VEGETATION TYPES IN BHAL AREA, MAHI RIGHT BANK AND UKAI-KAKRAPAR COMMANDS OF GUJARAT

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FOREWORD

Soil degradation through salinisation has seriously affected productivity of over 1.2 million hectares land in the Gujarat state alone. Salt affected soils occur under diverse agroecological regions and are usually found barren and occasionally carry sparse native woody plants and/or hardy grasses as surface cover Cataloguing of plant species growing on saline soils and assessing their economic utilities form a basis for selecting suitable plant types for such lands. Identification and grouping of plant species according to salinity range in which they are met provide a scope for plant selection

Salt affected and waterlogged soils are common in irrigation command areas of Mahi Right Bank Canal Command, Ukai-Kakrapar Command and the Bhal area of Gujarat state. In order to have a data base on vegetation types and associated salinity status and ideal species suitable for growing on salt affected soils, a survey was conducted by traversing MRBC, Ukai-Kakrapar command and parts of the Bhal region of Gujarat state.

Drs. G. Gururaja Rao, Ravender Singh and G.P. Bhargava had surveyed the above areas and collected valuable information on plant types and associated soil characteristics. The bulletin gives a valuable account of different types of vegetation, their economic utilities, the range of salinity to which the plants have adopted and plant species suitable for saline soils. The information given is very useful to those who wish to plan future line of work on vegetation in relation to soil salinity and for vegetating such lands

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(N.K. Tyagi)
Director

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EXECUTIVE SUMMARY

Soil salinity is an important constraint in agricultural crop production. Soil degradation through salinisation has seriously affected productivity of over 1.2 million hectares of land in Gujarat state. Majority of these soils are lying either barren or possess some native hardy species and some coarse grasses with varying economic utilities. Since crop production on such highly saline soils is not economically feasible, they can be brought under cultivation using potential salt tolerant species which can provide food, fodder, fuel, fibre, medicines etc. Thus there is a scope to bring these soils by evolving and promoting ecologically sustainable and economically viable technological packages giving primacy to conservation agriculture.

In an attempt to identify salt tolerant and economically potential species, a survey was conducted by traversing the salt affected soils under the canal command areas, coastal region and Bhal area in Gujarat state and cataloguing of plant species with soil salinity levels was done. The economic utilities of plants were assessed and grouped according to in situ salinity levels.

The survey indicated the prevalence of highly saline soils in Bhal area, coastal belt and certain pockets under Mahi Right Bank Canal and Ukai-Kakrapar Commands. The study revealed the predominant occurrence of *Salvadora persica* (seed oil, fodder); *Suaeda maritima* (fodder, crude protein); *Tamarix ericoides* (fuelwood); *Cressa cretica* (fodder); *Aleuropus lagopoides* and *Cynodon dactylon* (fodder) on very highly saline soils with EC_2 ranging from 25.0 to 38.0 dS/m. Plants like *Acacia nilotica* (timber, fodder); *Capparis decidua* (fruits); *Parkinsonia aculeata* (live fence, fodder); *Albizia lebbeck* (fodder, medicines); *Prosopis cineraria* (fodder), *Zizyphus nummularia* (fruits), *Eragrostis* and *Sporobolus* spp. (fodder) were noticed on moderately saline soils.

Further, the bulletin covers aspects on the preponderance of plant species, a general vegetation index, promising fodder trees, potential plants with medicinal value and some ideal candidate species for salt affected black soils particularly of the arid and semi-arid regions.

1. INTRODUCTION

Population in developing countries is growing so fast that land and water, the two finite resources shall soon become limiting for its sustenance with conventional modes of land use. Although canal irrigation has been extended to augment productivity of arid and semi-arid regions, it has often led to secondary salinisation and waterlogging. Soil is the basic natural resource on which rests the edifice of agricultural productivity. With the increase in pressure on the existing arable lands, utilization of available waste lands for crop production is being increasingly emphasized.

Economic upliftment of the society demands efficient utilization of soil and water resources. Saline and waterlogged soils occupy 1 2 million hectares in Gujarat state (Table 1) which are either barren or sparsely covered of native indicator species which have little economic or ecological value. Crop production on these marginal lands with fragile ecosystem is not sustainable ecologically and economically unless reclamative measures are adopted. Such lands can be profitably diverted to silvi-pastoral system for promoting ecologically sustainable technological packages giving primacy to conservation agriculture.

Table 1. Distribution of salt affected soils in Gujarat State (ha)

District	Coastal salinity	Other than coastal salinity	Total
Valsad	20235	9675	29910
Surat	24300	9700	34000
Bharuch	47500	1435	48935
Kheda	20235	39765	60000
Ahmedabad	49780	9220	59000
Surendranagar	16190	9810	26000
Bhavnagar	14200	1200	15400
Amreli	8095	30105	38200
Rajkot	2000	—	2000
Jamnagar	22300	700	23000
Junagadh	19020	270980	290000
Kutch	58400	435600	494000
Mehsana	—	1000	1000
Banaskantha	—	92720	92720
Total	**302255**	**911910**	**1214165**

Source: Kharland Development Board, Ahmedabad, Gujarat

In India, 142 million hectares of land area is in use for agricultural purposes. In order to meet the increasing requirement of food, fodder, fuel and timber, the country would need 150 million hectares of net sown area, 70 million hectares under forest cover and about 15 million hectares under permanent pastures by 2000 AD (Shankaranarayan, 1988). In other words, the country requires an additional area to fulfill the above requirements.

Salt affected soils which are devoid of vegetation or represented by native species could be an alternative land resource for growing salt tolerant plants, which could supplement the national economy and contribute to various developmental activities Through available technologies, these lands can be brought under cultivation without heavy investments on reclamative measures. Amelioration of these degraded soils on the other hand is of significance for resource conservation as well as for meeting the requirement for agricultural products.

A survey has been conducted to catalogue the natural vegetation in the irrigation command areas of Mahi Right Bank Canal, Ukai Left Bank Canal and Kakrapar irrigation projects and parts of 'Bhal' area.

The main objectives of the survey were:

* to identify plant species naturally occurring on saline soils
* to assess the salinity status of the soils on which the plant species occur
* to evaluate the economic importance of the natural vegetation
* to create greater awareness on the salt tolerance of naturally occurring plants
* to introduce plant species occurring on saline soils to other salt affected soils for economic importance

2. STUDY AREA

The following areas have been surveyed to catalogue the natural vegetation.

* Areas coming under Mahi Right Bank Canal Command (MRBC)
* Ukai Left Bank Canal (ULBC) and Kakrapar Irrigation Project-Kakrapar Right Bank Canal (KRBC) and Kakrapar Left Bank Canal (KLBC) command areas
* Parts of area under 'Bhal' region covering parts of Kheda, Ahmedabad and Bhavnagar district

2.1 DESCRIPTION OF THE STUDY AREA

The state of Gujarat is located in the western most part of India between 20° 06' and 20° 42' N latitude and 68° 24' and 74° 24' E longitude. The coast-line of Gujarat is largely formed of gulfs, ranns, creeks and marshes, and the interior parts of hills, plateaus and valleys. It has a distinct maritime character in between the Gulf of Cambay and Gulf of Kutch, forming the major core area of the region. The climate of the state is semi-arid tropical, intense heat is experienced during summer and the winter is cool and dry The Arabian sea and Gulf of Cambay help in moderating the climate of the state. Large areas in the state are vulnerable to varying weather conditions as experienced in south Gujarat which receives high rainfall, while in north Gujarat the rainfall is low. Notwithstanding the availability of canal water, Surat and Valsad districts are experiencing waterlogging and salinity necessitating drainage for reclamation.

2.2 MAHI RIGHT BANK CANAL COMMAND AREA

Mahi Kadana Irrigation Project is one of the major irrigation projects in the state having two segments: (1) Mahi Right Bank Canal (MRBC) covering seven talukas of Kheda district *viz.* Anand, Borsad, Cambay, Matar, Nadiad, Petlad and Thasra through Wanakbori weir since 1955, and (2) Mahi Left Bank Canal (MLBC) covering Lunawada and Santrampur talukas of Panchmahal district. Mahi Right Bank Canal command falls between 22° 26' and 22° 55' N latitude and 72° 49' and 73° 23' E longitude. After supplementing Wanakbori weir system through the Kadana reservoir since 1978 (Fig. 1), an irrigation potential of 1.93 lakh ha has been created, of which one lakh ha is under irrigation (Anon., 1989).

2.2.1 Climate

The climate of Gujarat is characterized by three distinct seasons: (i) hot and dry season (May-June), (ii) warm and rainy (July-September); and (iii) cool and post-rainy season (October-April). The study areas have distinct climate patterns. The MRBC lies in the semi-arid tract (agroclimatic zone IV in middle Gujarat) with extreme climate conditions characterized by hot summer and general dryness except during south-west monsoon. The daily temperature varies between 27.7°C (low) and 40°C (high), with an abrupt increase from March to attain maximum in May, being the hottest. Day and night temperatures tend to drop from November onwards. January being the coldest month, the mean daily maximum temperature is about 30°C and the minimum around 11°C.

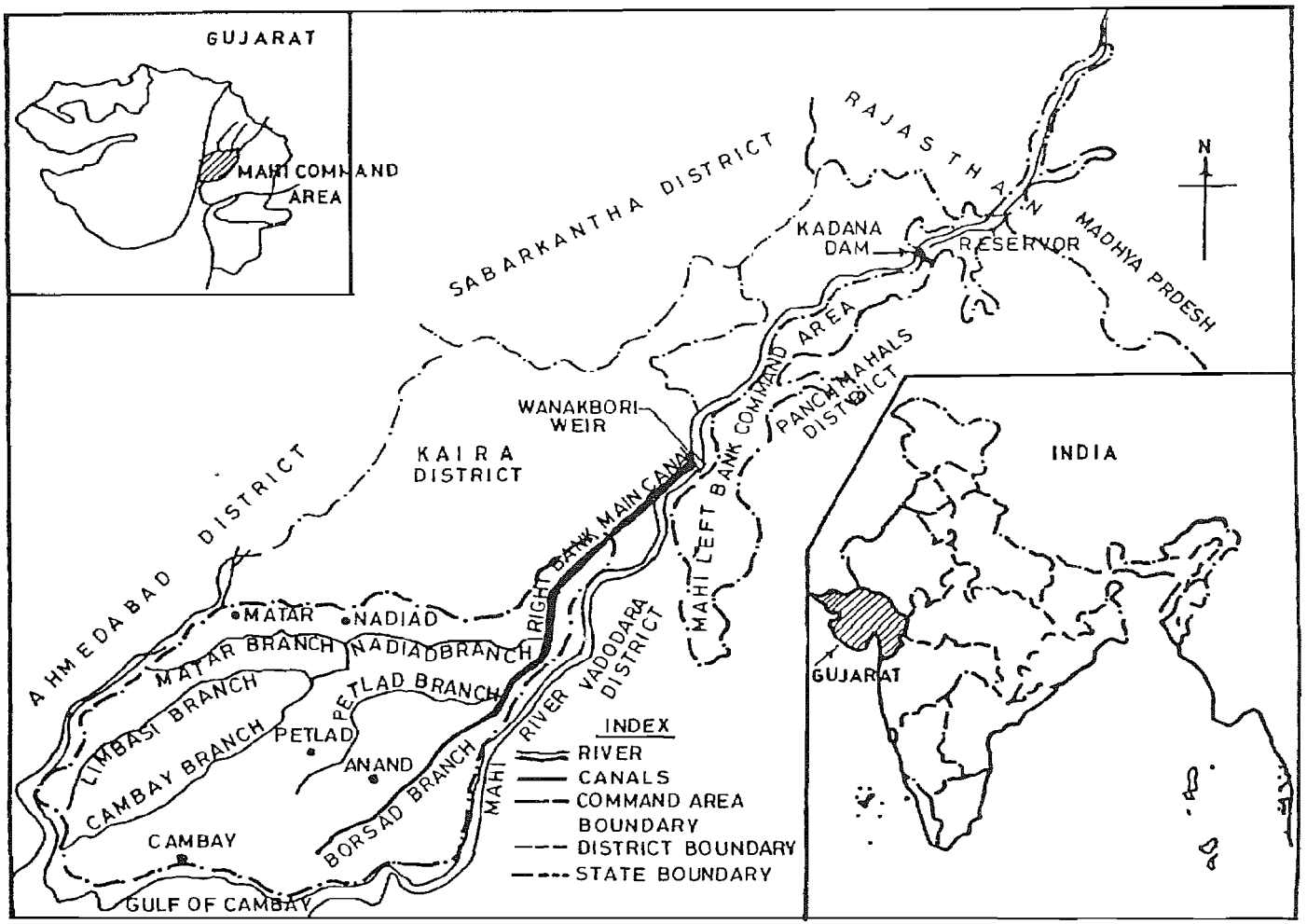

Fig.1. Location map of Mahi Right Bank Canal Command (MRBC) area irrigation project

Cold waves occur at times with passage of western disturbances across north India during later half of December till mid-January. The mean daily open pan evaporation varies from 3 5 mm/d (December) to 10.5 mm/d (June).

The Ukai-Kakrapar command (Bharuch, Surat and parts of Valsad districts) represents the heavy rainfall zone The mean temperature of the region varies between 34 0°C (maximum) and 20 7°C (minimum). In Bhal region, weather is usually hot and dry with exceptionally hot summer during May-June. More desiccating conditions prevail in the Bhal tract. The rainfall is seasonal and the south-west monsoon remains active from the last week of June to the second week of September. However, the distribution of rainfall is erratic and irregular leading to occasional droughts and resultant crop failures in those particular seasons. The mean annual rainfall in MRBC region is 790 mm. However, Ukai-Kakrapar command area (Valsad - 1944 mm; Navsari - 1662 mm; Surat - 1166 mm) constitutes the high rainfall zone in the state. The lowest rainfall (456 mm) was noticed in the Bhal region. In the areas surveyed maximum rainfall is received from a few high intensity storms. Such temporal and spatial variations in rainfall pose problems for regional crop planning.

2.2.2 Soils

Soils in the MRBC command area are generally deep and formed on alluvial deposits brought in by Mahi and Sabarmati rivers From the head to the tail end, a hydro-topo sequence has influenced the origin of different soils. Geologically, a mixed parent material comprising basalt, sandstone, quartzite, phyllite, schist and granite has given rise to various soil types.

Large areas of Anand and Thasra talukas and parts of Nadiad, Petlad and Borsad talukas have well drained soils and are grouped in Land Irrigability Class I. These are coarse textured, non-saline, highly porous and permeable soils with mixed mineralogy with illite as the dominant mineral. These generally represent Fluventic Ustochrepts. Western parts of Nadiad and a sizeable part of Matar, Petlad, Borsad and Cambay talukas have deep dark colored, moderate to poorly drained soils with salinity problems either on the surface or in the profile substratum These are generally characterized as Vertic Halaquepts. A sizeable area in the MRBC command has gone out of cultivation due to saline and/or waterlogging conditions, which could be attributed to poor water management and drainage characteristics and lack of knowledge on the part of the farmers.

The soils of Matar taluka are well drained, very deep, light coloured derived from heterogenous materials, particularly from residual deposits of sandstone, granite, quartzite etc The colour of the surface layer varies from light yellowish brown in hue of 10 YR with sandyloam texture and loose to fine weak subangular blocky structure. Sub-surface horizon has dark yellowish brown colour in hue of 10 YR, sandyloam texture and fine to medium weak subangular blocky structure. These belong to loamy, mixed hyperthermic very deep family of Typic Ustorthents The physico-chemical characteristics of these soils are given in Table 2

Macromorphology of typical profile (Typic Ustorthents) from MRBC command area

Location: Matar Village, Matar Taluka, Kheda District, Gujarat

HORIZON	DEPTH (cm)	MACROMORPHOLOGY
A_p	0 - 15	Yellowish brown (10 YR 5/4, d) and dark yellowish brown (10 YR 4/4, m), sandyloam, fine, weak, subangular, blocky, dry, slightly hard; moist friable; wet non-sticky and plastic; strongly effervescent; common medium to fine roots; clear smooth boundary.
A_2	15 - 45	Yellowish brown (10 YR 5/6, d) and dark yellowish brown (10 YR 4/4, m); sandyloam; fine weak sub angular blocky peds; dry, slightly hard, moist friable, wet non-sticky, non-plastic, strongly effervescent, common fine roots; diffuse smooth boundary.
A_2	45 - 90	Dark yellowish brown (10 YR 4/4, m); sandyloam; moderate medium subangular blocky; moist friable;wet non-sticky and non-plastic; violently effervescent few fine roots; diffuse smooth boundary
A_2	90 - 130	Dark yellowish brown (10 YR 4/4), sandyloam; weak subangular blocky, moist friable; wet non-sticky and non-plastic; violently effervescent; diffuse smooth boundary.
A_1	130 - 180	Yellowish brown (10 YR 5/4, m); sandyloam; massive, wet, non-sticky, non- plastic; violently effervescent.

Table 2. Physico-chemical characteristics of Typic Ustorthents from Matar Taluka, Gujarat

Depth (cm)	Sand	Silt	Clay	Texture Class	pH_2	EC_2 (dS/m)	Org. C (%)
	----------(%)----------						
0-15	69.5	16.4	14 1	Sl	8 4	0 48	0.30
15-45	63.1	18.2	18.7	Sl	8.4	0.31	0.31
45-90	56 2	24.6	19.2	Sl	8.4	0.16	0.32
90-130	59.8	29.8	20.4	Sl	8.6	0.15	0 20
130-155	57.8	21 6	20.6	Sl	8.6	0.10	0.14

2.3 UKAI KAKRAPAR COMMAND

The Ukai Kakrapar project, the largest irrigation scheme in Gujarat state, comprises of (i) Ukai Left Bank Canal (ULBC) which takes off direct from the dam and runs as a contour canal parallel to the left bank ex-Kakrapar weir and commands the area above the Kakrapar dam up to the river Par; and (ii) Ukai Right Bank Canal (URBC) which takes off from the Kakrapar Right Bank Canal (KRBC) and commands the area between the rivers Kim and Narmada. Kakrapar also has two canal systems, one on each bank which together irrigate more than 2 lakh hectares (Fig. 2). The ULBC and URBC together serve an additional canal system of over 1.5 lakh hectares.

2.3.1 Soils

The dominant soils are deep black soils with loamy surface suitable for irrigation. The soil crust in over 80 per cent of the area remains deeper than 2 m predominated by black cotton soils. The soils in the region are dominantly montmorillonitic usually with clay texture which develops deep and wide cracks on drying. Some of the soils are flat while others have a rolling topography. Waterlogging is a widespread menace with watertable prevailing at shallow depths for most part of the year, while salinity is confined largely to the coastal fringe. Detailed macromorphology of Udic Chromusterts is described in the later part of the text.

The soils are deep to very deep, poorly drained, clay textured occurring on nearly level to gently slopy surfaces. Soil texture varies from clay to clay loam or sandy loam. Lime nodules and gravel sized fragments of basaltic parent material

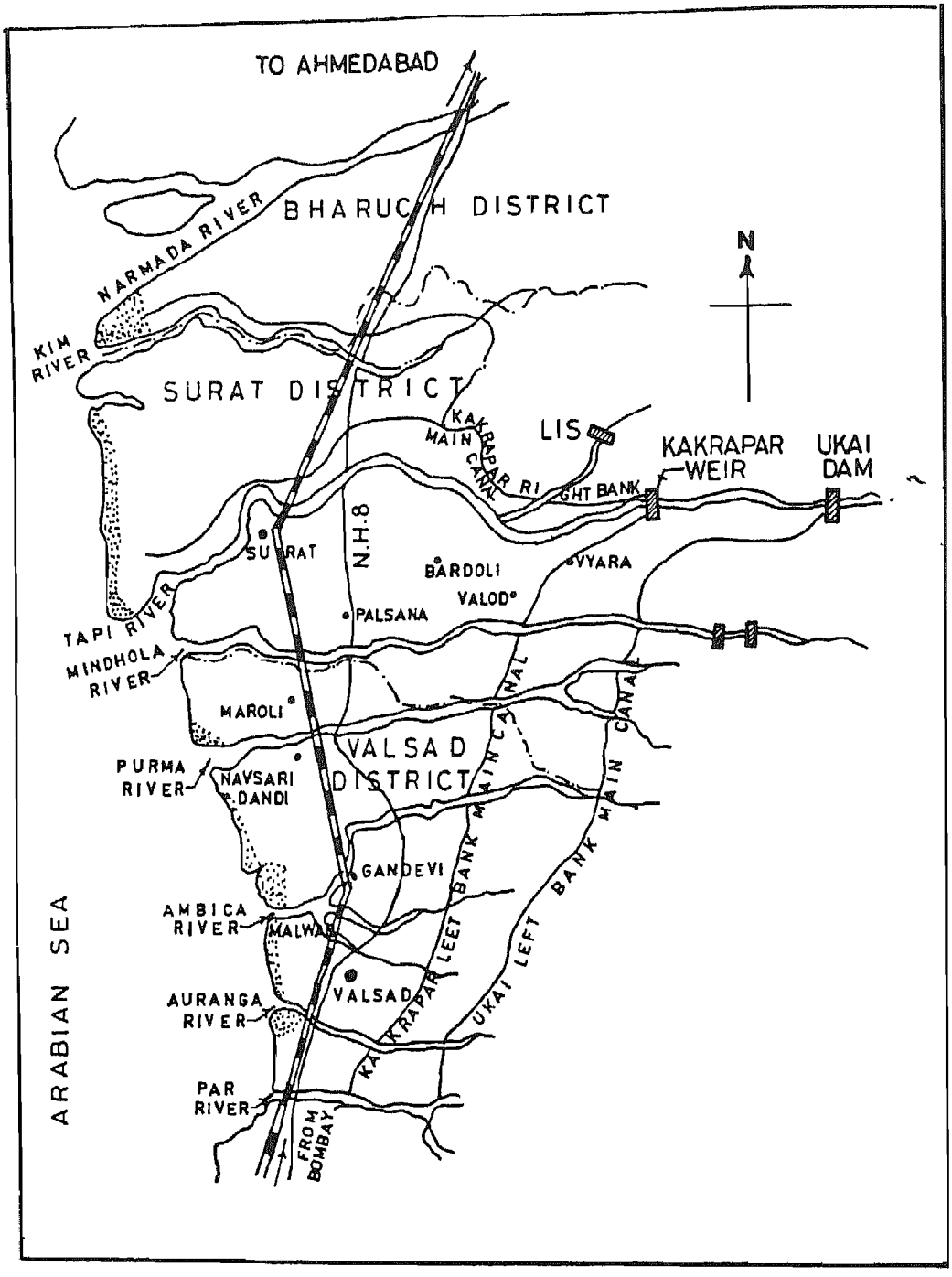

Fig. 2. Index map of the Ukai Kakrapar Project

and ferromanganese concretions are found in the central section. The soils shrink and swell considerably according to moisture status and wide cracks develop vertically as the soil dries. These soils belong to fine clayey, montmorillonitic hyperthermic family of Udic Chromusterts. The physicochemical characteristics of these soils are presented in Table 3.

Table 3. Physicochemical characteristics of Udic Chromusterts from Panchpipla, Jambusar taluka, Bharuch district

Depth (cm)	Sand	Silt	Clay	Texture Class	pH_2	EC_2 (dS/m)	Org. C (%)
	----------(%)----------						
0-20	18.2	20.7	61.1	C	8 7	2.7	0 45
20-52	22.4	22.7	54.9	C	8 8	3.8	0.48
52-78	20.7	30.2	49.1	C	8.8	4.0	0 56
78-100	18.8	26.8	54.4	C	9 0	4 5	0.62
100-150+	40.8	20.7	38.5	Sl	8.6	4.8	0.42

2.4 BHAL AREA

The 'Bhal' area which is an alluvial coastal plain situated at 22° N latitude and 72° E longitude is at a marginal elevation above the highest tide mark in the Gulf of Cambay. Due to its marine origin, large parts of the plain are saline with the least saline areas being used for arable farming, moderately saline soils for grazing and highly saline soils left barren. Physiographically, the area comprises of the recent and old flood plains with mudflats along the tidal inlets. The Bhal tract is made up of Sanand, Dholka and Dhandhuka talukas of Ahmedabad district and Vallabhipur, Sihor and Bhavnagar talukas of Bhavnagar district.

Soils in the Bhal tract generally represent Entisols, Inceptisols and Vertisols. Some of the soils are highly saline and have shallow watertable in the substratum. The soil texture varies from sandy loam to clay loam. The soils of the region are very low in organic matter (0.7 to 1.4%) which is further low in subsoil. The ground water in the area is saline with varied composition over the year, which during summer becomes highly saline and unsuitable for irrigation.

Macromorphology of typical profile of Udic Chromusterts in Ukai Kakrapar Command area
Location: Village Panchapipla; Taluka Jambusar; Bharuch District

HORIZON	DEPTH(cm)	MACROMORPHOLOGY
A_p	0- 20	Very dark grayish brown (10 YR 3/2 d & m); clay; coarse prismatic breaking to moderate medium sub angular blocky; dry very hard; moist firm; wet very sticky and plastic; strongly effervescent, common fine roots; abrupt smooth boundary.
A1	20- 52	Very dark grayish brown (10 YR 3/2, d & m) ;clay, coarse; prismatic breaking into moderate medium subangular blocky peds; dry very hard; moist very firm; wet very sticky very plastic; strongly effer vescent; few fine roots; clear smooth boundary.
A1	52- 78	Very dark grayish brown (10 YR 3/2, m); clay; coarse prismatic breaking into moderate coarse angular blocky peds; strongly effervescent; few basaltic gravels; few fine roots; clear smooth boundary.
A1	78-100	Very dark grayish brown (10 YR 3/2, m); coarse weak medium angular blocky peds; wet sticky and plastic; few coarse roots; few basaltic gravels; violently effervescent; clear smooth boundary
C	100-150+	Dark yellowish brown (10 YR 4/4, m); sandy, clay; weak subangular blocky peds; moist firm; wet sticky and plastic.

These soils are poorly drained, very deep alluvial and developed on a mixed parent material derived from a mixture of quartzite, phyllite, schist and granite rock types. These soils occur on nearly level to gently sloping landscapes of the flood plain. The pedon exhibits A-B-C horizon sequence. The soils belong to fine clayey mixed hyperthermic family of Vertic Halaquepts and are generally saline in nature with watertable fluctuating between 1 to 3 meters depth The physico-chemical characteristics of these soils are give in Table 4.

Macromorphology of a typical profile (Vertic Halaquepts) from Bhal region Location: Golana Village, Cambay Taluka, Kheda District, Gujarat.

HORIZON	DEPTH (cm)	MACROMORPHOLOGY
A_p	0- 24	Dark grayish brown (10 YR 4/2,m), very dark grayish brown (10 YR 3/2,m), clay prismatic breaking to medium; weak subangular, blocky; dry hard; wet very sticky very plastic;moist firm; common macro inped outped pores;few gravels of 2-4 mm size; strongly effervescent; many fine roots; clear smooth boundary.
B_2	24-60	Very dark grayish brown (10 YR 3/2,m); clay; prismatic breaking into medium moderate sub angular blocky with shining pressure peds ; dry hard, wet very sticky very plastic; moist firm; few gravels (2-4 mm); strongly effervescent; common fine roots; diffuse smooth boundary.
B_2	60- 90	Very dark grayish brown (10 YR 3/2, m); clay; prismatic breaking into moderate medium sub angular blocky with shining pressure peds, dry hard; wet very sticky very plastic; moist firm; few gravels (2-4 mm), strongly effervescent; few fine roots; diffuse smooth boundary.
B_2	90-130	Very dark grayish brown (10 YR 3/2, m); clay; prismatic breaking to medium weak subangular blocky with shining pressure faces; dry hard; wet very sticky very plastic; moist firm, few gravels; diffuse smooth boundary.
C	130-150+	Pale brown (10YR 6/3, d) and brown (10 YR /3, m); clay; massive; dry hard; wet sticky and plastic; moist firm; few gravels; common lime nodules (2-5 mm size) present.

Table 4. Physico-chemical characteristics of Vertic Halaquepts from Golana

Depth (cm)	Sand	Silt	Clay	Texture Class	pH_2	EC_2 (dS/m)
	----------(%)----------					
0-24	22.6	25 5	51.9	C	7 2	8.5
24-60	15 8	26.8	57.4	C	7.6	5.5
60-90	18 2	30.6	51.2	C	8.2	3.2
90-130	16 4	32.4	51.2	C	8.0	4.3
130-150+	25.2	30.8	44.0	C	7.5	8 1

Details on the studies conducted in the area along with the observations recorded are discussed further.

3. THE STUDY

Plant species occurring in different habitats in the study area were collected and catalogued. Soil samples collected from the plant vicinities were analyzed for electrical conductivity and pH following standard procedures.

The vegetation in canal command areas, the Bhal region and inland saline areas has considerable diversity due to variations in soil and environmental characteristics Besides *Prosopis*, the dominant species in the Bhal area; the wetlands, scrub jungles; marshy area; swampy and boggy areas each supported a characteristic assemblage of plant populations.

Earlier reports of Shah (1978) embodied the plant wealth in Gujarat. In this bulletin, the changes in plant populations due to variations in climate, irrigation programs etc. have also been recorded along with the associated soil salinity/ alkalinity status. In addition, the economic importance of these plants, species for adverse environmental conditions have also been suggested.

The expanding human and livestock population, *vis-a-vis* indiscriminate felling of plant wealth for fuelwood, fodder and other human and livestock needs are the major biotic factors which exert tremendous pressure on the plant wealth. Canal irrigation has also effected variations in the native plant populations in the area.

The irrigation water from canals usually carries with it a number of weeds which establish themselves along the canal banks and on waterlogged lands At the same time xerophytic species which are unable to tolerate excess water get eliminated A combination of such biotic influences along with modern developmental activities and also the effects of climatic variations have forced considerable changes on the indigenous natural vegetation It was observed that natural vegetation in degraded and salt affected soils is very poor and is formed of stunted and scattered species of *Prosopis juliflora, Acacia nilotica, Capparis decidua, Prosopis cineraria, Salvadora persica, S. oleoides, Zizyphus nummularia, Tamarix ericoides, Suaeda maritima, Cassia auriculata, Cressa cretica* and *Cynodon dactylon* etc.

3.1 STUDY AREA

Starting from Wanakbori weir, areas under Anand, Borsad, Cambay, Matar, Nadiad, Petlad and Thasra talukas of Kheda district were covered and the natural vegetation types were catalogued. Soil EC and pH (0-30 cm depth) were measured from samples collected from the immediate vicinities of the plant species. Thirty three villages covered by the command were also surveyed to record the experiences of the local populace on the economic utilization of the plant species in the area.

Forty three villages in Bardoli, Palsana, Vaslad, Vyara, Mahuva, Mandvi and Kamrej talukas in Surat district and Navsari, Gandevi, Chikhali and Valsad talukas in Valsad district were surveyed for their natural vegetation. Coastal areas *viz.* Dandi, Dharasana, Malvan and Bhatta were also surveyed and the vegetation types recorded along with the soil salinity and pH (0-90cm depth). In the Bhal area, Dholka and Dhandhuka talukas of Ahmedabad district and Vallabhipur taluka of Bhavnagar district were surveyed during the study. The entire Bhal tract was represented by plant species like *Prosopis juliflora, Suaeda maritima and Salvadora persica.* Majority of soils in the region are highly saline.

The present compilation constitutes exclusively the typical plants of different parts of MRBC and Ukai-Kakrapar commands and the Bhal region. The index does not include garden plants and plants which are purely ornamental, while avenue trees grown on road side have been included. Exotic species like *Eucalyptus, Casuarina and Leucaena* also find a place in the bulletin. The vegetation has been categorized under the following heads: (i) Trees; (ii) Shrubs; (iii) Undershrubs, (iv) Herbs; (v) Climbers/twiners/runners; and (vi) Grasses and sedges. Species are listed alphabetically in each category according to their

botanical names, irrespective of their systematic classification in order to facilitate easy reference.

4 OBSERVATIONS

4.1 MRBC COMMAND

4.1.1 Trees: Species of *Prosopis, Albizia* and *Salvadora* are commonly found on highly saline soils where the salinity (EC_2) ranged between 10.4 and 33.0 dS/m in 0-30cm soil layer. In highly saline areas of Laval, Tadtalav, Padra, Golana, Vadagam, Navagam Bara, Pandad, Traj, Rohini, Moraj, Mithli, Kathana, Pandoli and Ralej (coastal area), the predominant species were *Prosopis juliflora, Salvadora persica* and *Albizia lebbeck* (Table 6).

4.1.2 Shrubs: Among the shrubs, *Capparis decidua, Suaeda maritima* and *Tamarix ericoides* were observed on very highly saline soils (EC_2 29.0 to 37 0 dS/m in the 0-15 cm layer and 16.5 to 29.6 dS/m in the 15-30 cm layer). *Capparis decidua* was found on soils of salinity 6.5 to 8.6 dS/m

4.1.3 Herbs: Among herbs, *Ammania baccifera, Caesulia axillaris, Heliotropium supinum, Sphaeranthus indicus* and *Vernonia cinera* could be identified in soils of EC_2 2.3 to 8 8 dS/m. *Cressa cretica* was observed on very highly saline soils of EC_2 37 dS/m.

4.1.4 Grasses: Grasses like *Aristida adscensionis, Dactyloctenium aegyptium* and *Dichanthium annulatum* were noticed on soils with EC_2 2.5 to 3.4 dS/m. *Sporobolus* species was observed on soils of EC_2 9.2 to 12.4 dS/m and *Cynodon dactylon* on very highly saline soils with EC_2 29.6 to 37.0 dS/m.

4.1.5 Vegetation on waterlogged areas

Waterlogged areas were observed throughout the command. Plant species like *Ageratum conyzoides, Ammania bacciafera, Caesulia axillaris, Chenopodium album, Heliotropium supinum, Merremia gangetica, Commelina benghalensis, C. forskalaei, Cyperus rotundus, C. iria, C. difformis, C. compressus; Fimbristylis tenera and Typha angustata* were noticed in these areas Most of the species disappear with the onset of summer leaving few hardy species like *Argemone mexicana* which could withstand the extreme hot weather conditions during summer months

Table 5. Vegetation types in MRBC, ULBC and Kakrapar Commands and Bhal Region in Gujarat

Plant species	Common name	Family	H'tat	Occ'ce	Uses
TREES					
Acacia chundra (Roxb. ex. Rott.) Willd.	Khair	Mimosaceae	D	U	2,7
Acacia farnesiana (L) Willd. Sp	Vilayati Babul	Mimosaceae	D	U	3
Acacia melanoxylon Willd	—	Mimosaceae	D	U	2,3
Acacia nilotica (L) Del.	Babul	Mimosaceae	B,D	M,U,B	1,2,3,8
Acacia tortilis (Roxb.) Craib.	Israeli Babul	Mimosaceae	D	M,U	1,2,3,8
Adansonia digitata L.	—	Bombacaceae	D	U	-
Adina cordifolia Hook.f.	Haldu	Rubiaceae	D	U	1,2
Aegle marmelos (L.) Corr.	Bel	Rutaceaae	D	M,U	1,2,4,9
Ailanthus excelsa (Roxb.) Bth.	Maharuk	Simarubaceae	D	M,U	1,2,9
Albizia lebbeck (L.) Bth.	Siris	Mimosaceae	B,D	M,U,B	1,3,6,7
Albizia procera (Roxb) Bth.	Safed Siris	Mimosaceae	B,D	M,U,B	1,2,3
Anacardium occidentale L.	Kaju	Anacardiaceae	D	U	2,3,4
Annona reticulata L.	Ramphal	Annonaceae	D	U	4
Annona squamosa L.	Seetaphal	Annonaceae	D	U	4,6
Anthocephalus cadamba L	Kadamb	Rubiaceae	D	U	9
Artocarpus integrifolia Lamk.	Jack Fruit	Moraceae	D	U	2,3,4
Azadirachta indica A.Juss	Neem	Meliaceae	B,D	M,U,B	1,2,3,6
Bauhinia purpurea L.	Kachner	Caesalpinaceae	D	M,U	1.2.3 6
Bauhinia racemosa L.	Kachnar	Caesalpinaceae	D	M,U	1,2,3,6
Bombax ceiba L.	Silk Cotton	Bombacaceae	B,C,D	M,U	1;2,9
Borassus flabellifer L.	Toddy palm	Palmaceae	B,D	M,U,B	1,4,9
Butea monosperma (Lam.) Taub.	Flame of the Forest	Fabaceae	D	U	1-3,5-7
Callistemmon lanceo-latus L.	Bottle Brush	Myrtaceae	D	M,U	3,9
Capparis decidua (Forsk.) Edgew.	Kerdo	Capparaceae	B,D	M,U,B	1,4

Plant species	Common name	Family	H'tat	Occ'ce	Uses
Carica papaya L.	Papaya	Caricaceae	D	M,U	4,6,7
Caryota urens L.	Travellers' palm	Araceae	D	U	9
Cassia siamea Lam.	Amaltas	Caesalpinaceae	B,D	M,U,B	1,2
Cassia fistula L	—	Caesalpinaceae	D	U	1,2
Casuarina equisetifolia L.	Saru	Casuarinaceae	A,B,D	M,U	1,2,9
Cestrum nocturnum L.	Night Queen	Solanaceae	D	U	9
Citrus limonia (L.) Burm f.	Lime	Rutaceae	D	M,U	4
Citrus sinensis L.	Orange	Rutaceae	D	U	4
Cocos nucifera L.	Coconut	Palmaceae	D	M,U	1,4,9
Cordia dichotoma Forst	Lishora	Ehretiaceae	D	U	1,2,4-6
Couroupita guanensis Taub.	Cannon Ball Tree	Lecythidaceae	D	U	1,3,9
Crateva nurvela Buch.Ham.	Varno	Capparaceae	D	M,U	2,3,4
Dalbergia sissoo Roxb.	Shisham	Fabaceae	D	M,U	1,2,3
Delonix elata (L.) Gamble.	Sandro	Caesalpinaceae	D	M,U	1,9
Delonix regia(Boj.) Raf.	Gulmohur	Caesalpinaceae	D	M,U	1,9
Dendrocalamus strictus Nees	Bamboo	Poaceae	B,D	U	1,4,6
Dendrophthoe falcata Etting.	Vandha	Loranthaceae	D	U	-
Derris indica (Lam.) Bennet.	Karanj	Fabaceae	B,D	M,U	2,3,4
Diospyros cordifolia Roxb	Dheki	Ebenaceae	D	M,U	2
Diospyros melanoxylon Roxb	Ebony	Ebenaceae	D	M,U	1,4
Emblica officinalis Gaertn.	Goosberry (Aonla)	Euphorbiaceae	B,D	M,U	1,2,4
Eucalyptus tereticornis Hybrid	Nilgiri	Myrtaceae	D	M,U	1,7,9
Euphorbia tirucalli L	Dirkhadi	Euphorbiaceae	D	M,U	9
Erythrina monosperma . Lam.	Khakhro	Fabaceae	D	U	1,2,8
Ficus bengalensis L.	Vad	Moraceae	D	M,U	1,2,6
Ficus carica L.	Anjir	Moraceae	C,D	U	4
Ficus elastica Roxb	India Rubber	Moraceae	D	U	9
Ficus glomerata Roxb.	Gular	Moraceae	D	M,U	2,9

Plant species	Common name	Family	H'tat	Occ'ce	Uses
Ficus microcarpa L f.	Nandrak Vad	Moraceae	D	M	2,9
Ficus religiosa Lin.	Pipal	Moraceae	D	M,U	1 ,2,7
Garuga pinnata Roxb.	Kharpat	Bursuraceae	D	U	-
Gmelina asiatica Linn.	Sewan	Verbenaceae	D	U	-
Grewia subinequalis DC.	Phalsa	Tiliaceae	B,D	M,U	1,2,4
Grewia tenax (Forsk.) Fiore.	Nagbala	Tiliaceae	D	M,U	1,2
Hardwickia binata Roxb.	Anjan	Caesalpinaceae	D	U	1,2
Holoptelia integrifolia (Roxb.) Planch.	Kanajo	Ulmaceae	D	M,U,B	1,2
Hymenodictyon excelsum (Roxb.) Wall.	Boisal	Rubiaceae	D	U	2 ,3,4
Lagerstroemia parviflora Roxb.	Dhuara	Lythraceae	D	M,U	1,2
Leucaena leucocephala (Lam) de Wit	Subabul	Mimosaceae	B,D	M,U,B	3
Limonia acidissima L.Sp.	Kotha	Rutaceae	B,D	M,U	1,2,4
Madhuca indica J.F. Gmel.	Mahua	Sapotaceae	D	M,U	1,2,4
Mangifera india L.	Mango	Anacardiaceae	D	M,U	1,2,4,7
Manilkara hexandra (Roxb.) Dub.	Rayana	Sapotaceae	D	M,U	4
Manilkara zapota (L.) Van Royen.	Sapota	Sapotaceae	D	M,U	4
Melia azadirach Linn.	Persian Lilac	Meliaceae	D	MUB	1,2,6,7
Mimusops elengi L.	Mulsari	Sapotaceae	D	U	4
Morinda tomentosa Heyne ex. Roth	Ali	Rubiaceae	D	U	—
Moringa oleifera Lam.	Drumstick	Moringaceae	D	M,U	2,3,4
Morus alba L.	Mulberry	Moraceae	D	M,U	1,2,4
Murraya koenigi (L.) Sp.	Curry Leaf	Rutaceae	D	M,U	1,2
Musa paradasiaca L	Banana	Musaceae	D	M,U	4
Nyctanthus arboritristis L	Parijat	Oleaceae	D	U	9
Oreodoxa regia H.B.& K	Travellers' Palm	Palmaceae	D	U	9
Pandanus fascicularis L	Kewda	Pandanaceae	B,D	U	6,7,9
Parkinsonia aculeata L	Horsebean	Caesalpinaceae	B,D	M,U,B	1,2,3,9
Peltophorum pterocarpum (DC.) Baker ex Heyne.	Copper Pod Tree	Caesalpinaceae	D	M,U	1,2,3,9

Plant species	Common name	Family	H'tat	Occ'ce	Uses
Phoenix dactylifer L	Datepalm	Palmaceae	B,D	U	4,9
Phoenix sylvestris (L) Roxb.	Toddypalm	Palmaceae	B,C	U	4
Pithacellobium dulce (Roxb.) Bth	Jangli Jilebi	Mimosaceae	B,C	M,U	2,3,4
Plumeria rubra L	Champo	Apocynaceae	D	U	—
Polyalthia cerasoides Roxb. Hk f & Bth. ex Hk.f. & Th	Umda nu zad	Annonaceae	D	U	1,2
Polyalthia longifolia (Sonn) Thv.	Ashok	Annonaceae	D	M,U	1,9
Prosopis cineraria L.	Khejri	Mimosaceae	A-D	M,U,B	1-4, 6-8
Prosopis juliflora (SW.) DC.	Mesquite	Mimosaceae	A-D	M,U,B	2,3,8
Psidium guajava L	Amrut	Myrtaceae	D	M,U	4
Pterocarpus marsupium Roxb	Bia	Fabaceae	D	U	1,2,6,7
Punica granatum L	Pomegranate	Punicaceae	D	M,U,B	4
Salvadora oleoides Decne	Mithi Piludi	Salvadoraceae	B,C	M,U,B	1,4,6,7
Salvadora persica L	Piludi	Salvadoraceae	B,C,D	M,U,B	1,2,6,9
Sapindus laurifolius Vahl	Soapnut	Sapindaceae	D	M,U	1,2
Sesbania grandis (L.)Pers	Agathi	Caesalpinaceae	D	U	9
Syzygium cumini (L.) Skeels.	Black Plum	Myrtaceae	D	M,U	1,2,3,4
Tamarindus indicus Linn.	Tamarind	Caesalpinaceae	D	M,U	1,2,4,7
Tectona grandis L.f	Teak	Verbenaceae	D	U	1,2,6,7
Terminelia arjuna (Roxb.) W & *A*	Arjun	Combretaceae	D	M,U	1,2,6
Terminelia catappa L.	Almond	Combretaceae	D	M,U	1,2,4
Thevitia peruviana (Pers.) Merr.	Pilikaren	Apocynaceae	D	U	6,7
Wrightia tomentosa R & S	Indarjan	Apocynaceae	D	U	1,4,6
Zizyphus mauritiana Lam.	Ber	Rhamnaceae	B,C,D	M,U	2-4,6-7
SHRUBS					
Aloe barbadens Mill.	Kunvarpato	Liliaceae	D	U	7
Asparagus racemosus Willd.	Satavri	Liliaceae	B,D	M,U	4,6
Bougainvillea spectabilis Willd.	Bougainvillea	Nyctaginaceae	D	M,U	9

Plant species	Common name	Family	H'tat	Occ'ce	Uses
Cadaba fruticosa(L.) Druce	Bathak	Capparaceae	D	M,U	3,9
Calotropis gigantea (L.) R.Br.	Aak	Asclepiadaceae	D	M,U	2,5
Calotropis procera (Alt.) R. Br.	Aak	Asclepiadaceae	D	M,U,B	1,2,5,6
Capparis spinosa L.	Kantharo	Capparaceae	D	M,U	4
Capparis zeylanica L Se.	-	Capparaceae	D	M,U	2
Carissa congesta Wt	Karaunda	Apocynaceae	D	M,U	4
Cassia auriculata L.	Awal	Caesalpinaceae	B,D	M,U,B	2,6,7
Cleome gynandra L. Sp	Ghandatu	Capparaceae	D	U	9
Clerodendron inerme (L.F.) Gaertn	-	Verbenaceae	D	U	6
Cycas beddomi L.	Cycas	Cycadaceae	D	U	9
Dodonea viscosa (L.) Jacq.	Jangli Mehndi	Sapindaceae	D	M,U	6
Duranta plumeri Jacq	-	Verbenaceae	D	M,U	9
Euphorbia nerifolia L	Dandathor	Euphorbiaceae	D	M,U	2,6
Euphorbia nivulia Buch. Ham.	Thor	Euphorbiaceae	D	M,U	2,6
Euphorbia pulcherrima L	-	Euphorbiaceae	D	M,U	6
Foeniculum vulgare Mill.	Fennel	Apiaceae	D	M,U	4
Gymnema sylvestre (Retz.) Schult	Madhu Nasini	Asclepiadaceae	D	U	6
Hibiscus rosa-sinensis L.	Shoe Flower	Malvaceae	D	M,U	6,9
Holarrhena antidysenterica (Heyne ex Roth.) Wall.	Dudheli	Apocynaceae	D	M,U	1,2,6,7
Ipomoea cornea Auct.. Non. Jacq.	-	Convolvulaceae	A	M,U	
Jasminum articulatum Vahl	Jaji	Oleaceae	D	M,U	9
Jasminum rigidum Zenk	Jui	Oleaceae	D	M,U	9
Kirganellia reticulata (Poir). Baill.	Datwan	Euphorbiace	D	M,U	4,6
Lantana camara Auct. non. Linn.	Lantana	Verbenaceae	D	M,U	2
Lawsonia inermis L..	Mehndi	Lythraceae	D	M,U	2
Nerium indicum Mill.	Lalkaren	Apocynaceae	D	M,U	4,6
Opuntia dillinii Grah	Nag Phani	Cactaceae	D	M,U	4,6
Pavetta crassicaulis Bremek	Papat	Asteraceae	D	U	-
Rauvolfia serpentina L.	Sarpa Gandha	Apocynaceae	D	U	6

Plant species	Common name	Family	H'tat	Occ'ce	Uses
Rhus mysurensis Heyne ex. W. & A.	Dasui	Anacardiaceae	D	U	2,6
Ricinus communis L.	Castor	Euphorbiaceae	D	M,U	9
Sesbania bispinosa (Jacq)w.f.Wight	Dhiancha	Caesalpinaceae	D	M,U	9
Strychnos potatarum L	Nirmal	Loganiaceae	D	U	-
Suaeda maritima (Cl.) Gamble.	Noonkhai	Chenopodi-aceae	B,C,D	M,U,B	3
Tamarix ericoides L	Tamarix	Tamaricacea	D	M,B	2
Thevitia peruviana (Pers.) Merr.	Palikaren	Apocynaceae	D	U	7
Thuja occidentalis L.	Thuja	Thujoidae	D	U	9
Xanthium strumarum L	Gokhru	Asteraceae	D	M,U	6
Zizyphus nummularia (Burm. F.) W.& A.	Chani Bor	Rhamnaceae	B,C,D	M,U	2-4,6
UNDERSHRUBS					
Abutilon indicum (L.) SW.	Dabi-Dabiya	Malvaceae	D	M,U	2,3, 5,6
Adhatoda zeylanica (L) Nees.	Adusa	Acanthaceae	D	M,U	2,6,7
Agave americana L.	Agave	Agavaceae	D	M,B	5
Cassia occidentalis L.	Sundra	Caesalpinaceae	D	M,U	2
Celosia argentea L.	Cock's Comb	Amaranthaceae	A,B,D	M,U	3,4
Datura innoxia Mill	Datura	Solanaceae	D	M,U	6
Datura metel Auct.	Datura	Solanaceae	D	M,B	6
Glossogyne bidens (Retz.) Alst.	Kagasawa	Asteraceae	D	U	9
Hemidesmus indicus (L.) R Br.	Dudheli	Periplocaceae	D	U	6
Plumbago zeylanica L.	Chitro	Plumbaginaceae	D	M,U	3
Sida cordifolia L	Bala	Solanaceae	D	M,U	3,4
Solanum inidcum L	Ubhiringni	Solanaceae	D	M,U	6,7
Solanum nigrum L.	Kamanchi	Solanaceae	D	M,U	3,4
Tylophora indica (Burm.f.) Merr	Damnivel	Asclepiadaceae	D	U	-

Plant species	Common name	Family	H'tat	Occ'ce	Uses
HERBS					
Acalypha indica L.	Dadari	Euphorbiaceae	D	M.U	-
Achanthospermum hispidum DC	-	Acanthaceae	D	U	3,4,6
Achyranthes aspera L.	Undakanta	Amaranthacea	D	M,U	6
Aerva lanata (L.) Juss	Bui	Amaranthaceae	D	M,U,	6
Ageratum conyzoides L.	Ajgandha	Asteraceae	D	M,U,B	6,7
Alternanthera sessilis (L.)DC	-	Amaranthaceae	D	M,U	2,3
Amaranthus gangeticus L	Bhajileaf	Amaranthaceae	D	U	3,4
Amaranthus paniculatus L.	Rajgira	Amaranthaceae	D	U	3,4
Amaranthus spinosus L.	-	Amaranthaceae	D	U	3,4
Amaratnhus viridis L.	-	Amaranthaceae	D	M,U,B	3,4
Ammania baccifera L.	Jal Bhangro	Lythraceae	D	M,U	4,6
Amarphophallus campanu latus (Roxb) Bl.ex. Decne	Suran	Araceae	D	M,U,	4,6
Argemone mexicana L.	Satyanashi	Pepaveraceae	D	M,U	6,7
Asclepias cerasoides L.	-	Asclepiadaceae	D	M,U	-
Asclepia currosavica L.	-	Asclepiadaceae	D	M,U.	-
(L.) Roth,					
Bacopa monneiri (L.) Pannel	Brahmi	Scrophulariaceae	A,D	U	-
Blepharis madraspatensis L.Roth	Untigan	Acanthaceae	D	U	-
Boerhavia diffusa L.	Lalsata	Nyctaginaceae	B,C,D	M,U	4,6
Bryophylllum species	-	Cactaceae	B,D	U	4,9
Caesulia axillaris Roxb.	-	Asteraceae	A,B	M,U	3
Canna indiica L.	Canna	Cannaceae	D	U	9
Cassia italica (Mill) Lam.	Patavel	Caesalpinaceae	B,D	M,U	3
Cassia tora L.	Panver	Caesalpinaceae	D	M,U	6
Catharanthus roseus (L.) G. Don.	Periwinkle	Apocynaceae	B,D	M,U,B	6,9
Centella asiatica (L.) Urb.	Vidya Brahmi	Apiaceae	A,B,D	U	6,7
Chenopodium album L.	Bathua	Chenopodiaceae	A,D	M,U	3,4
Chenopodium murale L.	--	Chenopodiaceae	A,D	M,U	3,4
Chrysanthemum indicum DC	Chrysan-themum	Asteraceae	D	U	9
Cleome viscosa L.	Pilitilvan	Capparaceae	D	M,U	6
Cocculus hirsutus (L.) Diels.	Jaljamni	Menispermaceae	A,B	M,U	9
Commelina benghalensis L.	-	Commelinaceae	A	M,U	9
Commelina forskalei Vahl.	-	Commelinaceae	A	M,U	3
Convolvulus microphyllus (Roth.) Sieb.	Shankavli	Convolvulaceae	D	M,U	-

Plant species	Common name	Family	H'tat	Occ'ce	Uses
Convolvulus obscurus L.	--	Convolvulaceae	A	M,U	-
Corchorus depressus (L.) Stocks.	Bahuphali	Tiliaceae	D	U	-
Cressa cretica L.	Luni	Convolvulaceae	B,C	M,U,B	3
Crotalaria medicaginea Lam.	Guladi	Fabaceae	D	M,U	3
Croton bonplandianum Baill.	—	Euphorbiaceae	D	M,U	6
Digera muricata (L.) Mart	Kanjro	Amaranthaceae	D	M,U	4
Eclipta prostrata (L.) L.	—	Asteraceae	D	M,U,B	-
Euphorbia hirta L.	Duthi	Euphorbiaceae	D	M,U	6
Evolvulus alsinoides (L.) L.	Shankh Pushpi	Convolvulaceae	D	M,U	6,7
Gloriosa superba L.	Nabhi	Liliaceae	D	U	4
Gomphrena globosa L.	Globe Amaranth	Amaranthaceae	D	M,U	9
Heliotropium supinum L.	Heliotrop	Boraginaceae	A,B	M,U	4,5
Hibiscus cannabinus L.	Hemp	Malvaceae	A	M,U	4,5
Hydrilla verticillata (L.F.) Royle.	Hydrilla	Hydrocharitaceae	A	U	-
Indigofera cardifolia Heyne ex. Roth.	—	Fabaceae	D	M,U	4,8
Indigofera linnaei Ali.	Fatakiya	Fabaceae	D	M,U	6
Ipomoea obscurus (L.) Ker. Gavl.	—	Convolvulaceae	A	M,U	4,8
Ixora brachiata Roxb.	Garbale	Rubiaceae	D	U	4
Justicia procumbens L.	—	Acanthaceae	D	U	9
Justicia prostrata Linn .	—	Acanthaceae	D	M,U	9
Lacera species	—	Asteraceae	A,B,D	M,U	3
Leucas aspera (Willd.) Sp.	Kubi	Lamiaceae	D	M,U	4,6
Leonotes nepetifolia R.Br.	—	Lamiaceae	D	U	4
Linum usitatissimum L.	—	Linaceae	D	U	4
Mentha-spicata L	Mint	Lamiaceae	D	M,U	3
Merremia gangetica L.	Undari	Convolvulaceae	D	M,U	-
Mimosa pudica L.	Lajwanti	Mimosaceae	A,D	M,U	-
Mirabilis jalapa L.	4'O Clock Plant	Nyctaginaceae	D	M,U	9
Mollugo nudicaulis Lam.	—	Molluginaceae	D	U	3

Plant species	Common name	Family	H'tat	Occ'ce	Uses
Mucuna prurita Hk. f.	-	Fabaceae	D	U	6
Nelumbo nucifera Gaertn.	Lotus	Nympheaceae	A	U	9
Ocimum basillicum L.	Dumro	Lamiaceae	D	M,U	6,9
Ocimum sanctum L.	Tulsi	Lamiaceae	D	M,U	6,9
Oxalis corniculata L.	Nalvar	Oxalidaceae	A,C	M	-
Parthenium hysterophorus L.	Cong.weed	Asteraceae	D	M,U	-
Pedalium murex L.	-	Pedaliaceae	D	M,U	6
Pergularia *daemia* (Forsk.) Chiov.	Chamar Dudheli	Asclepiadaceae	D	M,U	6
Peristrophe bicalyculata (Retz.) Nees	Adhedi	Acanthaceae	D	M,U	5,8
Petunia parviflora Juss.	-	Solanaceae	D	U	9
Phyllanthus niruri Auct. non. L.	Bhonya Amli	Euphorbiaceae	D	M,U,B	6
Phyllanthus madras-patensis L.	Konocha	Euphorbiaceae	D	M,U	6
Physalis minima L	Strawberry tomato	Solanaceae	A,D	M ,U	4
Pistia strateotes L.	Jalsankhla	Araceae	A	U	9
Polyanthes tuberosa L.	Gulchadi	Agavaceae	D	U	9
Polycorpea corymbosa (L.) Lam.	-	Caryophylla-ceae	D	U	3
Portulaca oleracea L.	Motiluni	Portulacaceae	D	U	4
Pulicaria wightiana (D.C.) Cl.	Sonasalia	Asteraceae	D	M,U	-
Puppalia lappacea (L.) Juss.	-	Amarantha-ceae	D	U	-
Rubia cordifolia L.	-	Rubiaceae	D	U	6
Sesuvium portulacastrum L.	-	Aizoaceae	D	M,U	3
Solanum incannum L.	Ubhi Ringni	Solanaceae	D	M,U	6
Solanum xanthocarpum (Solanum surattense Burm.f)	Bhoi Ringni	Solanaceae	D	M,U	6
Sphaeranthus indicus L.	Gorakh Mundi	Asteraceae	A,D	M,U	-
Suaeda nudiflora (Willd.) Moq.	Moras	Chenopodi-aceae	D	M,U,B	4
Tagetus patula Willd.	Marigold	Asteraceae	D	M,U	9

Plant species	Common name	Family	H'tat	Occ'ce	Uses
Tephrosea purpurea (L) Pers.	Dhamasia	Fabaceae	D	M,U	3,6
Tephrosea villosa (L.) Pers.	--	Fabaceae	D	M,U	6
Torenia fornieri L.	--	Scrophulariaceae	D	M,U	4
Trachyspermum ammi (L.) Sprague	Ajmo	Apiaceae	D	M,U	4
Tradescantia axillaris L.	--	Commelinaceae	A,D	M,U	9
Trianthema decandra L	--	Ficoidaceae	D	M,U	-
Tribulus terrestris L.	Chota Gokhru	Zygophyllaceae	D	M,U	3,6
Tridax procumbens L.	Pardeshi Bhangro	Asteraceae	D	M,U	3
Trifolium repens L.	—	Fabaceae	D	M	-
Typha angustata Bory & Chaub.	Ramban	Typhaceae	A	M,U	9
Vernonia cinera (L) Less	Sahadevi	Asteraceae	A,D	M	3,6
Vicoa auriculata Cass	Sonasali	Asteraceae	D	M,U	-
Vigna catjung Walp.	Cowpea	Fabaceae	D	M,U	3,4
TWINERS/CLIMBERS/RUNNERS					
Abrus precatorius L.	Ratti	Fabaceae	D	M,U	6
Basella rubra L.	Poi	Basellaceae	D	U	4
Canavalia gladiata D.C.	Abbo	Fabaceae	D	M	-
Citrullus colocynthis (L.) Soland.	Colocynth	Cucurbitaceae	A,D	M, B	2,4,6
Clitorea ternatea L.	—	Fabaceae	D	M,U	6
Coccinia grandis (L.) Viogt.	Ghiloda	Cucurbitaceae	D	M,U	4
Cryptostegia grandiflora R. Br.	Rubbervel	Asclepiadaceae	B,D	M,U	9
Cuscuta reflexa Lam.	Amarvel	Cuscutaceae	D	M,U,B	-
Lagenaria leucantha ((Roxb.) Rusby.	Duthie	Cucurbitaceae	D	M,U	4
Leptadenia reticulata (Retz.) W & A	Dodi	Asclepiadaceae	D	M,U	4
Luffa acutangula (L.) Roxb.	Ridge gourd	Cucurbitaceae	D	M,U	4
Luffa cylindrica (L.) M J. Roem	Ghee turai	Cucurbitaceae	D	M,U	4
Passiflora edulis Sims.	Krishna Kamal	Passifloraceae	D	M,U	9
Quisqualis indica L.	Madhu Malti	Combretaceae	D	M,U	6

Plant species	Common name	Family	H'tat	Occ'ce	Uses
GRASSES/SEDGES					
Aleuropus lagopoides L.	--	Poaceae	B	M,B	3
Aristida adscensionis L.	Lapdo	Poaceae	D	M,U	3
Cynodon barberi Rang. et. Tad.	--	Poaceae	B	M,U	3
Cynodon dactylon (L.) Pers.	Dab	Poaceae	B,D	M,U,B	3,6
Cyperus compressus	Sedge	Cyperaceae	A	M,U	3,6
Cyperus difformis L.	Common Sedge	Cyperaceae	A	M,U	3
Cyperus iria L.	Yellow Sedge	Cyperaceae	A	M,U	3
Cyperus rotundus L.	Nut grass	Cyperaceae	A	M,U	3
Dactyloctenium aegyptium (L.) P. Beauv	--	Poaceae	D	M,U	3,4
Dichanithum annulatum (Forsk) Staff.	Jinjvo	Poaceae	B,D	M,U	3,6,8
Echinocloa colonum (L.) Link	Abdau Samo	Poaceae	A	M,U	3
Echinocloa crusgalli (L.) P. Beauv.	--	Poaceae	D	M,U	3
Eulalia trispicata (Schult.) Henr.	--	Poaceae	D	M,U	3
Eragrostis ciliaris R.Br.	Murmur	Poaceae	D	M,U	3
Eragrostis tenella (L.) P. Beauv.	Limor	Poaceae	D	M,U	3
Eragrostis spp.	Kalavo	Poaceae	B,D	M,U,B	3
Fimbristylis tenera L.	--	Cyperaceae	A	M,U	-
Juncus maritimus L.	--	Juncaceae	A	M,U	-
Sporobolus spp.	Khariyu	Poaceae	D	M,U	3

Habitat (H'tat) :
A: Aquatic/Marshy/Wetlands; B: Saline soils; C: Coastal area; D: Normal soils.

Occurrence (Occ'ce):
M: MRBC Command; U: UKai-Kakrapar command; B: Bhal Area.

Uses:
1. Timber; 2. Fuel; 3. Fodder; 4. Food; 5. Fibre; 6. Medicine;
7. Extracts; 8. Soil Conservation; 9. Miscellaneous.

4.2 UKAI KAKRAPAR COMMAND

4.2.1. Trees

Acacia catechu, Adansonia digitata, Adina cordifolia, Aacardium occidentale, Anthocephalus cadamba, Bamboosa arundanacea, Butea monosperma, Couroupita guanensis, Caryota urens, Cordia dichotoma, Delonix elata, Dalbergia sissoo, Erythrina variegata, Hardwickia binata, Holoptelia integrifolia, Millingtonia hortensis, Oreodoxa regia, Pandanus fascicularis, Pterocarpus marsupium, Sesbania grandis, Spondias pinnata, Tectona grandis, Thevitia peruviana, Thuja occidentalis, Cycas spp. and *Wrightia tomentosa* were the tree species noticed in the command.

In the salt affected areas under Bardoli, Palsana, Vyara and Kamrej talukas of Surat and Navsari and Valsad talukas of Valsad district, woody plants like *Acacia nilotica, Ailanthus excelsa, Albizia lebbeck, Azadirachta indica, Bombax ceiba, Borassus flabellifer,, Capparis decidua, Dendrocalamus strictus, Derris indica, Leucaena leucocephala, Pandanus fascicularis, Parkinsonia aculeata, Phoenix sylvestris, Prosopis juliflora, Salvadora persica* and *Zizyphus nummularia* were common (Table 8). *Prosopis juliflora and Salvadora persica* were found on highly saline soils of EC_e as high as 31.0 and 27.0 dS/m at 0-15 and 15-30 cm depths, respectively. The pH_s of soil samples collected from the vicinity of plants did not show much variation. Plant species like *Acacia nilotica, Albizia lebbeck, A. procera, Borassus flabellifer, Pandanus fascicularis, Parkinsonia aculeata, Pithacellobium dulce, Phoenix dactylifer* and *Zizyphus nummularia* were found on soils of EC_e 6.2 to 9.4 and 4.3 to 9.6 dS/m at 0-15 and 15-30 cm depths, respectively. pH_s of the soils in majority areas ranged from 7.8 and 8.2.

Khanpur, Jokha, Mota, Bhatta, Kolasnai, Gopla, Dandi, Dharasana, Mandir and Kewada villages in the command had highly saline areas. Salinity of soils ranged from 1.3 to 1.9 dS/m where plants like *Ailanthus excelsa, Derris indica, Diospyros cordifolia, Grewia subinequalis, Holoptelia integrifolia* and *Sapindus laurifolius* were noticed.

4.2.2 Shrubs

Capparis decidua and *Suaeda maritima* are the two prominent species noticed on highly saline areas with EC_e of 6.5 to 9.4 and 16.8 to 38.0 dS/m, respectively.

Table 6. Predominant plant species noticed on salt affected soils of MRBC

Plant species	EC_2 (dS/m)		pH_2	
	0-15	15-30	0-15	15-30cm
WOODY PERENNIALS				
Acacia nilotica	11.6	9.2	8.3	8.2
Albizia lebbeck	10.4	9.8	8.8	8.6
Albizia procera	10.4	9.8	8.8	8.6
Borassus flabellifer	9.2	7.3	8.8	8.4
Capparis decidua	29.0	16.5	8.0	8.1
Capparis sepiaria	8.8	8.6	8.6	8.5
Casuarina equisetifolia	12.4	9.2	8.8	8.3
Diospyros cordifolia	7.4	6.8	8.3	8.5
Emblica officinalis	2.0	-	8.6	-
Feronia limonia	2.5	-	8.5	-
Parkinsonia aculeata	3.3	2.5	8.0	8.1
Pithacellobium dulce	7.1	5.3	7.8	7.9
Prosopis cineraria	9.8	9.5	8.8	8.6
Prosopis juliflora	33.0	29.0	7.9	7.7
Salvadora oleoides	12.4	9.2	8.8	8.3
Salvadora persica	32.0	27.0	8.3	8.1
Tamarix ericoides	9.0	19.8	9 8	9.3
Zizyphus nummularia	6.5	15.9	8.3	7.9
HERBACEOUS SPECIES				
Ammania baccifera	8.6	6.5	8.6	8.8
Caesulia axillaris	9.8	9.5	8.8	8.6
Cressa cretica	37.0	29.6	8.1	7.9
Heliotropium supinum	4.9	4.2	8.1	8.0
Sphaeranthus indicus	2.5	2.3	9.8	9.3
Suaeda maritima	37.0	9.6	8.1	8.0
Vernonia cinera	2.6	2.5	8.0	8.1
Aristida adscensionis	3.4	2.5	8.0	8.1
Cynondon dactylon	37.0	29.6	8.1	8.6
Aleuropus lagopoides	37.0	29.6	8.1	8.6
Dactyloctenium aegyptium	3.3	2.5	7.6	8.2
Dichanthium annulatum	3.4	2.5	8.0	8.1
Sporobolus spp.	12.4	9.2	8.8	8.3

Table 7. Distribution of predominant plant species in MRBC command

Plant species	Area (Habitat)
Acacia nilotica	B,E,G,I-N, P,S,T,U
Albizia lebbeck	B F.G.H J.K,M-P,R,S,T,U
Albizia procera	F-K, M-P, R,S,T,U
Capparis decidua	A-L, T,U
Pithacellobium dulce	A-P, T,U
Prosopis juliflora	A-R, T,U,V
Prosopis cineraria	A-L, N-R, T,U,V
Salvadora persica	B-F, H-K, M,N,R,S,T,U,V
Salvadora oleoides	B-F, H-K, M,N,R,S,T,U,V
Zizyphus nummularia	B,F,H,N,P,S,U,V
Ammania baccifera	B,F,H,I,L,N,Q
Boerhavia diffusa	B-F, H,K,L,M,P,Q,R,S
Caesulia axillaris	B,C,G,L,O,P,Q,S
Chenopodium album	F,K,L,M,S,T,V
Cressa cretica	A,P,R,S,T,U,V
Digera muricata	B,E,O,P,R,S,T,U,V
Heliotropium supinum	A,E,H,K, M-P, Q,S,T,U,V
Suaeda maritima	A-P,R,S,T,U,V
Lacera species	A,K,M,N-P, S,U
Sphaeranthus indicus	A,H,K,M,N-P, S,T,U
Vernonia cinera	A,B,H,K, M-P, S,T,U
Vicoa indica	A,B,K,M,P,R,S,T
Cyperus species	A,D,J,K,L,M,Q,R,T,U
Cynodon dactylon	A,D,J,K,L,M, P-S, U,V
Dichanthium annulatum	B,D,K,L,M,O,PmV
Eragrostis species	C,E,F,I
Typha angustata	A,D,J,KL,N, P-V

A Golana B Mithli C. Rohini D Padra E: Moraj
F Laval G: Traj H: Maghrol I Pariaj J. Dehda
K Kathana L. Kalsar M: Ramodri N: Peej O: Jhaj
P: Gora; Q: Azarpura R: Dabhon S: Dali
T. Mobha; U. Navagam Bara V: Tadtalav

Table 8. Predominant plants noticed on salt affected soils of Ukai -Kakrapar Command

Plant species	EC_2 (dS/m)		pH_2	
	0-15	15-30	0-15	15-30cm
WOODY PERENNIALS				
Acacia nilotica	6.7	6.6	8.4	7.8
Albizia lebbeck	7.2	6.5	7.8	7.9
Albizia procera	7.2	6.5	7.8	7.9
Ailanthus excelsa	1.3	1 4	8.6	8 1
Borassus flabellifer	9.4	8.0	8.2	8.1
Casuarina equisetifolia	9.4	8.0	8.2	8.1
Derris indica	1.3	1.4	8.6	8.1
Diospyros cordifolia	1.3	1.4	8 6	8.1
Dendrocalamus strictus	1.3	1.4	8.6	8.1
Ficus carica	1.9	1.9	8.6	8.1
Grewia subinequalis	1 9	1.9	8 6	8.1
Holoptelia integrifolia	1 9	1.9	8.6	8.1
Leucaena leucocephala	3.3	2.5	7.6	8 0
Pandanus fascicularis	6.7	6.0	8.4	7.8
Parkinsonia aculeata	6.2	4.3	8.0	8.2
Pithacellobium dulce	9.4	9.6	8.1	8.2
Phoenix dactylifer	8 3	5.8	8.0	8.1
Prosopis cineraria	9.0	6.8	8 0	8.1
Prosopis juliflora	31.0	27.4	8.0	8.1
Salvadora oleoides	19.0	16.8	8.5	8.1
Salvadora persica	31.0	27.4	8.0	8.1
Zizyphus mauritiana	9.4	9 6	8.2	8.1
Zizyphus nummularia	9.4	9 6	8.2	8.1
HERBACEOUS SPECIES				
Bacopa monnieri	1.9	1.5	8.0	8.4
Capparis decidua	9.4	8 6	8.2	8.1
Cassia auriculata	3 3	2.5	7.6	8.6
Cassia italica	3.3	2.5	7.6	8.6
Catharanthus roseus	1.9	1.5	8.0	8.4
Chenopodium album	1.9	1 5	8.0	8.4
Cressa cretica	10.3	10.6	8.2	7.6
Suaeda maritima	39.0	19.0	7.7	8.2
Aristida adscensionis	3.3	2.5	7.6	8.6
Cynodon dactylon	31.0	27.4	8.0	8.1
Dactyloctenium aegyptium	3.3	2.5	7.6	8.6
Dichanthium annulatum	3.3	2.5	7.6	8.6
Eulalia trispicata	3 3	2.5	7.6	8.6
Sporobolus spp.	10.3	10.6	8.2	7.6

4.2.3 Herbs

Species like *Bacopa monnieri, Cassia auriculata, C. italica, Catharanthus roseus* and *Chenopodium album* were found on soils of EC_2 1.3 to 7.3 dS/m, respectively. While *Heliotropium supinum* was noticed on soils with EC_1 7.8 to 10.6 dS/m, *Cressa cretica* was noticed on soils of salinity 16.8 to 31.0 dS/m.

4.2.4 Grasses

Among grasses, *Dactyloctenium aegyptium, Dichanthium annulatum, Aristida adscensionis* and *Eulalia trispicata* were observed on soils of salinity 1.5 to 3.3 dS/m. *Sporobolus* species and *Cynodon dactylon* were found on highly saline soils of 7.8 to 10.3 dS/m and 16.8 to 31.0 dS/m, respectively.

4.2.5 Vegetation on Waterlogged Soils

Waterlogged and wet lands are prevalent in most parts of the command which could be due to perennial irrigation facilities provided for sugarcane cultivation, improper maintenence of field channels and inadequate drainage causing water stagnation and luxuri ant growth of hydrophytes and sedges. Plant species occurring on weaterlogged and aquatic lands include *Cyperus* species, *Commelina benghalensis , C. forskalaei, Fimbristylis tenera, Typha angustata, Juncus* spp., *Ipomoea aquatica, Nelumbo nucifera, Cesulia axillaris* etc. On swampy and boggy areas in Gopla village of Navsari taluka, *Typha angustata* and *Prosopis juliflora (*stunted bushes*), Suaeda maritima* and *Cressa cretica* were noticed. In aquatic, waterlogged and wet areas, *Ageratum conyzoides, Ammania baccifera, Chenmopodium album, Merremia gangetica, Cyperus difformis, Fimbristyslis tenera* and *Commelina benghalensis* were noticed.

4.2.6 Common Vegetation

The most common vegetation in the command area are listed in Table 9. Among trees, *Acacia nilotica, Albizia lebbeck, Pandanus fascicularis, Parkinsonia acuelata, Pithacellobium dulce, Prosopis juliflora, Salvadora persica* and *S. oleoides* and herbs like *Boerhavia diffusa, Caesulia axillaris, Chenopodium album, Cressa cretica, Lacera* species and *Vernonia cinera* were found ubiquitous in the command.

Table 9. Predominant plant species of saline soils and their distribution in Ukai-Kakrapar command

Plant species	Area (Habitat)
Acacia nilotica	A-I, K,M,N
Albizia lebbeck	B,D,E-N
Bombax ceiba	A,D,F,J-N
Capparis decidua	A.B.D.G
Dendrocalamus strictus.	B,E,H,I-K,L
Pandanus fascicularis	B,I,J,H,N,P
Parkinsonia aculeata	A,B,D,F,H,J,K
Pinthacellobium dulce	A,B,D,F,G,H,J,K
Prosopis juliflora	A,B,C,D,G,H,K
Salvaodora persica	A,B,C,D,G,H,K,L
Salvadora oleoides	E,F,G,H,I,J,L
Boerhavia diffusa	B,F,G
Chenopodium album	B,F,G,H,J,K,L,M,P
Cressa certica	A,C,D,K
Suaeda maritima	A,C.D.K
Lacera species	A,B,D-N
Vernonia cinera	A,D,F,H,J,K-P

A:Bhata	B: Dandi	C: Dharasana	D : Degama
E: Gopla	F: Bhattai	G: Jokha	H : Khanpur
I : Fadvel	J :Malwan	K : Kolasnai	L : Kewada
M : Sisodra	N: Vedchi	O :Unchamala	P : Champawada

4.3 BHAL AREA

In the Bhal region, where salt affected soils are quite prevalent, the species identifed included *Acacia nilotica, Albizia lebbeck, Azadirachta indica, Borassus flabellifer, Cassia siamea, Holoptelia integrifolia, Leucaena leucocephala, Melia azadirach, Parkinsonia aculeata, Prosopis juliflora, Prosopis cineraria, Punica granatum, Salvadora persica* and *S. oleoides.*

Among the species identified, *Salvaodora persica* and *Prosopis juliflora* were noticed on very highly saline soils (EC_2 58.0 and 29.0 dS/m at 0-15 and 15-30 cm depths, respectively). Stunted bushes of *Acacia nilotica* , *Albizia lebbbeck, Capparis decidua* and *Parkinsonia aculeata* were noticed on soils of EC_2 16.6 and 16.4 dS/m at 0-15 and 15-30 cm depths, respectively (Table 10).

Highly saline soils were encountered in Bagodra, Fedra, Kharad, Pachham, Velvador, Dholera and Dhandhuka in Ahmedabad and Vallabhipur in Bhavnagar districts On vast stretches of highly saline areas of Dholera, only *Prosopis juliflora* and *Salvadora persica* were noticed in the area along with salt tolerant shrubs like *Suaeda maritima and Tamarix eridocides.* Other species noticed in the area were *Agave americana, Ageratum conyzoides, Argemone mexicana, Boerhavia diffusa* etc. (Table 5). Grasses, *Cynodon dactylon* and *Dichanthium annulatum* were found in abundance in the area.

Table. 10. Vegetation noticed on saline soils of Bhal Region

Plant species	Family	EC_2 (dS/m)		pH_2	
		0-15	15-30	0-15	15-30 cm
Acacia nilotica	Mimosaceae	16.6	16.4	8.3	8.4
Albizia lebbeck	Mimosaceae	16.6	16.4	8.3	8.4
Capparis decidua	Capparaceae	16.6	16.4	8.3	8.4
Parkinsonia aculeata	Caesalpinaceae	19.0	11.7	8.1	8.4
Prosopis juliflora	Mimosaceae	58.0	29.0	8.4	8.6
Salvadora persica	Salvadoraceae	58.0	29.0	8.4	8.6
Cressa cretica	Convolvulaceae	53.0	32.0	8.1	8.6
Suaeda maritima	Chenopodiaceae	53.0	32.0	8.1	8.6
Tamarix ericoides	Tamaricaceae	53.0	32.0	8.1	8.6
Aleuropus lagopoides	Poaceae	19.0	11.7	8.1	8.6
Cynodon dactylon	Poaceae	19.0	11.7	8.1	8.4

5. VEGETATION ON SALINE SOILS

The studies conducted so far in the MRBC and Ukai-Kakrapar commands and parts of Bhal region indicate that vegetation vary with varying degrees of salinity. Based on *in situ* salinity, soils in the surveyed area have been categorized into (a) slightly saline; (b) moderately saline, (c) highly saline and (d) very highly saline. The salinity status of the area along with the plants identified at different salinity levels are presented in Table 11.

Under the very highly saline category, plant species included were those occurring on soils having EC_2 ranging from 10 to 25 dS/m and those occurring on soils of EC_2 25 to 38 dS/m in 0-30 cm soil depth. Plant species noticed on slightly saline soils were not noticed on moderately, highly or very highly saline soils. Plant species noticed on moderately saline soils were not seen on highly and very highly saline soils; those included under highly saline soils were not seen on very highly saline soils.

On very highly saline soils, where the soils had EC_2 of 25 to 38 dS/m in the 0-30 cm layer, plant species like *Prosopis juliflora, Salvadora persica, Cressa cretica, Suaeda maritima, Suaeda nudiflora, Tamarix ericoides, Aleuropus lagopoides* and *Cynodon dactylon* were noticed in MRBC and Ukai-Kakrapar commands. However, these species werealso observed on very highly saline soils of EC_2 58 dS/m in 0-15 cm layer of the Bhal area (Table 10).

On soils of EC_2 10-25 dS/m in top 0-30 cm layer, woody species like *Acacia nilotica, Albizia lebbeck, Capparis decidua, Casuarina equisetifolia, Parkinsonia aculeata, Prosopis cineraria, Salvadora oleoides, Zizyphus nummularia* and herbaceous plants like *Heliotropium supinum* and grasses *Sporobolus* and *Eragrostis* were noticed.

Woody plants. *Albizia procera, Borassus flabellifer, Manilkara hexandra, Pithacellobium dulce, Phoenix dactylifer, Zizyphus mauritiana* and *Jatropha curcas* and herbaceous species *Asparagus racemosus, Vernonia cinera, Vicoa indica* and grass *Dichanthium annulatum* were noticed on soils of salinity 4-10 dS/m in 0-30 cm and 3 2 to 6.5 dS/m in 30-90 cm layer.

Table 11. Natural vegetation occurring at different levels of soil saliniity (EC_2, dS/m)

SLIGHTLY SALINE: **1.2-2.0*; 1.0-1.5** [*: 0-30cm; **:30-90 cm]**

Acacia melanoxylon; Aegle marmelos; Ailanthus excelsa; Bauhinia racemosa; Bauhinia variegata; Couroupita guanensis; Diospyros cordifolia; Diospyros melanoxylon; Ficus glomerata; Grewia subinequalis; Holoptelia integrifolia; Sapindus laurifolius; Terminelia catappa; Ammania baccifera; Bacopa monnieri; Caesulia axillaris; Merremia gangetica; Cymbopogon citratus.

MODERATELY SALINE: 2.0 TO 4.0*; 1.8 TO 3.2**

Acacia catechu; Azadirachta indica; Bombax ceiba; Cassia siamea; Derris indica; Dendrocalamus strictus; Emblica officinalis; Feronia limonia; Leucaena leucocephala; Morus alba; Pandanus fascicularis; Peltophorum pterocarpum; Syzygium cumini; Tamarindus indicus; Terminelia arjuna; Argemone mexicana; Boerhavia diffusa; Cassia auriculata; Catharanthus roseus; Chenopodium album; Digera muricata; Aristida adscensionis; Dactyloctenium aegyptium; Eulalia trispicata.

HIGHLY SALINE **4.0 TO 10.0*; 3.2 TO 6.5****

Albizia procera; Borassus flabellifer; Manilkara hexandra; Pithacellobium dulce; Phoenix dactylifer; Zizyphus mauritiana; Asparagus racemosus; Jatropha curcas; Vernonia cinera; Vicoa indica; Dichanthium annulatum.

VERY HIGHLY SALINE - A: 10.0 TO 25.0*; 6.5 TO 12.0**

Acacia nilotica; Albizia lebbeck; Capparis decidua; Casuarina equisetifolia; Parkinsonia aculeata; Prosopis cineraria; Salvadora oleoides; Zizyphus nummularia; Heliotropium supinum ; Eragrostis spp.*; Sporobolus* spp.

VERY HIGHLY SALINE - B: 25.0 TO 38.O*; 15.0 TO 16.8**

Prosopis juliflora; Salvadora persica; Cressa cretica; Suaeda maritima; Tamarix ericoides; Cynodon dactylon ; Aleuropus lagopoides.

6. RELATIVE DISTRIBUTION

Based on their relative distribution, the plant species identified were grouped as dominant, codominant, frequent, occasional and rare species (Table 12) The most dominant species on all the soils were *Prosopis juliflora, Salvadora persica, Cressa cretica, Suaeda maritima and Cynodon dactylon. Prosopis cineraria, Tamarix ericoides* and *Sporobolus* constitute codominant ones. The plants noticed frequently are *Pithacellobium dulce, Zizyphus nummularia, Dichanthium annulatum* and *Eragrostis* species. Plant species like *Acacia nilotica, Albizia lebbeck, A. procera, Dendrocalamus strictus, Manilkara hexandra, Pandanus fascicularis, Salvadora oeloides, Asparagus racemosus, Heliotropium supinum, Jatropha curcas, Sphaeranthus indicus, Dactyloctenium aegyptium* and *Eulalia trispicata* are occasionally seen on moderate to high saline soils

Table 12. Relative distribution pattern of plant species on saline soils of the study area

Distribution	Plant species
Dominant	*Prosopis juliflora; Salvadora persica ; Cressa cretica ; Suaeda maritima; Aleuropus lagopoides ; Cynodon dactylon*
Codominant	*Prosopis cineraria; Tamarix ericoides; Sporobolus* spp.
Frequent	*Pithacellobium dulce; Zizyphus nummularia; Dichanthium annulatum ; Eragrostis* spp.
Occasional	*Acacia nilotica; Albizia lebbeck; Albizia procera ; Manilkara hexandra; Dendrocalamus strictus; Pandanus fascicularis; Salvadora oleoides; Asparagus racemosus;Heliotropium supinum; Jatropha curcas; Sphaeranthus indicus; Eulalia trispicata; Dactyloctenium aegyptium*
Rare	*Aegle marmelos; Ailanthus excelsa; Azadirachta indica; Derris indica; Diospyros cordifolia; Sapindus laurifolius; Tamarindus indicus; Zizyphus mauritiana; Ammania baccifera; Argemone mexicana; Boerhavia diffusa; Caesulia axillaris; Cassia auriculata; Chenopodium album; Digera muricata*

7. MEDICINAL PLANTS AND THEIR USES

Personal contacts with the local populace and the available recorded information revealed medicinal properties in the flora of the area surveyed. Uses of such plants with medicinal qualities are as follows In a few plants, latex/sap, bark and fruits have medicinal value. Among the plants with medicinal properties *Albizia lebbeck, Azadirachta indica, Derris indica, Feronia limonia, Sapindus laurifolius, Holoptelia integrifolia, Tamarindus indicus, Argemone mexicana* and *Jatropha curcas* were found growing on saline soils.

Table 13. Important medicinal plants and their uses in the surveyed area

Plant species	Plant part	Medicinal uses
TREES		
Aegle marmelos	Unripe fruits	Warmed pulp is mixed with butter milk and the paste is applied on the forehead to get cooling effect.
Albizia lebbeck	Bark powder	Mixed in unboiled milk of black goat along with garlic, pepper and turmeric and the filtered juice is given for curing rheumatic pains and for epileptic convulsion.
Artocarpus integrifolia	Milky juice	Antidote for dog bite
Azadirachta indica	Seed oil	Used as hair tonic
	Bark powder	Soaked in water overnight, mixed with sugar and taken as a beverage of cooling effect.
	Leaf paste	Mashed with turmeric powder and applied to cure skin diseases and chicken pox.
Butea monosperma	Root(crushed)	Applied for stomach aches on the reverse side of the pain
	Dried leaves	Burn the leaves on fire and inhalation of the fumes gives relief from head aches.

Plant species	Plant part	Medicinal use
Cocos nucifera	Sap (toddy)	Cooling beverage (fresh)
Citrus aurantifolia	Fruit juice	Mixed with freshly obtained milk and for control of dysentery.
Delonix elata	Leaf	Leaf decoction is mixed with tamarind for rheumatism and also used as a purgative.
Derris indica	Bark(pounded)	When given along with ginger improves digestion in cattle.
Erythrina indica	Leaf paste	For wound healing in cattle
Ficus bengalensis	Latex	For curing dullness and fever in children.
Feronia limonia	Fruit	Checks diarrhoea and dysentery.
Holoptelia integrifolia	Tender leaves	Mashed with leaf of *Gmelina asiatica* and *Leucas aspera* and mixed with garlics, cumin and pepper for control of chronic bronchitis in cattle.
Mangifera indica	Seed kernel	Paste for curing ring worm infection.
Moringa oleifera	Bark powder	Antidote for venomous bites and to cure boils.
Musa paradasiaca	Leaf sheath	Juice for dysentary and diarrhoea.
Phoenix sylvestris	Fresh leaves	Poultice from fresh leaves and pith from top of the stem used in beverage preparation.

Plant species	Plant part	Medicinal use
Sapindus laurifolius	Fruit juice	Antidote for poisonous substances like endrin.
Sesbania grandiflora	Leaf juice	For angular stomatitis.
Syzygium cumini	Bark	Decoction for cleaning wounds.
Tamarindus indicus	Fruit pulp	Mixed with lime juice for controlling muscle swellings
	Leaves	Crushed leaves are mixed with fresh cow dung for rheumatic pains.
HERBS/SHRUBS		
Abrus precatorius	Leaf Poultice	Antidote for scorpion bite
Achyranthus aspera	Leaf	Leaf juice is mixed with dry ginger paste and applied to eye injuries of cattle
Argemone mexicana	Yellow Latex	Applied externally as an antisceptic for healing the wounds and also for boils.
Basella rubra	Leaf	Leaf curry used for angular stomatitis
Calotropis gigantea	Leaf	Warmed leaves are used as bandage on the painful area of the body to cure rheumatic joint pains and swellings
	Latex	Latex is applied around the thumb nails and legs for getting immediate relief from the burning sensation while urinating
	Flower buds	Flower buds and turmeric powder are mashed with butter milk and the paste is applied for healing wounds

Plant species	Plant part	Medicinal use
Capparis sepiaria	Bark powder	Bark powder is mixed with garlics, pepper and palm gaggery for rheumatic pains.
Clerodendron inerme	Stem sap	Resinous sap from the young stems for healing wounds
	Leaf juice	Leaf juice is applied externally and also consumed to cure scabies
Coccinia indica	Leaf	Leaf juice is mixed with salt and breast milk for eye diseases
Commelina benghalensis	Leaf	Leaf poultice is mixed with turmeric powder and applied on boils for healing
Dodonea viscosa	Leaf	Leaf paste with turmeric powder and salt is used for swellings and bone fractures
Eclipta alba	Leaf	Curry prepared from leaves of this species and *Phyla nudiflora* increases appetite in children.Leaf juice is used as an antisceptic. Leaf powder is used for cleaning teeth in case of spongy gums.
Euphorbia pulcherrima	Leaf	Leaves are warmed with castor oil and then mashed with tamarind, chillies and common salt and given as purgative for curing rheumatic joint pains.
Hemidesmus indiccus	Roots	Cooling beverage Roots are soaked in coconut oil and used as hair tonic

Plant species	Plant part	Medicinal use
Hibiscus cannabinus	Leaves	Boiled leaves, turmeric and salt are made into a paste on boils for opening and healing
Ipomoea obscura	Leaf	Leaf juice is given in children for coughs. Leaf paste is applied on boils for opening.
Jatropha curcas	Stem sap	Sap from the stem apex is used for gargling to contain tooth ache and to cure angular stomatitis.
Justicia prostrata	Leaf	Leaves are curshed and applied for dental caries.
Leucas aspera	Leaf	Leaf juice is mixed with turmeric powder and lime and applied externally around the throat for tonsilitis.
Leptadenia reticulata	Latex	Latex from the stem apex is used as nasal stimulant for releif from cold.
Ocimum basilicum	Leaf	Leaf juice is applied in drops for control of pains in the ear.
Ocimum sanctum	Leaf	Leaf juice mixed with cumin is taken for control of coughs.
Phaseolus trilobus	Leaf Poultice	Antidote for scorpion stings.
Pedalium murex	Leaf	Leaf juice mixed with sugar or *khandsari* and pepper is taken to cure sexually transmitted diseases.

Plant species	Plant part	Medicinal use
Pergularia daemia	Leaf	Juice is mixed with turmeric and salt for common colds and fever.
Solanum xanthocarpum	Fruits	Unripe fruits are fried with gingelley oil and the chutney prepared is good for coughs.
Tephrosea purpurea	Root	Roots chewed for stomach pains and poisonous bites.
Trachyspermum ammi	Seeds	Inhaling smoke of burning seeds gives soar throat relief.
Tridax procumbens	Leaf	Leaf juice is used for healing wounds.
Typha angustata	Rhizome	Rhizomes are sliced and soaked in water and mixed with butter milk and used as a cooling beverage.
Zingiber officinale	Root	Root stock tubers are crushed with other ingredients and given into the stomach of the cattle to improve digestion.

8. FODDER TREES

The agricultural economy in the country has to face the national challenge of meeting the food requirements of the population which continue to be on a rising trend year after year. The cattle population which supplements the nutritive deficiencies of the human beings also has to be provided with feed and fodder for their sustenance. Farmers prefer cash croops, cereals etc. to fodder crops due to higher returns they gain out of their lands. There is little room for further expansion of the available agricultural lands for forage production. The alternative source

Table 14. Fodder quality and crude protein content in leaves of some fodder trees from saline soils.

Plant species	Fodder Quality	Crude Protein (%)
SLIGHTLY SALINE		
Acacia catechu	Good	130.0-18.7
Aeglemarmelos	Excellent	15.0
Ailanthus excelsa	Excellent	19.8
Bauhinia variegata	Excellent	41.4.49.8
Diospyros melanoxylon	Medium	7.1
Ficus glomerata	Good	11.1-15.2
Holoptelia integrifolia	Good	13.7
MODERATELY SALINE		
Azadirachta indica	Good	12.4-18.3
Derris indica	Medium	11.6
Leucaena leucocephala	Good	24.2
Morus alba	Good	15.0-27.0
Prosopis cineraria	Good	15.2
Syzygium cumini	Medium	8.4
Tamarindus indicus	Good	13.5
HIGHLY SALINE		
Acacia nilotica	Excellent	5.0
Albizia lebbeck	Good	16.8-26.5
Zizyphus mauritiana	Good	15.0
VERY HIGHLY SALINE		
Prosopis juliflora	Good	-

Slightly Saline : 1.0- 2.0 dS/m; Moderately Saline : 2.0- 4.0 dS/m;
Highly Saline : 4.0- 10.0 dS/m; Very highl Saline: 10.0-38.0 dS/m.
Salinity levels are given from our observations
Source : Singh (1985)

of lands in those areas are lying barren as have mentioned in the beginning, but here again the farmers are inclined to accept only those technologies which could augment food production from the other-wise non-productive lands.

In order to circumvent the situation there is a need to identify plants with fodder value or alternative forage plants particularly those requiring least land are and could withstand the stress conditions of the wastelands. Tree species which could be exploited to meet the requirements are of great significance in this context.

Trees produce more green fodder per unit area compared to agricultural crops. Moreover, some of the tree species could grow under the existing adverse conditions of salinity and waterlogging on marginal lands, where arable crops could least survive. The ability of trees to absorb water from deeper horizons to withstand drought stress situations is another advantage in preferring tree species over agricultural crops on marginal lands. In addition to providing leaf fodder, they also provide fuel wood to meet to a certain extent the energy requirements of the rural population. Tree species which have been identified as a good source of fodder are listed in Table 14.

Foliage of *Acacia nilotica, Aegle marmelos, Azadirachta indica, Bauhinia variegata, Butea monosperma, Cordia dichotoma, Ficus* species, *Hardwickia binata, Holoptelia intergrifolia, Lagerstroemia parviflora, Leucaena leucocephala, Melia azadirach , Moringa oleifera, Morus alba, Prosopis cineraria, Tamarindus indicus and Terminelia arjuna* have been reported as good to excelent fodder sources. Majority of the species indicated have good nutritive value with crude protein content between 11 to 27 per cent. *Bauhinia variegata* containing 40 to 50 per cent crude protein is a good fodder. Other species like *Adina cordifalia, Diospyros melanaxylon, Madhuca indica, Syzygium cumini and Mangifera indica* are reported to be of moderate fodder value. The crude protein content in these varies from 8 to 11 per cent. Some of the tree species with good fodder qualities which could grow on saline soils have been listed in Table 5.

9. PLANT SPECIES FOR SALINE SOILS

Salt tolerant plants can withstand conditions otherwise considered unfavourable for normal crop production. Plant species that have economic potential for being introduced on deteriorated lands are discussed below.

Salt tolerant fruit species like *Carica papaya, Manilkara hexandra, Punica granatum, Phoenix dactylifer, Pithacellobium dulce and Zizyphus mauritiana* appear to grow well on saline soils. Berries of *Salvadora persica* are edible and this species was found growing well on very highly saline soils in Bhal region. *Pennisetum typhoides* (pearl millet) has been found to perform well even when sea water with EC_2 of 216.6 to 37 5 dS/ m was used for irrigation (Iyengar, 1980). Herbs like *Suaeda maritima* and *Asparagus racemosus* also thrive on saline soils with shallow ground water.

9.1 FUELWOOD SPECIES

Marginal or degraded lands can be better utilized for growing salt tolerant fuelwood tree. Fuelwood plantations established on saline soils or irrigated with saline water would allow more fertile lands and fresh water to be reserved for food or forage production.

Plantation of tree species like *Acacia nilotica, Albizia lebbeck, Cassia siamea, Casuarina equisetifolia, Prosopis juliflora, Azadirachta indica, Holoptelia integrifolia, Tamarix ericoides, Pithacellobium dulce* and *Cassia auriculata* on saline soils will not only help in rehabilitation of degraded lands by establishing the ecosystem and also will supplement to the fuelwood needs.

9.2 FODDER CROPS

Forage trees and shrubs are valuable components of grazing lands and they could also be complementary nutrient sources to grasses in arid and semi arid regions. Species like *Acacia nilotica, Albizia lebbeck, Azadirachta indica, Leuceaena leucocephala, Pithacellobium dulce, Prosopis juliflora, Prosopis cineraria and Salvadora persica* form good fodder source on saline soils.

In arid and semi-arid regions, trees and shrubs have several advantages over grasses since they are generally less susceptible than grasses to seasonal variations in avaialability of moisture. Though less palatable than grasses, they could form the supplementary fodder sources. Among shrubs, *Suaeda maritima, Atriplex species, Leptochloa fusca, Dichanthium annulatum, Cynodon dactylon* and *Erogrostis* show great promise as fodder.

9.3 OTHER PRODUCTS

Salt tolerant plants also produce economically important extracts like gums, resins, flavours, fragrances, pharmeaceutical base materials, fibers etc. *Pandanus fascicularis* is the natural source of Kewada water, perfumes and flavouring ingredient. Fibre is obtained from plants like *Hibiscus cannabinus, Agave americana, Sesbania bispinosa* etc. which grow on saline soils. Seeds of *Sesbania bispinosa,* which is also an important legume and green manure crop, forms good source of glactomannan gum used for sizing and stabilizing applications Seeds of *Salvadora persica,* a highly tolerant plant yields oil which is rich in lauric and myristic acids and is used in detergent industry. Seed oil from *Derris indica* (Pongamia) is used for leather treatment and soap making. The active ingredient of the seed, Karanjan, possesses antibacterial and insecticidal properties.

Neem oil, extracted from *Azadirachta indica* (neem tree), a moderately salt tolerant plant, is traditionally used in soap making. Seed extracts are used as antifeedants and pesticides and are noin-toxic to humans and animals. Extracts of *Adhatoda vasica,* a salt tolerant evergreen shrub are effective as antifeedants, viricides and insecticides. Bark and leaves of this plant contains an alkaloid Visicin. Alkaloids from roots of periwinkle (*Catharanthus roseus*) are used in treatment of leukamia and to lower blood pressure.

The dried pulp of unripe and full grown fruits of *Citrullus colocynthis* constitutes a drug called Colocynth, which is used as a catharact. Plant species like *Agave americana, Derris indica, Eucalyptus spp., Parkinsonia aculeata, Pithacellobium dulce* and *Prosopis cineraria* are good sources of by-products like honey in addition to various other uses already discussed.

10. FUTURE RESEARCH NEEDS

Significant research on identification and development of salt tolerant species with varying economic utilities could, with appropriate crop management strategies result in large scale vegetation of salt affected soils. The present study indicates that some undomesticated plant species possess greater salt tolerance and show better survival and agronomic qualities, which need to be further tried to develop new suitable lines. Such species are need to be domesticated and exploited for their potential uses.

Exploration of new plant species need to be continued to identify candidates for further economic development. The basic information on the mechanism of salt tolerance of such plant species need to be generated.

Salvadora perisca, a perennial tree or shrub, an alternative source of non-edible oil, is one of the predominant species which grows well on highly saline soils. Its seed contains about 40 per cent oil, which can be used in soap making. Attempts are underway to grow this species on salt affected black soils as a source of non-edible oil, fodder and fuel, wnich could alternatively contibute in restoring the ecosystem. Emphasis need be given to grow salt tolerant forage grasses and fodder trees. Efforts are also needed to grow tolerant plants which could act as good sources of food, medicines, oils, bioactive derivatives etc.

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