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Digital database of salt affected soils in India using Geographic Information System

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ABSTRACT

Salt affected soils were mapped on 1:250000 scale, based on the interpretation of remote sensing data, ground truth and laboratory analysis for pH, ECe and ESP. These maps covering fifteen states (printed on 125 paper sheets) contained voluminous data on spatial coverage, physiography and categories of salt affected soils following USDA approach. In analog form such data is difficult to handle for users of varied background and interest. For easy access, quick retrieval and spatial analysis with multiple thematic layers, the analog maps were geo-referenced and digitized to develop theme layers of salt affected soils and basemap comprising of infrastructure (roads/railways), irrigation/drainage (canal/river), settlements (State/district capitals) and political/ administrative boundaries. Such maps prepared for fifteen states were integrated in Geographic Information System (GIS) to develop a composite map at the country level. Compilation of state-level estimates showed 6.7 M ha salt affected soils in India, of which saline and sodic soil covered 2.9 and 3.7 M ha, respectively. Superimposing physiography, rainfall, temperature, agro-climatic zones and geology data, interactive database were generated to show spatial associations with salt affected soils.

Keywords: database, GIS, saline soil, sodic soils

Introduction

Salt affected soils are distributed in 120 countries covering 953 M ha and reduced productivity to 7-8% at the global scale (Yadav, 2003). Sodic soils are dominant (>50%) with largest area in Australia while sizeable area (20%) is saline in dry-lands of Asia and Pacific and waterlogged and secondary salinized (39.9 M ha) in irrigated regions (Ghessami and Nix, 1995; World Watch Institute, 1990). In India, variable estimates (7.0 to 26.1 M ha) of salt affected soils were reported in absence of any systematic survey. Based on remote sensing, ground truth and soil physico-chemical properties, the National Remote Sensing Centre (NRSC), Hyderabad developed salt affected soil's maps involving CSSRI, Karnal and NBSS & LUP, Nagpur (NRSA, 1997). These maps contain voluminous data on soil and terrain characteristics and are difficult to handle by users of varied background and interest. GIS is now widely being used for storage, retrieval and analysis of natural resources data. Such technique using integrated GIS overlay of topology with the spatial and non-spatial soil attribute was successfully used for salinity management in irrigated agriculture (Mandal and Sharma, 2001). The salt affected maps were used for regional mapping at large scale (Mandal *et al.,* 2009). An attempt was made to develop a digital database of salt affected soils of India using GIS and perform spatial analysis with related data *viz.* climate, topography and geology, for planning and management of salt affected soils.

Material and Methods

Design and development of digital database for salt affected soils

Analog maps of salt affected soils (NRSC, 1997) were geo-referenced and digitized using ILWIS software (ver. 3.3) Thematic layers of state and district boundaries, roads/railways, rivers/canals, state capital and district headquarters were digitized from the Survey of India maps and overlaid to prepare the basemap (Fig. 1). By overlaying digital layers of basemap and polygons of salt affected soils, the state maps of salt affected soils were prepared. The codes and nomenclature of the segments and points were entered in a '*class domain*' file and were linked to a coloured '*representation*' file. An attribute table was prepared entering the soil physico-chemical properties and linked with the salt affected soils (polygons) to prepare a relational database (Fig. 2). Salt affected soil maps for fifteen states (112 map sheets) were integrated in GIS to prepare a composite map of salt affected soils of India

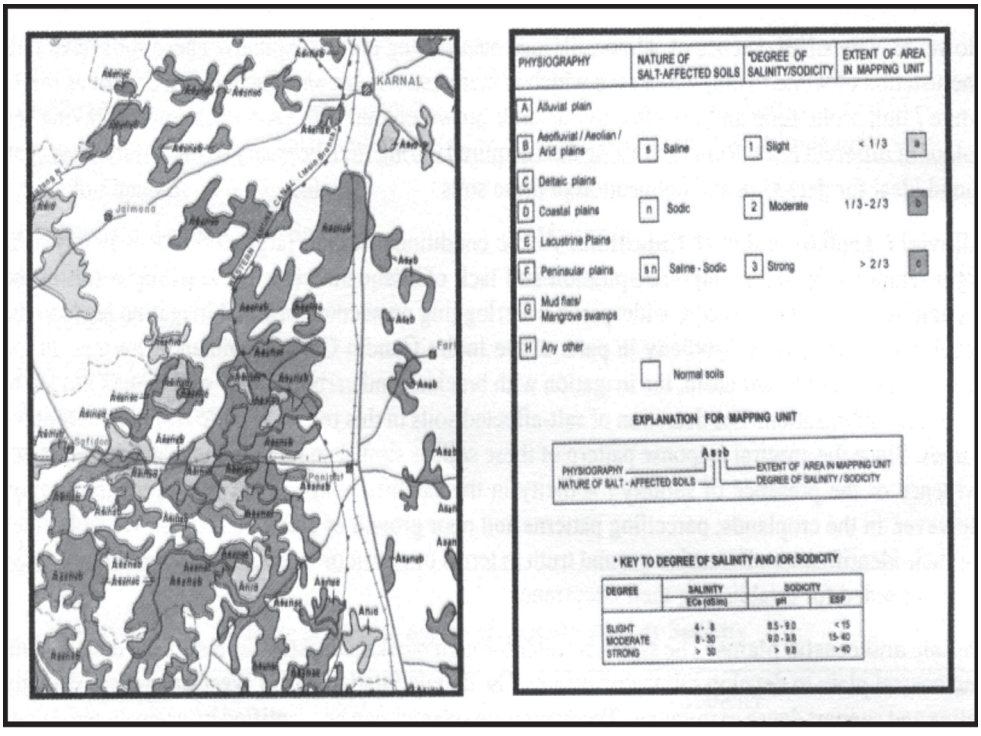


Fig. 1. Salt affected soil map and description of legends (NRSA & Associates 1997)

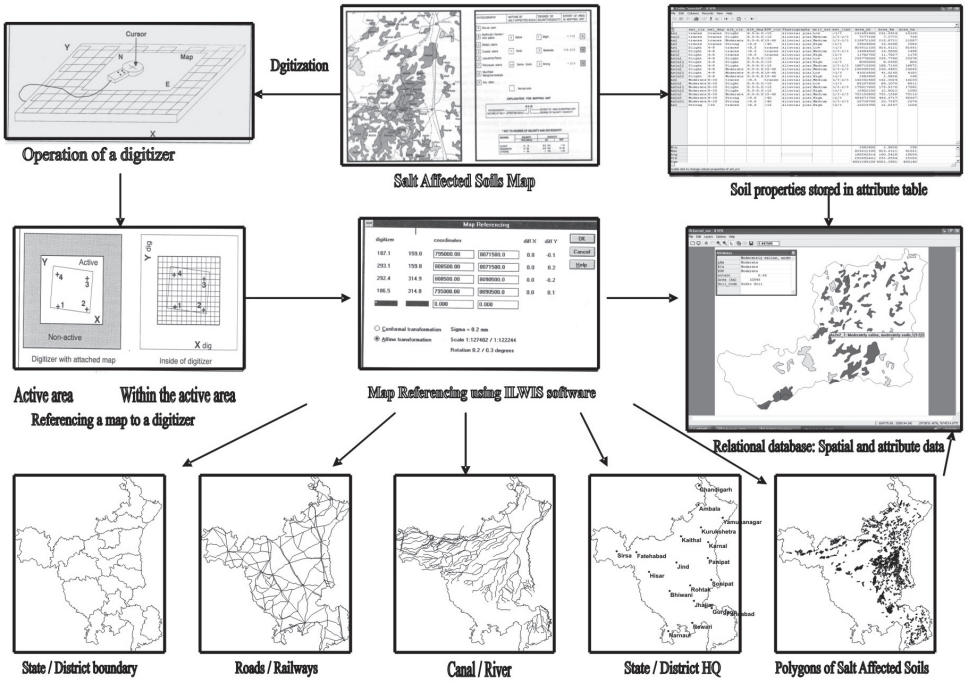


Fig. 2. Methodology for digitization of salt affected soils maps

(Fig. 3). The boundaries of agro-climatic regions (ACR) and zones (ACZ) (Ghosh, 1991), rainfall, temperature (NBSS&LUP, 2002) and geological zones (GSI, 1958) were overlaid to develop interactive database that showed spatial associations with salt affected soils (Fig. 4, 5 and 6). The final maps were annotated with suitable title, legend, scale, grid lines and north pointer etc.

Description of soil properties

An attribute table was developed entering physiography and physico-chemical characteristics of soils such as pHs, ECe and ESP (Table 1). It also includes nature (saline, sodic and saline-sodic) and degree (slight, moderate and strong) of salinity/sodicity and the extent

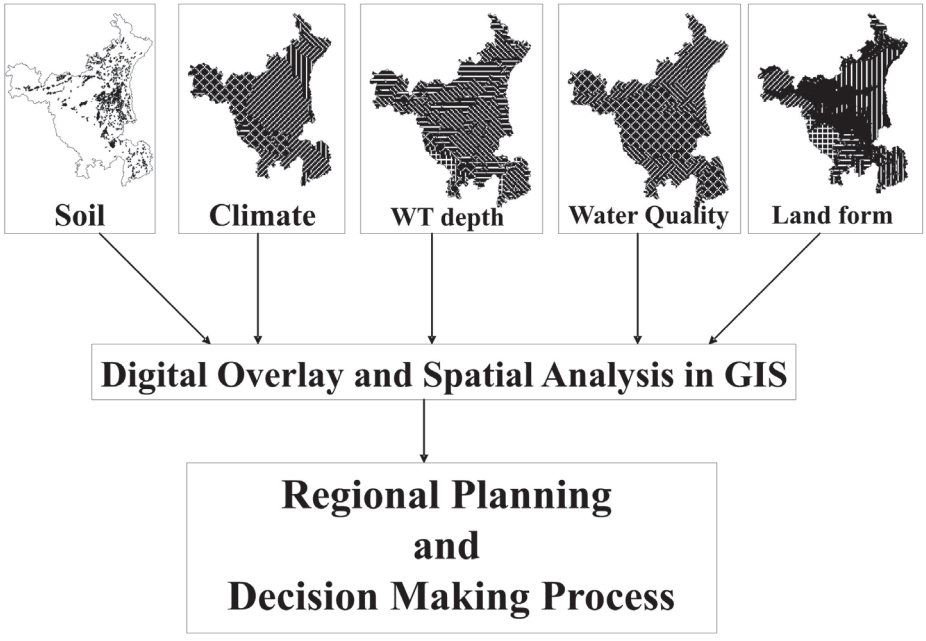


Fig. 3. Interactive databases for management of natural resources using GIS

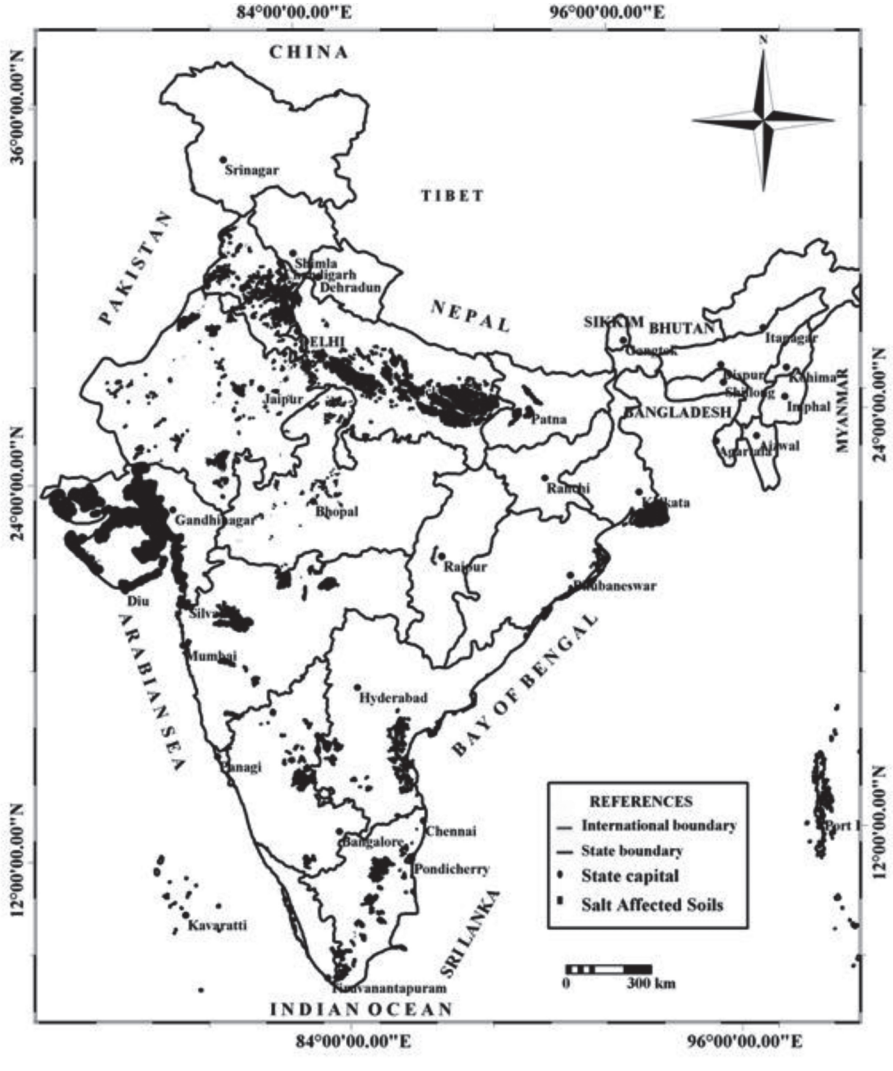


Fig. 4. Salt Affected Soils in India

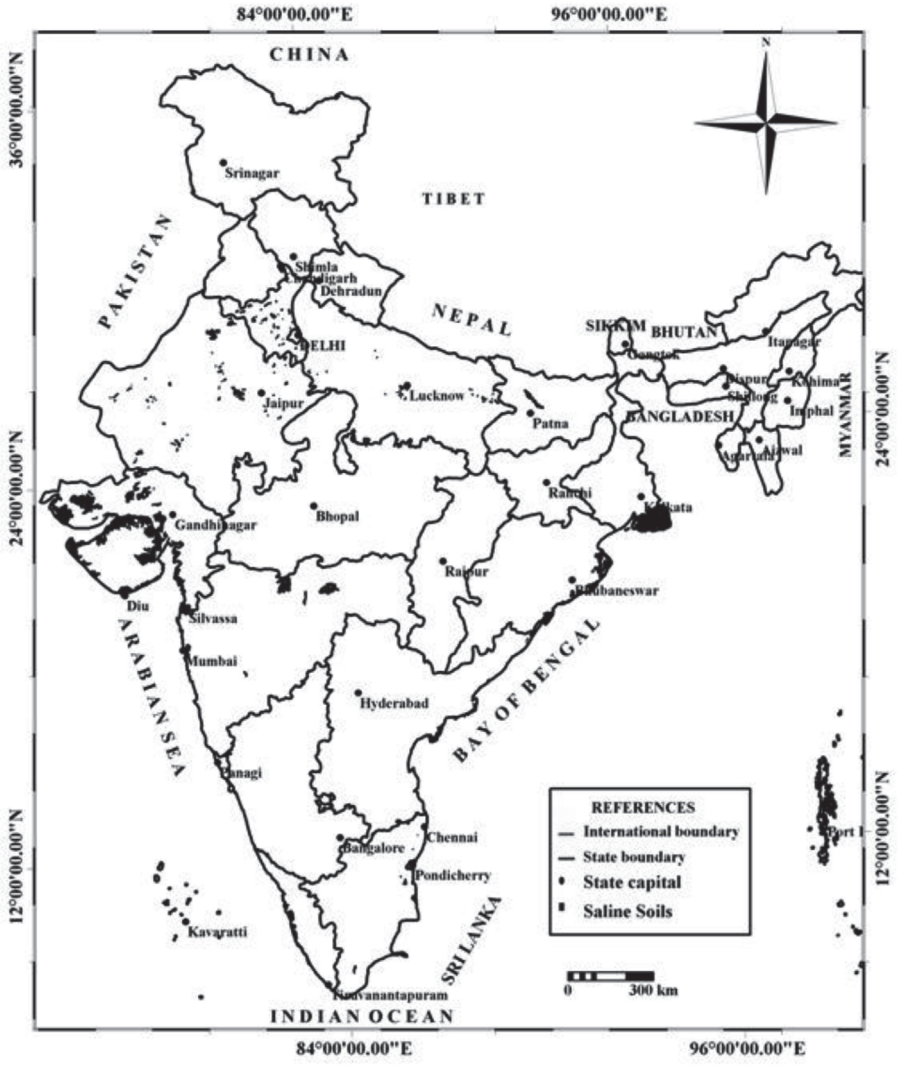


Fig. 5. Distribution of saline soils in India

Table 1. Description of mapping legend

Physiography		Nature of salt affected soils		Degree of salinity / sodicity		Extent of area in mapping unit		
Code	Description	Code	Description	Code	Description	Code	Description	Color
A	Alluvial plain	s	Saline	1	Slight	a	<1/3	Yellow
B	Aeofluvial/Aeolian/ Arid Plain	n	Sodic	2	Moderate	b	1/3-2/3	Orange
C	Deltaic Plain	sn	Saline-Sodic	3	Strong	c	>2/3	Magenta
D	Coastal Plain							
F	Peninsular Plain		Normal					
G	Mud Flats/ Mangrove Swamps							

of area in mapping unit as <1/3, 1/3-2/3 and >2/3 (Fig. 1). The map legends includes 's', 'n' and 'sn' to represent saline, sodic and saline-sodic soils; symbols '1', '2' and '3' were used for slight, moderate and strong categories; 'A', 'B', 'C', 'D', 'F', 'G' and 'H' symbols were used for alluvial, aeofluvial/aeolian/arid, deltaic, coastal, peninsular, mudflats/mangrove swamps and others physiographic units, respectively (Table 2). The colors yellow, orange and magenta were used for <1/3, 1/3-2/3 and >2/3 extent of areas. The ranges of ECe (4-8, 8-30 and >30 dS m^{-1}), pHs (<8.5, 8.5-9.0 and >9.0) and ESP (<15, 15-40, >40) were used to define slight, moderate

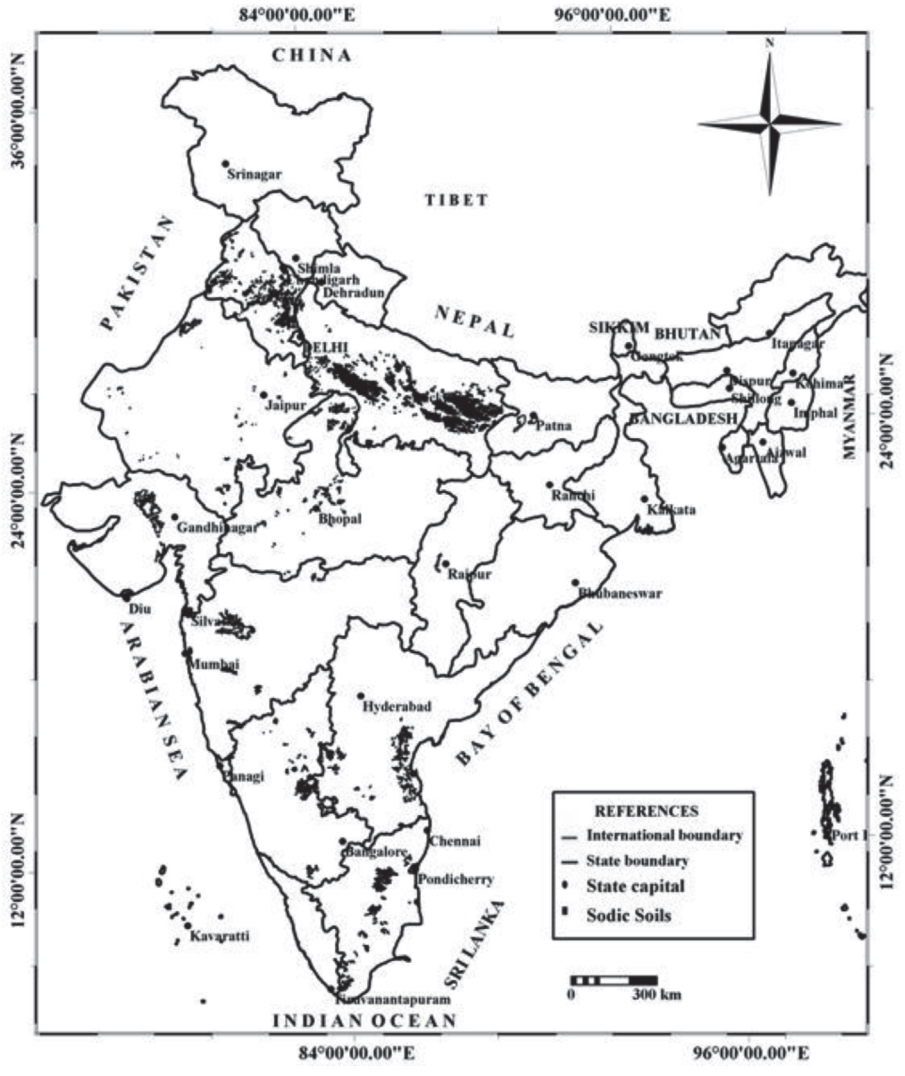


Fig. 6. Distribution sodic soils in India

and strong categories (Richards 1954). The saline soils were presented as s1, s2 and s3; sodic soils as n1, n2 and n3, and saline-sodic soils as s1n1, s1n2, s1n3, s2n1, s2n2, s2n3, s3n1, s3n2 and s3n3. For management purpose, these were merged to saline and sodic categories. Linking map and attribute data for soil properties by a common geo-reference, a relational database was also developed for easy retrieval.

Table 2. Keys to the degree of salinity / sodicity

Degrees	Salinity	Sodicity	
	ECe (dS m^{-1})	pHs	ESP
Slight	4.0-8.0	8.5-9.0	< 15
Moderate	8.1-30.0	9.1-9.8	15-40
Strong	> 30	> 9.8	>40

Results and discussion

Extent and distribution of salt affected soils

State, regional and country scale

Salt affected soils are distributed in fourteen states along with the UT of Andaman & Nicobar islands (Fig. 4). Significant area is distributed in the Indo-Gangetic Plain (IGP) of Uttar Pradesh, Bihar, Haryana, Punjab and West Bengal; the arid and semi-arid regions of Gujarat, Rajasthan, Madhya Pradesh and Maharashtra; and in the peninsular plains of Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh and Orissa. Considerable area occurs in the east and west coasts of Andhra Pradesh, Orissa, Tamil Nadu, Kerala, Karnataka, Maharashtra, Gujarat and the Islands of Andaman & Nicobar. Large affected areas can be viewed in different canal commands, which include the Sharda Sahayak (Uttar Pradesh), Tungabhadra (Karnataka), Indira Gandhi Nahar Pariyojona and Chambal (Rajasthan), Tawa (Madhya Pradesh), Mahi and Ukai (Gujarat). State-wise estimates of salt affected soils are presented in Table 4. These

Table 3. Description of soil characteristics

SAS code	Categories of SAS	ECe (dS m^{-1})	Saline class	pHs range	ESP range	Sodic Class	Physiography
s1	Slightly Saline	4.0-8.0	1	<8.5	<15	0	A, C, D
s2	Moderately Saline	8.1-30.0	2	<8.5	<15	0	A, B, C, D, G, H
s3	Strongly Saline	>30.0	3	<8.5	<15	0	A, B, D, G, H
n1	Slightly Sodic	<4	0	8.5-9.0	<15	1	A, B, D,F, H
n2	Moderately Sodic	<4	0	9.1-9.8	15-40	2	A, F, H
n3	Strongly Sodic	<4	0	>9.8	>40	3	A, D, F
s1n1	Slightly Saline, Slightly Sodic	4.0-8.0	1	8.5-9.0	< 15	1	A, B, D, F,H
s1n2	Slightly Saline, Moderately Sodic	4.0-8.0	1	9.1-9.8	15-40	2	A, B, D, F
s1n3	Slightly Saline, Strongly Sodic	4.0-8.0	1	>9.8	>40	3	A, B, F
s2n1	Moderately Saline, Slightly Sodic	8.1-30.0	2	8.5-9.0	<15	1	A, B, D, F, H
s2n2	Moderately Saline, Moderately Sodic	8.1-30.0	2	9.1-9.8	15-40	2	A, B, D, F
s2n3	Moderately Saline, Strongly Sodic	8.1-30.0	2	>9.8	>40	3	A, B, D, F, H
s3n1	Strongly saline, Slightly sodic	>30.0	3	8.5-9.0	<15	1	B, F, H
s3n2	Strongly saline, Moderately sodic	>30.0	3	9.1-9.8	15-40	2	B, D
s3n3	Strongly saline, Strongly sodic	>30.0	3	>9.8	>40	3	B, D

Table 4 State-wise extent and distribution of salt affected soils in India

Sl. No.	State	Saline Soils (ha)	Sodic Soils (ha)	Total (ha)	Total (M ha)
1	Andhra Pradesh	77598	196609	274207	0.274
2	Andaman & Nicobar	77000	0	77000	0.077
3	Bihar	47301	105852	153153	0.153
4	Gujarat	1680570	541430	2222000	2.22
5	Haryana	49157	183399	232556	0.232
6	Karnataka	1893	148136	150029	0.150
7	Kerala	20000	0	20000	0.020
8	Maharashtra	184089	422670	606759	0.607
9	Madhya Pradesh	0	139720	139720	0.140
10	Orissa	147138	0	147138	0.147
11	Punjab	0	151717	151717	0.152
12	Rajasthan	195571	179371	374942	0.375
13	Tamil Nadu	13231	354784	368015	0.368
14	Uttar Pradesh	21989	1346971	1368960	1.369
15	West Bengal	441272	0	441272	0.441
	Total	2956809	3770659	6727468	6.73

estimates were prepared by segregating areas under the saline and sodic soils.

Saline Soils

Saline soils occur in 29,56,809 ha (44% of the total salt affected soils) area in 12 states and in Andaman & Nicobar Islands (Table 4). These soils are located in inland plains (1.75 M ha) with poor quality groundwater under arid/semi-arid climate and in coastal plains (1.2 M ha) intercepted by seawater intrusion with humid climate (Fig. 5). The coastal saline soils are located in six states *viz.* Gujarat, Andhra Pradesh, West Bengal, Orissa, Tamil Nadu and Andaman and Nicobar islands. In the west coast, these soils are slight (44%), moderate (26%) and strongly (18%) saline, primarily distributed in Kachchh, Banaskantha, Jamnagar, Bhavnagar, Rajkot and Surendranagar districts of Gujarat. In the east coast, soils are strongly saline in Andhra Pradesh (East and West Godavari, Krishna and Srikakulam districts); slight, moderate and strongly saline in West Bengal (Midnapur and 24-Parganas districts) and Orissa states (Kendrapara, Puri, Bhadrak, Baleswar, Ganjam and Jagatsinghapur districts). These soils are strongly saline in South, Middle and North Andaman and Mayabandar.

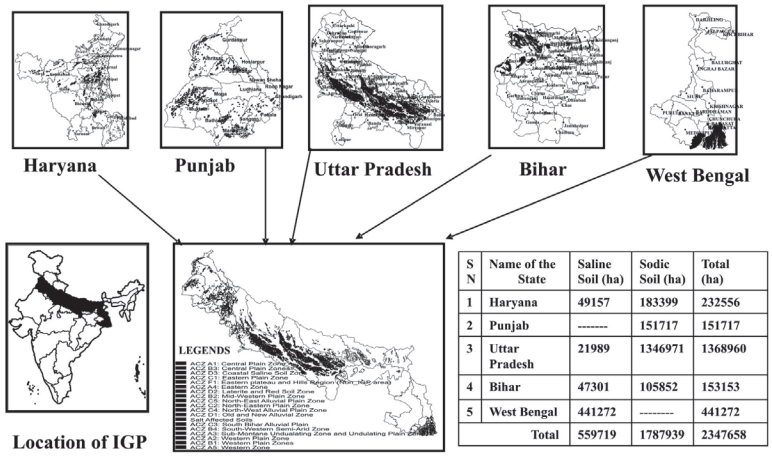
Among the inland plains, saline soils are confined in the arid and semi-arid areas of Gujarat (17%), Rajasthan

(6.6%), Maharashtra (5.9%), Karnataka (0.06%), Haryana (1.6%) and Bihar (1.6%) states. Prominent areas are distributed in Jalor, Bhilwara, Ajmer, Churu, Barmer and Pali districts of Rajasthan; Jind, Hisar, Sirsa, Rohtak and Jhajjar districts of Haryana; Surendranagar, Ahamadabad, Jamnagar, Rajkot and Amreli districts of Gujarat and Pune, Thane, Sangli, Satara and Rayagad districts of Maharashtra and Saran district of Bihar States

Sodic soils

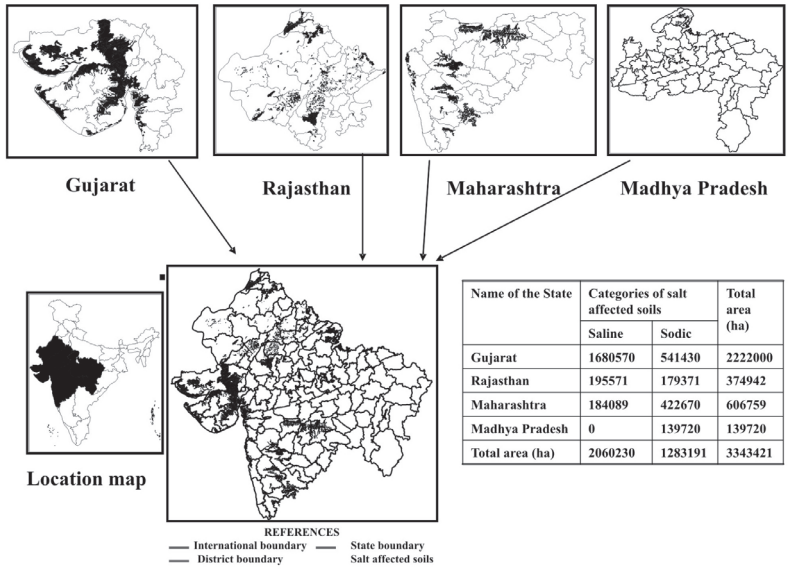
Sodic soils are located in the Gangetic Plain, arid and semi-arid region of Western and Central India and Peninsular region of the Southern India (Fig. 6). Significant areas (66%) are distributed in Uttar Pradesh, Gujarat, Maharashtra, Tamil Nadu, Andhra Pradesh, Haryana, Rajasthan, Punjab, Karnataka, Madhya Pradesh and Bihar states (Table 4). A considerable area (47%) is distributed in the Gangetic Plain covering Uttar Pradesh, Haryana, Punjab and Bihar states (Fig. 7). Sodic soils are widely distributed in the Upper-, Middle- and Lower-Gangetic Plains covering Mainpuri, Azamgarh, Etawah, Raebareli, Hardoi, Sultanpur, Jaunpur, Pratapgarh, Etah and Unnao districts of Uttar Pradesh,. In the Trans-Gangetic plain of Punjab, salt affected soils are distributed in Bathinda, Ferozpur, Sangrur, Amritsar, Faridkot, Mansa and Patiala districts. In Haryana, salt affected soils are found in Panipat, Sonepat, Kaithal, Karnal, Jind and Kurukshetra districts with poor quality groundwater. In the irrigated region, salt affected soils are also located in Western Yamuna and Bhakra canals in Haryana, Sirhind and Rajasthan Feeder in Punjab, Ganga and Sharda Sahayak in Uttar Pradesh and Gandak and Kosi commands in Bihar. These soils are moderately and strongly sodic in Uttar Pradesh, slight and moderately sodic in Haryana, Punjab and Bihar states.

Significant area (35%) of sodic soils is distributed in the arid and semiarid regions of Central and Western India covering Gujarat, Rajasthan, Madhya Pradesh and Maharashtra (Fig.8). Strong and moderately sodic soils are distributed in the Mehsana, Ahamadabad,



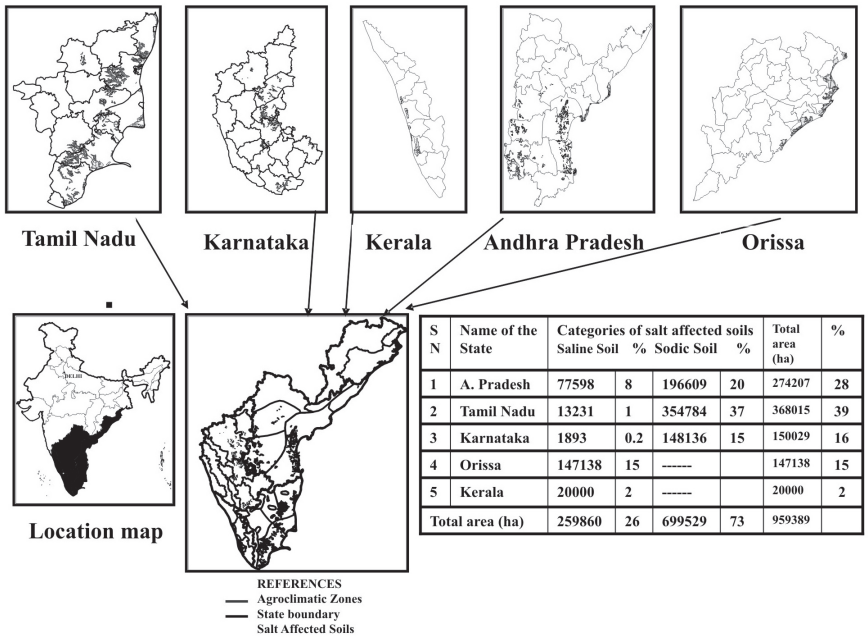
S N	Name of the State	Saline Soil (ha)	Sodic Soil (ha)	Total (ha)
1	Haryana	49157	183399	232556
2	Punjab	-------	151717	151717
3	Uttar Pradesh	21989	1346971	1368960
4	Bihar	47301	105852	153153
5	West Bengal	441272	--------	441272
	Total	559719	1787939	2347658

Fig. 7. Development of salt affected soils database for the Indo-Gangetic plain



Name of the State	Categories of salt affected soils		Total area (ha)
	Saline	Sodic	
Gujarat	1680570	541430	2222000
Rajasthan	195571	179371	374942
Maharashtra	184089	422670	606759
Madhya Pradesh	0	139720	139720
Total area (ha)	2060230	1283191	3343421

Fig. 8. Extent and distribution of salt affected soils in arid and semiarid regions



S N	Name of the State	Categories of salt affected soils Saline Soil	%	Sodic Soil	%	Total area (ha)	%
1	A. Pradesh	77598	8	196609	20	274207	28
2	Tamil Nadu	13231	1	354784	37	368015	39
3	Karnataka	1893	0.2	148136	15	150029	16
4	Orissa	147138	15	------		147138	15
5	Kerala	20000	2	------		20000	2
Total area (ha)		259860	26	699529	73	959389	

Fig. 9. Distribution of salt affected soils in the peninsular region

Surendranagar, Banaskantha and Junagadh districts of Gujarat. These soils are slight (41%) and moderately (6%) sodic in Rajasthan covering Chhitorgarh, Udaipur, Hanumangarh, Ganganagar and Jaisalmer districts. In Maharashtra, these are primarily sodic (69%) and are distributed in Ahmednagar, Jalgaon, Akola, Solapur, Buldhana, Amaravati, Nasik, Kolhapur and Aurangabad districts. Sodic soils (79%) are also found in Gwalior, Bhind, Morena, Vidisha and Ujjain districts of Madhya Pradesh.

Sodic soils covered 18% of salt affected areas in the peninsular plain and are distributed in Tamil Nadu, Andhra Pradesh and Karnataka states (Fig. 9). These are slight (59%), moderate (32%) and strongly (4%) sodic in Ramanathapuram, Cuddalore, Kanchipuram, Tirunelveli, Thanjavur, Pudukottai, Madurai and Tiruchirapalli districts of Tamil Nadu. Slight (71%) and moderately (24%) sodic soils are located in Chitradurga, Bellary, Raichur and Mysore districts of Karnataka. Sodic soils are highly variable (slight 41%, moderate 22% and strong 7%) in Andhra Pradesh covering Nalgonda, Anantpur, Krishna, Prakasam, East Godavari, Kurnool, Chittoor and Guntur districts (Gupta *et al.*, 1994; Minhas and Gupta, 1992).

Interactive database

a. Physiographic regions

Digital overlay of physiography and salt affected soils showed significant area of salt affected soils in the Indo-Gangetic, peninsular and coastal plains of India (Fig.10). Considerable area occurs in alluvial (38%), peninsular (19%), aeolian/aeofluvial/arid (9%), coastal, deltaic plains and mad flats/mangrove swamps (19%), and other (15%) regions (Table 5). In the alluvial plain, sodic (76%) and saline (24%) soils are distributed in Uttar Pradesh (53%), Gujarat (20%), Haryana (9%), Bihar (6%), Punjab (6%) and Karnataka (6%) states. In the peninsular plain (F), sodic (86%) and saline (14%) soils are distributed in Maharashtra (47%), Tamil Nadu (27%), Andhra Pradesh (15%) and Madhya Pradesh (11%). Saline soils are dominant (75%) in the aeofluvial/aeolian/arid plains (B) covering Gujarat and Rajasthan; coastal plain (D) of Gujarat (65%), Orissa (12%), Andhra Pradesh (8%), Kerala (3%), Tamil Nadu (2%), Maharashtra (1%) and Andaman and Nicobar (1.8%) islands and deltaic plain (C) of Orissa (28%) and West Bengal (72%) and the mud flats/mangrove swamp (G) areas of West Bengal (74%), Andaman and Nicobar (14%), Andhra Pradesh (6%) and Orissa (5.5%).

Sodic soils are distributed in the alluvial plains of Uttar Pradesh (52%), Haryana (7%), Punjab (6%), Karnataka (5.7%) and Bihar (4%). These are also found in the aeolian/aeofluvial/ arid plains of Rajasthan (23%) and Gujarat (2%); the peninsular plains of Maharashtra (33%), Tamil Nadu (27%), Andhra Pradesh (15%) and Madhya Pradesh (11%) and in the coastal plain of Gujarat (5%), Andhra Pradesh (0.6%), Tamil Nadu (0.5%) and Karnataka (<0.1%).

b. Agro-climatic zones

The Agro-climatic zones (ACZ) and regions (ACR) are important for agricultural development (Basu and Guha, 1996; Ghosh, 1991) in India (Fig. 11). Regional distribution of salt affected soils was delineated in GIS by superimposing boundaries of ACR and ACZ.

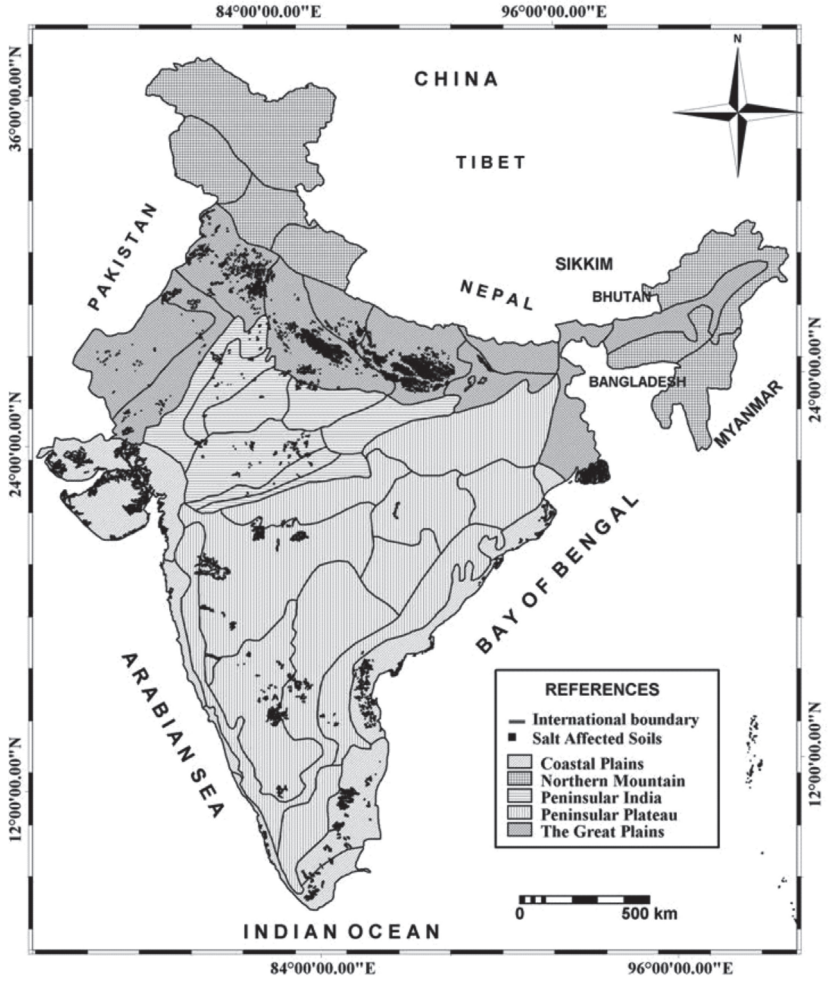


Fig. 10. Distribution of salt affected soils in physiographic regions

Table 5. Distribution of salt affected soils in Physiographic regions

Sl. No.	Name of the State	Physiographic Units							Total Area (ha)
		Alluvial Plain (A)	Aeofluvial/ aeolian/ arid Plain (B)	Deltaic Plain (C)	Coastal Plain (D)	Mud flats/ Mangrove Swamps (G)	Peninsular Plain (F)	Others (H)	
1.	Andhra Pradesh	—	—	—	56423	25111	192673	—	274207
2.	Andaman & Nicobar	—	—	—	12366	64634	—	—	77000
3.	Bihar	153153	—	—	—	—	—	—	153153
4.	Gujarat	510951	285574	—	462315	—	—	963160	2222000
5.	Haryana	232556	—	—	—	—	—	—	232556
6.	Karnataka	148922	—	—	586	—	521	—	150029
7.	Kerala	—	—	—	20000	—	—	—	20000
8.	Maharashtra	—	—	—	6713	283	599763	—	606759
9.	Madhya Pradesh	—	—	—	—	—	139720	—	139720
10.	Orissa	—	—	43023	79543	24572	—	—	147138
11.	Punjab	151717	—	—	—	—	—	—	151717
12.	Rajasthan	—	338128	—	—	—	—	36814	374942
13.	Tamil Nadu	—	—	—	16805	—	351210	—	368015
14	Uttar Pradesh	1368960	—	—	—	—	—	—	1368960
15.	West Bengal	—	—	109613	—	331659	—	—	441272
Total	2566259	623702	152636	654751	446259	1283887	999974	6727468	

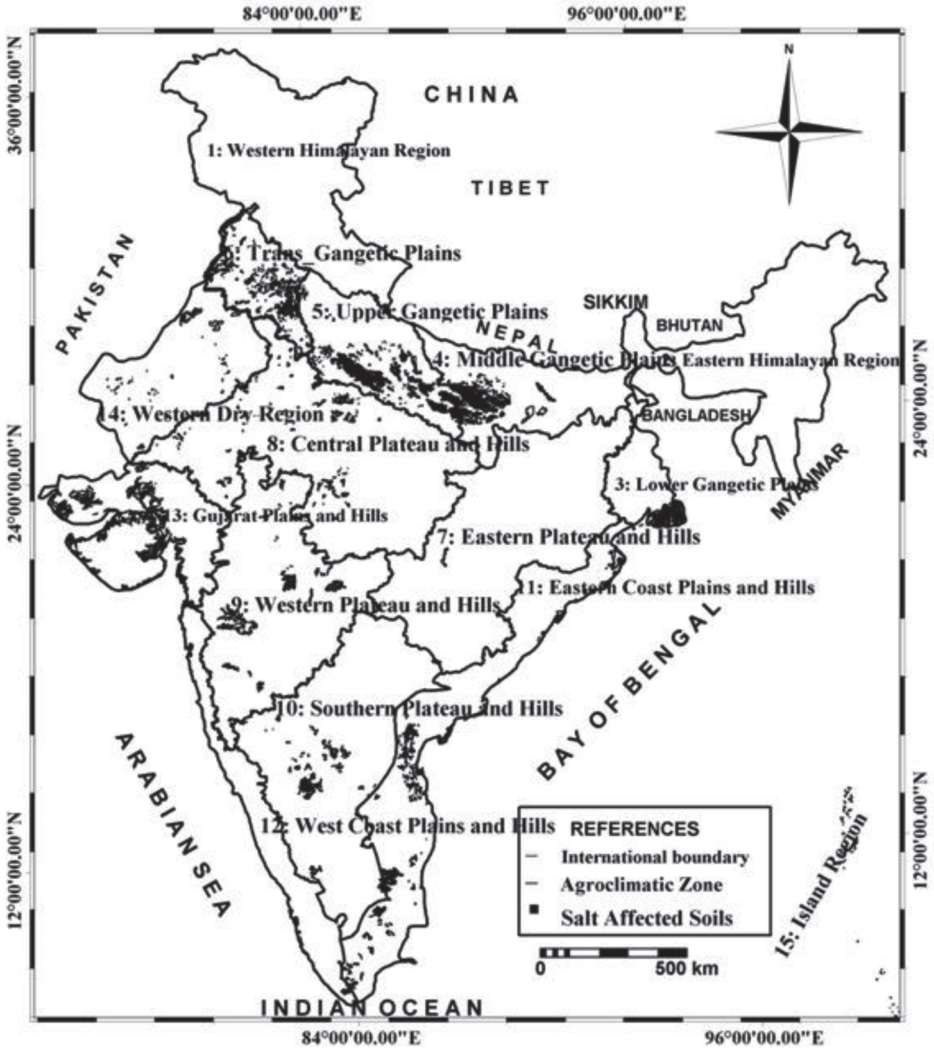


Fig. 11. Distribution of salt affected soils with agro-climatic zones

Significant area is distributed in the upper- (12.6%), trans- (11.3%), middle- (7%) and lower- Gangetic plain (9.3%); East coast plain (13.7%), Gujarat plain (14.2%), southern plateau (7.9%), central plateau (10.7%) and western dry regions (4.2%). Such data are useful in broad planning for reclamation and management at regional scale (Table 6).

c. Rainfall and temperature zones

Salt affected soils (51%) are located in low (<300 mm) to moderately low (500-800 mm) rainfall zones of Gujarat (64%), Rajasthan (10%), Uttar Pradesh (8%), Punjab (4%), Haryana (0.6%), Maharashtra (5%) and Karnataka (1.5%) (Fig.12). Saline soils are dominant in the low rainfall regions of Gujarat (47%) and Rajasthan (5.7%), while sodic soils occur in moderately low rainfall zones of Uttar Pradesh (7%), Gujarat (5%), Maharashtra (5%), Rajasthan (4%), Haryana (4%), Punjab (3.8%) and Karnataka (0.2%). Large area (44.8%) of salt affected soils is found in moderate (800-1000 mm) and moderately high (1000-

Table 6. Distribution of salt affected soils in Agro-climatic Zones in India

Zone No.	Name of the zone	Salt affected area	
		ha	%
3.	Lower Gangetic Plains Region	628400	9.3
4.	Middle Gangetic Plains Region	476018	7.0
5.	Upper Gangetic Plains Region	848340	12.6
6	Trans-Gangetic Plains Region	765470	11.3
7.	Eastern Plateau & Hills Region	17280	0.25
8.	Central Plateau and Hills Region	719370	10.7
9.	Western Plateau & Hills Region	441550	6.5
10.	Southern Plateau & Hills Region	535090	7.9
11.	East Coast Plains and Hills Region	925310	13.7
12.	West Coast Plains and Hills Region	58080	0.86
13.	Gujarat Plain and Hills Region	953910	14.2
14.	Western Dry Region	282010	4.2
15	Island Region	77000	1.1
	Total	6727468	

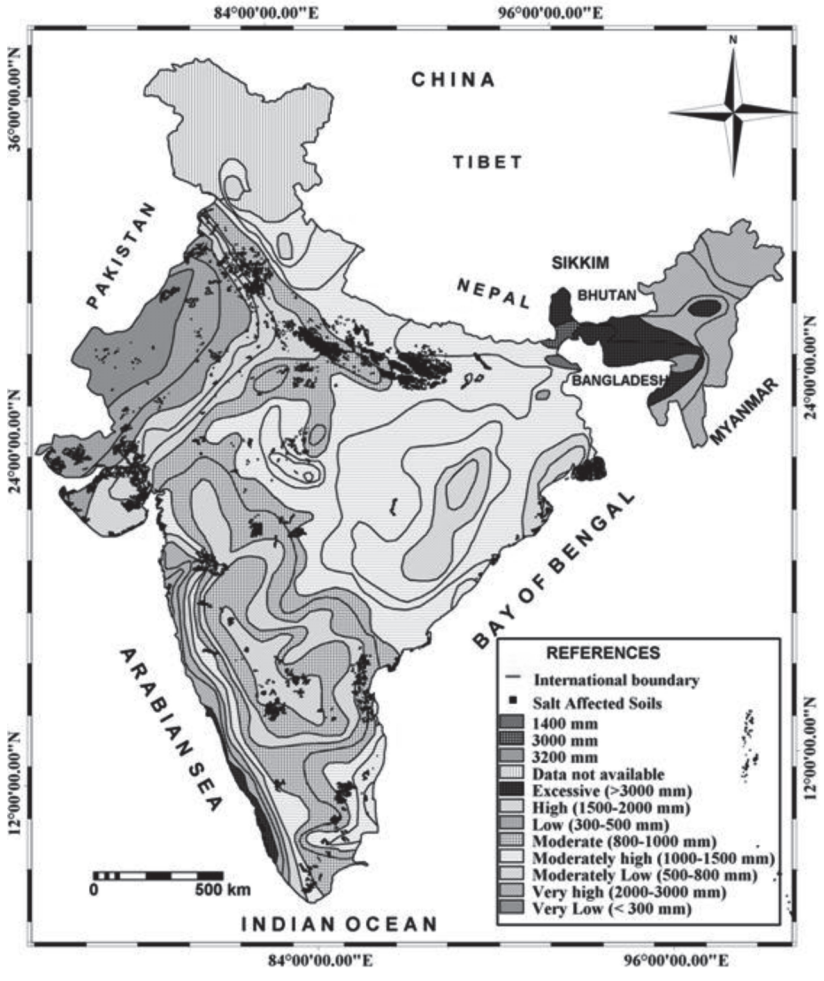


Fig. 12. Distribution of salt affected soils in rainfall zones

1500 mm) rainfall zones of Uttar Pradesh, Bihar, Tamil Nadu, Maharashtra, Andhra Pradesh and Madhya Pradesh (Table 7). Saline soils are found with high (1500-2000 mm), very high (2000-3000 mm) and excessive (>3000 mm) rainfall coastal zones of Kerala (7%), Orissa (5%), West Bengal (6%), Maharashtra (1%) and Andaman & Nicobar Islands (26.5%). Among the temperature zones, huge area (75.7%) is associated with strong hyperthermic (25-27.5°C) followed by hyperthermic (20-22.5°C) and megathermic (>27°C) temperature zones (Table 8). These are located in Gujarat, Uttar Pradesh, West Bengal, Maharashtra, Rajasthan, Andhra Pradesh and Bihar (Fig. 13).

Table 7. Distribution of salt affected soils in rainfall zones in India

Sl. No.	Name of the rainfall zone	SAS area (ha)	%
1	Very Low (<300 mm)	138754	2.0
2	Low (300-500 mm)	1296767	19.3
3	Moderately Low (500-800 mm)	1983516	29.4
4	Moderate (800-1000 mm)	1255559	18.6
5	Moderately High (1000-1500 mm)	1766423	26.2
6	High (1500-2000 mm)	157882	2.3
7	Very High (2000-3000 mm)	32652	0.5
8	Excessive (>3000 mm)	99484	1.5

d. Geology zones

The association of salt affected soils with geology is important for salinity management and reclamation (Fig. 14). These soils are located in various geological formations ranging from pleistocene and recent to cretaceous and Jurassic period (Table 9). Large area (70%)

Table 8. `Distribution of salt affected soils in temperature zones in India

Sl. No.	Name of the rainfall zone	SAS area (ha)	%
1	Mild Hyperthermic (20-22.5 °C)	403477	5.9
2	Hyperthermic (22.5-25 °C)	972109	14.4
3	Strong Hyperthermic (25-27.5°C)	5097855	75.7
4	Megathermic (>27.5 °C)	257592	3.8

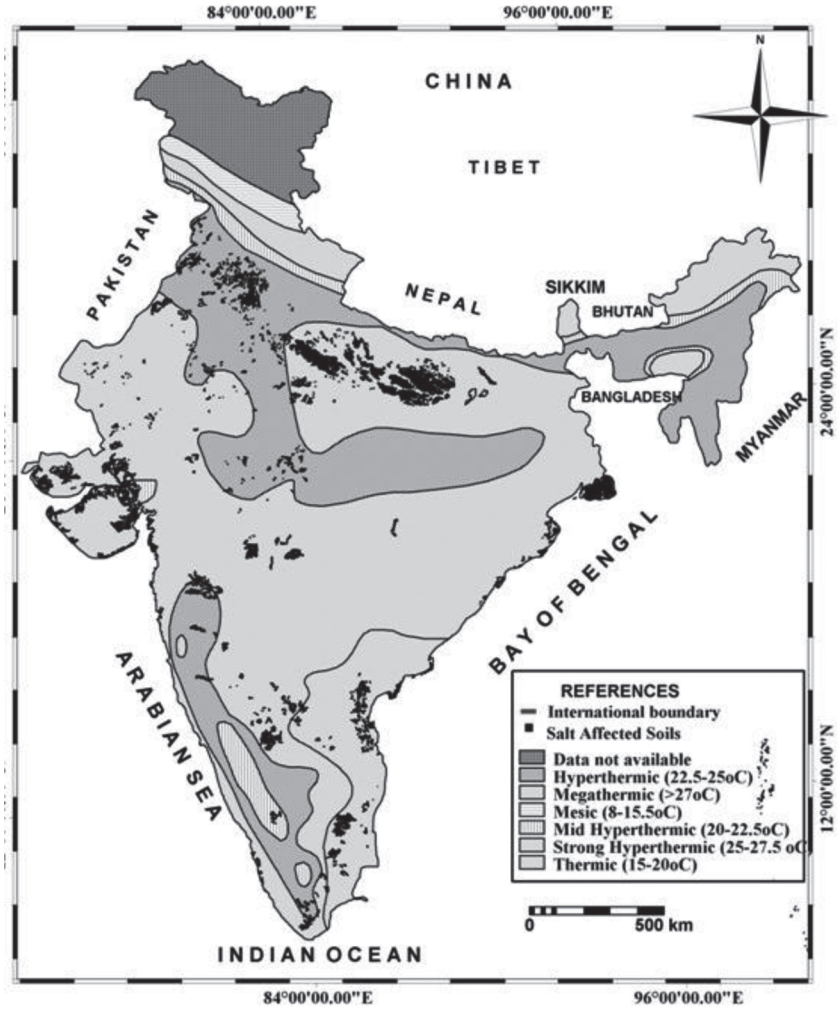


Fig. 13. Distribution of salt affected soils in temperature zones

Table 9. Distribution of salt affected soils in Geological Zones in India

Sl. No.	Name of the zone	Salt affected area (ha)			
		Saline	%	Sodic	%
1	Archaean Schist and Gneisses	8576	0.13	603766	9.5
2	Pleistocene and Recent	1962927	31.1	2449788	38.8
3	Dharwar Schist	0	0	86020	1.3
4	Lower Paleozoic	30706	0.5	67067	1.0
5	Deccan and Rajmahal trap	276746	4.4	493142	7.8
6	Tertiary	268016	4.3	22994	0.4
7	Cretaceous and Jurassic, Upper Gondwanas	38297	0.6	1343	0.02
	Total	2575268	41.7	3724120	49.4

is located in pleistocene and recent alluvial formations covering Gujarat, Uttar Pradesh, West Bengal, Rajasthan, Bihar and Orissa states (Bhargava *et al.,* 1981; Dhir, 1998). These soils are sodic (38%) and saline (31%) in nature. Salt affected soils are also found in the Deccan and Rajmahal trap region (12.2%) located in the coastal, aeolian and peninsular plains of Gujarat, Maharashtra and Madhya Pradesh. These are primarily sodic (64%) and also saline (36%) in nature (Wadia 1966). Sodic soils (65.9%) are also found in the archaean schist and gneisses formations located in the peninsular, coastal and alluvial plains of Tamil Nadu, Andhra Pradesh and Karnataka. Saline soils (4.6%) are common in the tertiary deposits at coastal and deltaic plains, covering Gujarat, Andaman and Nicobar and Tamil Nadu (Bhargava and Bhattacharjee, 1982; Dhir, 1998). Sodic soils are also located in lower Paleozoic formations (1.5%) of peninsular, coastal and alluvial plains covering Andhra

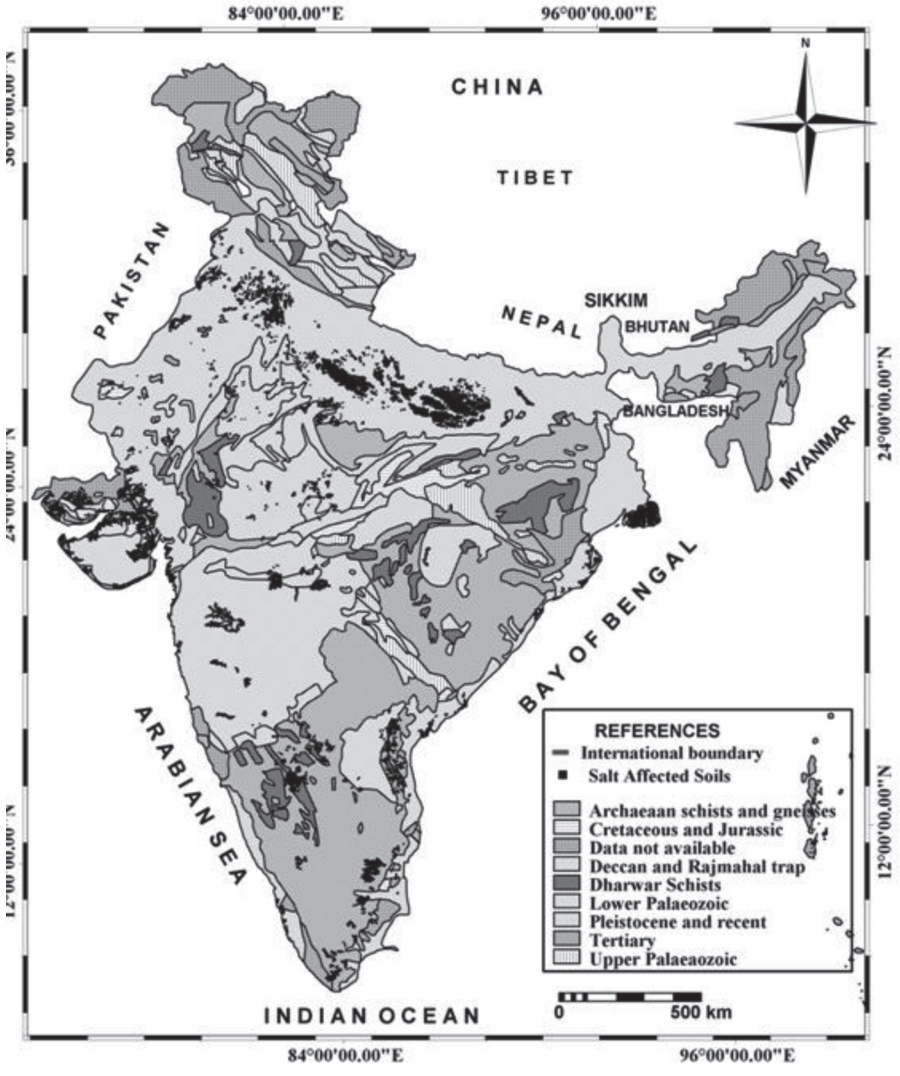


Fig. 14. Distribution of salt affected soils in geology zones

Pradesh, Orissa and Rajasthan. These soils are found in Dharwar schist formation located in Karnataka, Andhra Pradesh and Rajasthan (Bhargava and Bhattacharjee, 1982). In the cretaceous and Jurassic materials, saline soils are commonly found in Kachchh region of Gujarat and West Rajasthan.

e. Landform, water quality and water-table depth

Among the common landforms in Haryana, 60% of salt affected soils are distributed in the old alluvial plain, 25% in old alluvial plain with sand dunes, 10% in the recent alluvial plain and 4.7% in the active alluvial plain, Aravalli pediment, fluvio-aeolian plain and aeofluvial plain. Water-table in 66% salt affected soils varies from 3 to 10 m below ground level and in 34% soils varies from 10 to 20m below ground level. About 39% and 21% of salt affected areas lie in the saline and marginal groundwater zones and 40% in the fresh groundwater zone.

Conclusions

Computerized database of salt affected soils was developed on 1:250000 scale at state, regional and country level, using ILWIS software. By linking salt affected soils and physico-chemical properties, a relational database was developed in GIS for quick retrieval. State maps were integrated in GIS to develop salt affected soil map at country scale. Based on the state-wise area statistics, 6.7 M ha salt affected area was estimated at the country scale. The estimated areas for saline and sodic soils covering 2.9 and 3.7 M ha are useful for regional planning. These complex and variable nature of salt affected soils in inland plains under arid /semi-arid climate and coastal region showed site-specific reclamation/management needs for salt affected soils. The associations of salt affected soils with physiography, climate, geology and water quality are useful for salinity management.

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