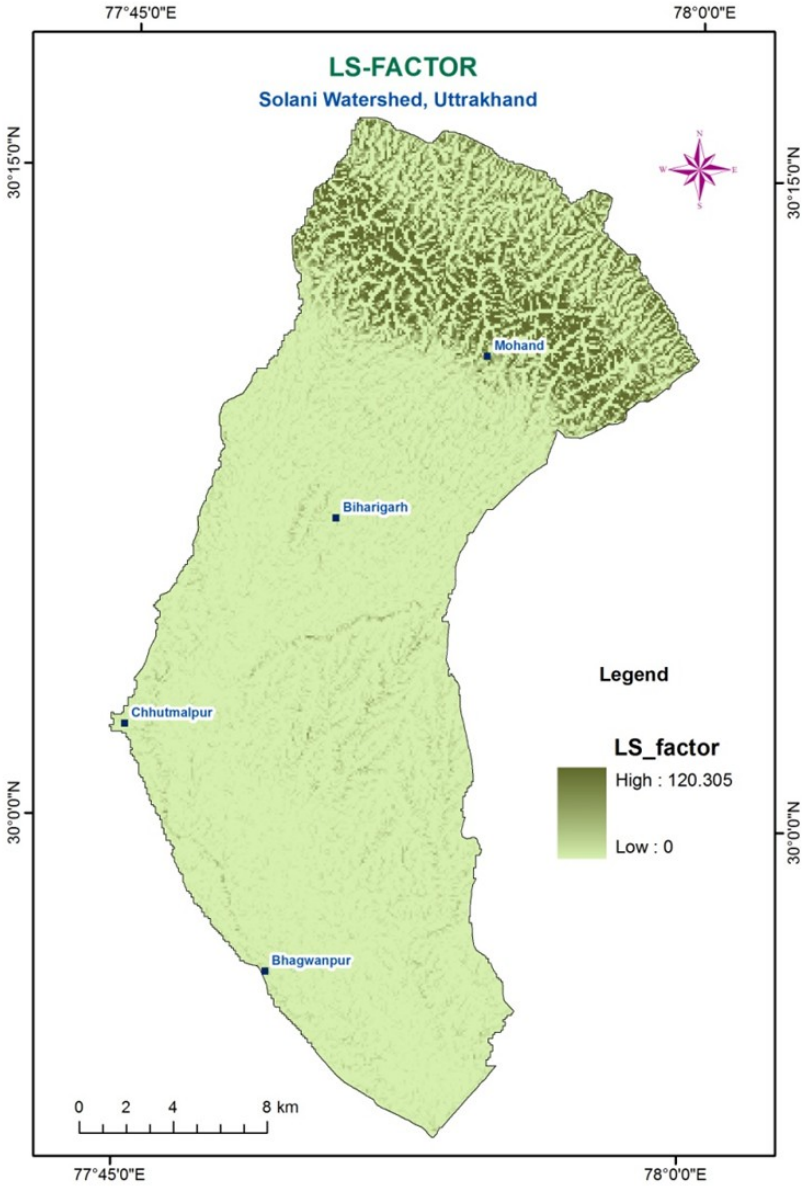
n = 0.4; and *m* = 1.3.

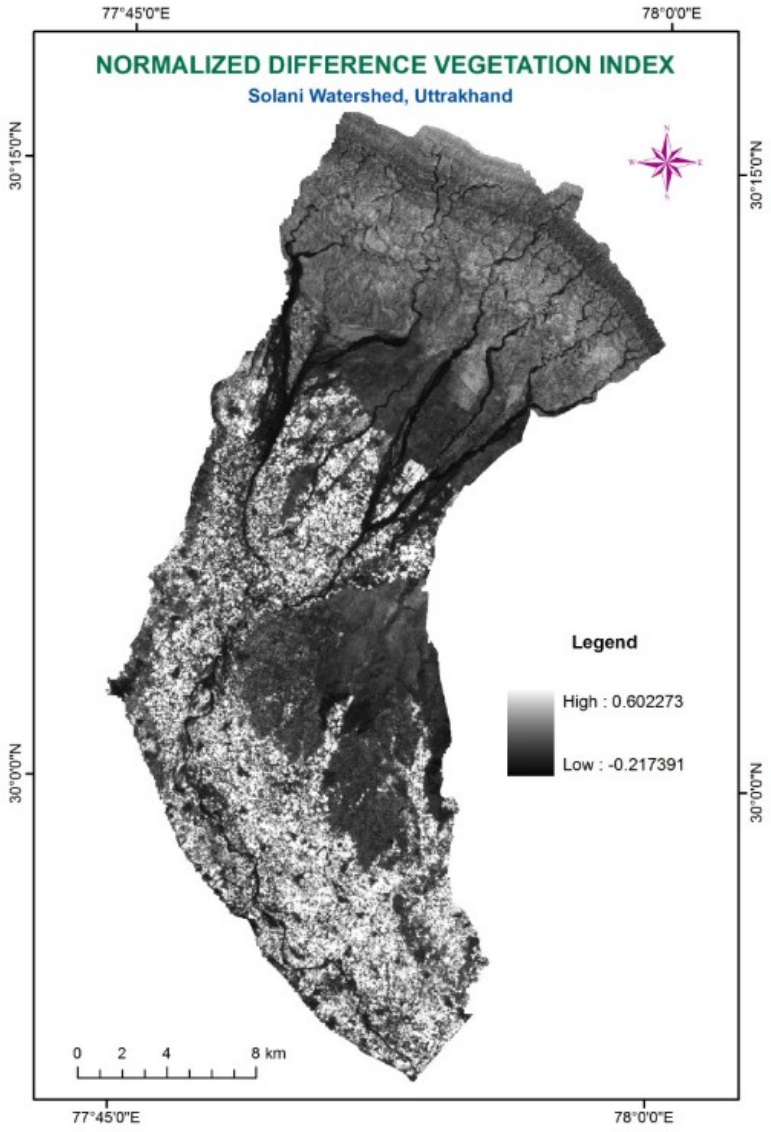
The slope steepness factor S, is evaluated from developed by McCool et al. (1987, 1993),

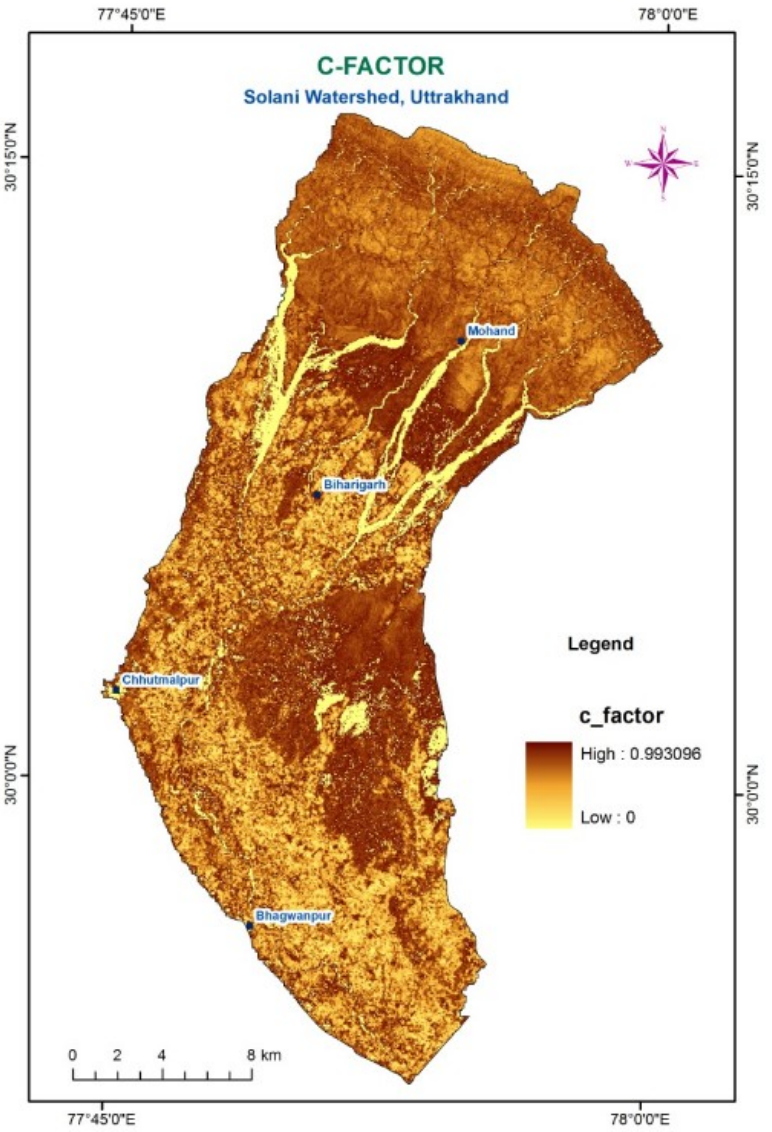
$$S = 10.8 \sin\theta + 0.03, \quad S < 9\ \% \text{ (i.e. } \tan\theta < 0.09)$$


FLOW DIRECTION MAP
Solani Watershed, Uttrakhand
77°45'0"E
78°0'0"E
30°15'0"N
30°0'0"N
Legend
1
2
3 - 4
5 - 8
9 - 16
17 - 32
33 - 64
65 - 128
0 2 4 8 km


FLOW ACCUMULATION MAP
Solani Watershed, Uttrakhand
77°45'0"E
78°0'0"E
30°15'0"N
30°0'0"N
Legend
0 - 1
2 - 3
4 - 5
6 - 7
8 - 9
10 - 11
12 - 13
14 - 15
16 - 18
19 - 20
0 2 4 8 km


LS-FACTOR
Solani Watershed, Uttrakhand
77°45'0"E
78°0'0"E
30°15'0"N
30°0'0"N
Mohand
Biharigarh
Chhutmalpur
Bhagwanpur
Legend
LS_factor
High : 120.305
Low : 0
0 2 4 8 km


NORMALIZED DIFFERENCE VEGETATION INDEX
Solani Watershed, Uttrakhand
77°45'0"E
78°0'0"E
30°15'0"N
30°0'0"N
Legend
High : 0.602273
Low : -0.217391
0 2 4 8 km


C-FACTOR
Solani Watershed, Uttrakhand
77°45'0"E
78°0'0"E
30°15'0"N
30°0'0"N
Mohand
Biharigarh
Chhutmalpur
Bhagwanpur
Legend
c_factor
High : 0.993096
Low : 0
0 2 4 8 km

$$K = \frac{2.1 \times 10^{-4} (12\text{-}OM)M^{1.14} + 3.25(s-2) + 2.5(p-3)}{759.4}$$

Where,

K = soil erodibility (tons-yr/MJ-mm,

OM= Per cent organic matter,

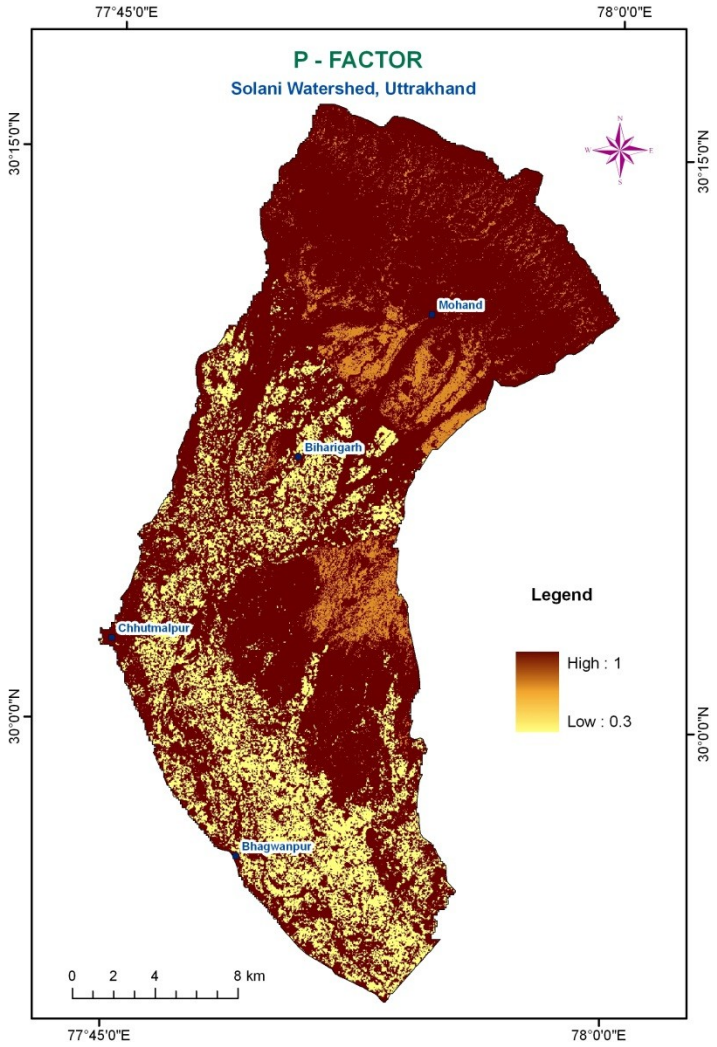
p = permeability code,

s = soil structure code,

M = a function of the primary partical size function given by

M = (% silt+% very fine sand) X (100-% clay)

For this case study the value of K is assumed as 0.05.

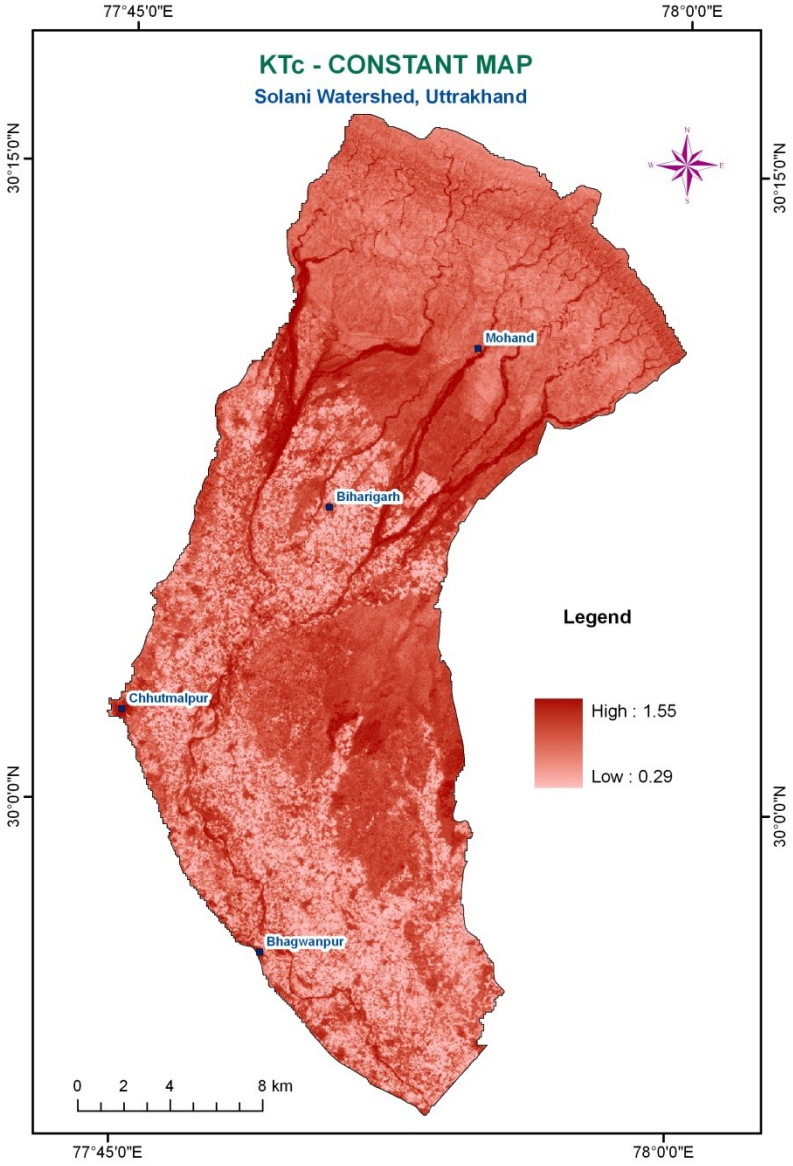


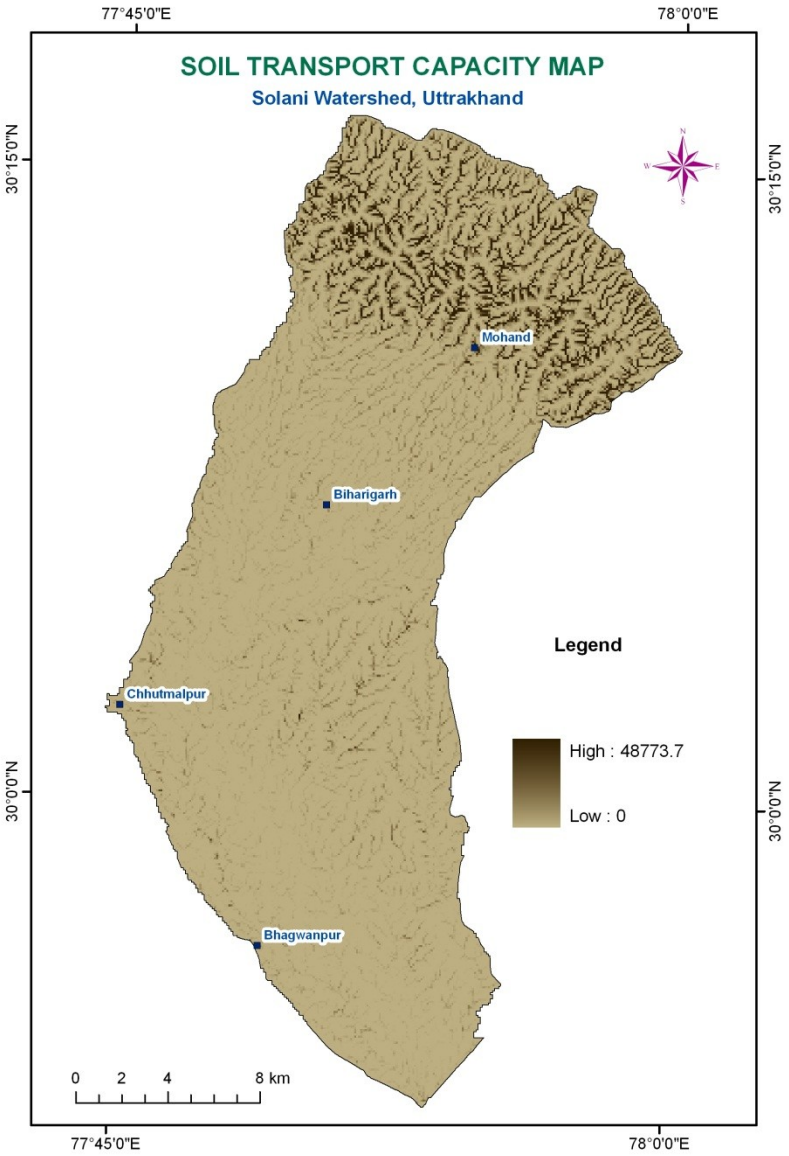
Soil Erodibility Factor (K) is considered here as 0.05

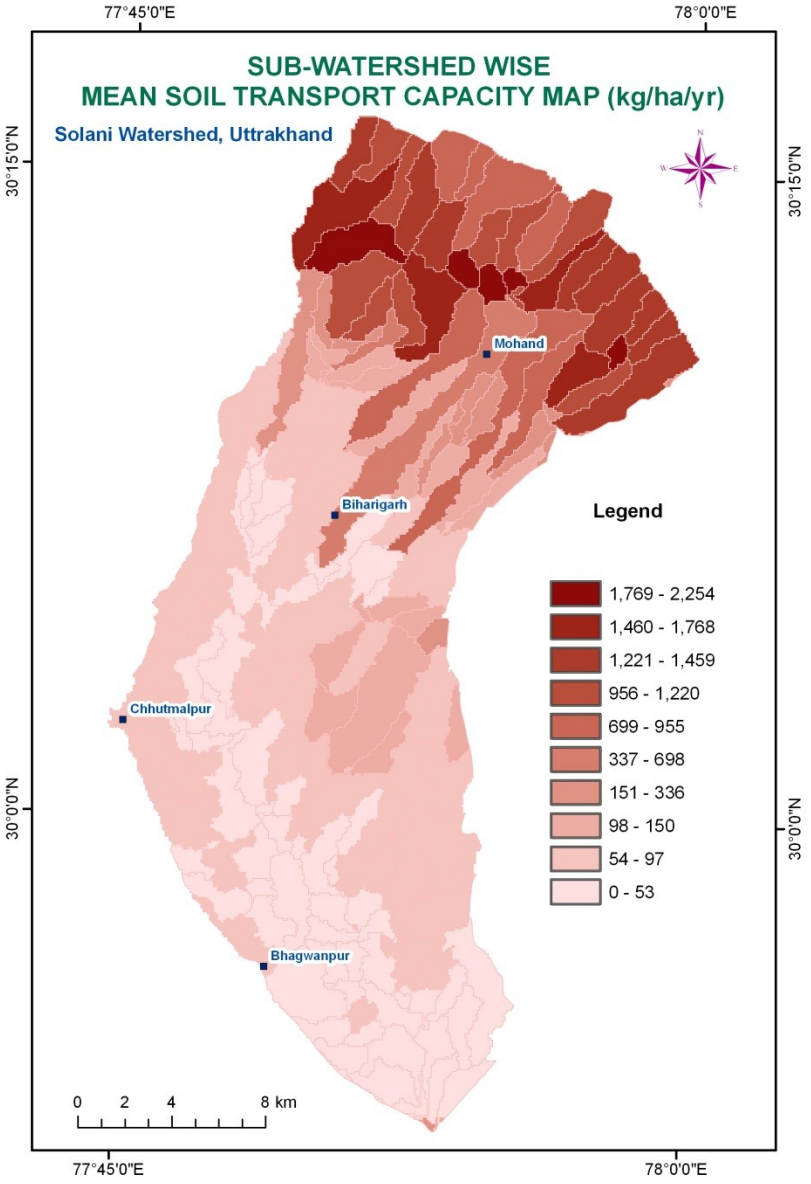
$$Tc = Ktc \cdot K.R.As^{1.44}.S^{1.14}$$

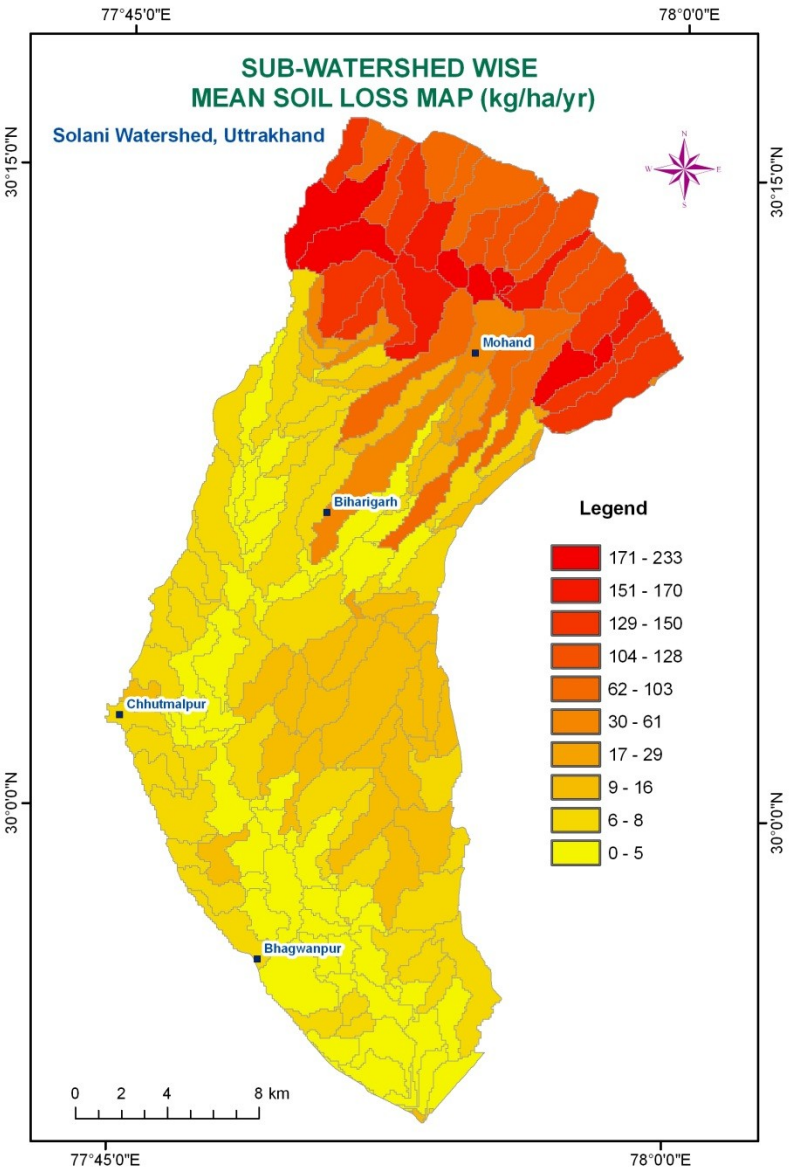
Where,

Tc = Transport capacity, kg/sq.m/yr
S = Slope gradient, m/m
As = Specific area, sq.m
R = Rainfall factor
K = Soil Erodability factor
Ktc = β. EXP (-NDVI/1-NDVI) (Ktc map is shown as Fig. 20)
β = 0.1-1.5, here the value of beta is taken as 1.


KTc - CONSTANT MAP
Solani Watershed, Uttrakhand
77°45'0"E
78°0'0"E
30°15'0"N
30°0'0"N
Mohand
Biharigarh
Chhutmalpur
Bhagwanpur
Legend
High : 1.55
Low : 0.29
0 2 4 8 km


SOIL TRANSPORT CAPACITY MAP
Solani Watershed, Uttrakhand
77°45'0"E
78°0'0"E
30°15'0"N
30°0'0"N
Mohand
Biharigarh
Chhutmalpur
Bhagwanpur
Legend
High : 48773.7
Low : 0
0 2 4 8 km


77°45'0"E
78°0'0"E
SUB-WATERSHED WISE
MEAN SOIL TRANSPORT CAPACITY MAP (kg/ha/yr)
Solani Watershed, Uttrakhand
30°15'0"N
30°0'0"N
Mohand
Biharigarh
Chhutmalpur
Bhagwanpur
Legend
1,769 - 2,254
1,460 - 1,768
1,221 - 1,459
956 - 1,220
699 - 955
337 - 698
151 - 336
98 - 150
54 - 97
0 - 53
0 2 4 8 km


77°45'0"E
78°0'0"E
SUB-WATERSHED WISE
MEAN SOIL LOSS MAP (kg/ha/yr)
Solani Watershed, Uttrakhand
30°15'0"N
30°0'0"N
Mohand
Biharigarh
Chhutmalpur
Bhagwanpur
Legend
171 - 233
151 - 170
129 - 150
104 - 128
62 - 103
30 - 61
17 - 29
9 - 16
6 - 8
0 - 5
0 2 4 8 km

CONCLUSIONS

- The integration of remote sensing and GIS techniques was successfully employed in this study to find out the erosion and sediment transport capacity of the Solani watershed.
- The results of this study has depicted that the amount of soil loss in the Solani watershed is ranging from 0 to 2385 kg/ha/yr. The soil transport capacity and soil loss are having a direct relationship.
- This approach could be applied easily for other watersheds for efficient and effective planning and implementation for various conservation measures.

STUDY - 6

Inter-Watershed Transfer

Back

- After working out the surface water potential, groundwater potential, natural recharge, artificial recharge was done to suggest strategies for inter-watershed transfer

- The aerial extent of rechargeable formations, volume of rechargeable formations total thickness of unsaturated zone, volume of recharge formations available for recharge, volume of allowable recharge etc were worked out.

- To workout the volume of rechargeable formations, the aerial extent of rechargeable formations was multiplied with the depth to bedrock data. The water level data was multiplied with the area of artificially rechargeable formations to arrive the volume of rechargeable formations available for recharge.

- As the area exposes mostly Gneisses, the storage coefficient of 0.23 or 23 % was taken as allowable storage. The data arrived at column 7 was multiplied with 0.23 to arrive the volume of allowable recharge (column 8)

- The total water potential available as run-off was less than the volume of allowable recharge (column 8) the said watershed was declared as deficit watershed. Instead, if the run-off was more than volume of allowable recharge, then it was declared as water surplus watershed

ANNEXURE - II

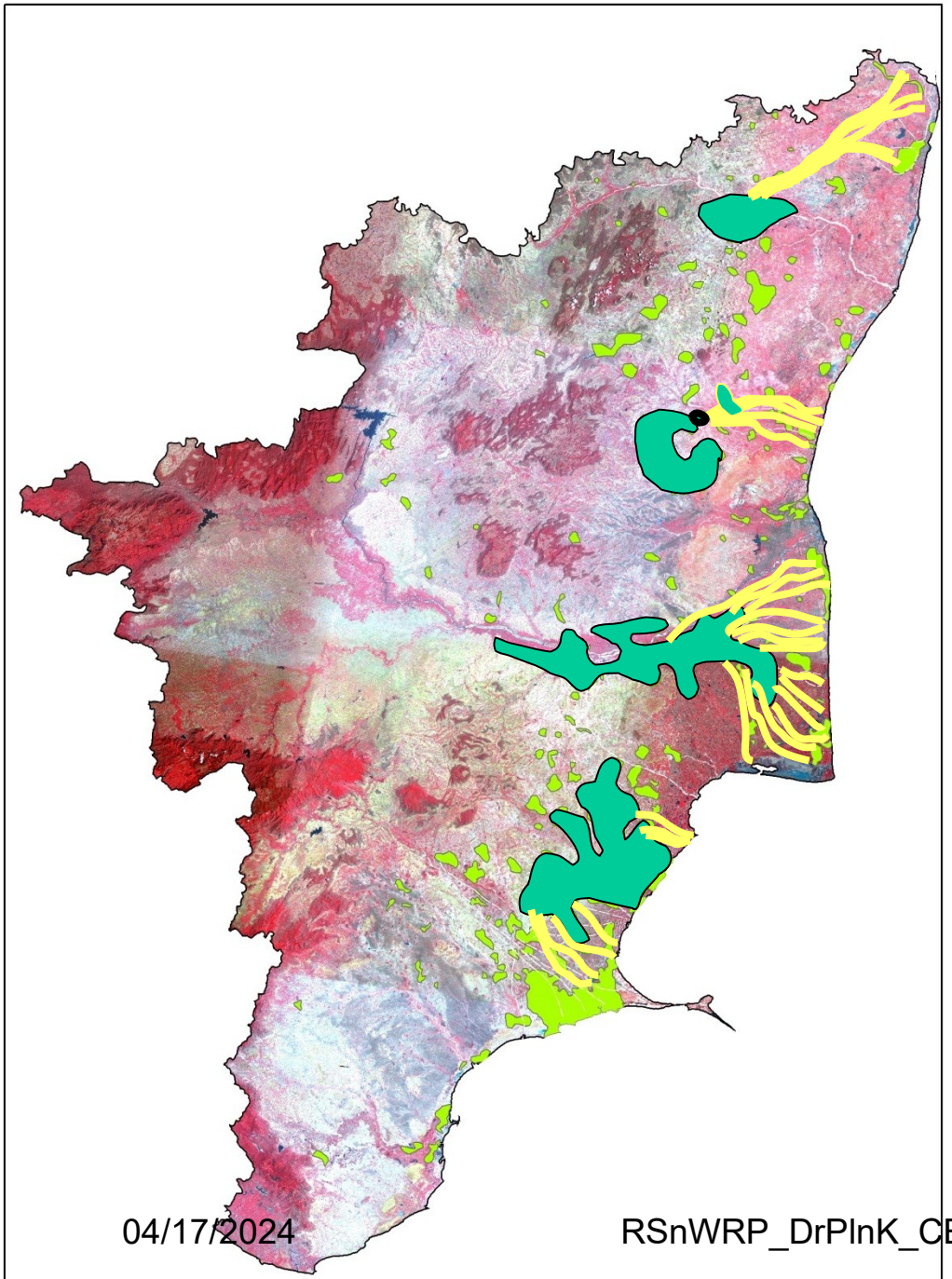
INTER WATERSHED TRANSFER

1 SL.No	2 WATER-SHED No	3 SURFACE WATER POTENTIAL	4 AREA OF ARTFICIAL RECHARGEABLE FORMATIONS IN MM^2	5 VOLUME OF RECHARGEABLE FORMATIONS IN MCM	6 THICKNESS OF UNSATU-RATED ZONE IN M	7 VOLUME OF RECHARGEABLE FORMATIONS AVAILABLE FOR RECHARGE IN MCM	8 VOLUME OF ALLOWABLE RECHARGE IN MCM (Storage coefficient)	9 REMARKS
1	1	5.590	58.834	2353.360	9.00	529.506	121.786	DEFICIT
2	2	58.990	24.613	246.130	8.50	209.211	48.119	SURPLUS
3	3	40.690	48.353	1160.472	4.90	236.930	54.494	DEFICIT
4	4	19.520	39.254	863.588	8.50	333.659	76.742	DEFICIT
5	5	56.810	20.481	491.544	7.50	153.608	35.330	SURPLUS
6	6	15.400	26.575	797.250	9.00	239.175	55.010	DEFICIT
7	7	46.060	71.908	2588.688	11.50	826.942	190.197	DEFICIT
8	8	4.280	22.798	1094.304	8.50	193.783	44.570	DEFICIT
9	9	9.400	24.909	647.634	10.00	249.090	57.291	DEFICIT
10	10	27.000	39.173	783.460	8.00	313.384	72.078	DEFICIT
11	11	22.900	4.233	186.252	11.00	46.563	10.709	SURPLUS
12	12	41.030	68.298	1434.258	11.50	785.427	180.648	DEFICIT
13	13	8.380	15.186	425.208	12.00	182.232	41.913	DEFICIT
14	14	38.230	15.074	361.776	14.00	211.036	48.538	DEFICIT
15	15	4.050	28.877	721.925	12.00	346.524	79.701	DEFICIT
16	16	3.860	12.925	361.900	9.50	122.788	28.241	DEFICIT
17	17	73.640	43.443	868.860	9.00	390.987	89.927	DEFICIT
18	18	65.130	51.270	1230.480	10.00	512.700	117.921	DEFICIT
19	19	70.220	39.181	940.344	9.00	352.629	81.105	DEFICIT
20	20	38.260	12.398	347.144	10.00	123.980	28.515	SURPLUS

ANNEXURE - II (Contd...)

INTER WATERSHED TRANSFER

1 SL.No	2 WATER-SHED No	3 SURFACE WATER POTENTIAL	4 AREA OF ARTFICIAL RECHARGEABLE FORMATIONS IN MM^2	5 VOLUME OF RECHARGEABLE FORMATIONS IN MCM	6 THICKNESS OF UNSATU-RATED ZONE IN M	7 VOLUME OF RECHARGEABLE FORMATIONS AVAILABLE FOR RECHARGE IN MCM	8 VOLUME OF ALLOWABLE RECHARGE IN MCM (Storage coefficient)	9 REMARKS
21	21	15.970	52.453	839.248	10.50	550.757	126.674	DEFICIT
22	22	13.600	44.320	975.040	11.00	487.520	112.130	DEFICIT
23	23	36.900	81.835	2618.720	10.50	859.268	197.632	DEFICIT
24	24	30.700	30.375	364.500	11.00	334.125	76.849	DEFICIT
25	25	11.900	27.099	541.980	12.50	338.738	77.910	DEFICIT
26	26	27.890	81.835	1964.040	8.50	695.598	159.988	DEFICIT
27	27	7.400	58.848	1647.660	9.00	529.605	121.809	DEFICIT
28	28	3.700	2.163	69.216	7.00	15.141	3.482	SURPLUS
29	29	6.400	50.991	1733.694	7.50	382.433	87.960	DEFICIT
30	30	9.700	3.908	132.872	6.50	25.402	5.842	SURPLUS
31	31	12.500	59.989	2159.604	9.50	569.896	131.076	DEFICIT
32	32	57.700	30.963	743.112	11.50	356.075	81.897	DEFICIT
33	33	29.600	5.325	127.800	9.50	50.588	11.635	SURPLUS



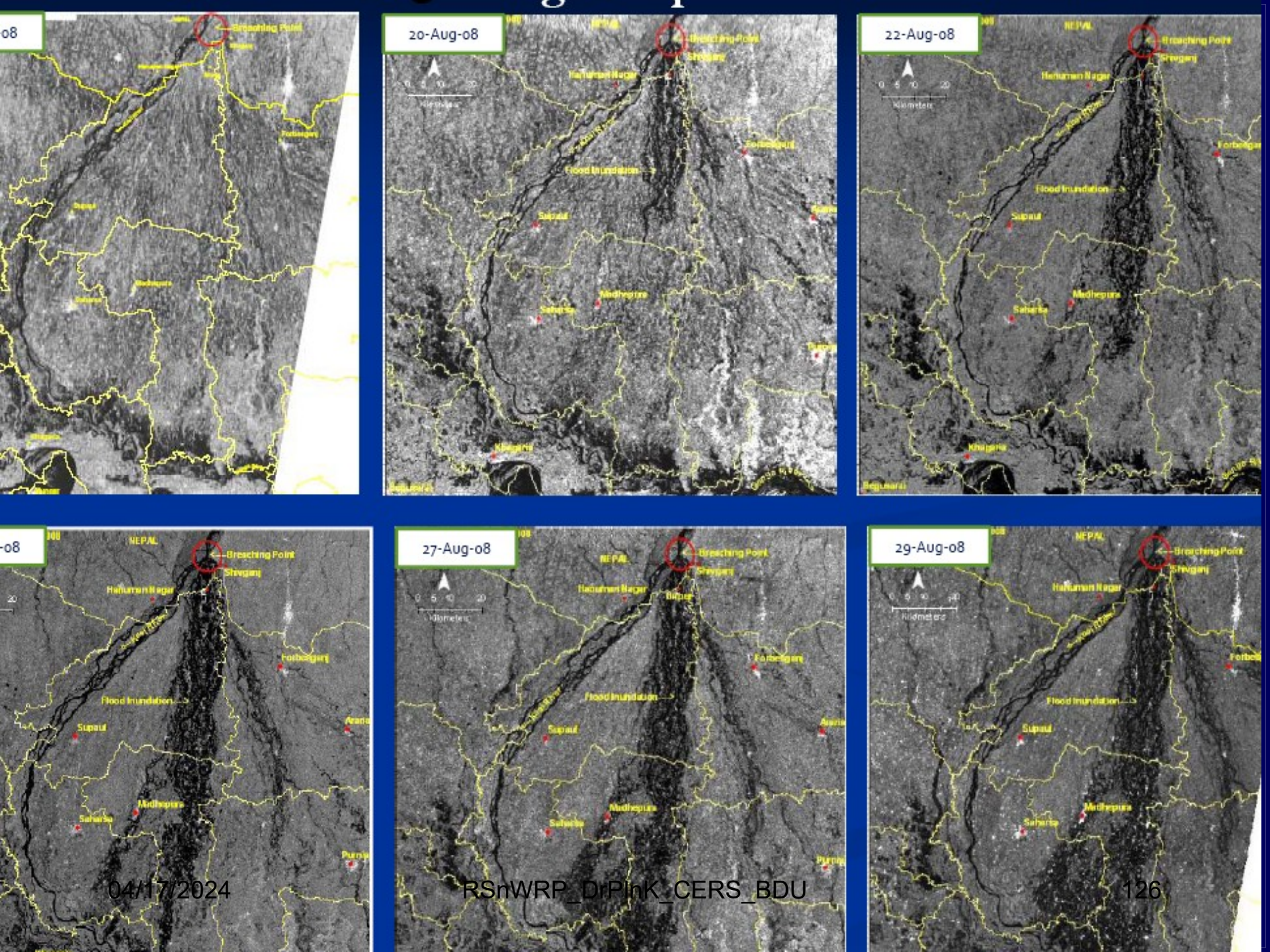
DIVERSION OF FLOOD THROUGH BURIED RIVERS

Back

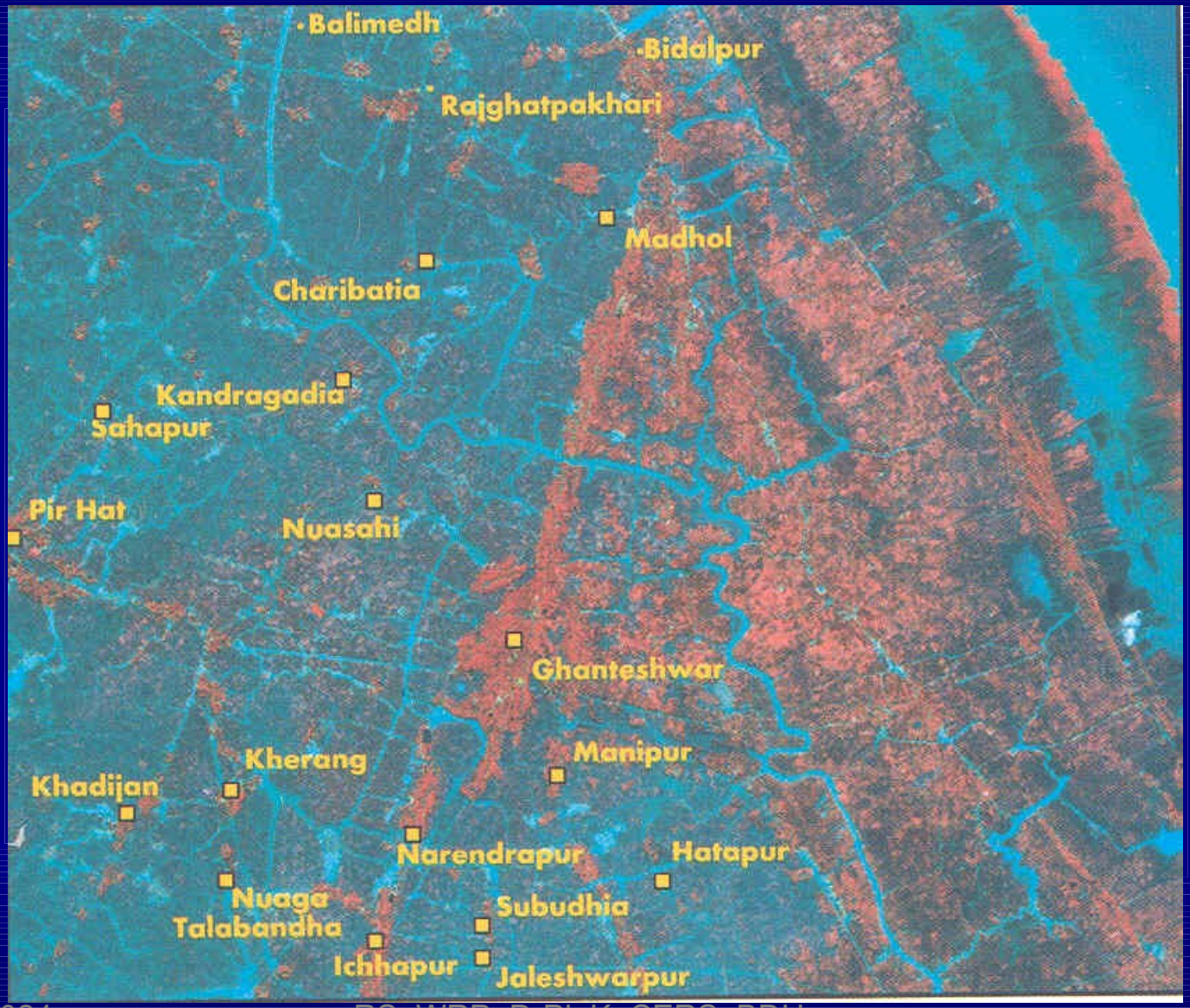
STUDY - 7

FLOOD WATER HARVESTING

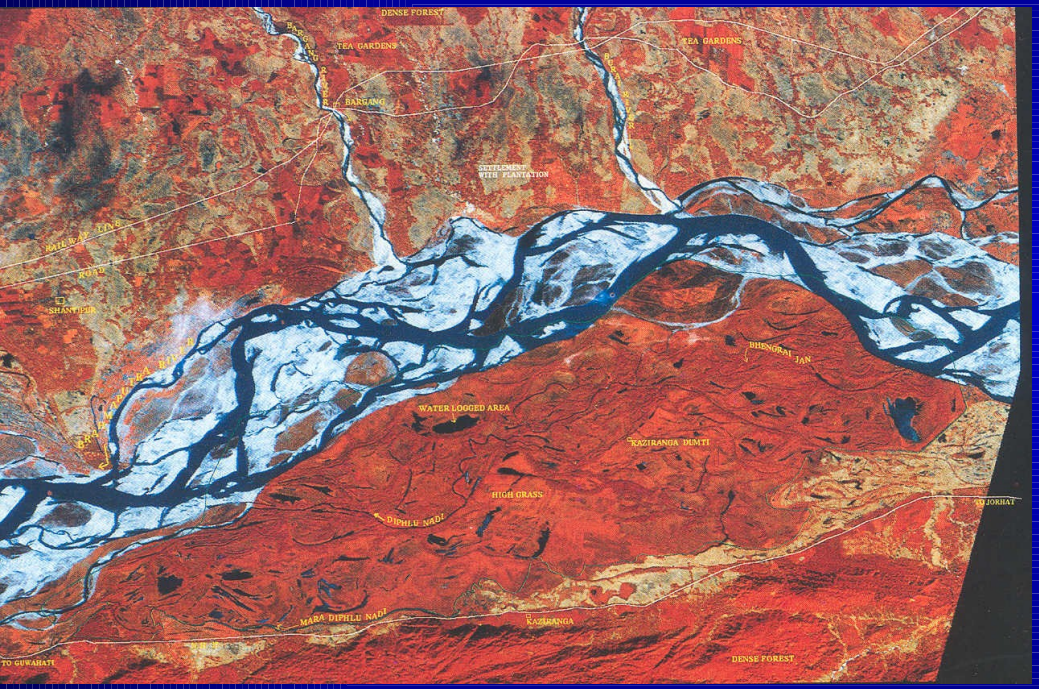
Back


08
Breaching Point
Forbesganj
Supaul
Madhepura
Saharsa
20-Aug-08
NEPAL
Breaching Point
Shivganj
Hanuman Nagar
Flood Inundation
Khagaria
22-Aug-08
-08
27-Aug-08
Araria
Purnia
29-Aug-08

RADARSAT – ORISSA – POST – CYCLONE

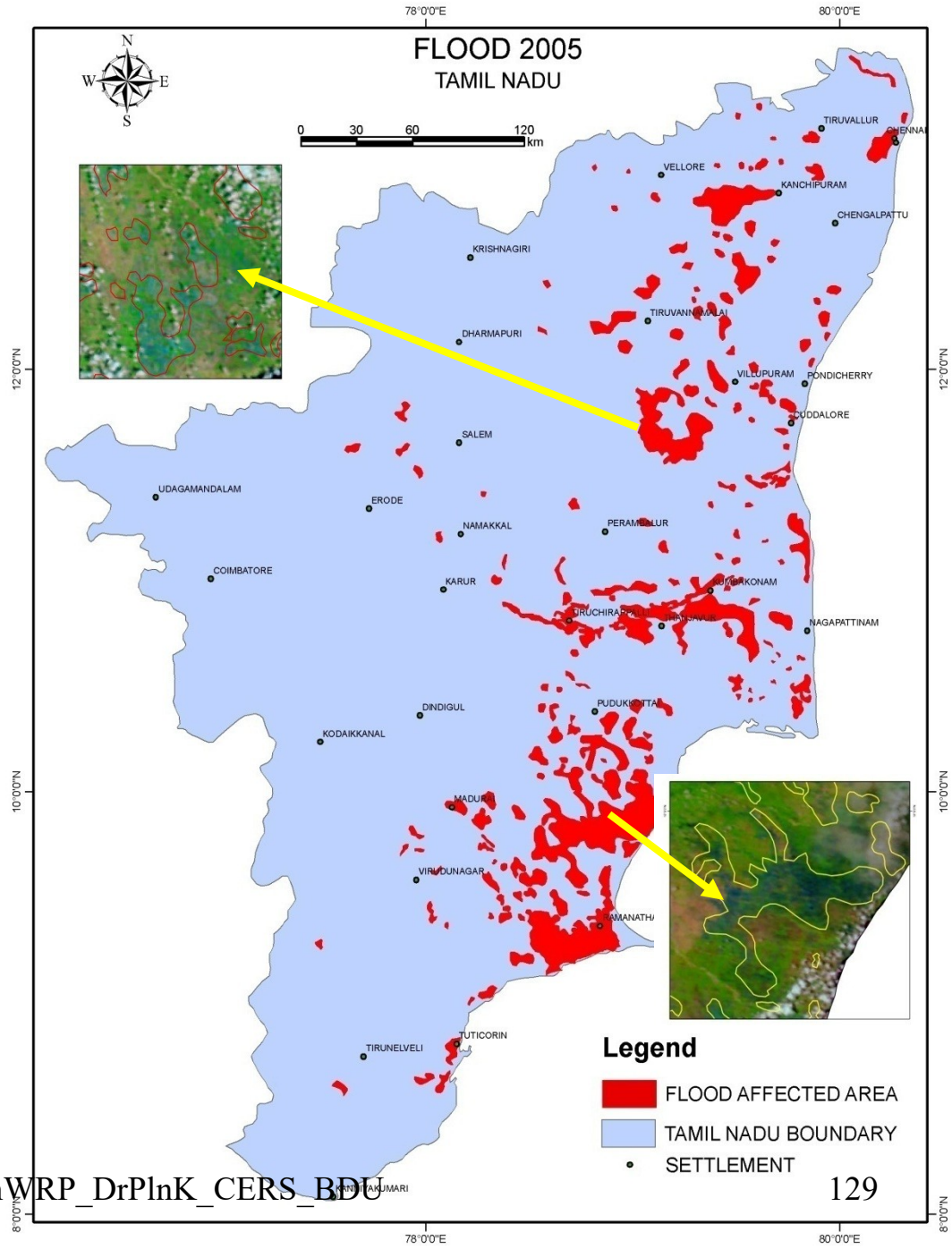


Disaster due to Flooding

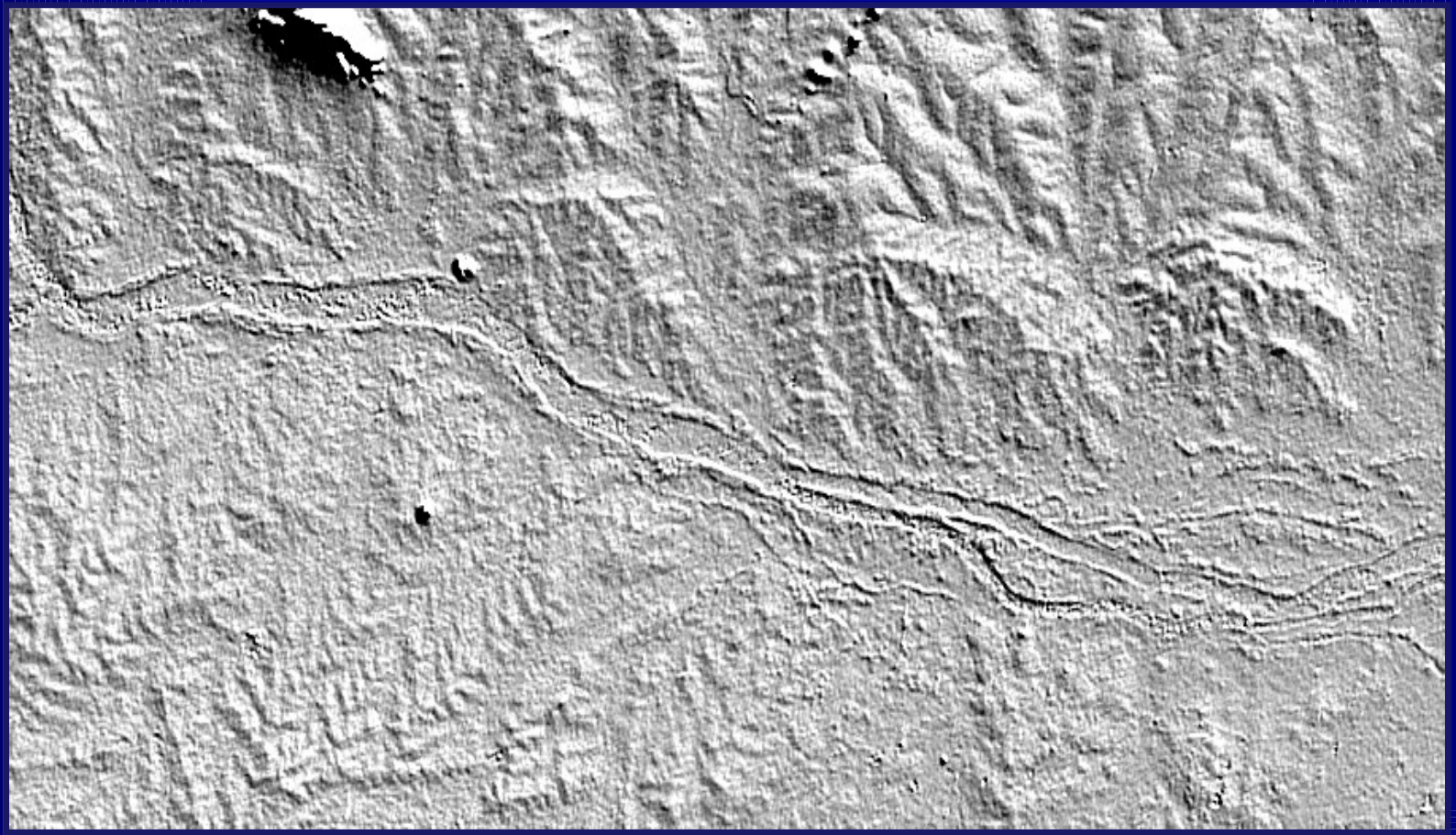


Flooded areas in Tamil Nadu

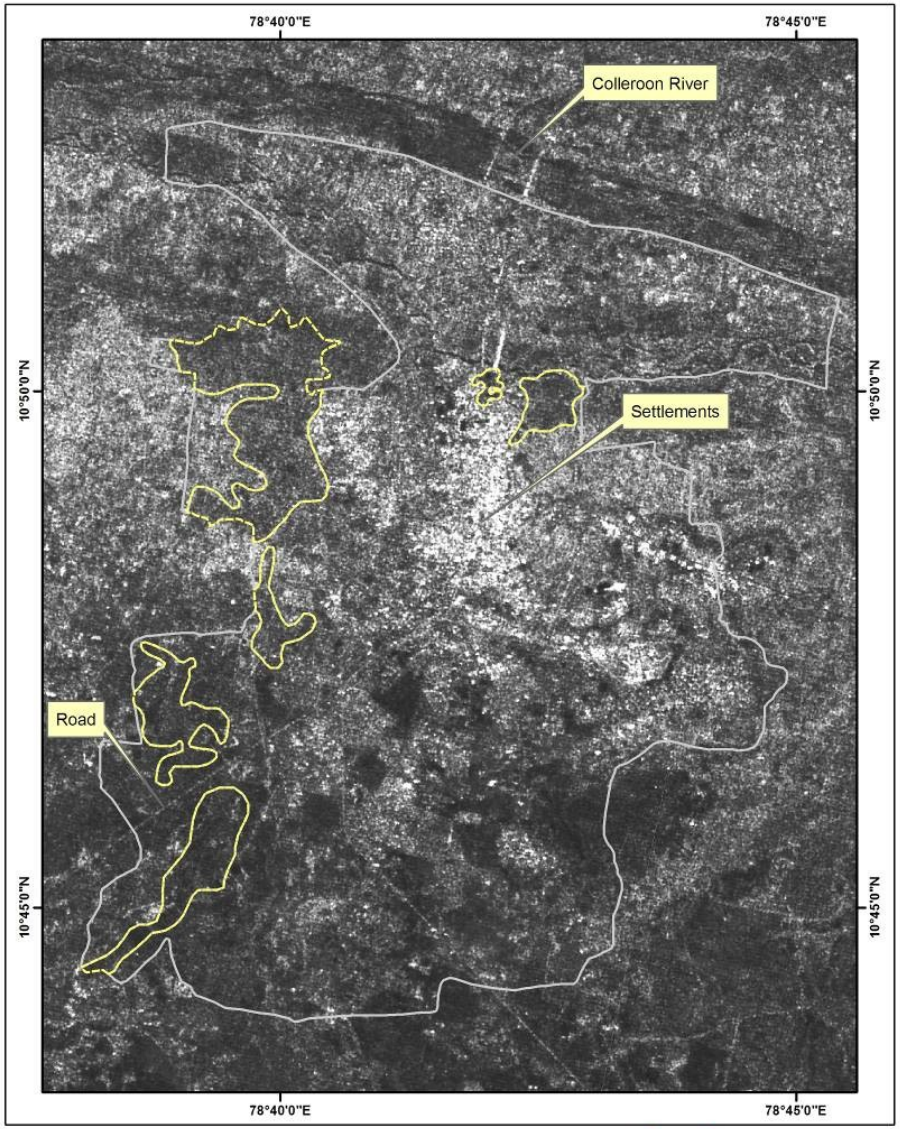
- Mapped using MODIS data



SHADED RELIEF MAP – Flood Vulnerable areas



Microwave Remote Sensing Data Showing Water Logged Areas in Tiruchirappalli Region

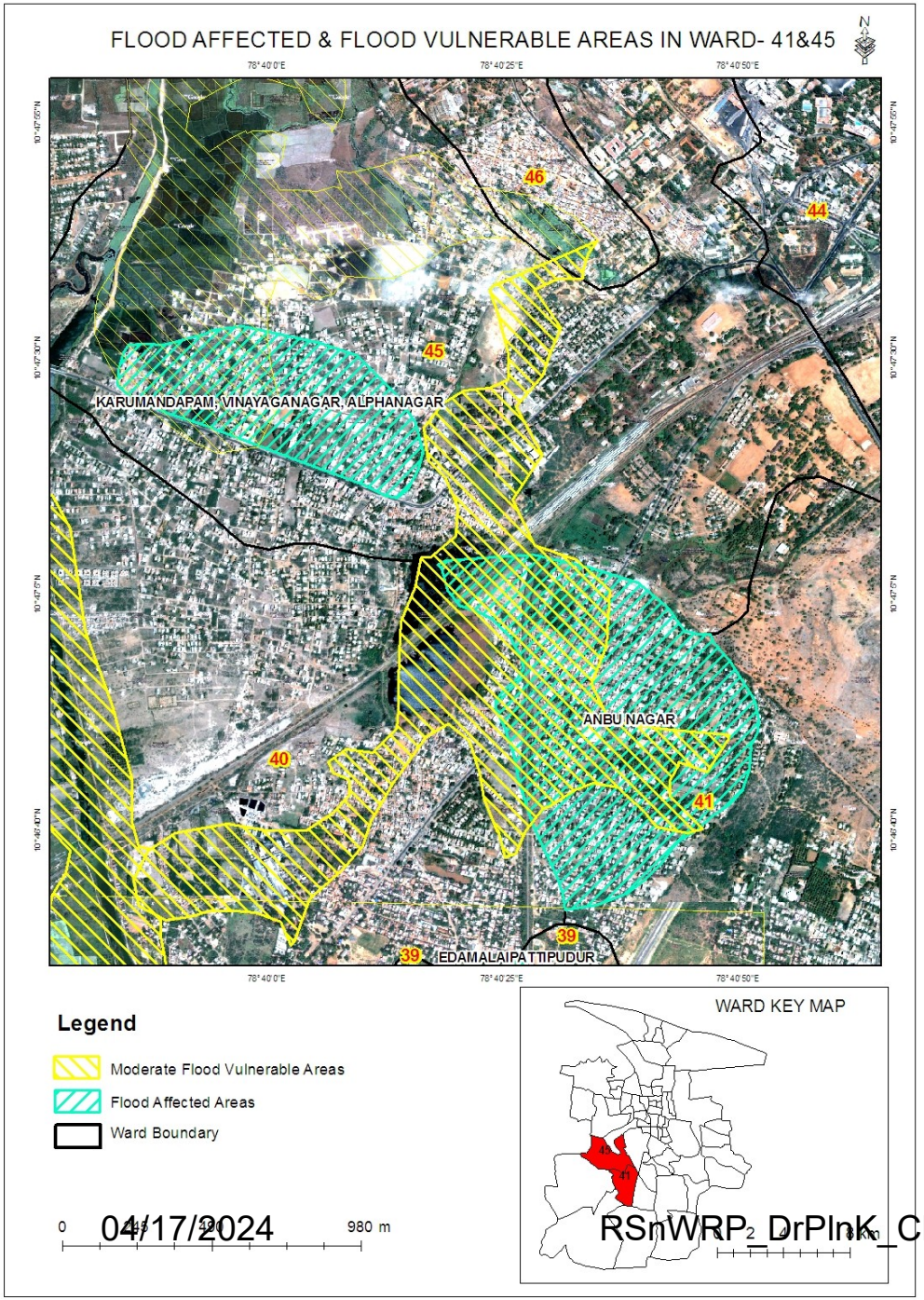


Legend

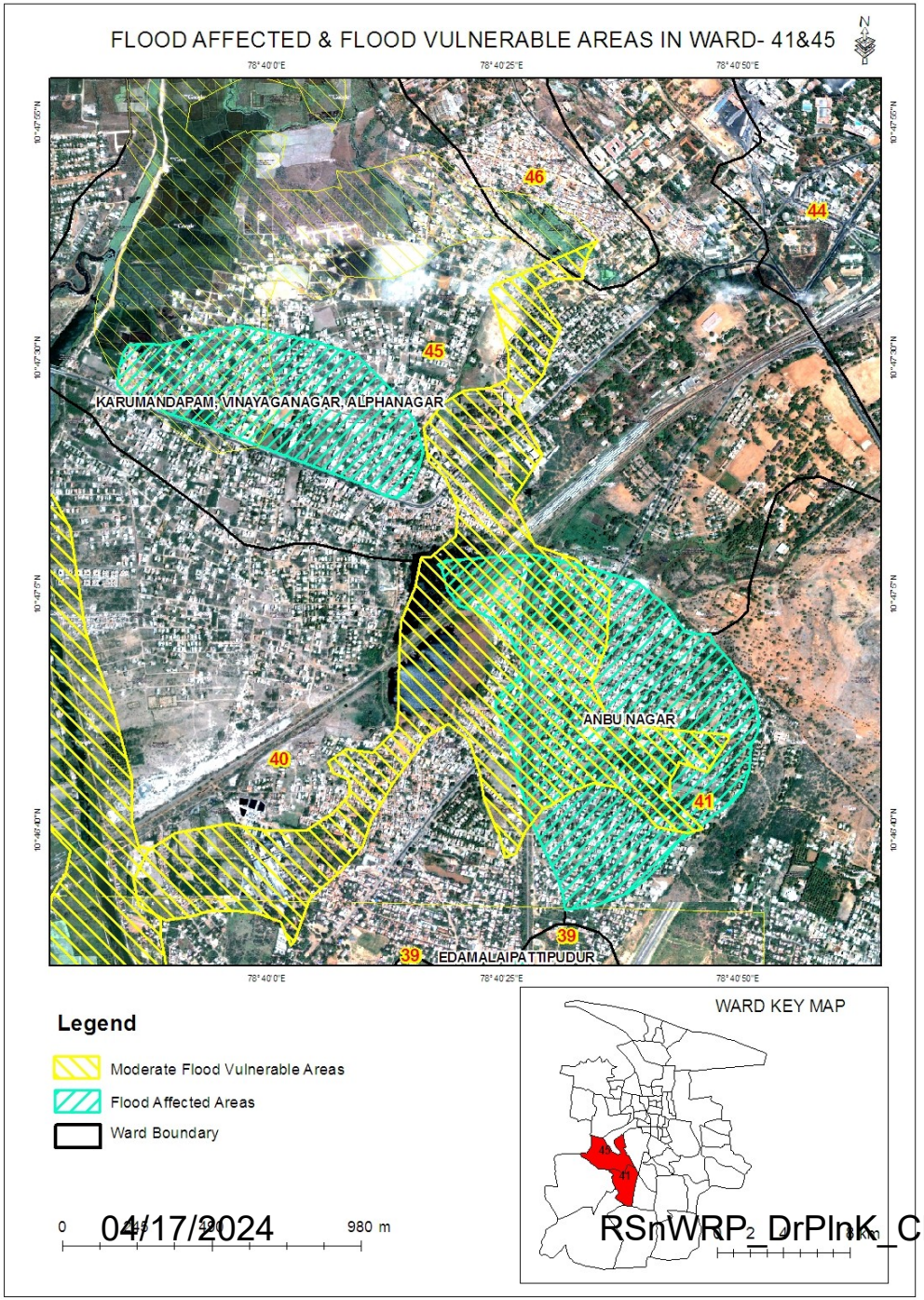
Water Logged Areas

Prepared by : Centre for Remote Sensing
Bharathidasan University

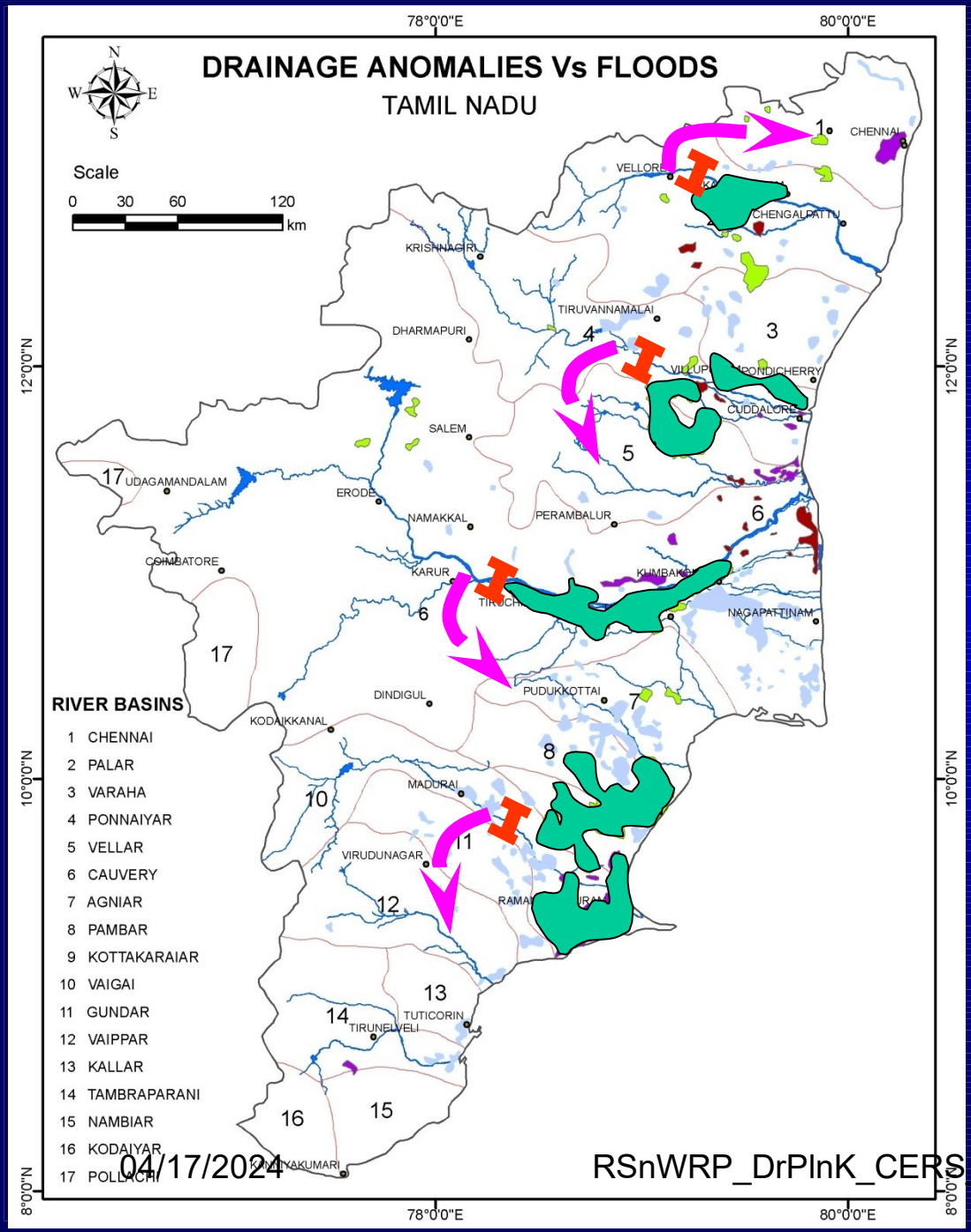
0 2 4 Km



Flood vulnerable areas and affected areas in Wards 26, 27&33, Tiruchirappalli Corporation

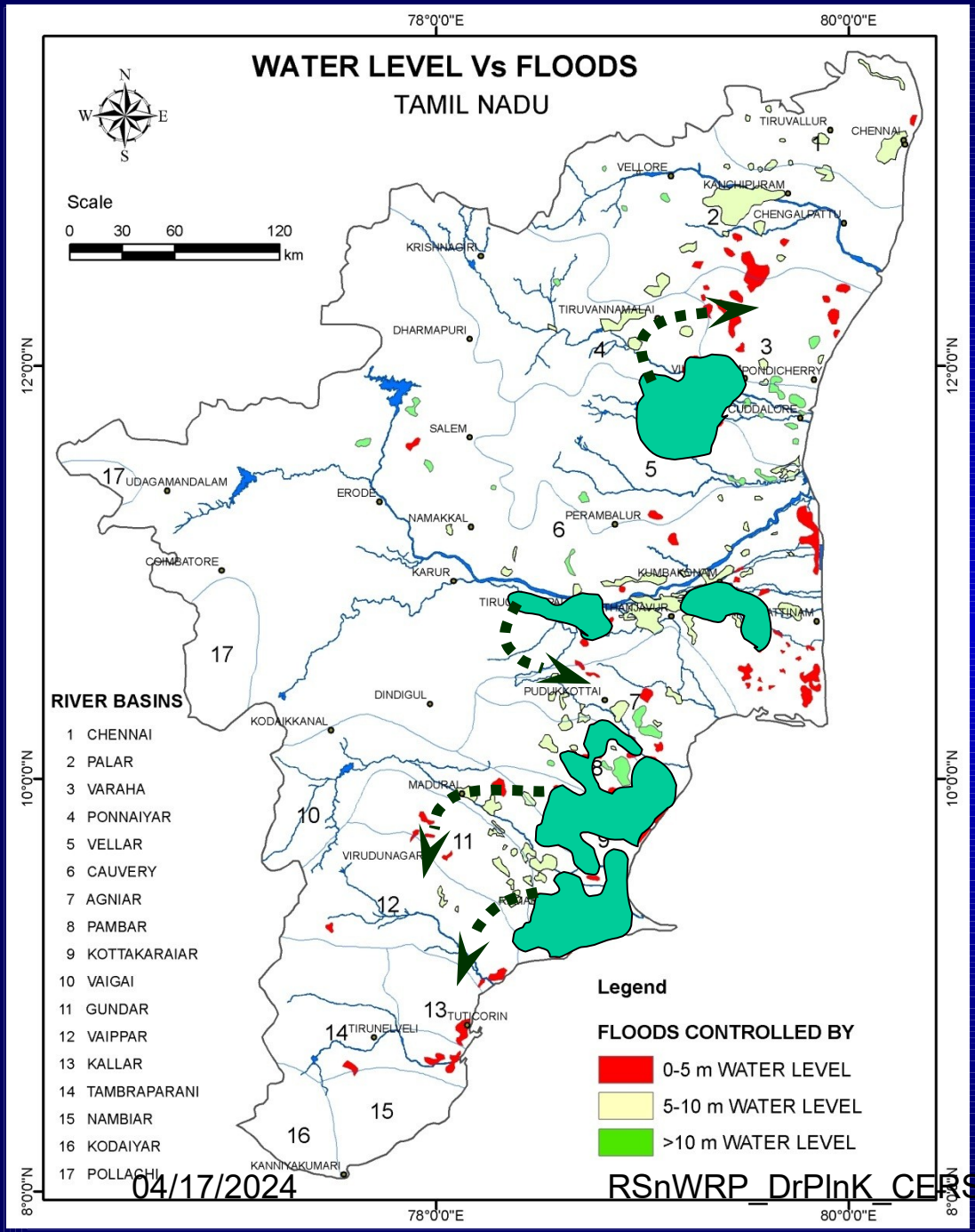


Flood vulnerable areas and affected areas in Ward 41&45, Tiruchirappalli Corporation



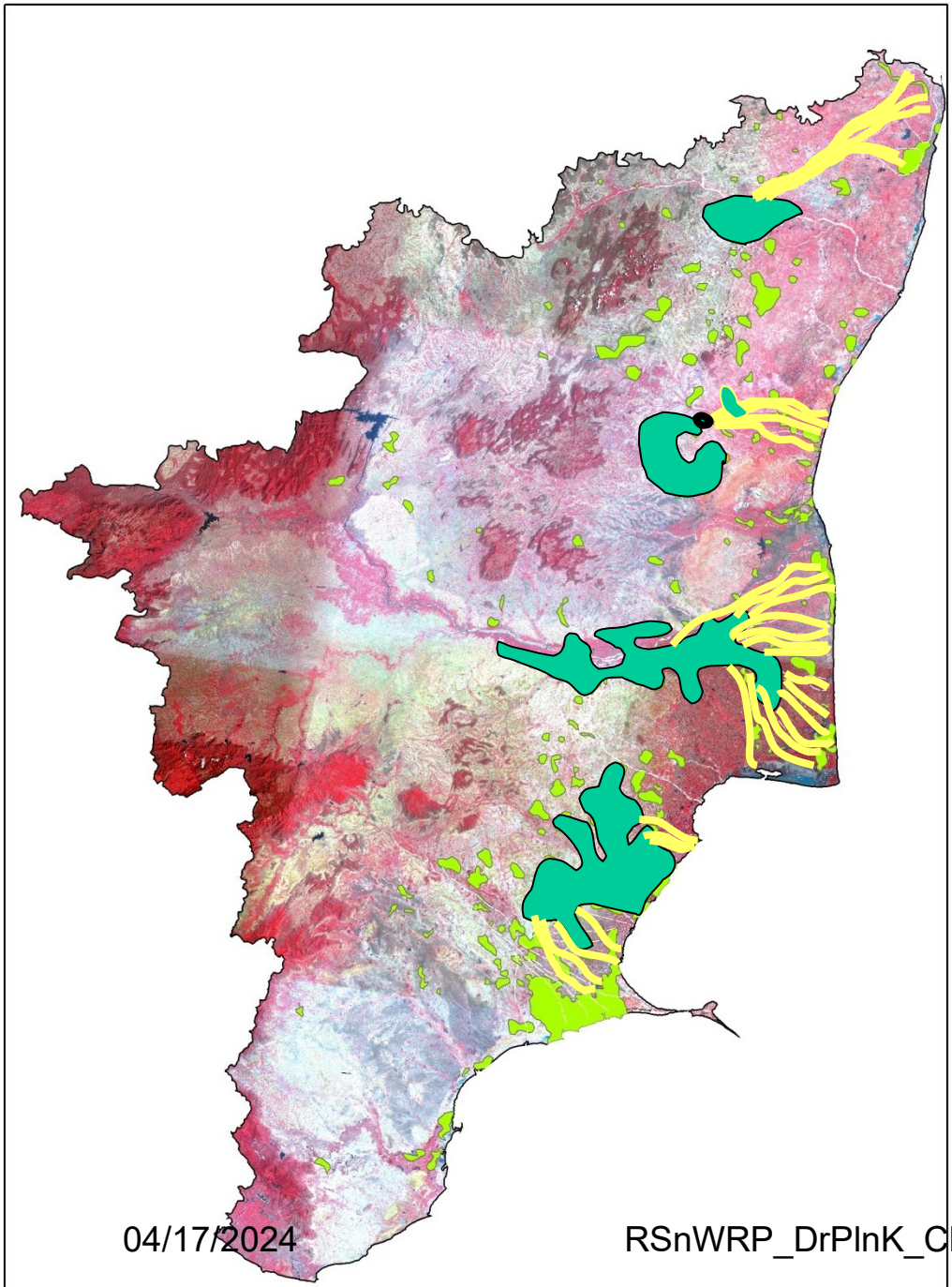
FLOOD CONTROLLED BY DRAINAGE ANOMALIES

- Check dam upper reaches
- Transfer to Other basins



FLOOD CONTROLLED BY WATER LEVEL

- Depress the water level
- Transfer to other basin



FLOOD WATER HARVESTING

DIVERSION OF FLOOD THROUGH BURIED RIVERS

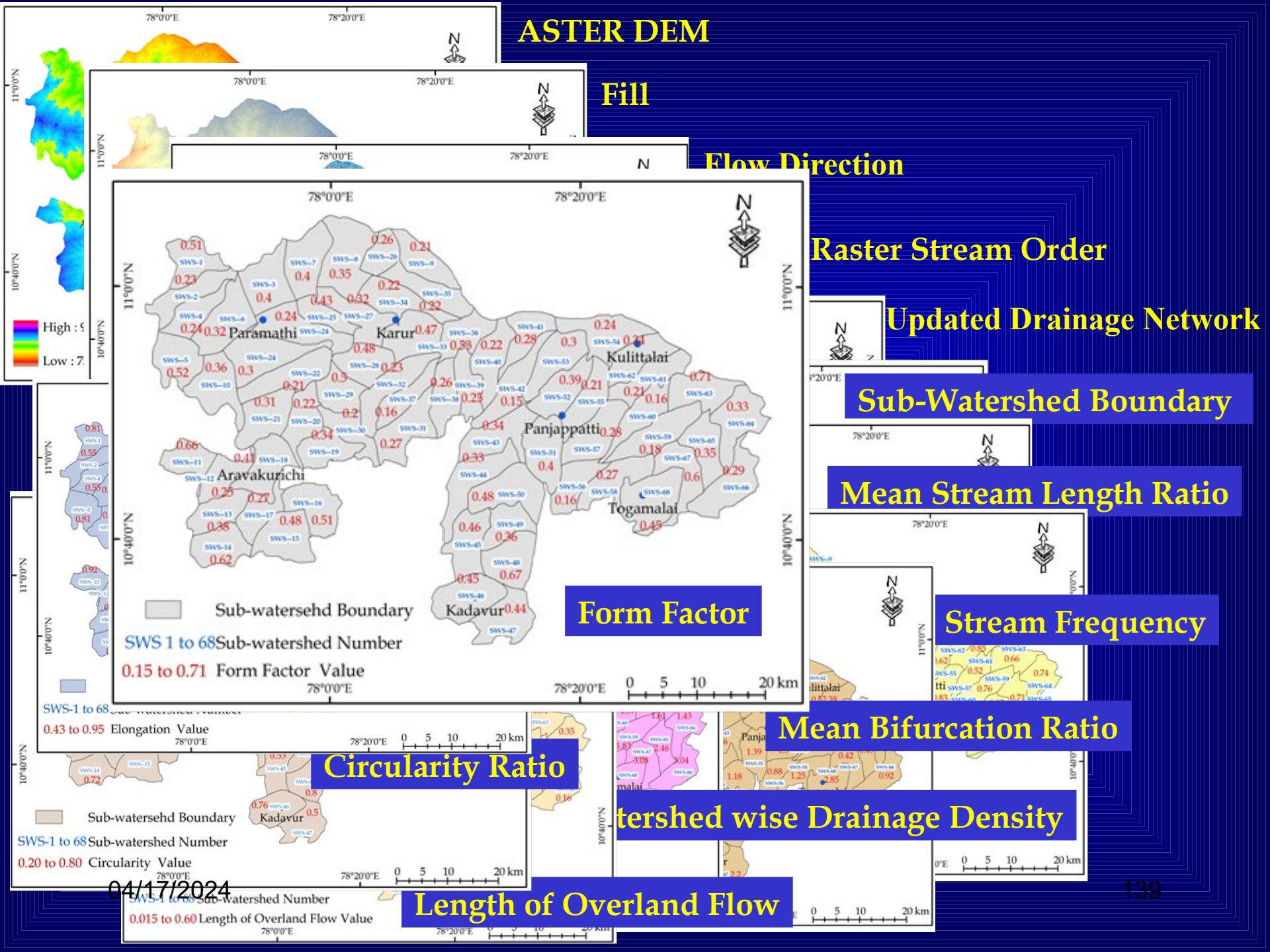
Transfer of excess flood water to the adjacent water deficit (Grey / Black) watersheds through favourable routes

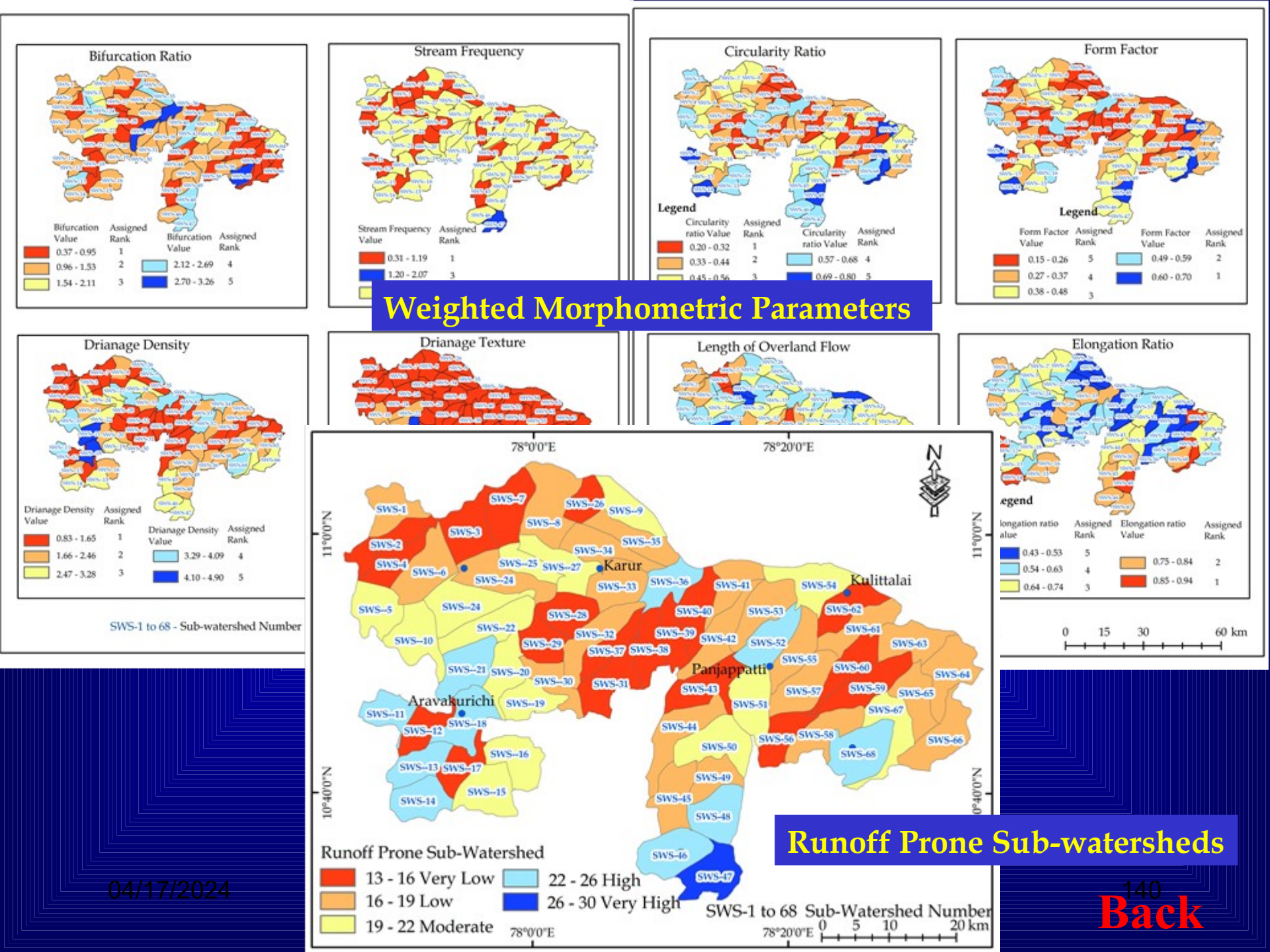
Back

STUDY - 8

GIS BASED DRAINAGE MORPHOMETRIC ANALYSES & RUNOFF ESTIMATION

Back


ASTER DEM
Fill
Flow Direction
Raster Stream Order
Updated Drainage Network
Sub-Watershed Boundary
Mean Stream Length Ratio
Form Factor
Stream Frequency
Mean Bifurcation Ratio
Circularity Ratio
tershed wise Drainage Density
Length of Overland Flow
Paramathi
Karur
Kulittalai
Panjappatti
Aravakurichi
Togamalai
Kadavur
Sub-watersehd Boundary
SWS 1 to 68 Sub-watershed Number
0.15 to 71 Form Factor Value
0.43 to 0.95 Elongation Value
SWS-1 to 68 Sub-watershed Number
0.20 to 0.80 Circularity Value
0.015 to 0.60 Length of Overland Flow Value
78°0'0"E
78°20'0"E
11°0'0"N
10°40'0"N
0 5 10 20 km


Bifurcation Ratio
Bifurcation Value
Assigned Rank
0.37 - 0.95 1
0.96 - 1.53 2
1.54 - 2.11 3
2.12 - 2.69 4
2.70 - 3.26 5
Stream Frequency
Stream Frequency Value
Assigned Rank
0.31 - 1.19 1
1.20 - 2.07 3
Circularity Ratio
Legend
Circularity ratio Value
Assigned Rank
0.20 - 0.32 1
0.33 - 0.44 2
0.57 - 0.68 4
0.69 - 0.80 5
Form Factor
Legend
Form Factor Value
Assigned Rank
0.15 - 0.26 5
0.27 - 0.37 4
0.38 - 0.48 3
0.49 - 0.59 2
0.60 - 0.70 1
Weighted Morphometric Parameters
Drianage Density
Drianage Density Value
Assigned Rank
0.83 - 1.65 1
1.66 - 2.46 2
2.47 - 3.28 3
3.29 - 4.09 4
4.10 - 4.90 5
SWS-1 to 68 - Sub-watershed Number
Drianage Texture
Length of Overland Flow
Elongation Ratio
egend
Assigned Rank
Elongation ratio Value
Assigned Rank
0.43 - 0.53 5
0.54 - 0.63 4
0.64 - 0.74 3
0.75 - 0.84 2
0.85 - 0.94 1
0 15 30 60 km
78°0'0"E
78°20'0"E
N
11°0'0"N
10°40'0"N
Karur
Kulittalai
Panjappatti
Aravakurichi
Runoff Prone Sub-Watershed
13 - 16 Very Low
16 - 19 Low
19 - 22 Moderate
22 - 26 High
26 - 30 Very High
SWS-1 to 68 Sub-Watershed Number
0 5 10 20 km
Runoff Prone Sub-watersheds