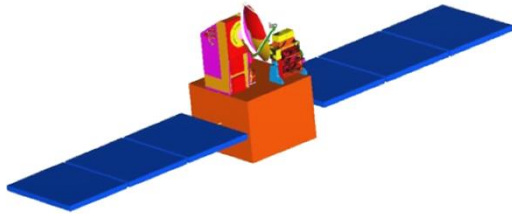
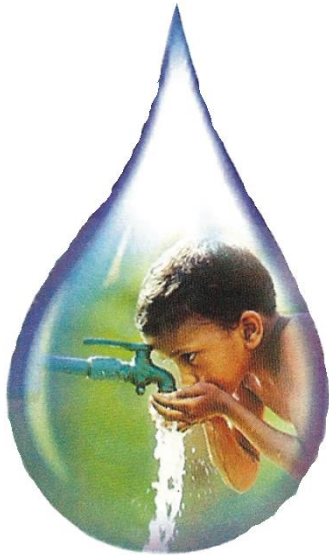


Application of geospatial technology for ground water studies



*AN EFFORT TOWARDS
A SAFE AND SUSTAINABLE FUTURE*

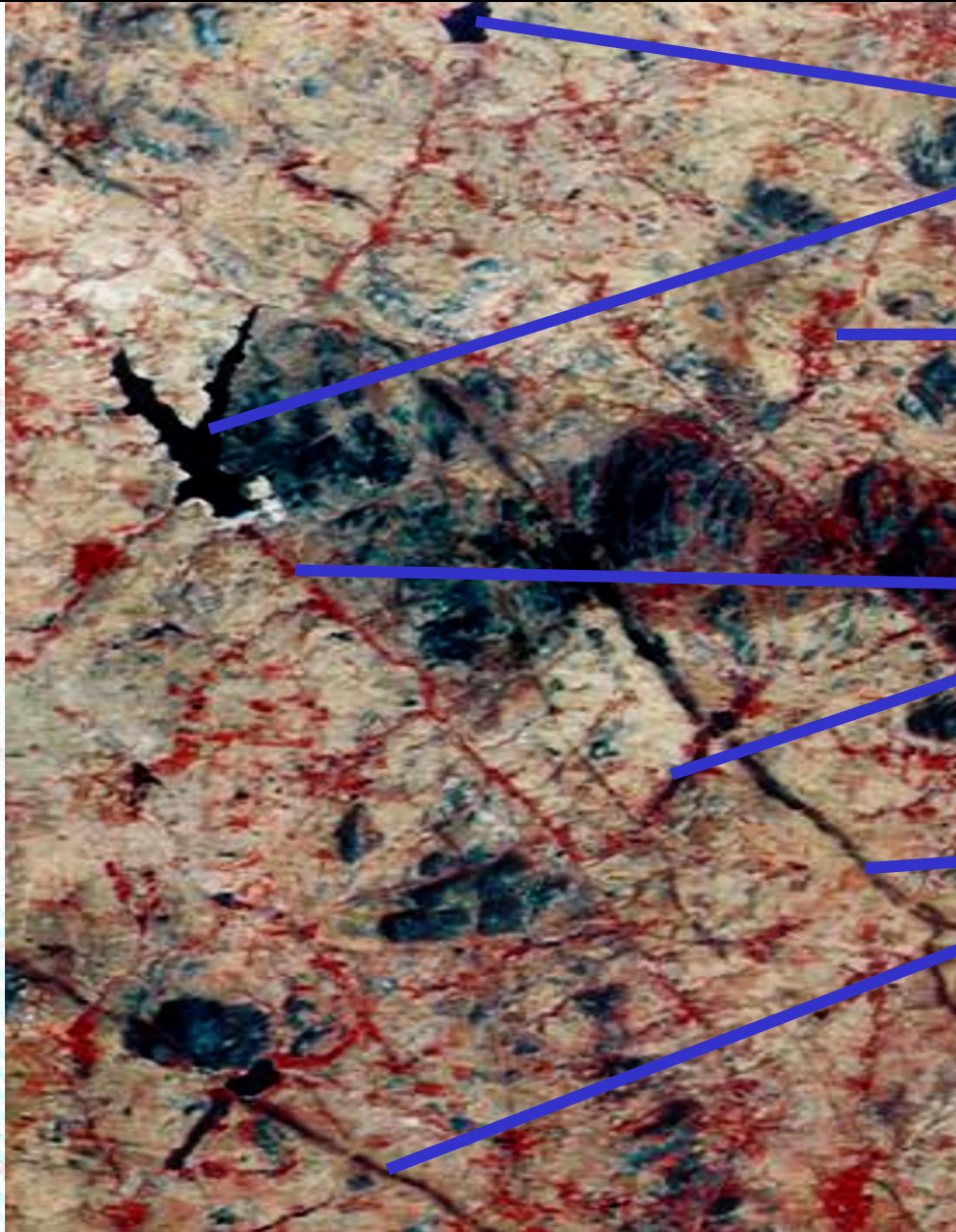


Dr. Iswar C. Das

**National Remote Sensing Centre ISRO / Dept. of
Space, Hyderabad**



ADVANTAGES OF SATELLITE DATA FOR GROUND WATER STUDIES



Hydrologic information
(Surface water bodies)

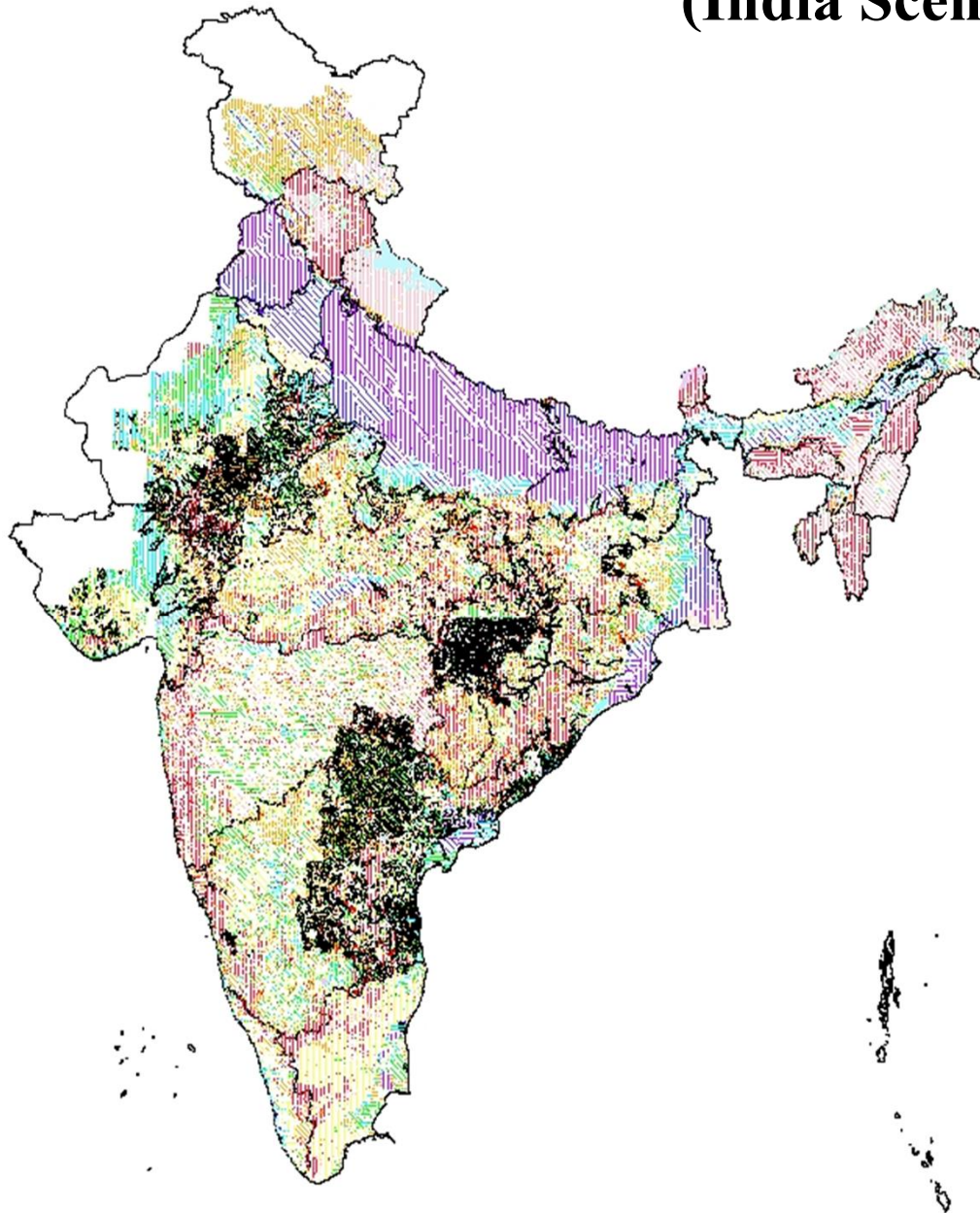
G.W. over exploitation
(Ground water irrigated area)

Conduits for G. W. movement
(Fracture / Lineament)

Barriers for G. W. movement
(Dolerite dyke)

Conduits for G. W. movement
(Fracture / Lineament)

Groundwater prospects map on 1:50,000 scale (India Scenario)



GROUND WATER PROSPECTS INFORMATION

| YIELD RANGE OF WELLS | COLOUR CODE | DEPTH RANGE OF WELLS | | |
|--|-------------|------------------------|---------------------------------|---------------------|
| | | SHALLOW < 30 METERS | MODERATE 30-80 METERS | DEEP > 80 METERS |
| > 800 LPM | Violet | | | |
| 400-800 LPM | Indigo | | | |
| 200-400 LPM | Blue | | | |
| 100-200 LPM | Green | | | |
| 50-100 LPM | Yellow | | | |
| 30-50 LPM | Orange | | | |
| 20-30 LPM | Brown | | | |
| 10-20 LPM | Pink | | | |
| Prospects limited to valley portions only (Hills, Plateaus etc.) | Red | | | |
| Run-off zone/Barrier for G.W. movement | | | (Inselberg / Ridge / Dyke etc.) | |

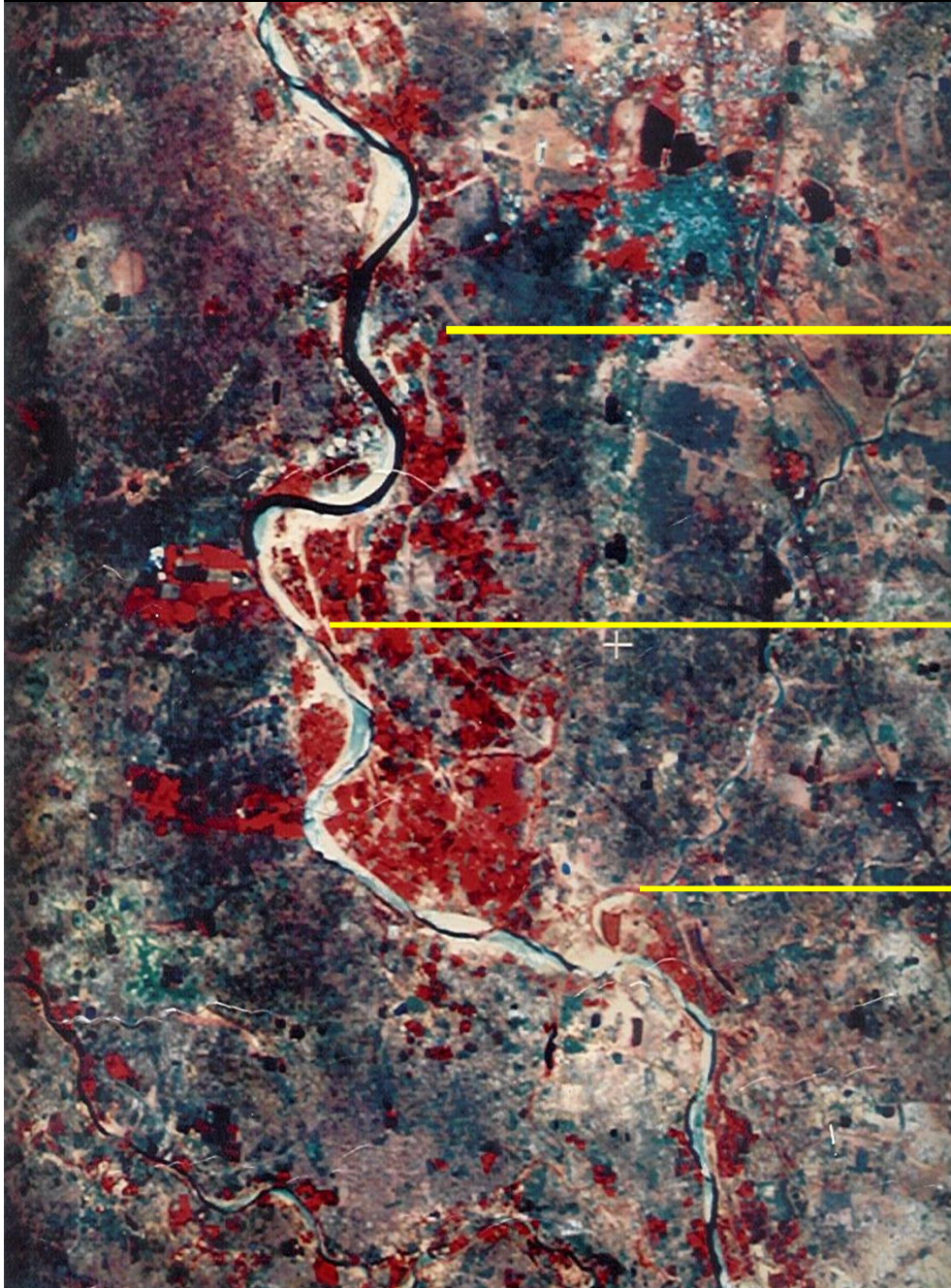
ADVANTAGES OF SATELLITE DATA



PALAEO CHANNEL

KOSI RIVER

ADVANTAGES OF SATELLITE DATA

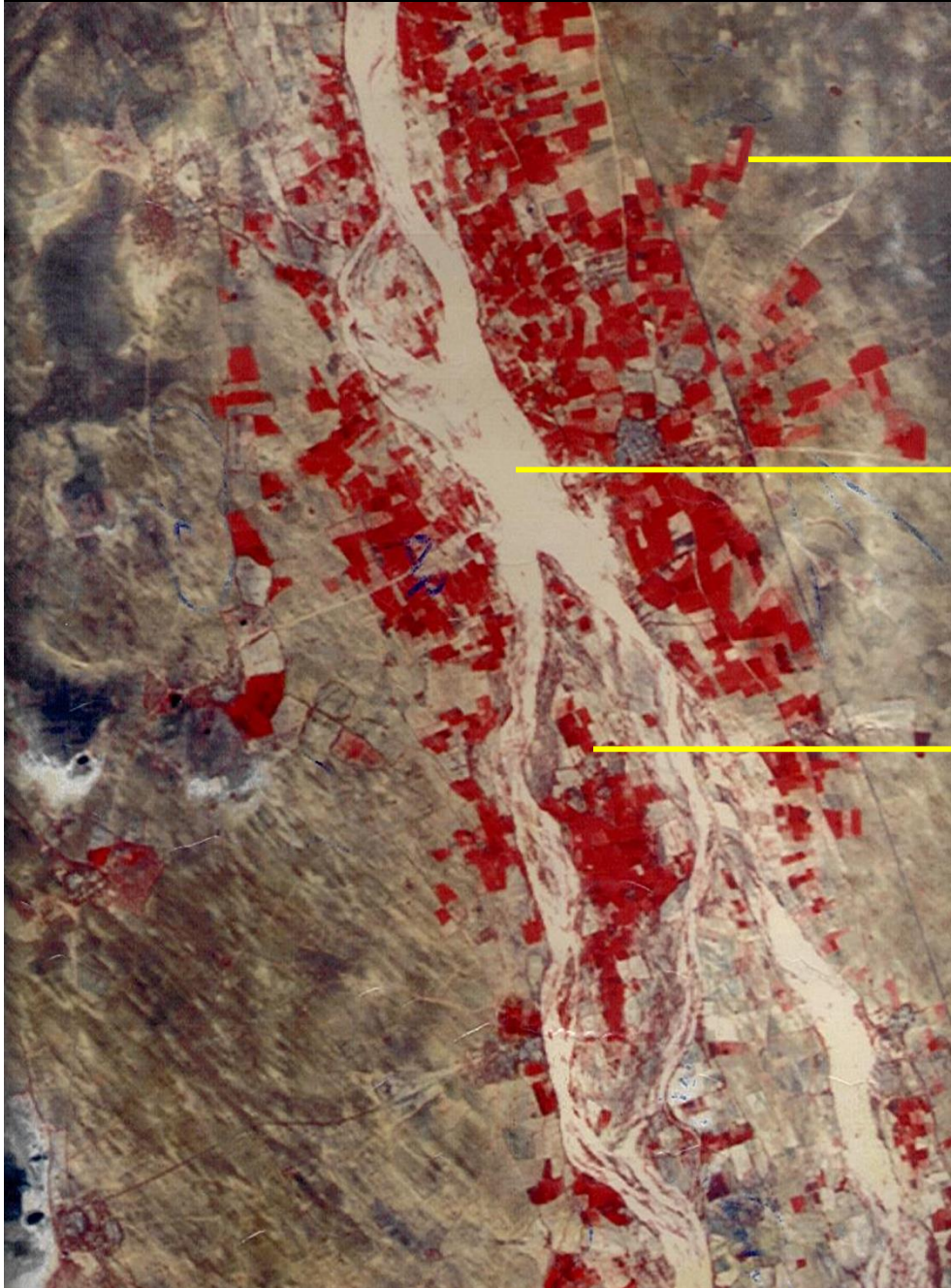


**GROUND WATER
IRRIGATED AREA**

MEANDER SCARS

**PALAEO
CHANNELS**

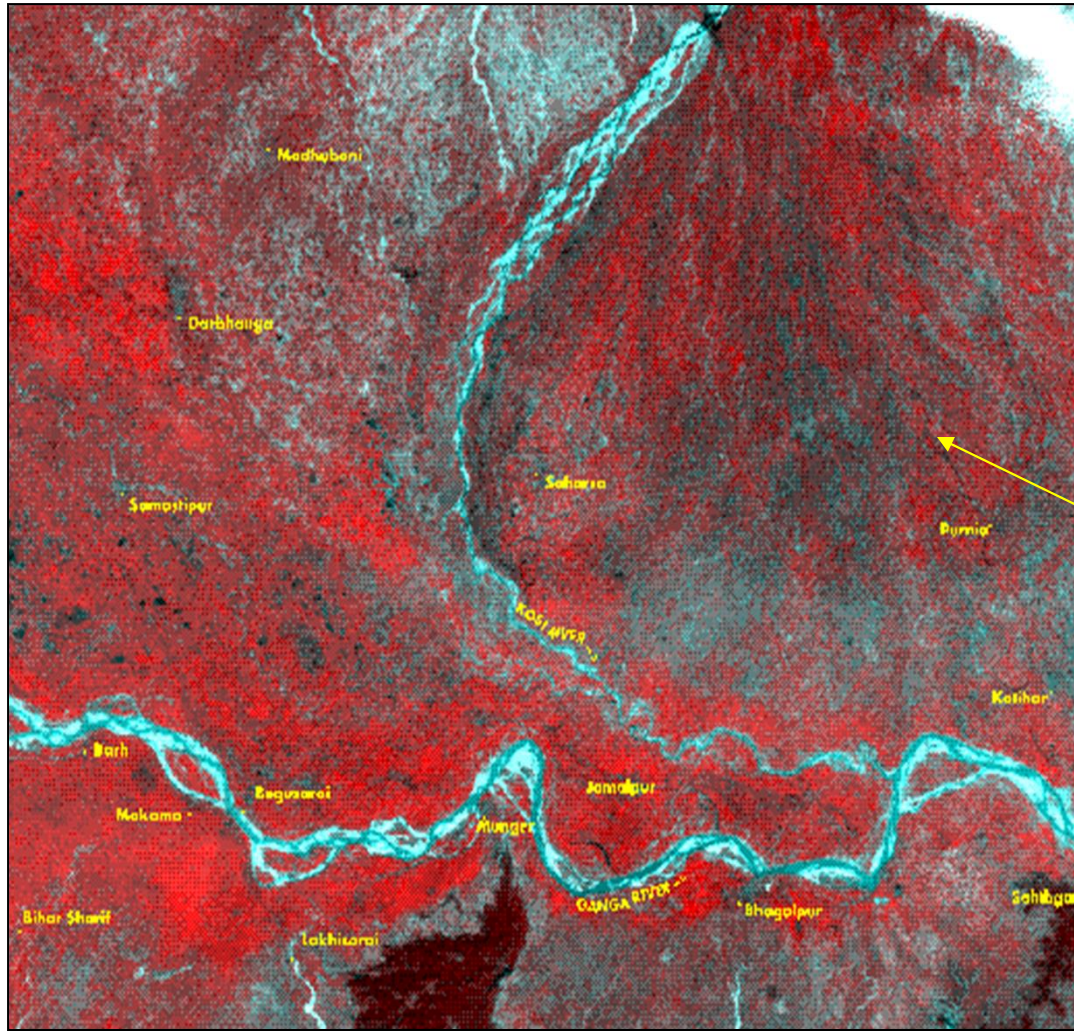
ADVANTAGES OF SATELLITE DATA



**GROUND WATER
IRRIGATED AREA**

DRY RIVER COURSE

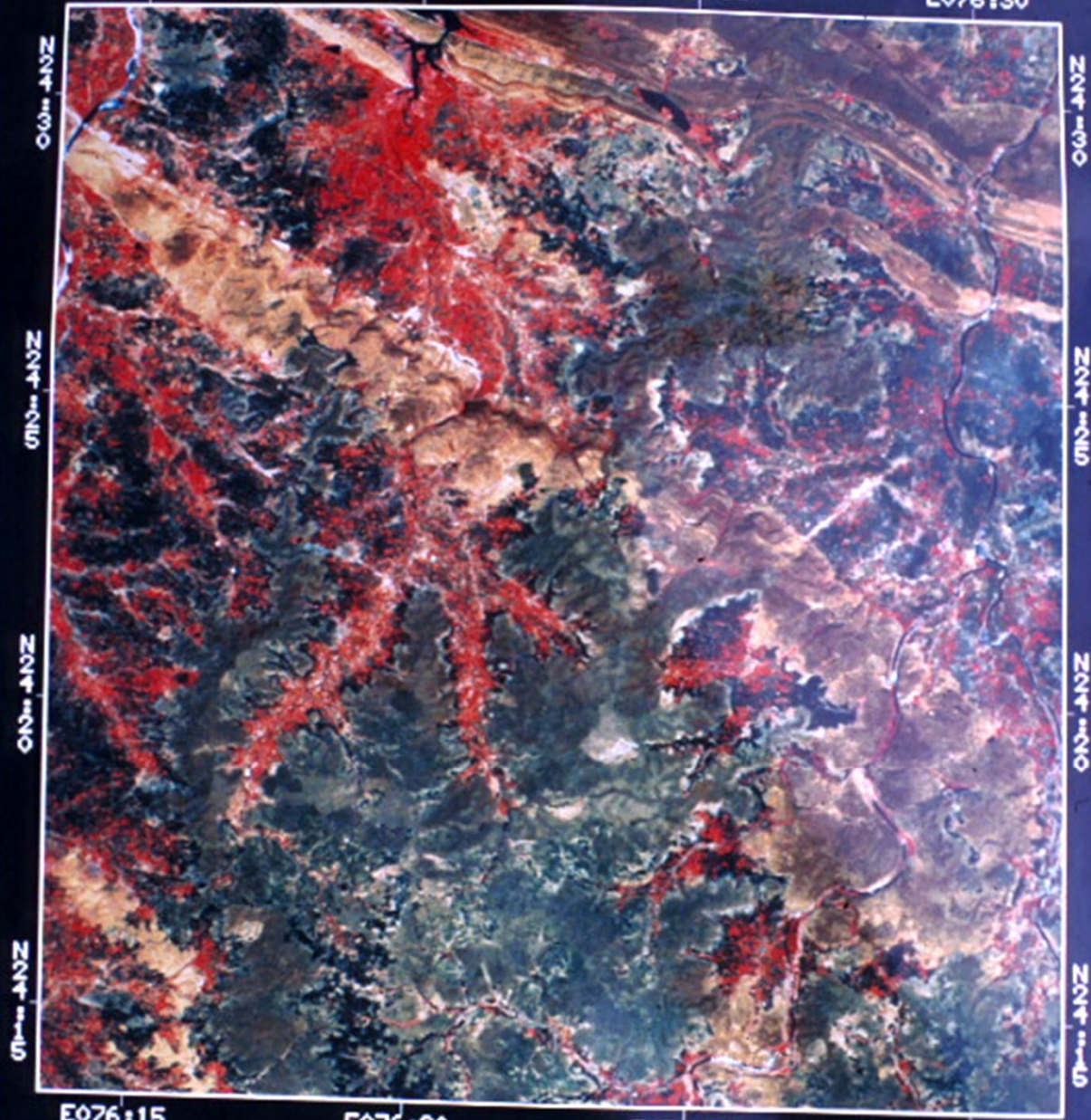
CHANNEL BAR



**PALEOCHANNELS
OF
KOSI RIVER
AS
SEEN
BY IRS-P6 AWIFS DATA**

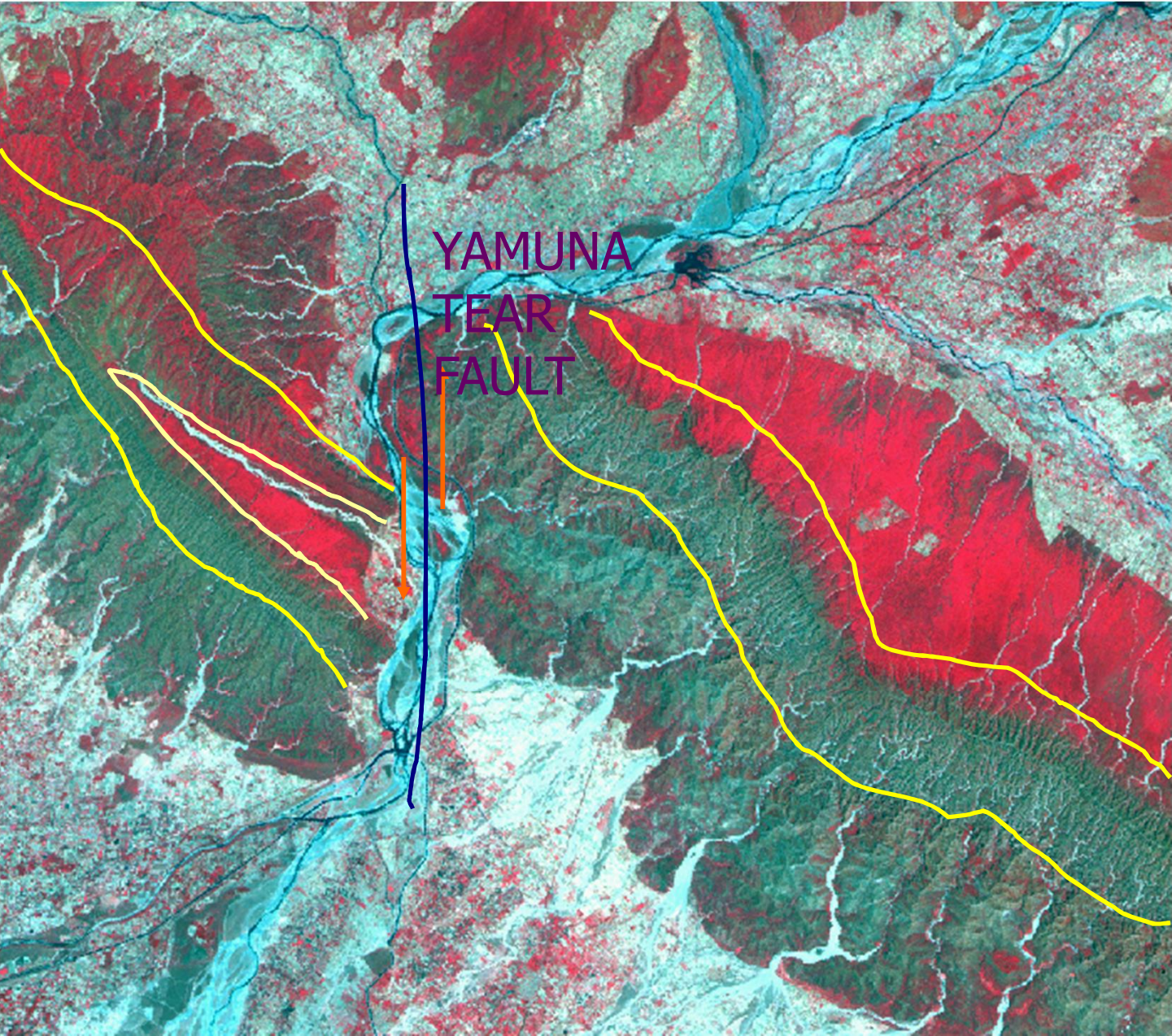
Old river course

GEOCODED SUBSCENE SAT-ID: IRS-1B L2B 2 MAP-ID: 54D07 P029-R50
BAND : 3+ ACQUIRED: 23-MAR-95 11:13:18 POL CC S59-A139 NO 6CP IND
E076:15 E076:20 E076:25 E076:30



E076:15 E076:20 E076:25 E076:30
IRS DPS I 6X-63309 15-DEC-1995 13:55:22 0 2 4 6 8 10 KM

IDENTIFYING VARIOUS GEOLOGICAL FEATURES FROM SPACE



YAMUNA
TEAR
FAULT

PEIDMONT

UPPER
SIWALIK

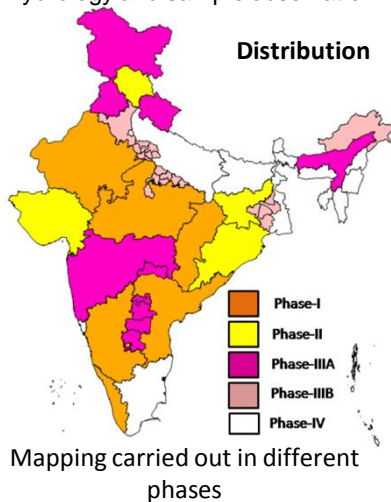
MIDDLE

RAJIV GANDHI NATIONAL DRINKING WATER MISSION PROJECT (RGNDWM)

Ground Water Prospects-Sustainability & Quality Mapping on 1:50,000 Scale

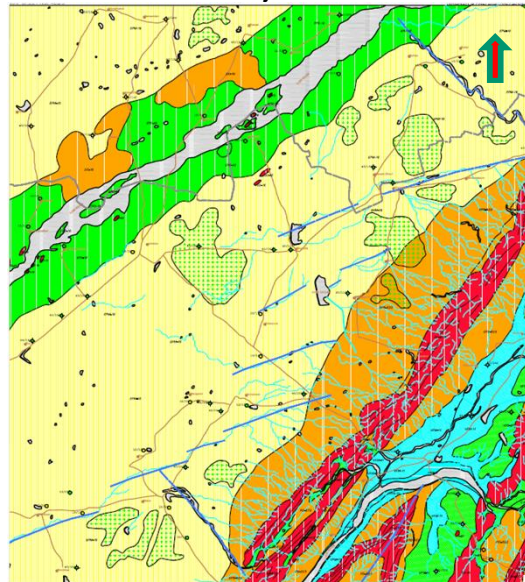


Ground water prospects maps were prepared on 1:50,000 scale for entire country in 4 phases. The ground water controlling parameters such as Lithology, Geomorphology, Geological structures extracted using satellite data are integrated to delineate the aquifers. Recharge to the aquifer is estimated based on hydrology and sample observation wells. Quality mapping to provide safe drinking water by mapping portable and non portable groundwater sources is in progress.



| Phase | State | Map sheet |
|---|--|----------------------|
| Phase I (1991-02) | Rajasthan, Madhya Pradesh, Chattisgarh, Andhra Pradesh (part), Karnataka, Kerala | 1654 |
| Phase II (2001-02) | Jharkhand, Himachal Pradesh, Odhisa, Gujarat | 724 |
| Phase IIIA (2009) | Jammu & Kashmir, Punjab, Uttarakhand, Assam, Maharashtra, Andhra Pradesh (rest) | 1290 |
| Phase IIIB (2011) | Haryana, Arunachal Pradesh, Uttar Pradesh (part), West Bengal (part) | 339 |
| Phase IV (2011-13) | Remaining states & UT | 891 |
| Total | | 4898 |
| Total Area (@ 650 Sq.km/Map sheet) : | | 3183700 Sq.km |

Groundwater prospect map of Part of Nagaur District Rajasthan

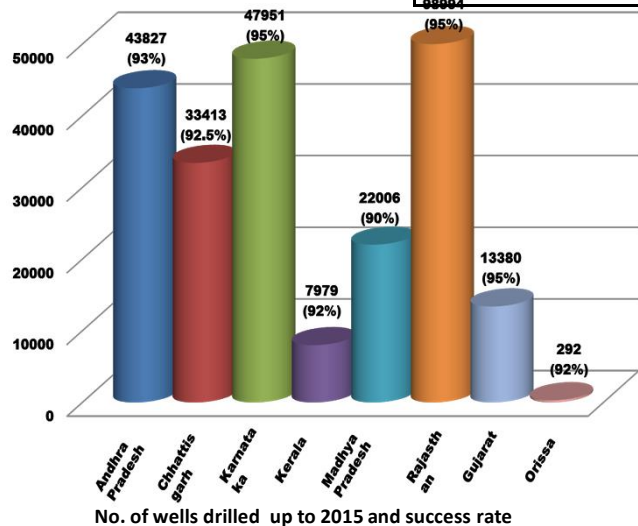


GROUND WATER PROSPECTS INFORMATION

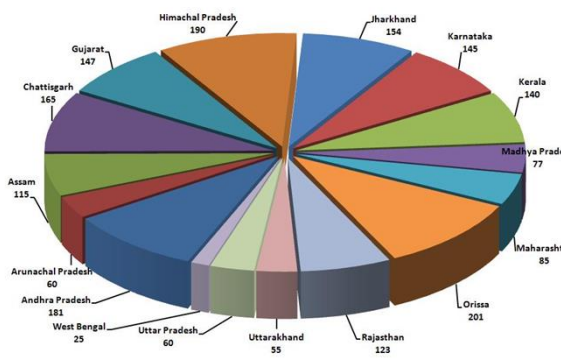
| YIELD RANGE OF WELLS | COLOUR CODE | DEPTH RANGE OF WELLS | | |
|--|--------------------------------|----------------------|-----------------------|------------------|
| | | SHALLOW < 30 METERS | MODERATE 30-60 METERS | DEEP > 60 METERS |
| > 800 LPM | Violet | [Hatching] | [Hatching] | [Hatching] |
| 400-800 LPM | Indigo | [Hatching] | [Hatching] | [Hatching] |
| 200-400 LPM | Blue | [Hatching] | [Hatching] | [Hatching] |
| 100-200 LPM | Green | [Hatching] | [Hatching] | [Hatching] |
| 50-100 LPM | Yellow | [Hatching] | [Hatching] | [Hatching] |
| 30-50 LPM | Orange | [Hatching] | [Hatching] | [Hatching] |
| 20-30 LPM | Brown | [Hatching] | [Hatching] | [Hatching] |
| 10-20 LPM | Pink | [Hatching] | [Hatching] | [Hatching] |
| Prospects limited to valley portions only (Hills, Plateaus etc.) | Red | [Hatching] | [Hatching] | [Hatching] |
| Run-off zone/Barrier for G.W. movement | (Inseberg / Ridge / Dyke etc.) | [Hatching] | [Hatching] | [Hatching] |

VIBGYOR colour scheme i.e. violet to red, is used for depicting different yield ranges from excellent to poor. Within each yield range, three hatching patterns are used for depicting the depth range of wells (Sample map).

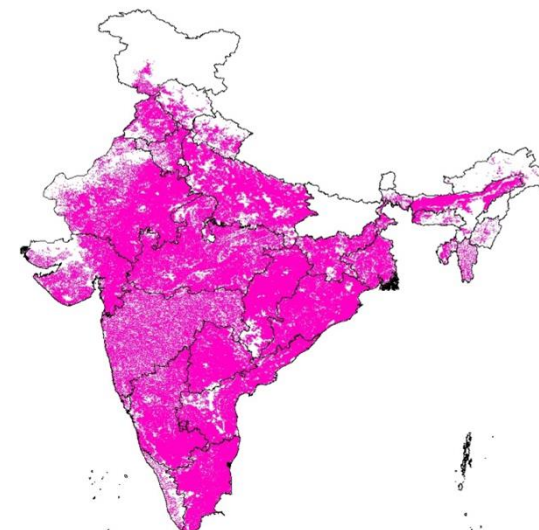
FEEDBACK



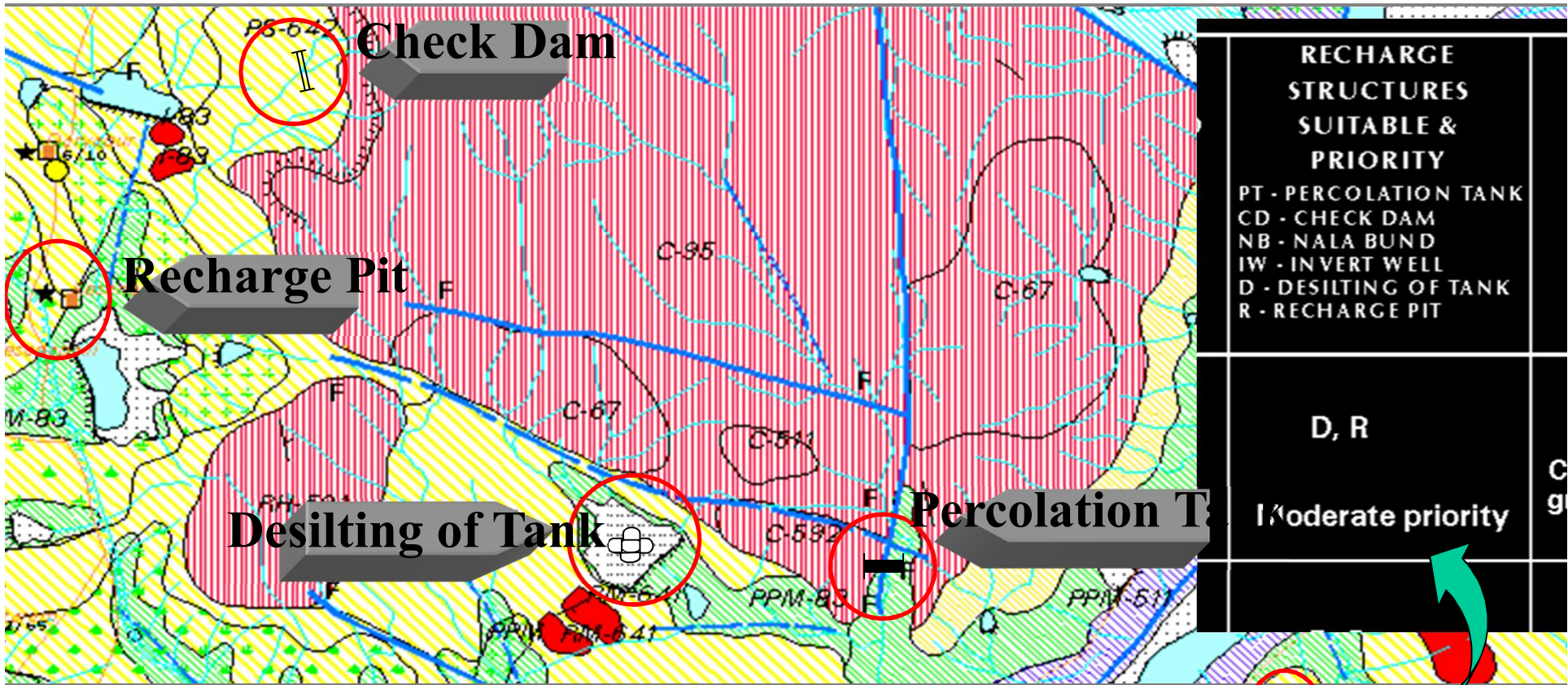
Ground water prospects map



Man power trained under this project



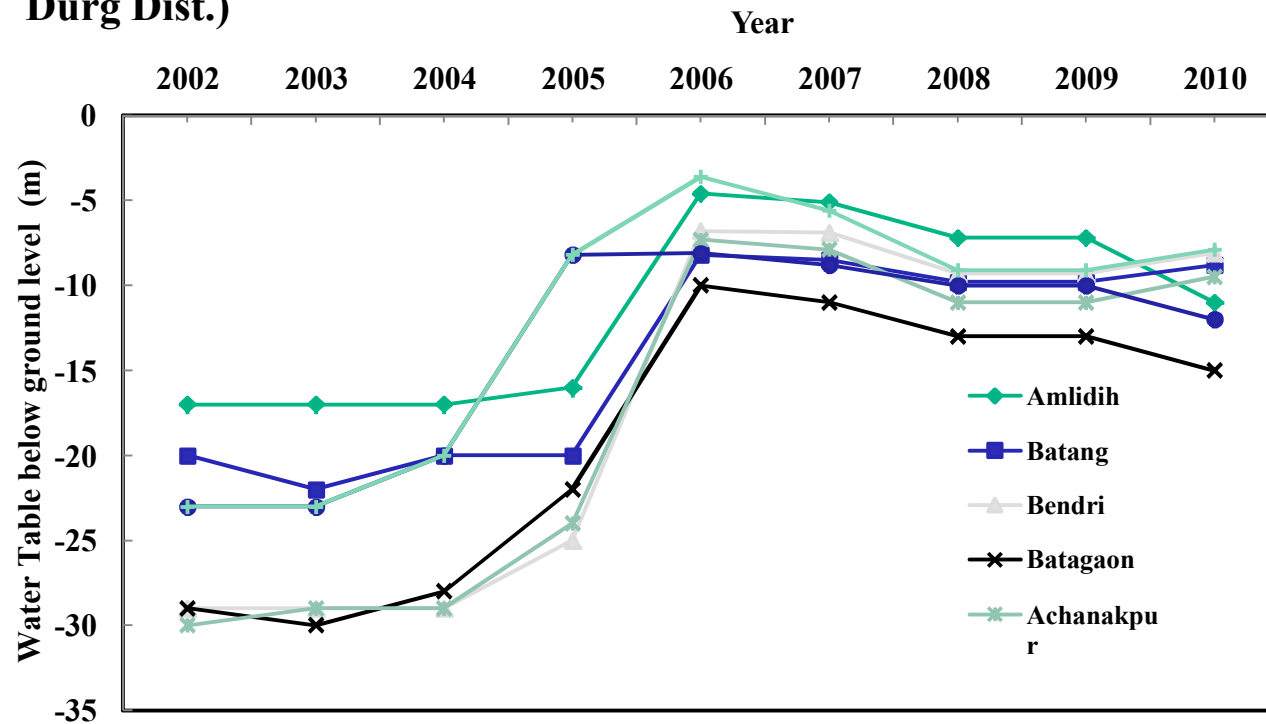
Contents (Sustainability) of Map



| |
|---|
| <p>RECHARGE STRUCTURES SUITABLE & PRIORITY</p> <p>PT - PERCOLATION TANK CD - CHECK DAM NB - NALA BUND IW - INVERT WELL D - DESILTING OF TANK R - RECHARGE PIT</p> |
| <p>D, R</p> <p>Moderate priority</p> |

| UNIT/LAND FORM | WATER TABLE | CONDITIONS | NO. OF WELLS | TYPE OF WELLS | DEPTH | YIELD | RECHARGE | QUALITY | GROUNDWATER | TECHNOLOGICAL | RECOMMENDATIONS |
|---------------------|-----------------|------------|--------------|---------------|-------|------------|-----------|---------|-------------|---------------|---|
| Buried channel [C] | 5-6 No wells | Very Good | LS | TW | 3-10 | >200 lpm | Very High | p | Ni | Not required | Very good scope for ground water development. Recharge structures not required. |
| Channel Bar [C] | 5-3 No wells | Very Good | LS | TW | 3-10 | >200 lpm | Very High | p | Ni | Not required | Very good scope for ground water development. Recharge structures not required. |
| Point Bar [P] | 5-6 No wells | Very Good | LS | TW | 3-10 | >200 lpm | Very High | p | Ni | Not required | Suitable for further Ground water development. Casing is required. |
| Aluvium Plain [APD] | 3-7 3TW | Good | LS | TW | 10-13 | 400-600lpm | High | p | 30-35 | Not required | Suitable for further Ground water development. Casing is required. |
| Aluvium Plain [APM] | 3-2 3TW | Good | LS | TW | 10-10 | 500-400lpm | High | p | 15-20 | DT | Further ground water development is suggested. Casing is required. |

CHHATTISGARH Success story under RGNDWM project (Gajra sub-watershed, Patan Block, Durg Dist.)



Impact of Recharge structures on ground water sustainability

- “ 101 recharge structures (Masonary stop dam-23, percolation tank-12, Boulder check dam-25, Nala bund-13 and desilting of pond-28) were constructed in this sub-watershed based on the knowledge gained from RGNDWM ground water prospects maps.
- ” It was observed that the water table has risen to a maximum



APPLICATION OF REMOTE SENSING IN GROUND WATER STUDIES

1. **GROUND WATER PROSPECTS MAPPING**
2. **GROUND WATER RESOURCE ESTIMATION –**
 - A) Recharge Estimation
 - B) Draft Estimation
 - C) Balance available for further utilisation
 - D) Categorisation into dark, grey & white areas
3. **IDENTIFICATION & MONITORING OF OVER EXPLOITED ZONES**
4. **SELECTION OF SITES FOR RECHARGE STRUCTURS**
 - A) Based on suitability of site condition
 - B) Based on priority ó need based
5. **GROUND WATER BUDGETTING & SYSTEMATIC EXPLOITATION FOR SUSTAINABLE DEVELOPMENT**

Methodology



IRS- LISS-III Data
WGS 84 - UTM

SOI toposheets
WGS 84 - UTM

On screen interpretation

Existing maps

Base map overlay

Lithological map overlay

Structural Map overlay

Geomorphic Map overlay

Hydrological Map overlay

Integration

Hydro geomorphic units

Identification of locations for recharge structures

Evaluation of ground water prospects

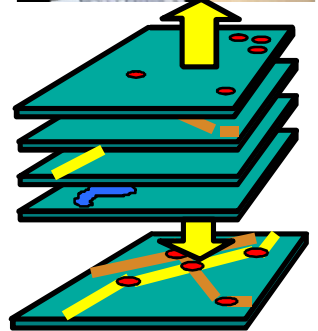
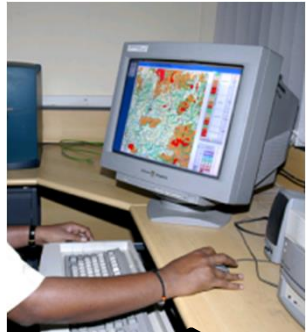
Observation Well data

Map composition using GIS

Ground water prospects map on 1: 50,000 Scale

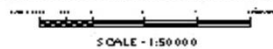
Geo data base of ground water

Ground Water Information System



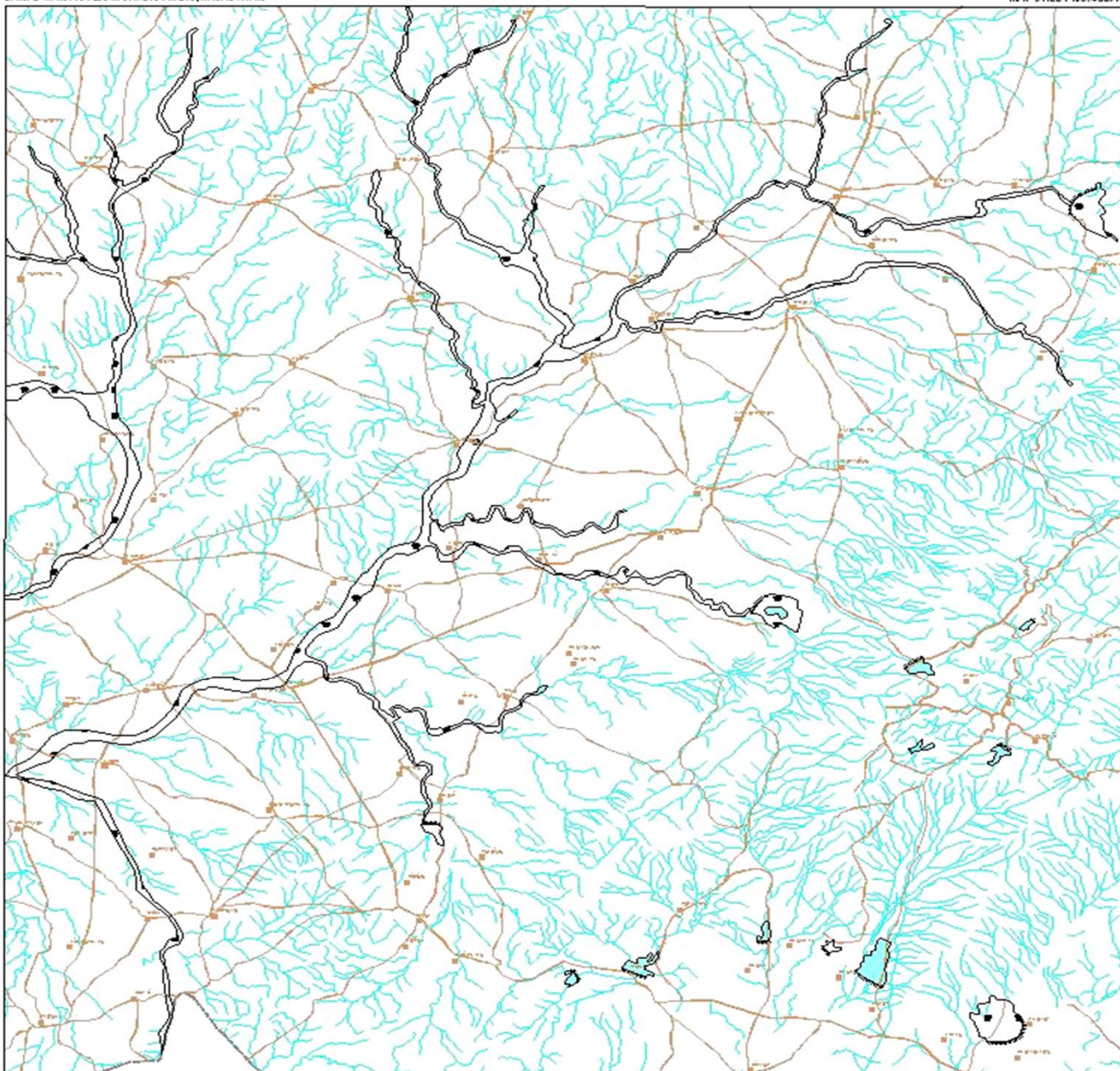
BASE MAP

(PREPARED FROM SATELLITE IMAGE INTERPRETATIONS WITH LIMITED FIELD CHECKS)



BANAS KANTHA & SIROHI DISTRICTS, RAJASTHAN

MAP SHEET NO. 45D/10



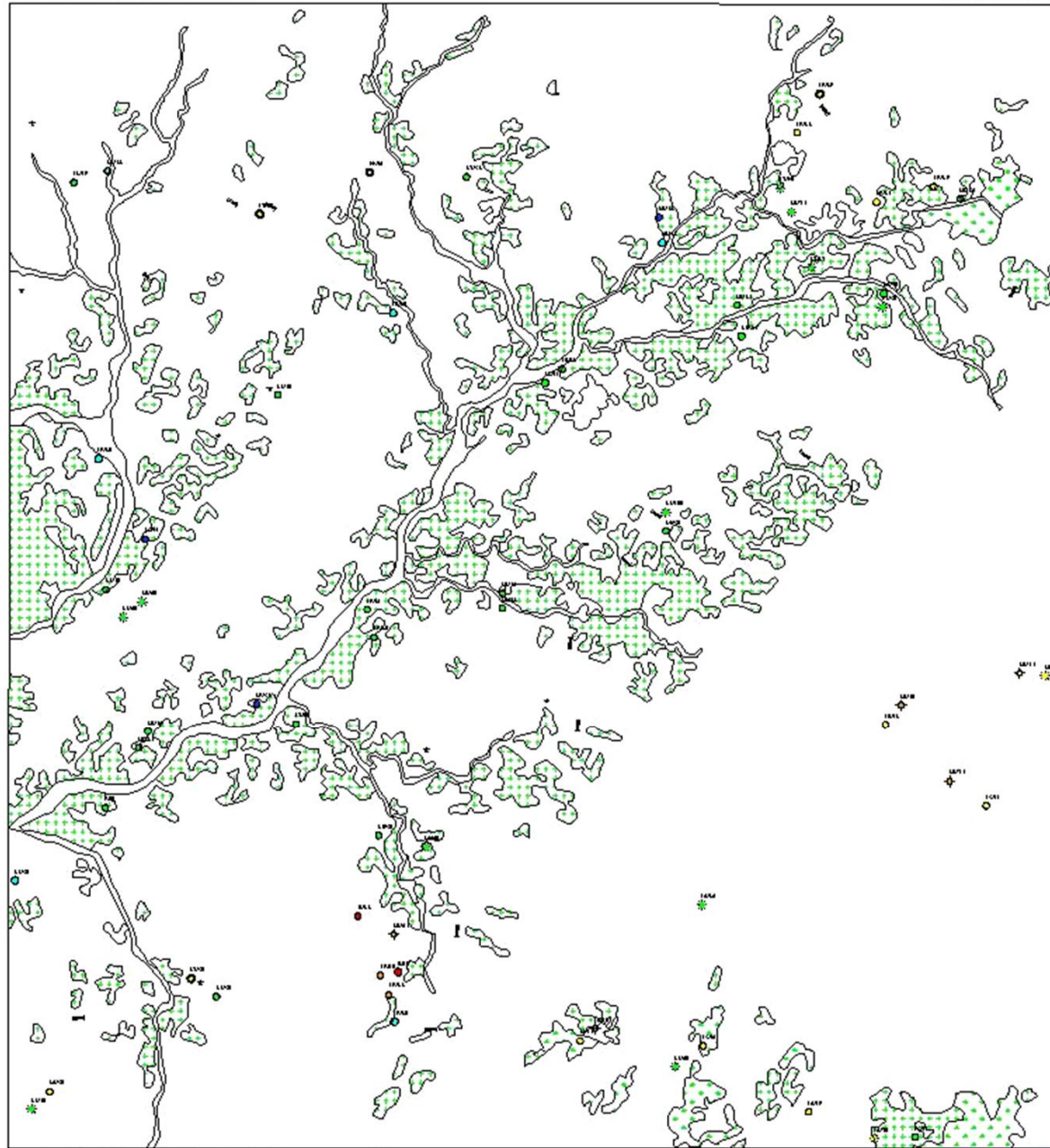
HYDROLOGICAL MAP

(PREPARED FROM SATELLITE IMAGE INTERPRETATIONS WITH LIMITED FIELD CHECKS)

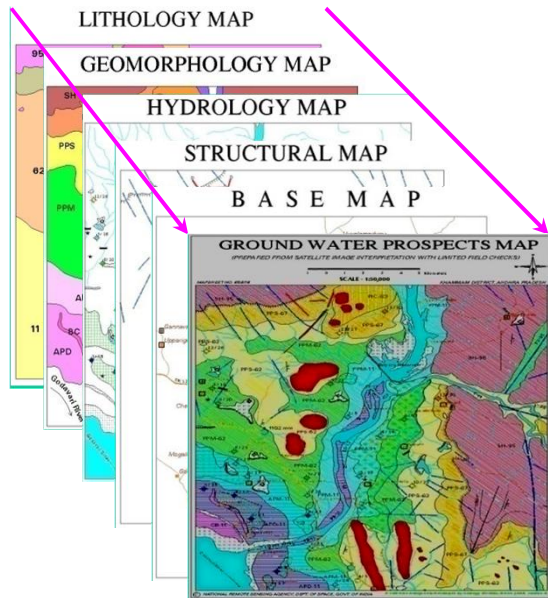
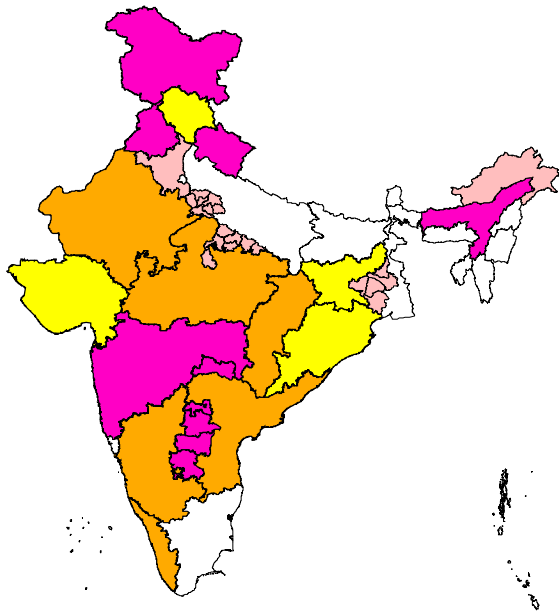


BANAS KANHA & SIROHI DISTRICTS, RAJASTHAN

MAP SHEET NO.45D10

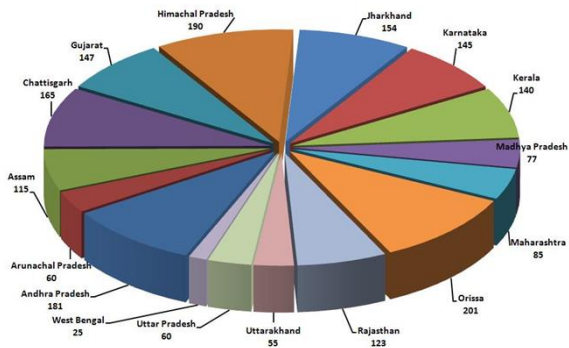
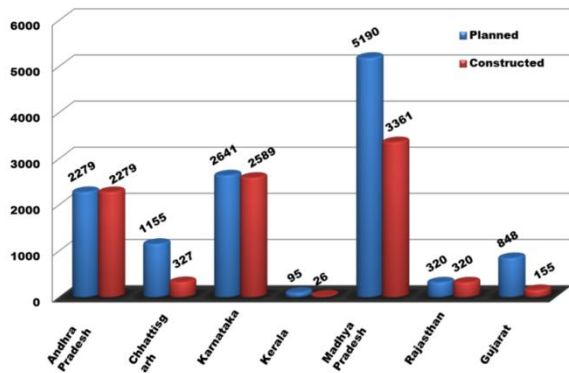
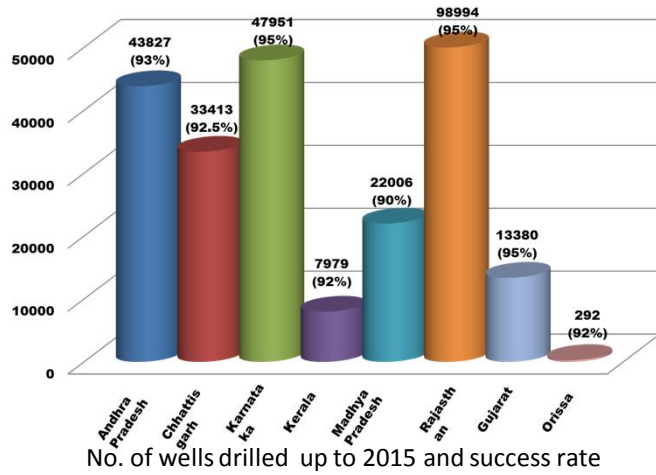


GROUND WATER PROSPECTS MAPS



| Phase | Coverage | No. of Maps | Schedule / Status | |
|-------|---|--|---|---|
| I. | 6 states (AP -Part, MP,Rajasthan, Karnataka, Kerala, Chattisgarh) | 1654 | Completed | |
| II | 4 states (Gujarat, Orissa, HP, Jharkhand) | 724 | Completed | |
| III | A | 6 states(Maharashtra, AP-Part, Assam, unjab, J&K, Uttarakhand) | 1290 | completed. |
| | B | 4 states (UP-Part, WB-Part, Haryana, Arunachal Pradesh) | 339 | Ground water prospects maps completed. Ground water quality layer in progress . |
| IV | 13 States & 5 UTs (Remaining States & UTs including Islands) | 891 | Project has been initiated. Duration - 2011-2013 | |

CAPACITY BUILDING & FEEDBACK



TRAINING IN CHHATTISGARH

National Remote Sensing Centre (NRSC), ISRO has prepared nationwide ground water prospects maps, sponsored by Department of Drinking Water and Sanitation (erstwhile RGNDWM), Ministry of Drinking water Sanitation (MDWS), Government of India (GOI). The above maps are generated under Accelerated Rural Water Supply Programme (ARWSP) which was the major developmental activity of GOI in water sector to provide drinking water to all the habitations in a time-bound-period. However, scientific database on ground water, which facilitates identification of prospective ground water zones for systematic selection of appropriate sites for drilling, is not available in many states to tackle the drinking water problem on war footing by the concerned state officials involved in rural water supply. Hence entire India ground water database was created (spread over 4898 maps) covering all the habitation in a phased manner (Phase-I to IV) on priority basis. The possible ground water sources were delineated for drinking within the radius of 1.5 km covering for all habitations using Indian Remote Sensing (IRS) series of satellite data (1C, 1D & Resourcesat) on 1:50,000 scale. Presently the GOI has renamed this programme as National Rural Drinking Water Programme (NRDWP).

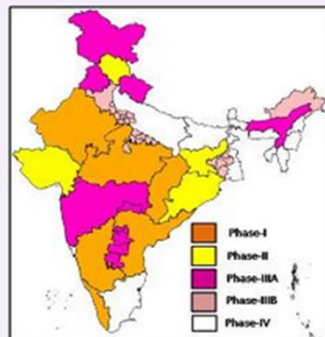
About Bhuvan-Bhujal

Ground water being a hidden resource is difficult to dig out without proper understanding. Hence NRSC/ISRO has brought out nationwide scientific database on prospective ground water information from the state-of-the-art ground water prospects maps generated for the past one and half decade through Bhuvan-Bhujal portal. This information can be utilized by the govt/private agencies for development of ground water. It provides the required information on geological parameters connected to ground water exploration and the probable ground water prospects. It narrow down the area of investigation for prolific selection of 1) sites for drilling and 2) for planning recharge structures, ultimately to address the drinking water problem more effective manner.

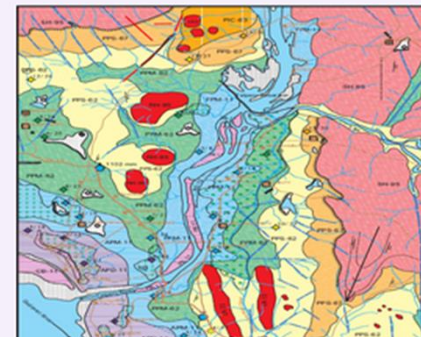
- i. Geological parameters : • Lithology (rock type), • Geomorphology (landform), • Geological structures (fractures/faults)
- ii. Ground water prospects (For Authorized users only) : • Probable Depth and yield range of wells.

Features of Bhuvan-Bhujal

- a) Spatially user can visualizes the Ground Water Prospects information in terms of depth (shallow, moderate and deep) shown with three colour hatching patterns (horizontal, inclined and vertical) and yield shown in seven colours (Violet, Indigo, Blue, Green, Yellow, Orange and Red).
- b) Legend for understanding the ground water prospects information
- c) Portal contains seamless state-wise mosaics of groundwater prospect maps. Presently it is populated with ground water prospects information for 24 states viz. Andaman & Nicobar, Arunachal Pradesh, Assam, Bihar, Chattisgarh, Delhi, Goa, Haryana, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Puducherry, Punjab, Sikkim, Tripura, Uttarakhand, Uttar Pradesh and West Bengal
- d) Remaining 12 states maps information will be available very soon



[Visit the site](#)



Bhuvan - Bhujal

Select State: KARNATAKA

- Ground Water Prospects
- Structures

For authorised users yield and depth information will be provided.

Select District: Gulbarga

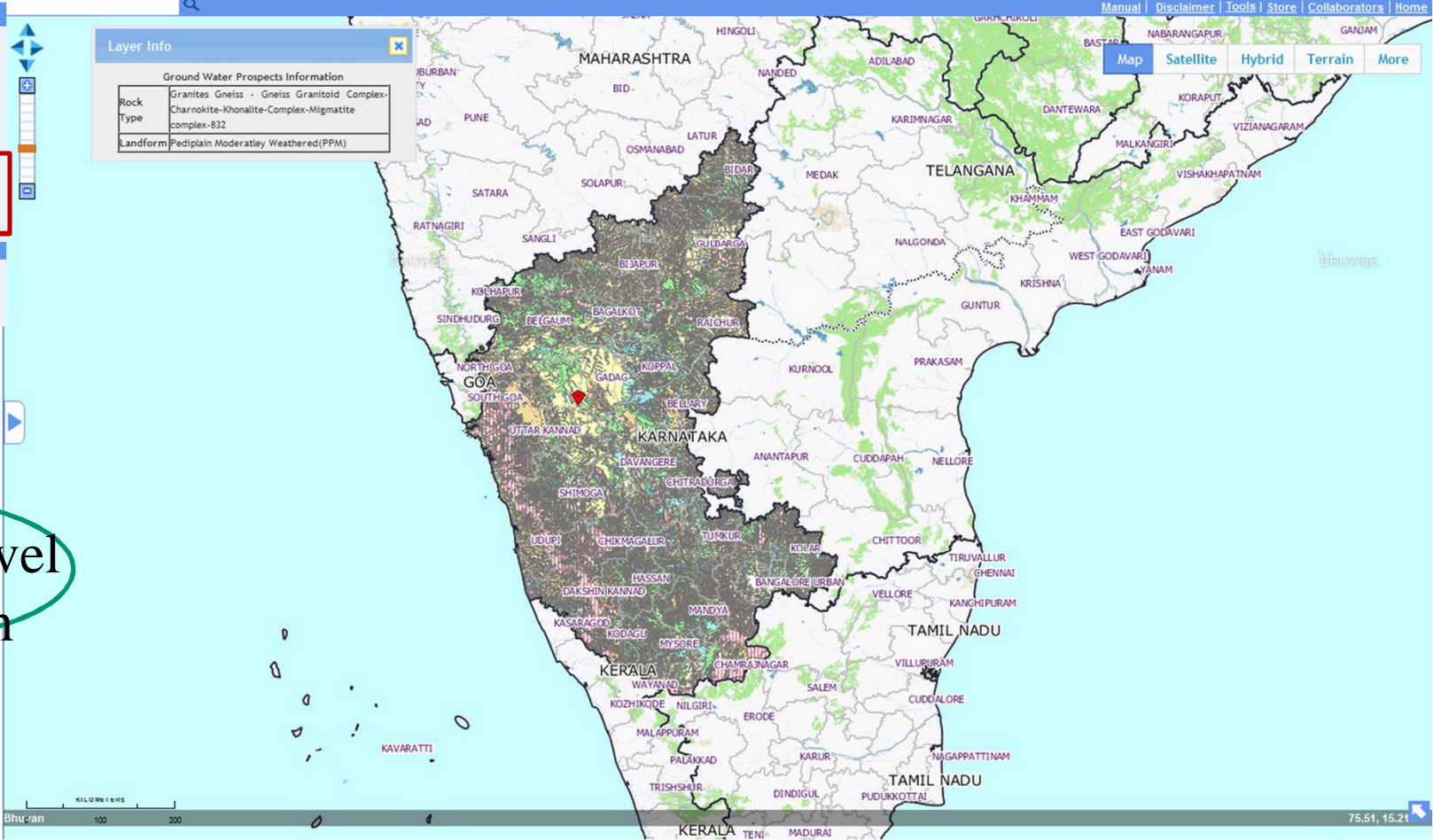
Select Taluk: Aland

User Added Layers

Local GIS (Shp, KML, WMS) Overlays can be viewed.

Layer Info

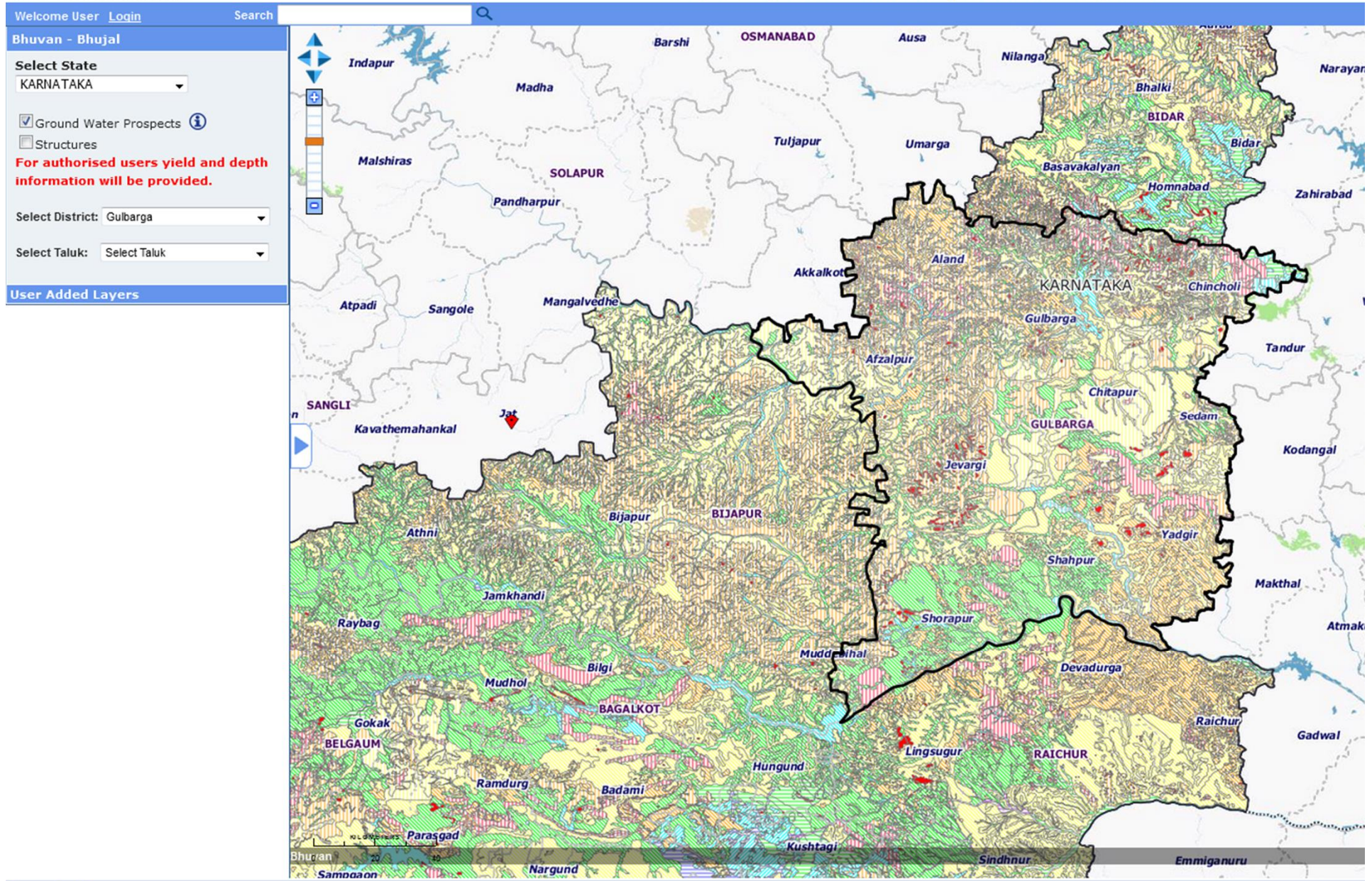
| Ground Water Prospects Information | |
|------------------------------------|---|
| Rock Type | Granites Gneiss - Gneiss Granitoid Complex-Charnokite-Khonalite-Complex-Migmatite complex-832 |
| Landform | Pediplain Moderatley Weathered(PPM) |



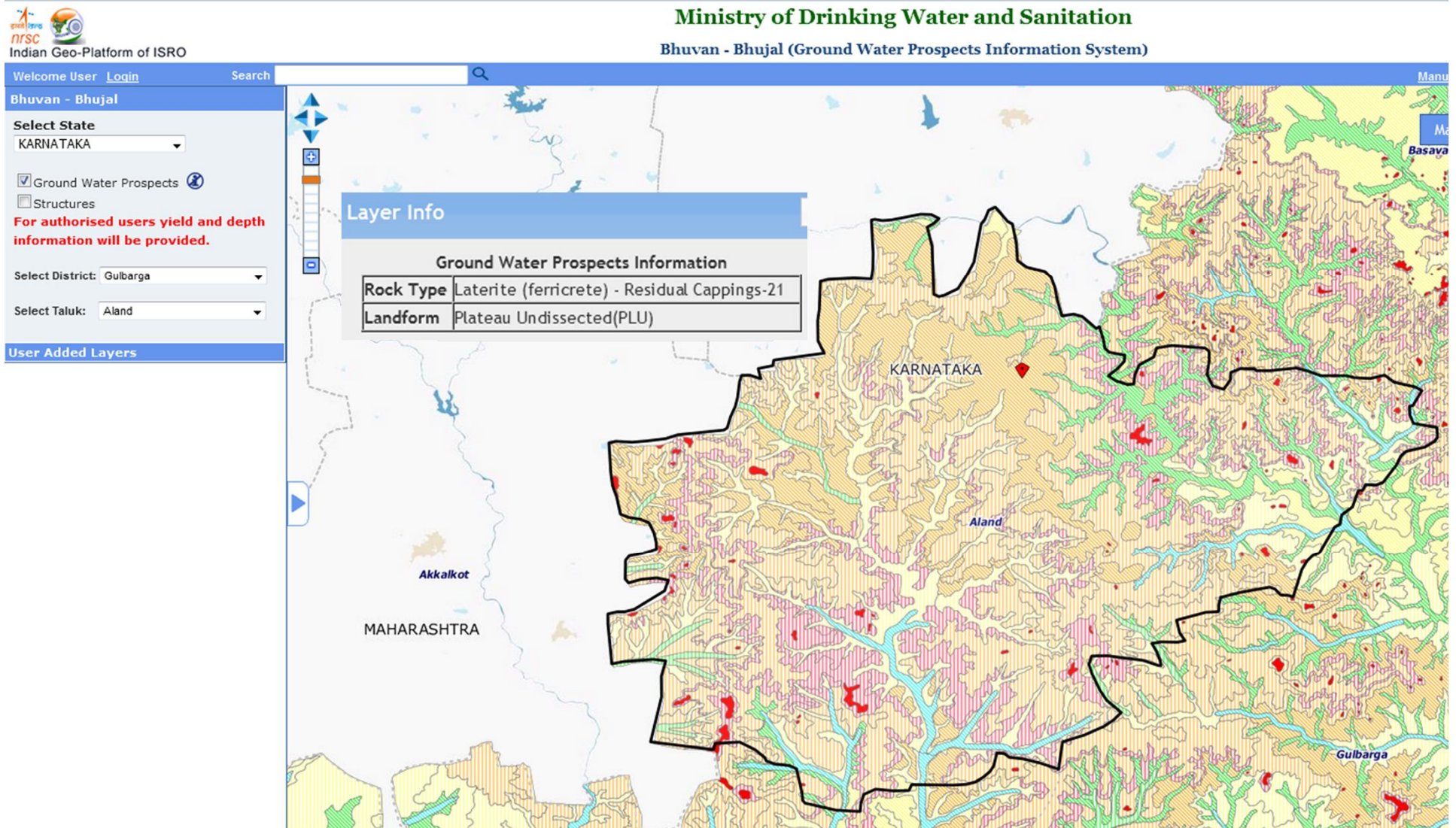
ist/ Taluk level
Segregation

Seamless Ground Water Prospect Maps of Karnataka Sta

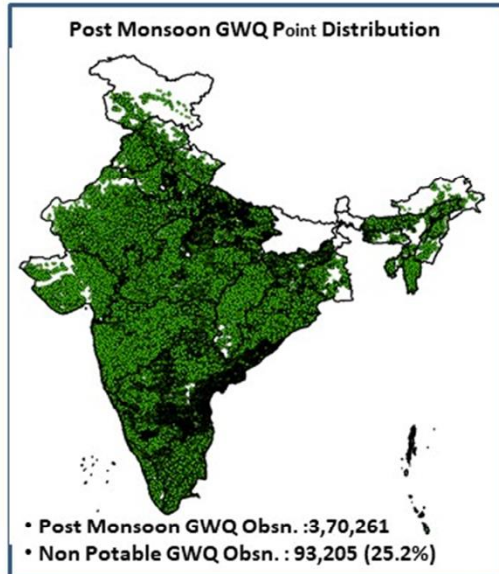
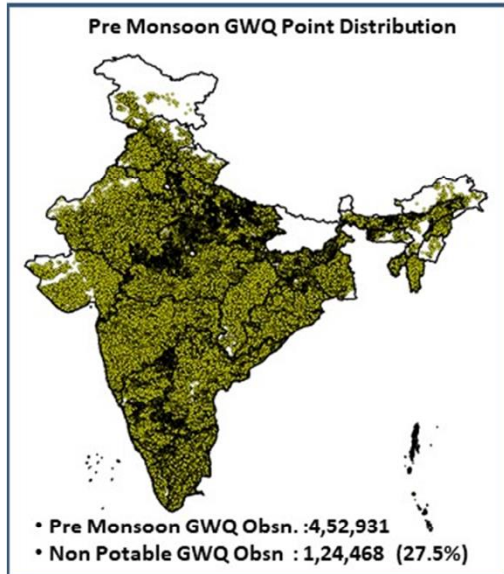
Seamless GWP Map OF Gulbarga Dist, Karnataka



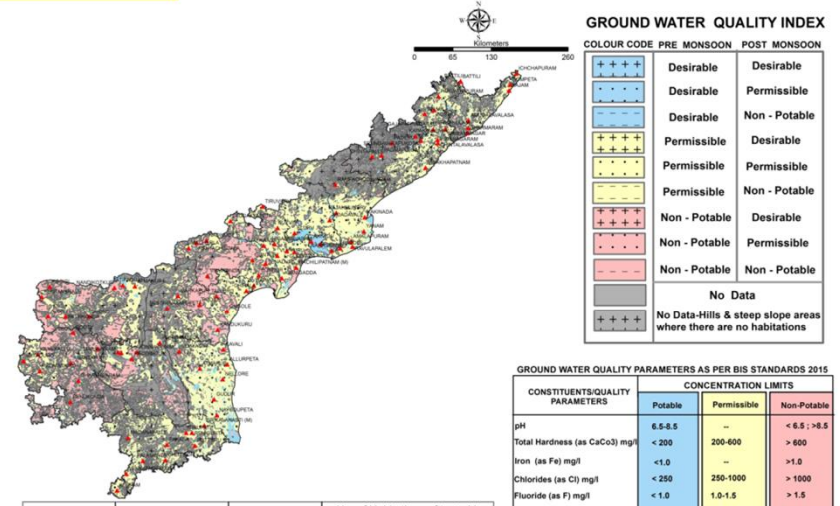
Seamless GWP Map OF ALAND taluk (Gulbarga Dist, Karnataka)



Groundwater Quality (GWQ) Mapping on 1:50,000 scale under National Rural Drinking Water Program (NRDWP) of Ministry of Drinking Water & Sanitation (MDWS)



ANDHRA PRADESH



GROUND WATER QUALITY PARAMETERS AS PER BIS STANDARDS 2015

| CONSTITUENTS/QUALITY PARAMETERS | CONCENTRATION LIMITS | | |
|---|----------------------|-------------|--------------|
| | Potable | Permissible | Non-Potable |
| pH | 6.5-8.5 | — | < 6.5 ; >8.5 |
| Total Hardness (as CaCO ₃) mg/l | < 200 | 200-600 | > 600 |
| Iron (as Fe) mg/l | <1.0 | — | >1.0 |
| Chlorides (as Cl) mg/l | < 250 | 250-1000 | > 1000 |
| Fluoride (as F) mg/l | < 1.0 | 1.0-1.5 | > 1.5 |
| Total Dissolved solids mg/l | < 500 | 500-2000 | > 2000 |
| Sulphate (as SO ₄) mg/l | < 200 | 200-400 | > 400 |
| Nitrate (as NO ₃) mg/l | < 45 | — | > 45 |
| Alkalinity mg/l | < 200 | 200-400 | > 400 |

| Total Area in sqkm | % of Area affected by | | Total No. of Habitations | No. of Habitations affected by | |
|--------------------|-----------------------|---------|--------------------------|--------------------------------|---------|
| | Fluoride | Nitrate | | Fluoride | Nitrate |
| 1,63,115.24 | 8.92 | 14.90 | 48451 | 3368 | 6535 |

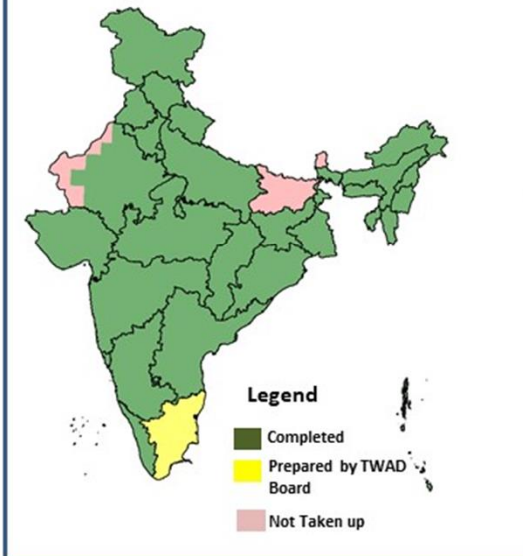
Summary :

- Habitation wise Ground water Quality (GWQ) point database prepared for 34 state & UTs.
- Seamless State Mosaic GWQ database prepared for 34 state & UTs.

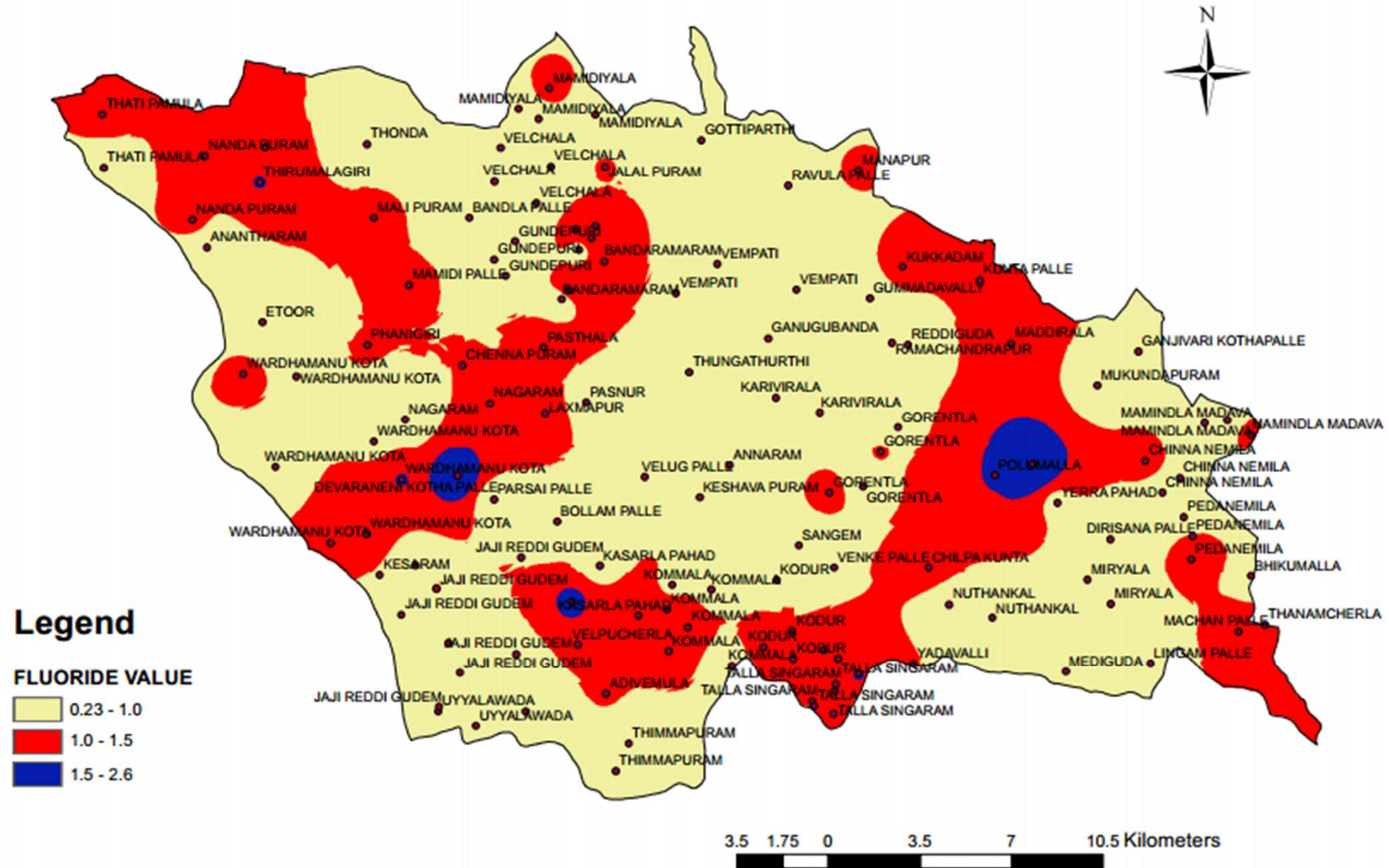
Major Pre-GWQ Contaminants

- **Arsenic:** 13,469 (in U.P, Punjab, Haryana, W.B. Tripura etc.)
- **Fluoride:** 32,601 (in U.P, Punjab, Rajasthan, M.P, A.P, W.B etc.)
- **Nitrate:** : 44,259 (in U.P Punjab, Haryana, Maharashtra, M.P A.P, Kerala, Karnataka etc.)
- **Iron:** 36,207 (in Rajasthan, Maharashtra, M.P, Jharkhand, Odhisa, Jharkhand, Tripura etc.)

State Mosaic GWQ Mapping Status (March,2019)

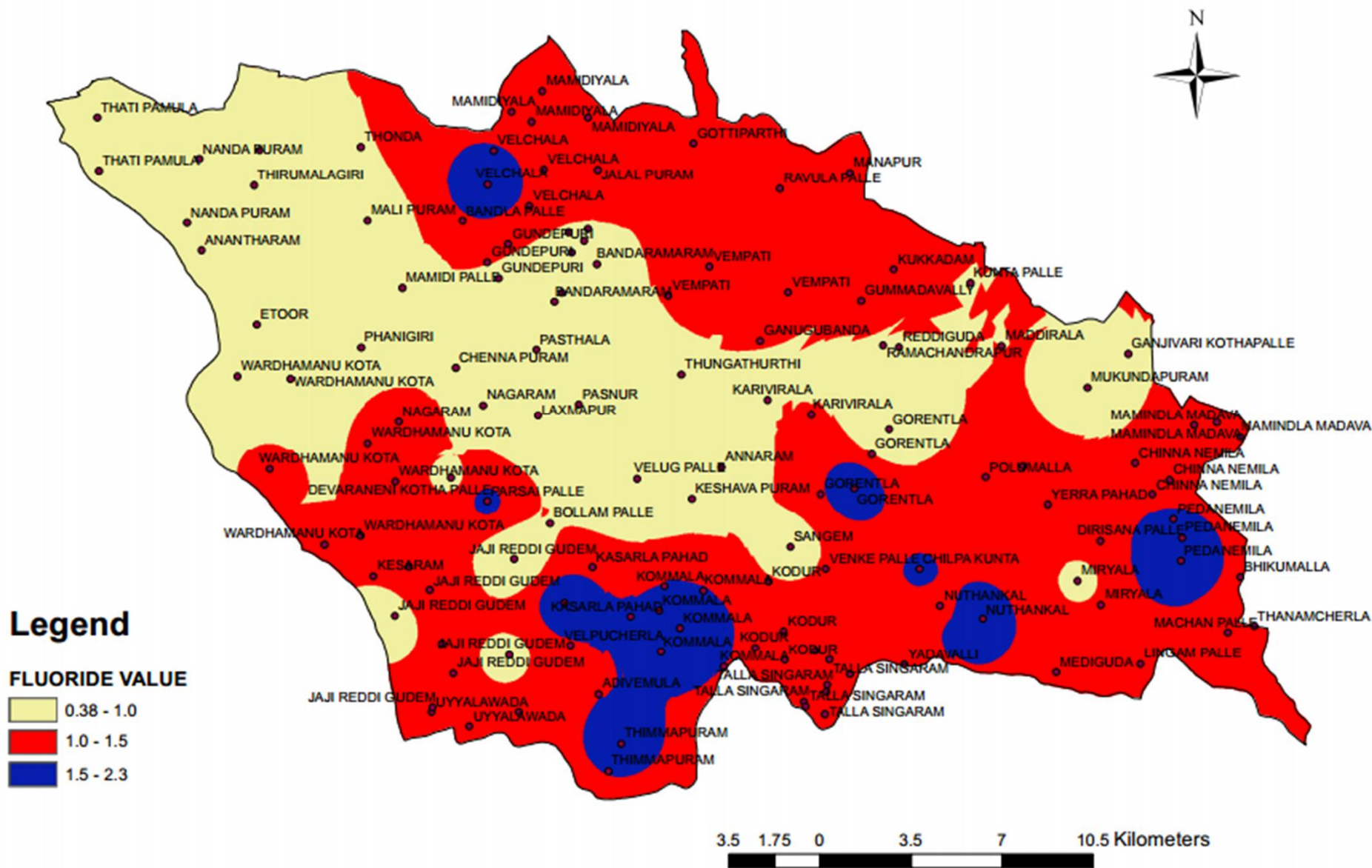


FLUORIDE CONTAMINATION IN PRE-MONSOON PERIOD



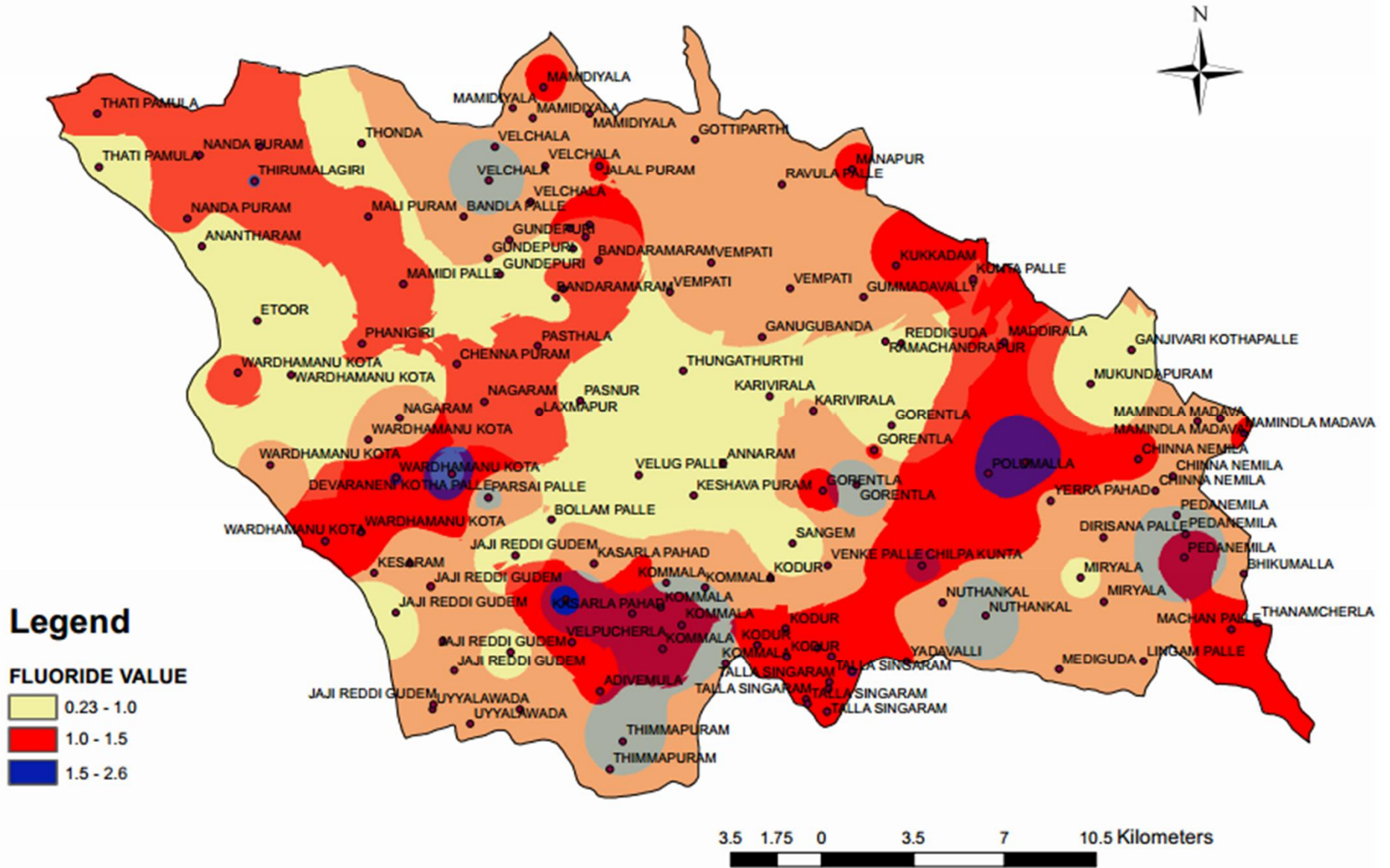
PART OF NALGONDA DISTRICT, ANDHRA PRADESH

FLUORIDE CONTAMINATION IN POST-MONSOON PERIOD



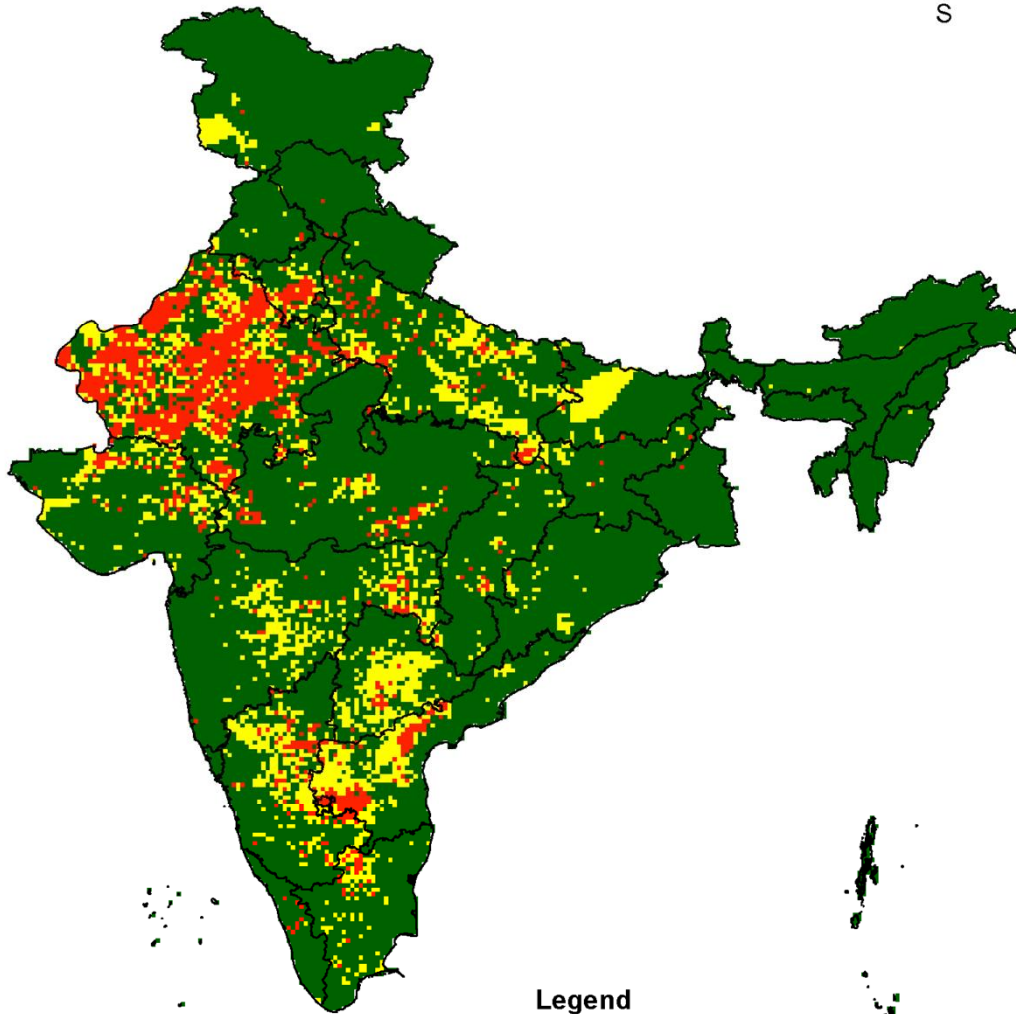
PART OF NALGONDA DISTRICT, ANDHRA PRADESH

FLUORIDE CONTAMINATION IN PRE- & POST- MONSOON PERIOD



PART OF NALGONDA DISTRICT, ANDHRA PRADESH

India Fluoride Pre-Monsoon



Legend

India State Boundary

Fluoride

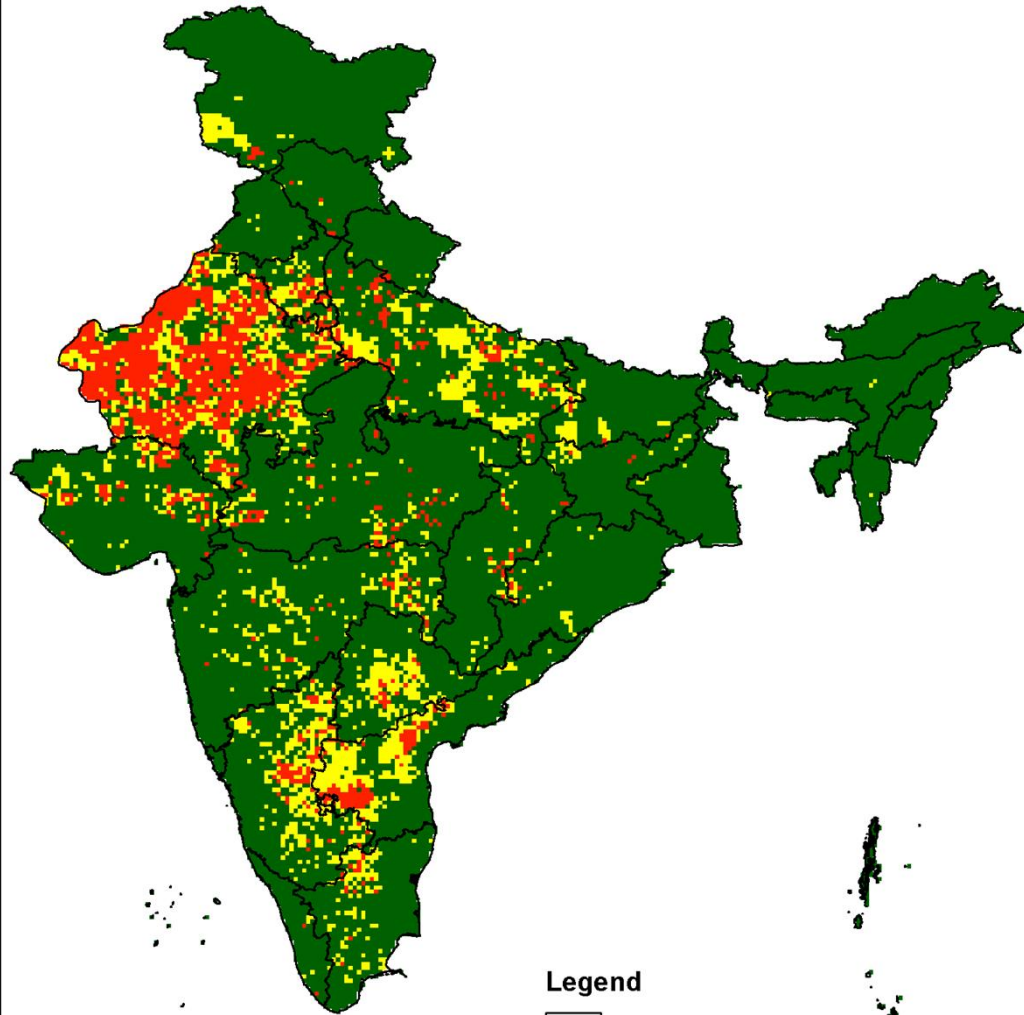
0 - 1

1.000000001 - 1.5

1.500000001 - 527.2953491

0 180 360 720 1,080 1,440 Km

India Fluoride Post-Monsoon





Legend

 India State Boundary

Fluoride

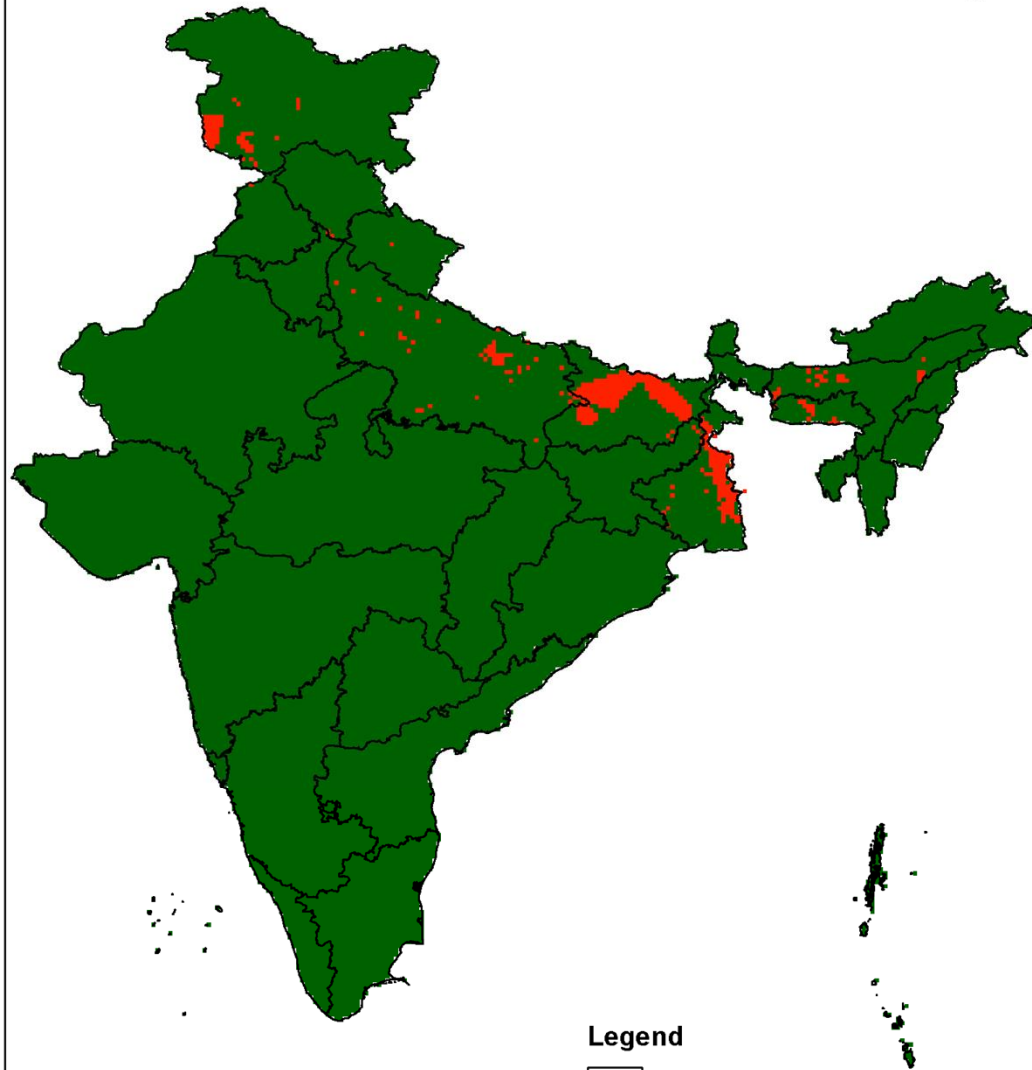
 0 - 1

 1.000000001 - 1.5

 1.500000001 - 270

0 175 350 700 1,050 1,400 Km

India Arscenic Pre-Monsoon




Legend

 India State Boundary

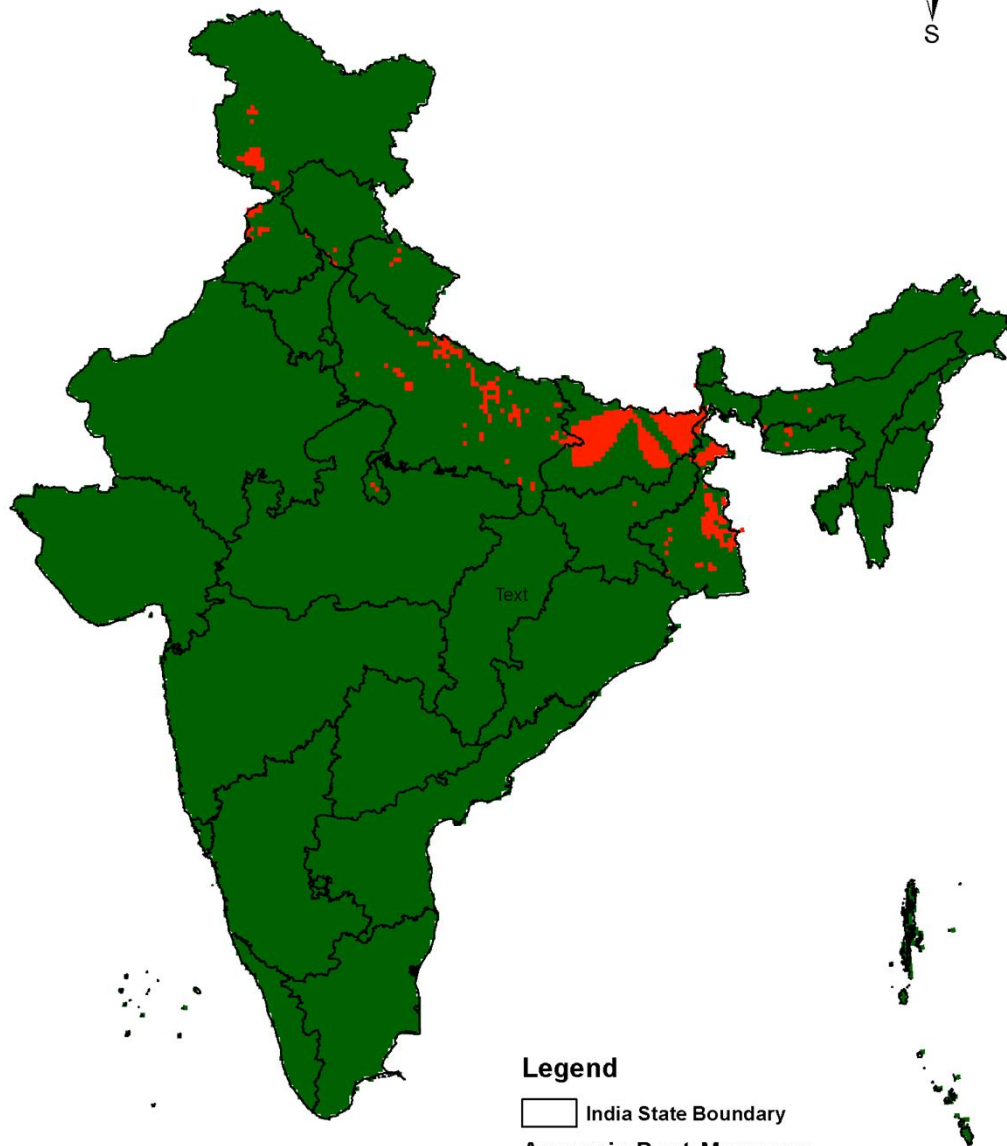
Arscenic Pre-Monsoon

 0 - 0.01

 0.010000001 - 40.89200974

0 170 340 680 1,020 1,360 Km

India Arscenic Post-Monsoon



Legend

India State Boundary

Arscenic Post-Monsoon

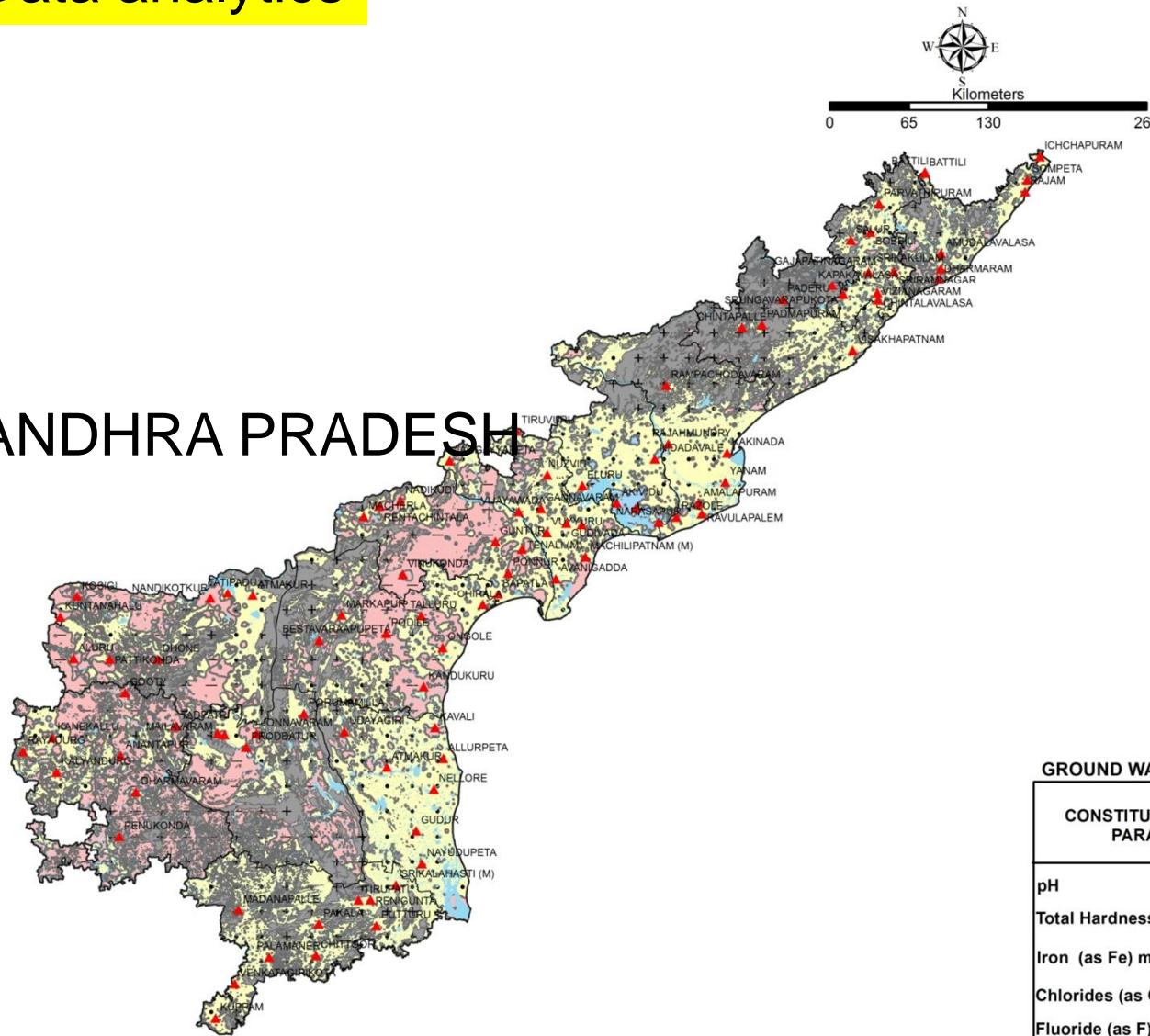
0 - 0.01

0.010000001 - 32.04994202

0 130260 520 780 1,040
Km

Data analytics

ANDHRA PRADESH



GROUND WATER QUALITY INDEX

| COLOUR CODE | PRE MONSOON | POST MONSOON |
|-------------|--|---------------|
| ++++ | 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-Hills & steep slope areas where there are no habitations | |

GROUND WATER QUALITY PARAMETERS AS PER BIS STANDARDS 2015

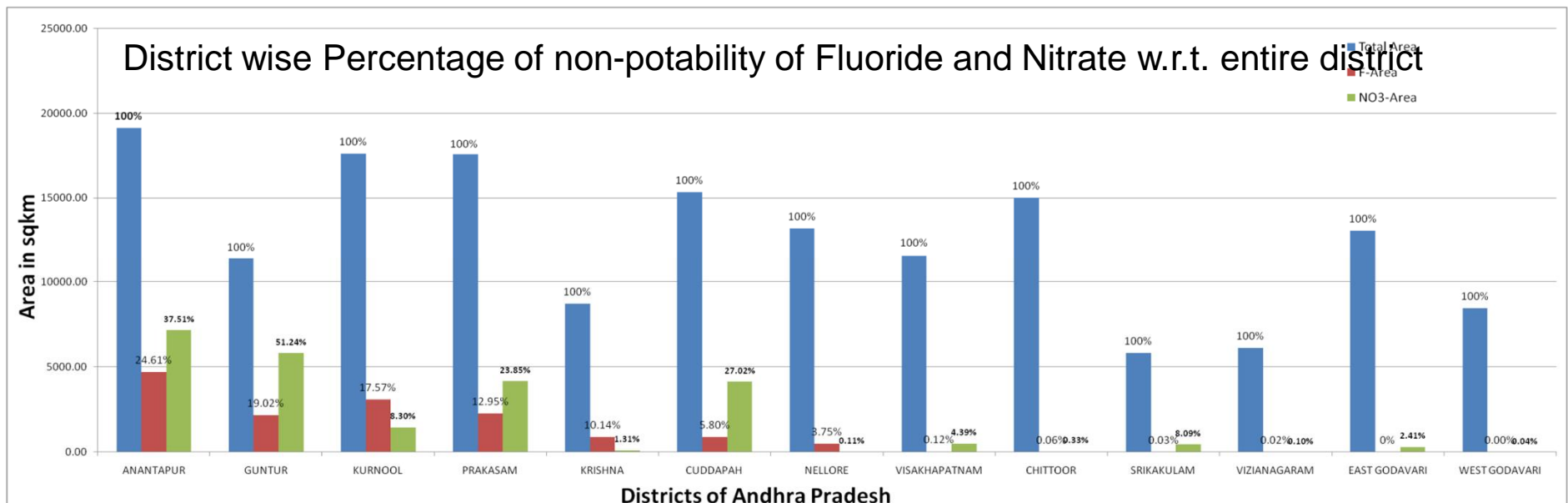
| CONSTITUENTS/QUALITY PARAMETERS | CONCENTRATION LIMITS | | |
|---------------------------------|----------------------|-------------|--------------|
| | Potable | Permissible | Non-Potable |
| pH | 6.5-8.5 | -- | < 6.5 ; >8.5 |
| Total Hardness (as CaCo3) mg/l | < 200 | 200-600 | > 600 |
| Iron (as Fe) mg/l | <1.0 | -- | >1.0 |
| Chlorides (as Cl) mg/l | < 250 | 250-1000 | > 1000 |
| Fluoride (as F) mg/l | < 1.0 | 1.0-1.5 | > 1.5 |
| Total Dissolved solids mg/l | < 500 | 500-2000 | > 2000 |
| Sulphate (as SO4) mg/l | < 200 | 200-400 | > 400 |
| Nitrate (as NO3) mg/l | < 45 | -- | > 45 |
| Alkalinity mg/l | < 200 | 200-600 | > 600 |

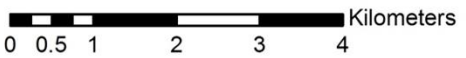
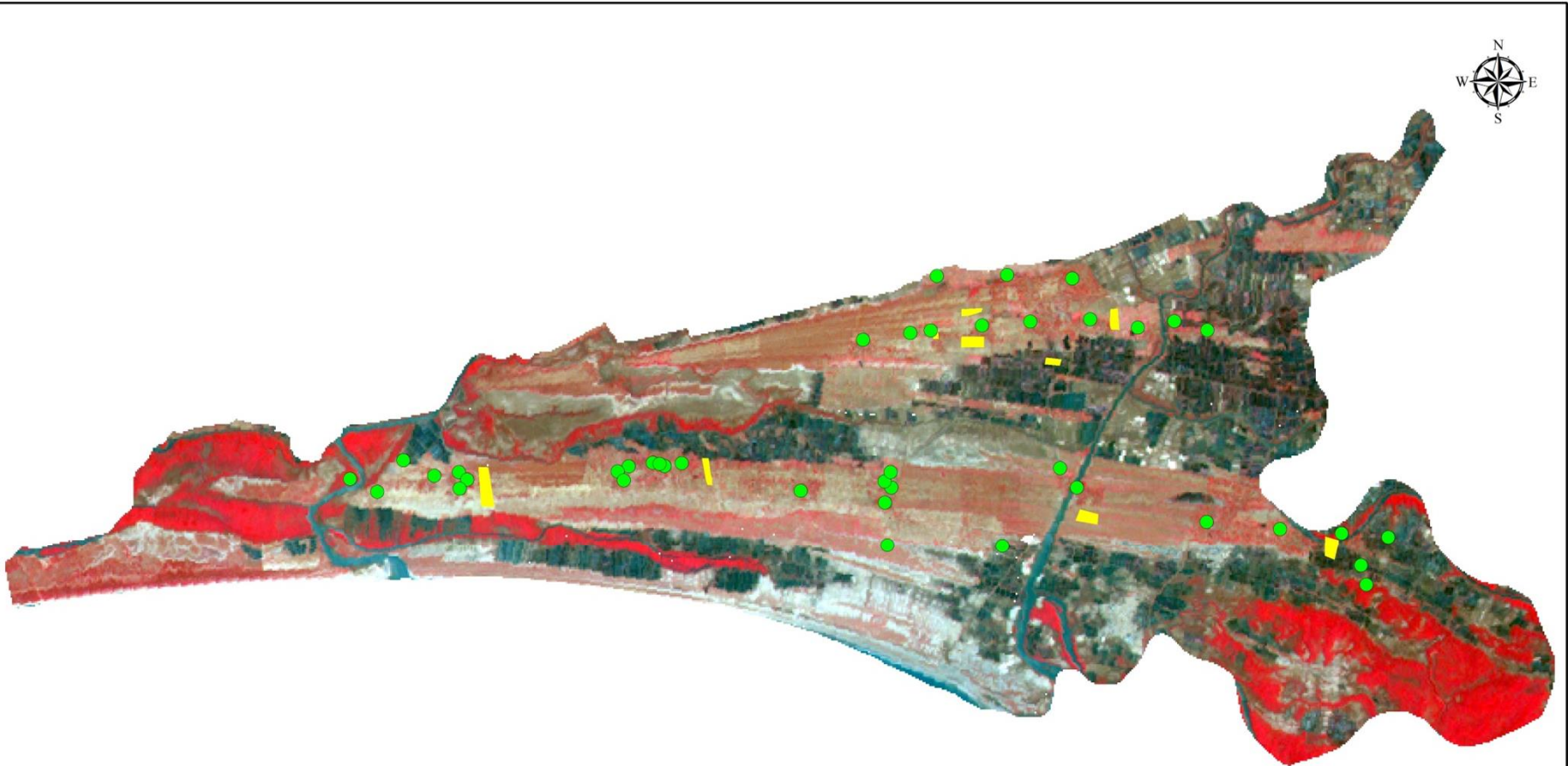
| Total Area in sqkm | % of Area affected by | | Total No. of Habitations | No. of Habitations affected by | |
|--------------------|-----------------------|---------|--------------------------|--------------------------------|---------|
| | Fluoride | Nitrate | | Fluoride | Nitrate |
| 1,63,115.24 | 8.92 | 14.90 | 48451 | 3368 | 6535 |

Data analytics

Comparison of point data vis-à-vis interpolated polygons for non-potable areas/points for Andhra Pradesh state.

| District | Non-potable % | | Deviation |
|---------------|---------------|-------|-----------|
| | Points | Area | |
| ANANTAPUR | 71.61 | 65.79 | 5.83 |
| CHITTOOR | 3.10 | 0.59 | 2.51 |
| EAST GODAVARI | 17.97 | 8.10 | 9.87 |
| GUNTUR | 61.06 | 59.50 | 1.56 |
| KADAPA | 57.93 | 49.58 | 8.35 |
| KRISHNA | 27.28 | 22.92 | 4.36 |
| KURNOOL | 61.42 | 54.91 | 6.51 |
| NELLORE | 12.90 | 7.91 | 4.98 |
| PRAKASAM | 48.75 | 41.03 | 7.72 |
| SRIKAKULAM | 20.94 | 18.66 | 2.28 |
| VISAKHAPATNAM | 14.89 | 13.05 | 1.84 |
| VIZIANAGARAM | 11.63 | 6.07 | 5.56 |
| WEST GODAVARI | 6.32 | 2.40 | 3.91 |
| State | 26.79 | 32.79 | -6.00 |

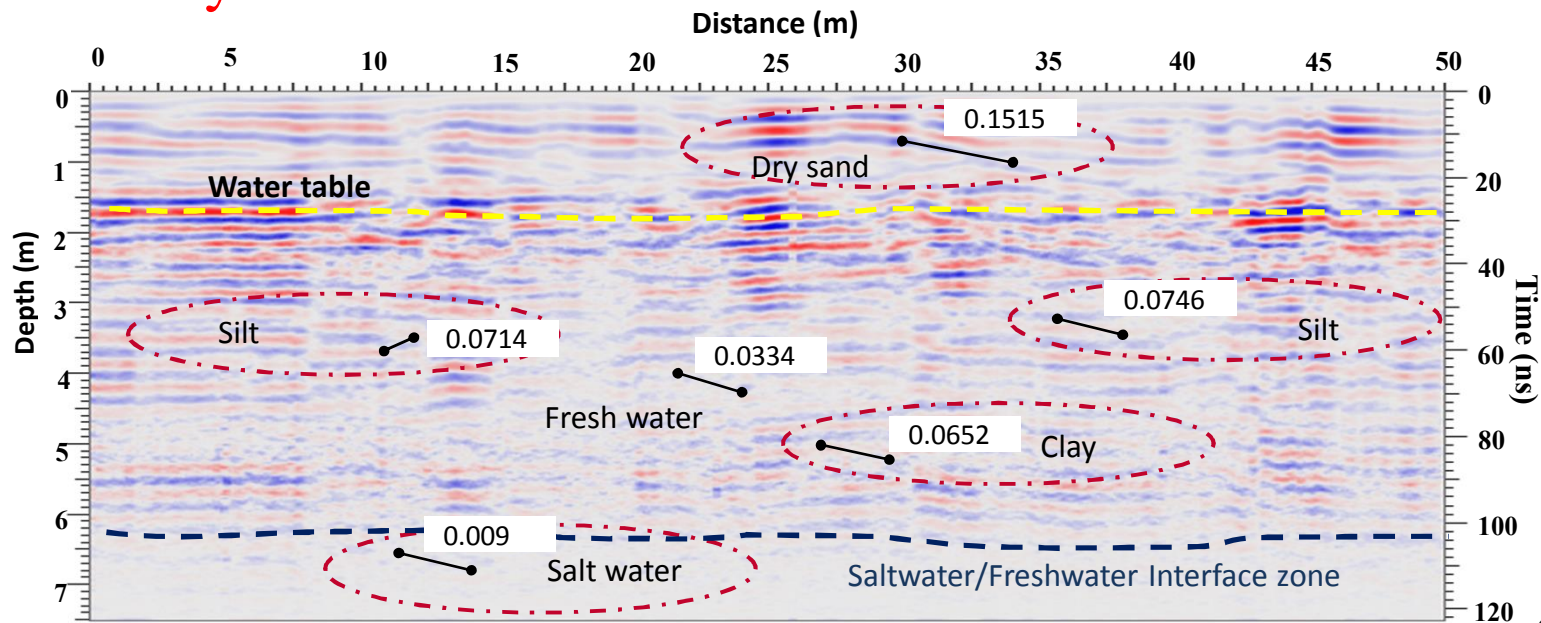




Legend

- Wells
- GPR Profile

GPR profile Velocity Analysis:



| Material | Velocity (m/ns) |
|----------------|-----------------|
| Dry sand | 0.15 |
| Saturated sand | 0.06 |
| silt | 0.07 |
| Clay | 0.06 |
| Fresh water | 0.033 |
| Sea water | 0.01 |

(After Annan A.P., 2003. "GPR principles, procedures and applications").

**THANK YOU FOR YOUR KIND
ATTENTION**