GLOBAL SYMPOSIUM ON
SALT-AFFECTED SOILS

20 - 22
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Virtual meeting

Mapping and Monitoring Sodic Land Reclamation in the Indo-Gangetic Plains of India Using Geo-Information Tools

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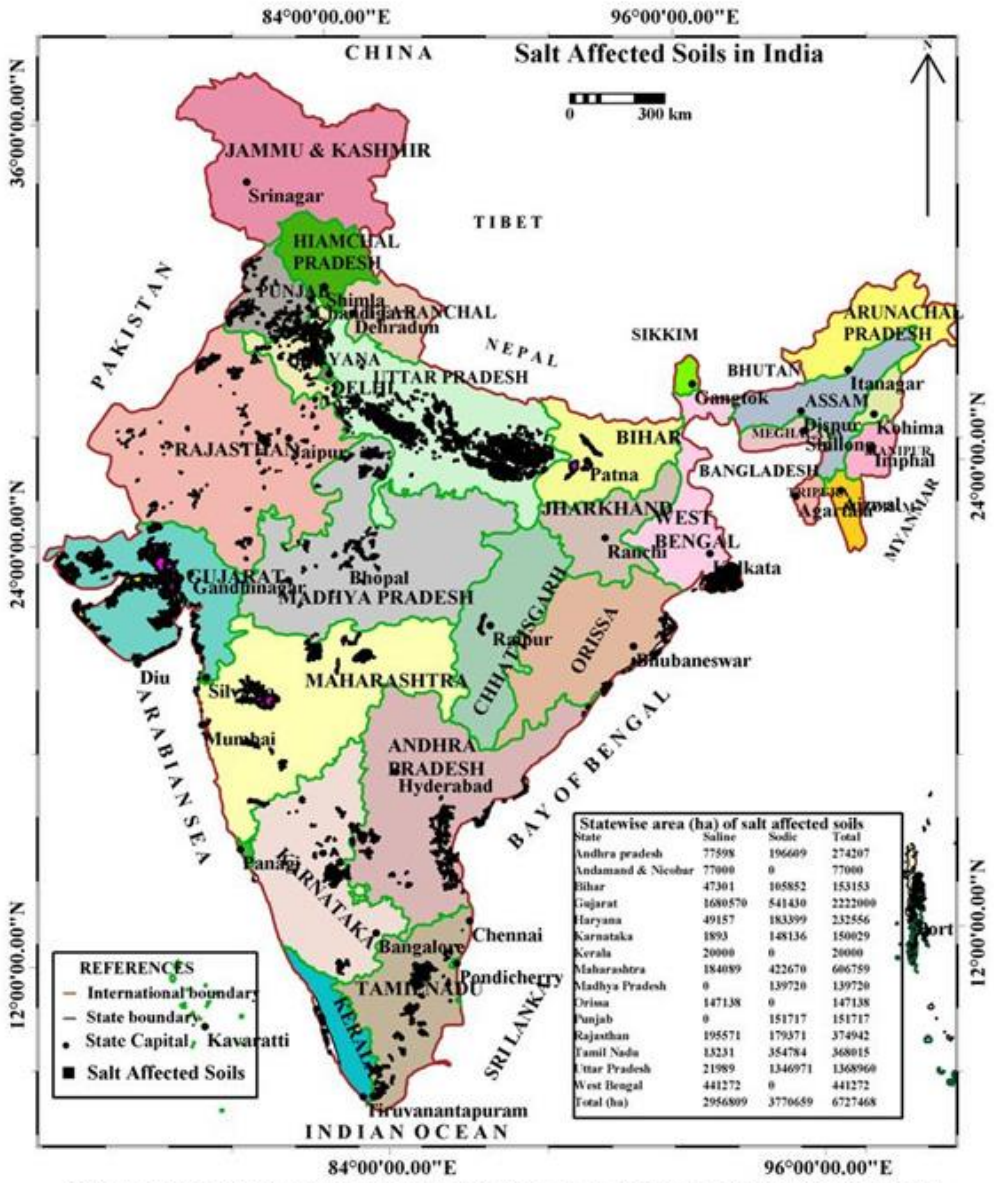
Indo-Gangetic Plains

- Vast fertile plain covering 255 Mha across India, Pakistan, Nepal and Bangladesh.
- Country's most important agricultural region, producing about 50% of India's food grains.
- Salinity/sodicity affected area in Indian portion of IGP is 2.35 Mha; India 6.73 Mha.
- Cultivated & irrigated System for thousands of years. Canal Irrigation System introduced since 1850.
- Presence of Vermiculite + Smectite minerals formed from weathering of biotite in long run due to repeated brief flooding of Micro Lows.
- In sodic lands, precipitation of Calcium carbonate in B Horizon forming nodules.

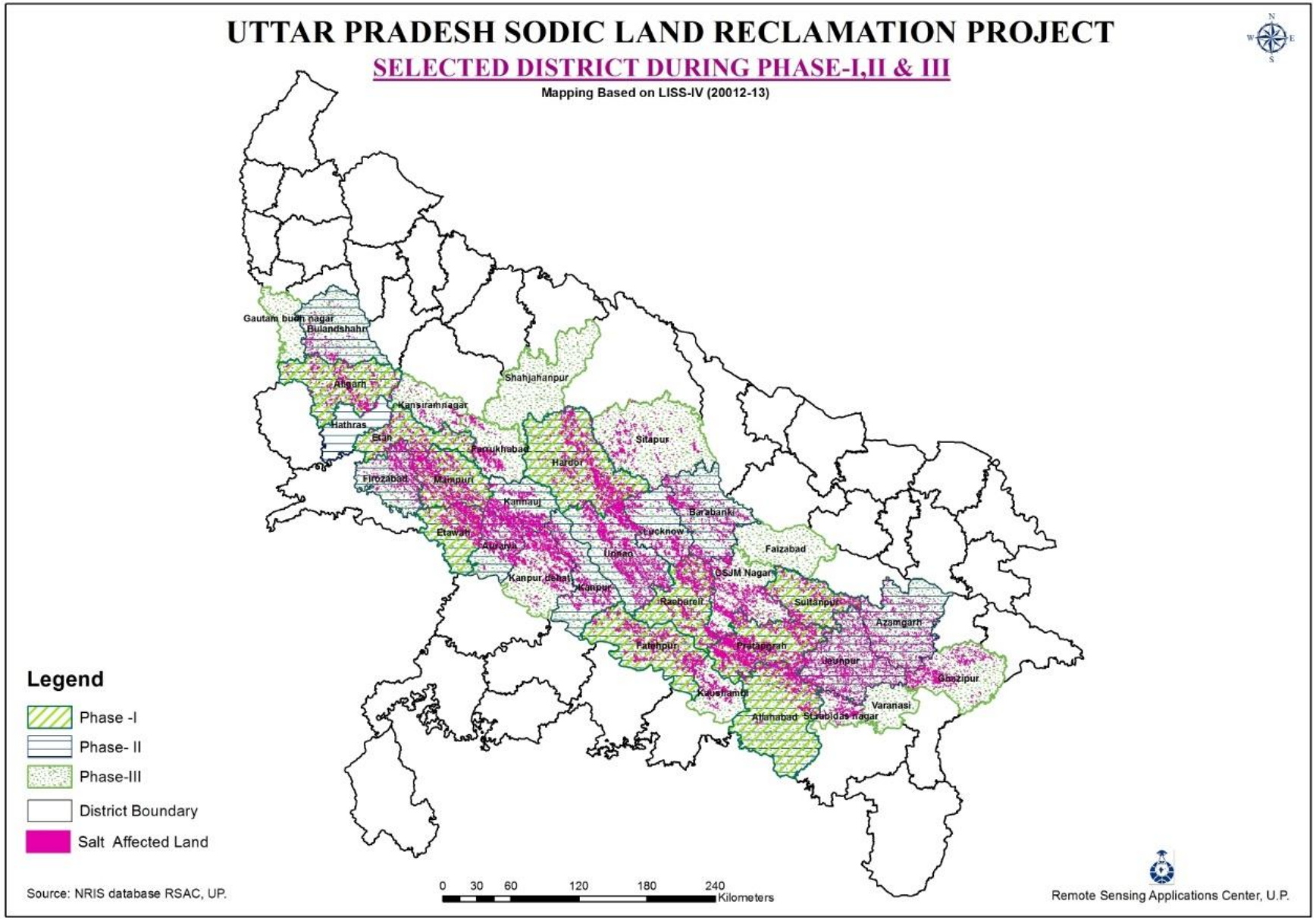


COMPUTERIZED DATABASE ON SALT AFFECTED SOILS IN INDIA

(Based on salt affected maps prepared by NRSC, Hyderabad, CSSRI, Karnal and NBSS & LUP, Nagpur, 1997)'

Uttar Pradesh Sodic Land Reclamation Project

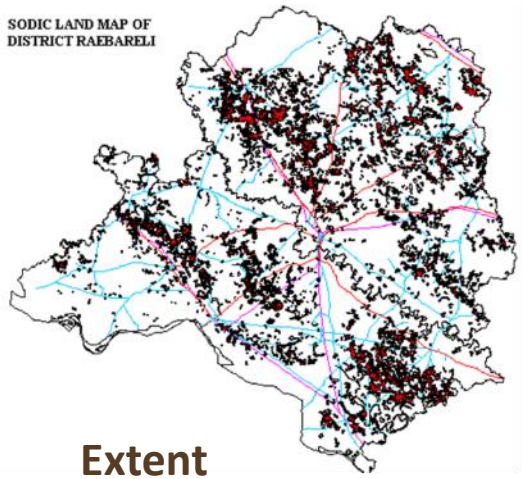
- The state of Uttar Pradesh has the largest concentration of salt-affected lands (1.37 M ha) out of which 1.35 M ha. Is under Sodic lands.
- With increasing population pressure, the per capita land availability for food, forage and fibre production is shrinking due to urban expansion, industrialization, infrastructure development and other competing uses.
- The option for achieving food and nutritional security is to sustainably reclaim salinity/ alkalinity affected and other problem soils.
- To reverse the process of sodic soil development through sustainable reclamation and prevention of further increase in sodicity, the state of U.P. initiated a large scale sodicland reclamation project through a World Bank loan in the year 1993 in order to alleviate poverty in these areas (70% barren uncultivated sodiclands, 30% under single or double crop, but poor crop growth. 94% small and marginal farmers).
- 400,000 ha sodiclands were reclaimed and brought under cultivation in three phases (1993-2018).


UTTAR PRADESH SODIC LAND RECLAMATION PROJECT
SELECTED DISTRICT DURING PHASE-I,II & III
Mapping Based on LISS-IV (20012-13)
N
W
E
S
Gautam budh nagar
Bulandshahr
Aligarh
Kansiramnagar
Hathras
Etah
Mainpuri
Firozabad
Etawah
Auraiya
Kanpur dehat
Kanpur
Kannauj
Farrukhabad
Shahjahanpur
Hardoi
Sitapur
Barabanki
Lucknow
Unnao
Raebareli
Faizabad
DSJM Nagar
Sultanpur
Azamgarh
Fatehpur
Pratapgrah
Jaunpur
Ghazipur
Varanasi
Allahabad
Sitamarhi
Sitabidas nagar
Legend
Phase -I
Phase- II
Phase-III
District Boundary
Salt Affected Land
Source: NRIS database RSAC, UP.
0 30 60 120 180 240
Kilometers
Remote Sensing Applications Center, U.P.

Mapping Requirement for Reclamation Project

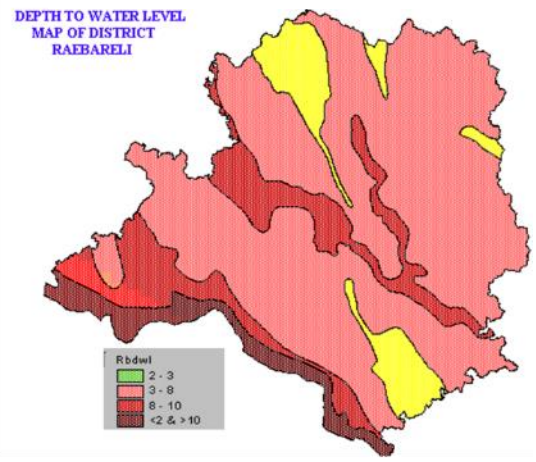
- **Location of sodic lands with plot numbers (khasra) on a village map (1: 3,960 scale),** as khasra linked to ownership of the farm.
- **Categorization of sodic lands:** A rapid method based on the soil reflectance on the image and land use was evolved**. 3 categories made: Class B+ (***double cropped area, but productivity below normal due to the presence of salts, soil pH generally ranging from 8.5 to 9.0***), Class B** (*single cropped, low productivity, soil pH ranging from 9.0 to 9.5***)** and **Class C (***barren land with soil pH> 9.5***). This categorization followed in U.P. after discussions with the DOA and UPBSN.**
- **The area of sodic lands under each class.**
- **Soil characteristics of each class (** *pH, EC and GR***).**
- **The ownership of each plot.**

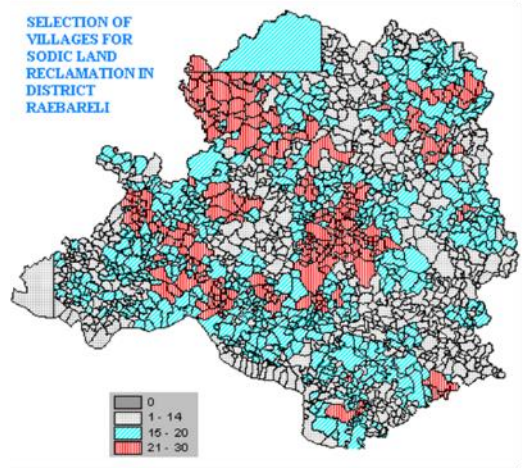
Selection of Sites and Villages for Reclamation



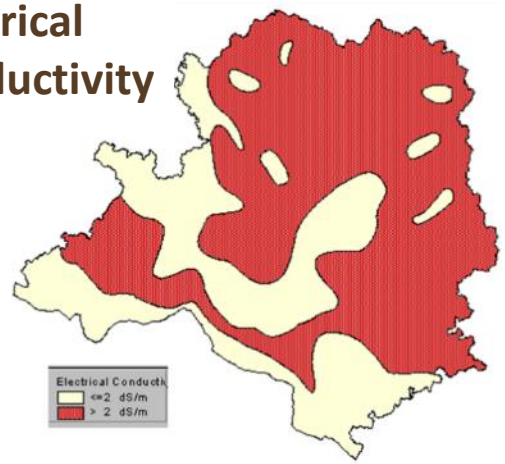
Extent

Ground water Level





Electrical Conductivity

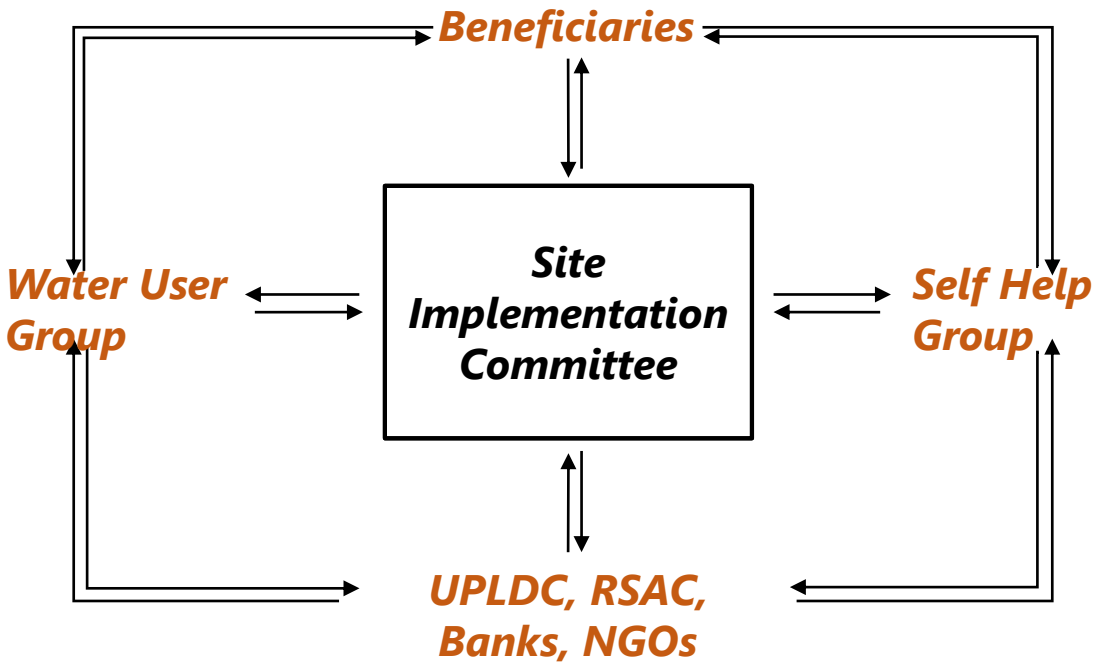


District Raebareli

Site Selection Criteria

- *Extent of sodic wasteland - 50% in a reclamation site and 33% in the villages.*
- *Natural drains are available nearby.*
- *Good quality of ground water (EC <2 dS/m and RSC < 1.5 me/l).*
- *Post-monsoon Ground water level >2m bgl.*

Participatory Management Structure



- The entire village reclamation plan was discussed in the site implementation committee meetings constituting of all beneficiary farmers, NGOs and the implementing agency.
- Water User Groups consisted of group of farmers benefitting from each TW (4 ha. Irrigated area)
- OFD & Drainage Implementation plan were discussed in periodic meetings and also the progress made in implementation and bottleneck, if any.

Site Selection, On-Farm Development and leaching of salts

Site Selection

On-Farm Development

Gypsum

Leaching

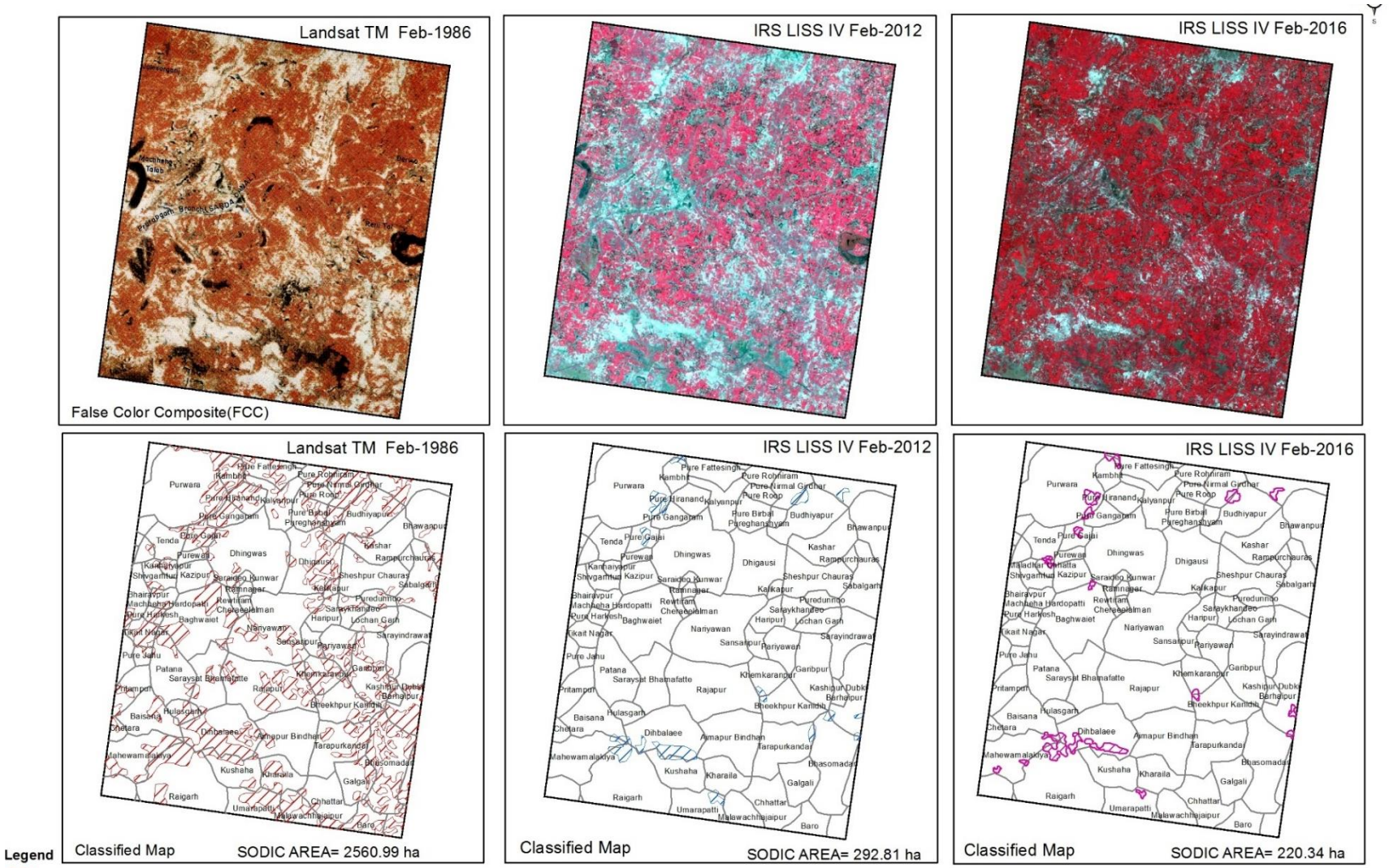
Main components of Reclamation Program UPSLRP

- Selection of sites, villages, categorization of sodicity classes- **B+ (*Double Cropped*)**, **B** (***Single Cropped***) and **C** (***Barren uncultivated***); Gypsum Requirement based on soil test
- On-farm development and land reclamation (*application of gypsum supplies Ca which replaces harmful Sodium from soil. Replaced sodium is then removed from root zone by drainage and leaching. Shallow TW every 4 ha for leaching and irrigation*)
- Rehabilitation and maintenance of main drains
- Technology dissemination (*Drainage improvement, green manuring, salts leaching*)
- Upgrading farm to market roads
- HRD and institutional capacity building of support services
- Adaptive research (*Study on reversion, Bio-drainage* etc.)
- Project management
- Environmental Monitoring (*Soil Quality, Water Quality, Biodiversity Monitoring*)

Key performance indicators of project

	Phase-I	Phase-II	Phase-III	Total
Period	1994-2001	1999-2007	2009-2018	
Area Reclaimed (Ha)	68,000	1,89,000	1,42,000	3,99,000
Funding (Million US$)	80.2	355.64	272.0	707.84
IDA share	54.7	224.68	197.0	476.38
State share	13.1	46.31	49.2	108.61
Beneficiaries	12.4	84.65	25.8	122.85
Districts Covered	10	18	29	57
Villages Covered	785	3369	2993	7,147
Beneficiary (Farmers)	1,56,000	3,67,000	2,40,000	763,000
Increase in productivity Qt/ha in C class Sodic lands)				
Paddy	0-29.92	0-32.23	0-35	
Wheat	0-26.05	0-26.91	0-30.00	
Rehabilitation of Main Drains (Kms)	2988	7620	5740	16348

Change in Spatial Extent of Sodiclands in Pratapgarh District during 1986-2016

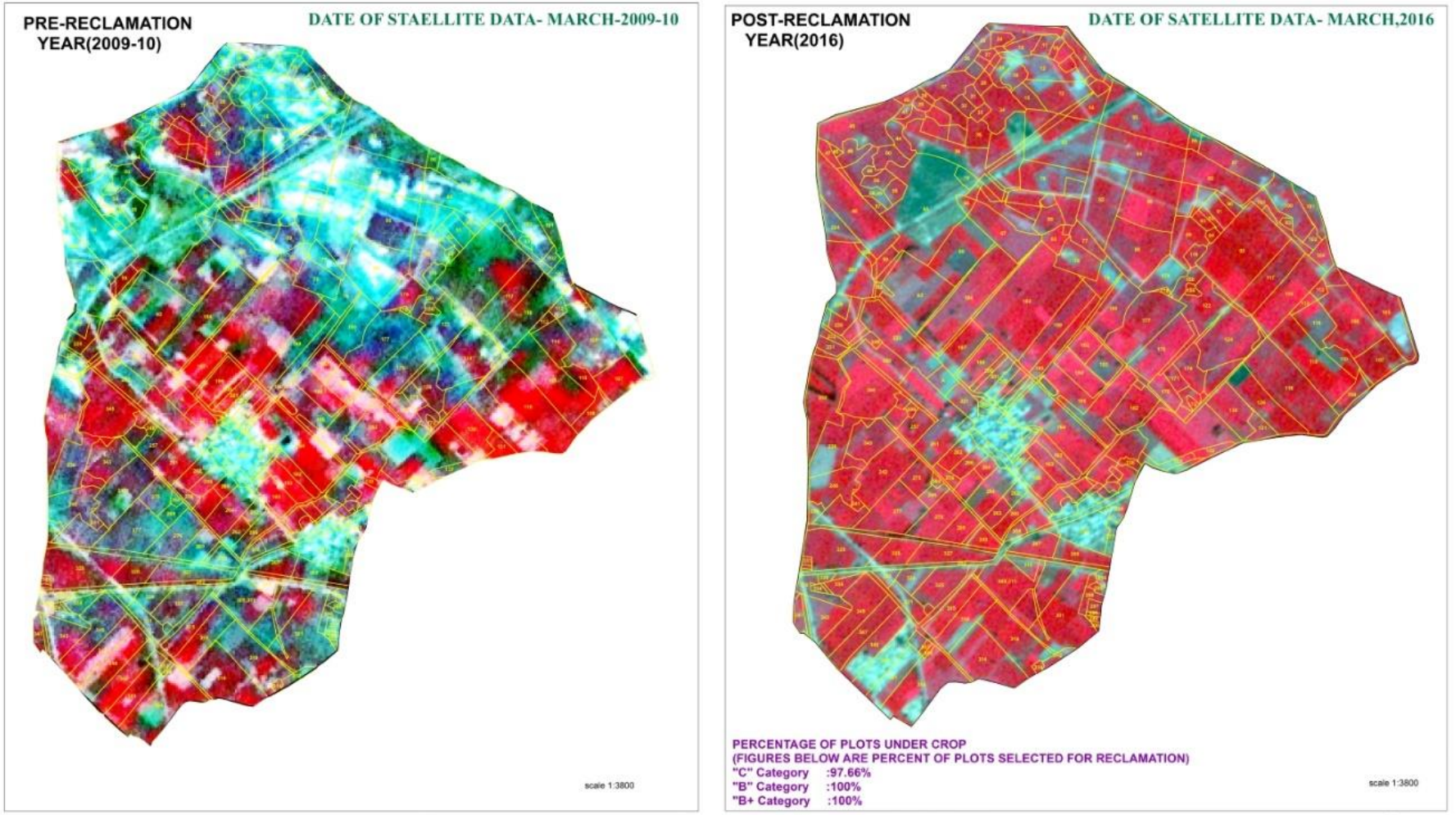


UTTAR PRADESH SODIC LAND RECLMATION PROJECT PHASE-III

PROJECT DURABILITY/SUSTAINIBILITY STUDY

STATUS OF SODICLANDS AFTER SIX YEARS OF RECLAMATION AT CADASTRAL LEVEL

VILLAGE- HURSAINA, DISTRICT ALIGARH

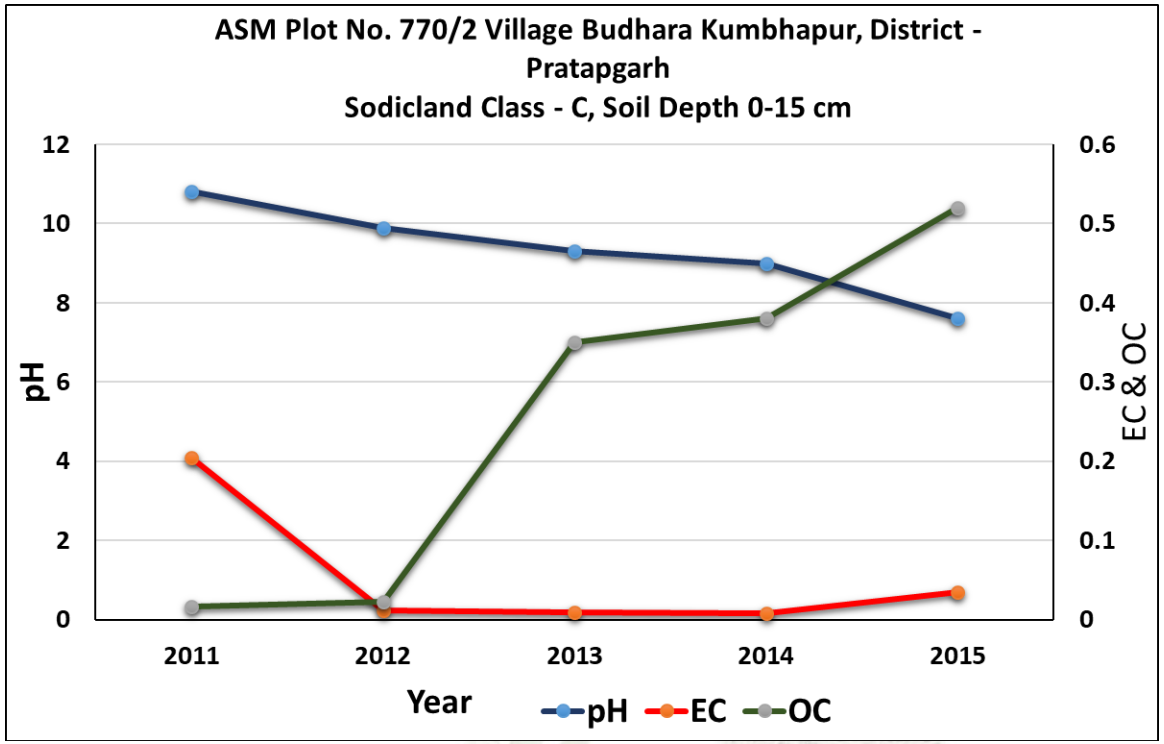


LISS IV Satellite Data with overlay of Cadastral Map

0 165 330 660 990 1,320 Meters

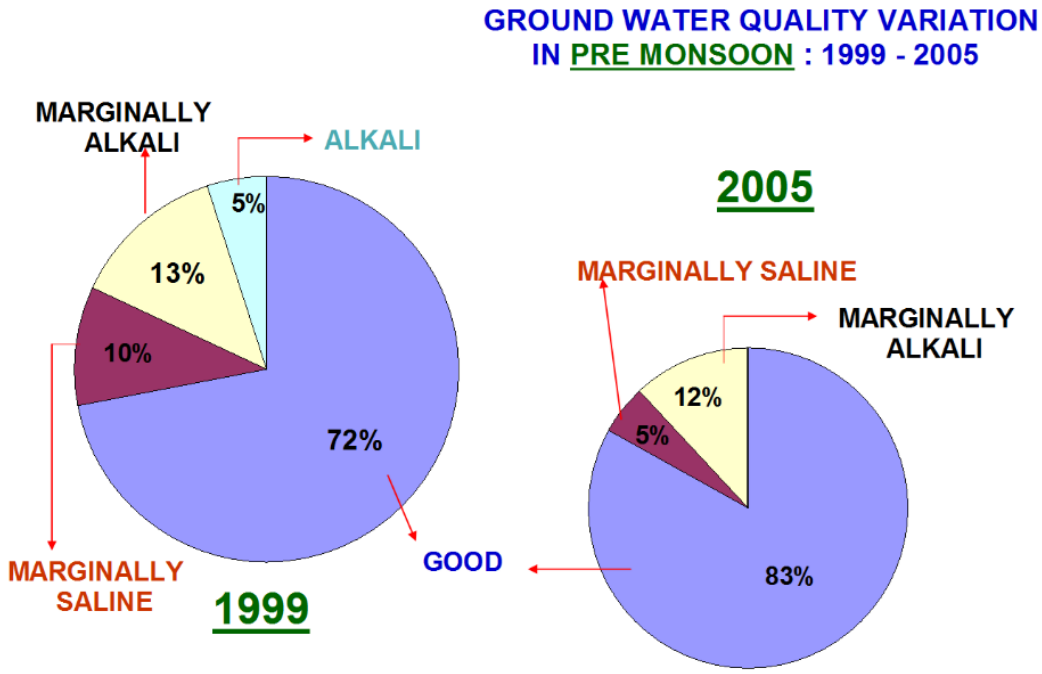
Soil Environmental Monitoring

- Soil samples collected annually after winter crop for pre reclamation and for 5 years after reclamation up to **120 cm** depth.
- Total **292** plots were monitored covering all **17** project districts.
- Improvement in surface horizon (0-15 cm) with significant reduction in pH & EC in all districts.
- Reduction in electrical conductivity is more rapid.



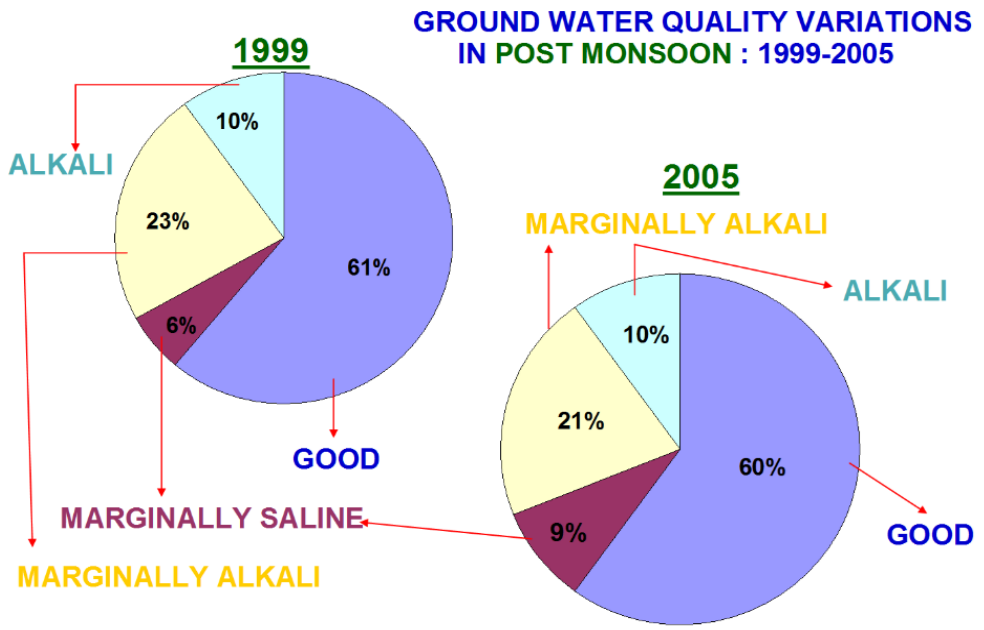
Ground water and Surface Water Monitoring-1

- GW monitoring program was designed to understand the movement of salts through the soil profile and into the GW system due to salt loading.
- GW level from open wells, piezometers , TWs; AWLRs to calculate GW gradients, recharge rates, and flow direction.
- Collection of water samples- pre- monsoon (May-June) and post monsoon (Oct-Nov). Analysis for pH, EC, cations, anions and trace elements.
- The fluctuation in water levels were calculated and fluctuation grid computed in GIS. Four groups made, <2, 2-3, 3-5 and >5 m bgl.
- Area under shallow GW (<2 mbgl) and potentially waterlogged (2-3 mbgl) in post-monsoon show declining trend, due to utilization of more GW for reclamation and irrigation. This is a positive effect of reclamation process.



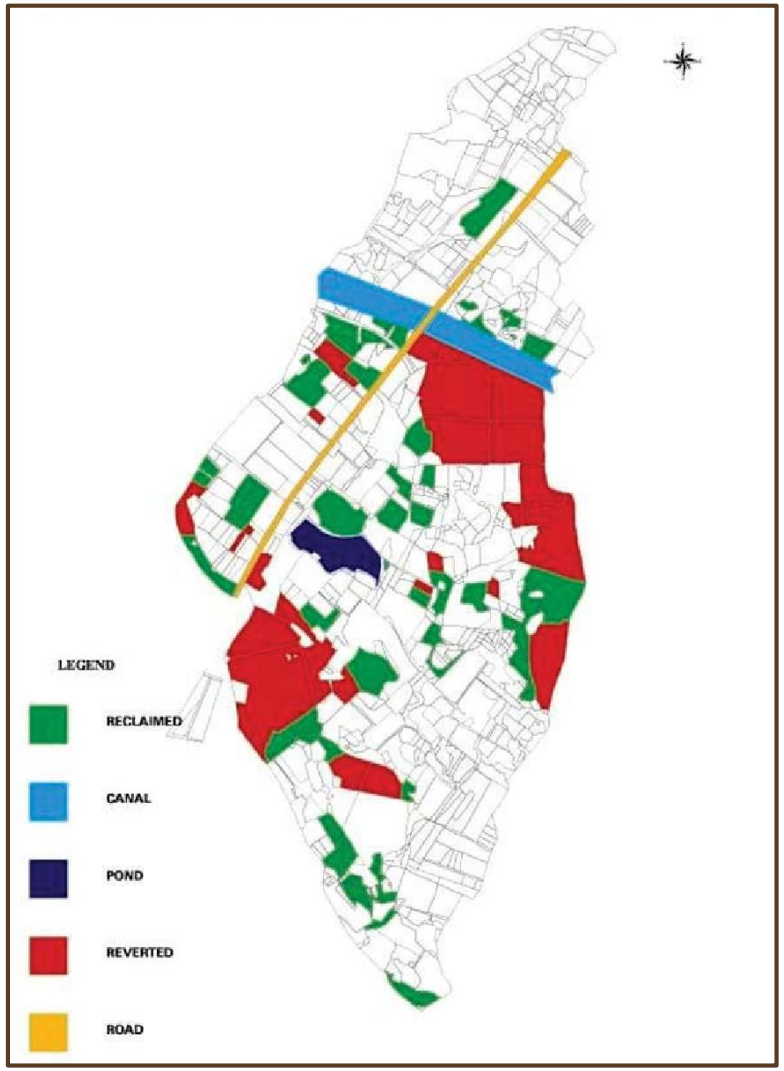
Ground water and Surface Water Monitoring-2

- GW quality widely variable from site to site depending upon the hydro-geological conditions of the area, reclamation activities, irrigation system and rainfall received during the year.
- GW quality from diff. years show pH and EC decreasing temporally. SAR and RSC, important parameters of irrigation, also within the permissible limit (<10 and <2.5 me/l) in all reclamation sites. These observations support to positive impact of reclamation on GW quality.
- Surface water samples from major drains in project area were also found to be within permissible limits.



Reversion of Sodicity

Village- Patna Bela, of Bidhuna Tehsil, District- Etawah, Reclamation year-1994



- In some areas of Phase-I where reclamation had been taken up by farmers, reversion of sodicity was reported.
- A study showed 27% reversion in the site area of 3,905 ha covering 57 villages. *High water table condition (<2m bgl post-monsoon*) was the most important cause for reversion, followed by *poor drainage conditions* due to either non-existence or choking of drains, and nearness to main canal (within 500 m)
- This study led to *mid-course correction in the reclamation methodology* and high water table areas (post-monsoon <2m bgl) and near the main canal (at 500 m distance) were excluded from reclamation, saving a significant project cost.

Outcome Benefits

- ***Area reclaimed 400,000 ha***. **Beneficiary share 30%** in form of labor
- **About 8 lac families** benefitted.
- ***Increase in productivity of cereals*** *(Rough Rice+ Wheat, t/ha)***-** 'C' sodic: **0** to **6.4;** 'B' sodic: from **1.4** to **6.5;** 'B^{+}' sodic: **4.3** to **6.9** (Annual incremental production of paddy & Wheat **1 million tons** each
- ***Increase in cropping intensity-*** from 45 to **206%**
- ***Increase in Crop income*** *(US$/year/household)***- 175 to 780**.
- ***Increase in 'C' class land value*** *(US$/ha)*- **3068** to **9776**
- ***Soil quality improvement -*** **pH** from **9.99** reduced to **8.86**; **EC** from **1.64** to **0.73**; **SOC** from **0.19** to **0.45**%
- ***Area brought under assured irrigation-*** **55000** ha
- ***Main drains rehabilitated -*** ~**16,348** km; ***main drains maintenance works-*** **26,400** km

Lessons Learnt

- Reclamation technology and capacity building at the village level should go hand-in-hand for its success.
- It took 1-2 years of capacity building at the village level to prepare the institutions and farmers with the skills, technical knowledge and communication experience to carry out the reclamation activity in a planned manner.
- Environmental monitoring (*concurrent monitoring of soil, surface and ground water levels and quality, land use, biodiversity*) were unique components which helped in taking up mid-term corrective measures.
- Transparency and participatory problem-solving by stakeholders (*farmers, project staff & NGOs*) builds ownership.
- The project was recognized as ***Best Practice in Social Development*** by the World Bank.

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