WASTELAND MAPPING PROJECT PHASE - V

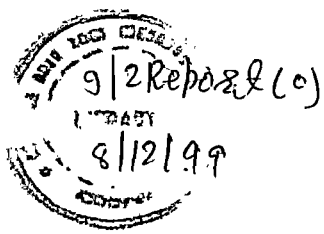
WASTELANDS IN BIKANER DISTRICT, RAJASTHAN

GHEESA LAL

DIVISION OF NATURAL RESOURCES AND ENVIRONMENT
CENTRAL ARID ZONE RESEARCH INSTITUTE (ICAR)
JODHPUR-342 003
1999

WASTELANDS IN BIKANER DISTRICT, RAJASTHAN

GHEESA LAL



DIVISION OF NATURAL RESOURCES AND ENVIRONMENT
CENTRAL ARID ZONE RESEARCH INSTITUTE (ICAR)
JODHPUR-342 003
1999

CONTRIBUTORS

PROJECT LEADER	BALAK RAM
ASSOCIATE	GHEESA LAL
TECHNICAL SUPPORT	A.R. MALAKAR J.S. CHAUHAN BAJRANG LAL PRAJAPATI SUMER SINGH GEHLOT
CONSULTANT	SURENDRA SINGH

FOREWORD

The hot arid ecosystem has inherent constraints due to unfavourable climatic conditions and fragile natural resources. Besides, the unprecedented growth of human and livestock population have resulted in over-exploitation and misuse of land and water resources. This has intensified land degradation and desertification processes. In order to save these lands from further degradation and put them in sustainable production system, proper assessment and mapping is must. The availability of high resolution, multidate and repetitive satellite data and GIS technology has made this task very easy and quick with high accuracy.

The CAZRI, since its inception has been engaged in integrated appraisal and mapping of natural resources and evolving technologies for their sustainable use. The Department of Space, Government of India, realising the capability, have identified CAZRI as an important work centre and involved in their prestigious projects like wasteland mapping, landuse/land cover mapping and Integrated Mission for Sustainable Development (IMSD). Under Phase-V of this programme the task of Wasteland Mapping of Hanumangarh and Bikaner districts were assigned to CAZRI. Waterlogging salinization and sand drift are major problems of the Bikaner district and their impact analysis is essential. This timely and much needed study has been carried out on 1:50,000 scale and digital (vector) data have been created under GIS environment in the line of Natural Resources Information System (NRIS).

It is hoped that the data base created in the project and development techniques suggested for rehabilitation of wastelands will be useful for planners and decision makers for their sustainable development.

28.5.99

JODHPUR
May28, 1999

A.S. FARODA
Director

PREFACE

Wastelands constitute nearly 22.98 per cent of the total geographical area of our country. In arid Rajasthan, about 35 per cent area is occupied by such degraded and desertified lands. This accounts for 9.7 per cent of country's total wastelands. For rehabilitation and sustainable development, identification, mapping and characterisation of wastelands is a pre-requisite. The widespectrum capability of Remote Sensing and GIS technology had now made it possible to create uptodate natural resources spatial and non spatial database accurately, efficiently as well as time and cost effective.

Realising the need, the Department of Space, Govt. of India has launched Wasteland Mapping Project in the year 1986. Under Phase-V of this programme it is planned to complete wasteland mapping of 192 districts of the country. Present study is a part of this programme. It is an endeavour to carry out wasteland mapping of Bikaner district on 1:50,000 scale and creation of digital (vector) data base under GIS environment. The present status, characteristics, spatial distribution and environmental impact of different categories of wastelands are discussed. For rehabilitation and development of such degraded and problematic lands suitable technologies have also been suggested.

We are highly grateful to Dr. N.C. Gautam, Group Director, NRSA for giving opportunity to undertake this study. Dr. R. Nagaraja, Head, LUS and Dr. Ravishankar have constantly monitored the progress of the project work and extended guidance for which we are highly thankful. Dr. J.R. Sharma, Project Director and Head, RRSSC, Jodhpur deserve our special thanks for sustained cooperation and for carrying out quality assessment of thematic maps and GIS output.

The Collector, Bikaner and other district officials have made available valuable secondary data and suggestions. Sincere thanks are placed on record for their generous help.

Dr. A.S. Faroda, Director, CAZRI has taken keen interest and has been prime source of encouragement and guidance for which we owe a debt of gratitude. We are extremely grateful to Er. M.A. Khan (ex-Head) and Dr. I.C. Gupta (present Head) of Division of NRE for providing all the facilities and to CP Cell for processing this project.

The Divisional staff, Photography team, Drivers, Technical, Supporting and other staff members have always helped and substantially contributed to complete the task in time and hence deserve our appreciation and thanks.

BALAK RAM
GHEESA LAL

1. INTRODUCTION

The Wasteland Development Board, Government of India, recently felt the need to have an upto date information and maps of our country on wastelands, their statistics and their different wasteland categories on district level for development planning. For this purpose, the Department of Space (NRSA), Govt. of India was entrusted with this responsibility to complete the semi-detailed district level wasteland mapping using remotely sensed data on 1:50,000 scale for the entire country. Under Phase V of this programme, the wasteland mapping of 192 districts of the country is to be completed. The wasteland mapping of Bikaner district of Rajasthan which is lying in the region no.6 and basin no. D, C and B and located in the agro-climatic zone XIV of arid zone of western Rajasthan, has been done by Central Arid Zone Research Institute, Jodhpur of the Indian Council of Agricultural Research. The study was done with the help of geo-coded IRS LISS II and III data of January and October 1998 and Survey of India topographical maps on 1:50,000 scale supported with limited sample checking and available existing resource inventories like land revenue records and forest data collected from DFO Bikaner. The maps have been digitized, digital (vector) data base has been created under GIS environment and final statistics have been generated on CD, hard copy transparent film.

Bikaner district, the north-western district of arid zone of Rajasthan (falling in the zone of rainfall 300-180 mm and below) is characterised by hostile climate, sandy and duny lands, meagre surface and groundwater resources, poor carrying capacity of land and low production. Under such adverse situations the wasteland mapping based on IRS data will provide a scientific approach for classification of wastelands and to know their status of degradation and will generate valuable data on wastelands. The technologies and preventive measures are also suggested for improvement, rehabilitation and development of different categories of wastelands.

2. STUDY AREA

Bikaner district lies in the north-west of Rajasthan in the heart of 'Thar' desert. The district in the west extends upto the international boundary with Cholistan district of Pakistan and on the north, east and south, it is bounded by district of Ganganagar, Churu, Nagaur, Jodhpur and Jaisalmer. The district is situated between the latitude 27°11' to 29°03' north and longitude 71°54' to 74°12' east comprising a total area of 27,244 sq km. The district is covered with 60 SOI topographical sheets on 1:50,000 scale of which effective coverage are 49 (Fig. 1 and Table 4). It accommodates about 12,11,140 (729998 rural and 481142 urban) people in its four tehsils (6,42,555 male and 5,68,590 female) viz., Bikaner, Nokha, Kolayat and Lunkaransar which is 2.8 per cent of the state population with a density of population 44 persons per sq km as per 1991 census. The urban population

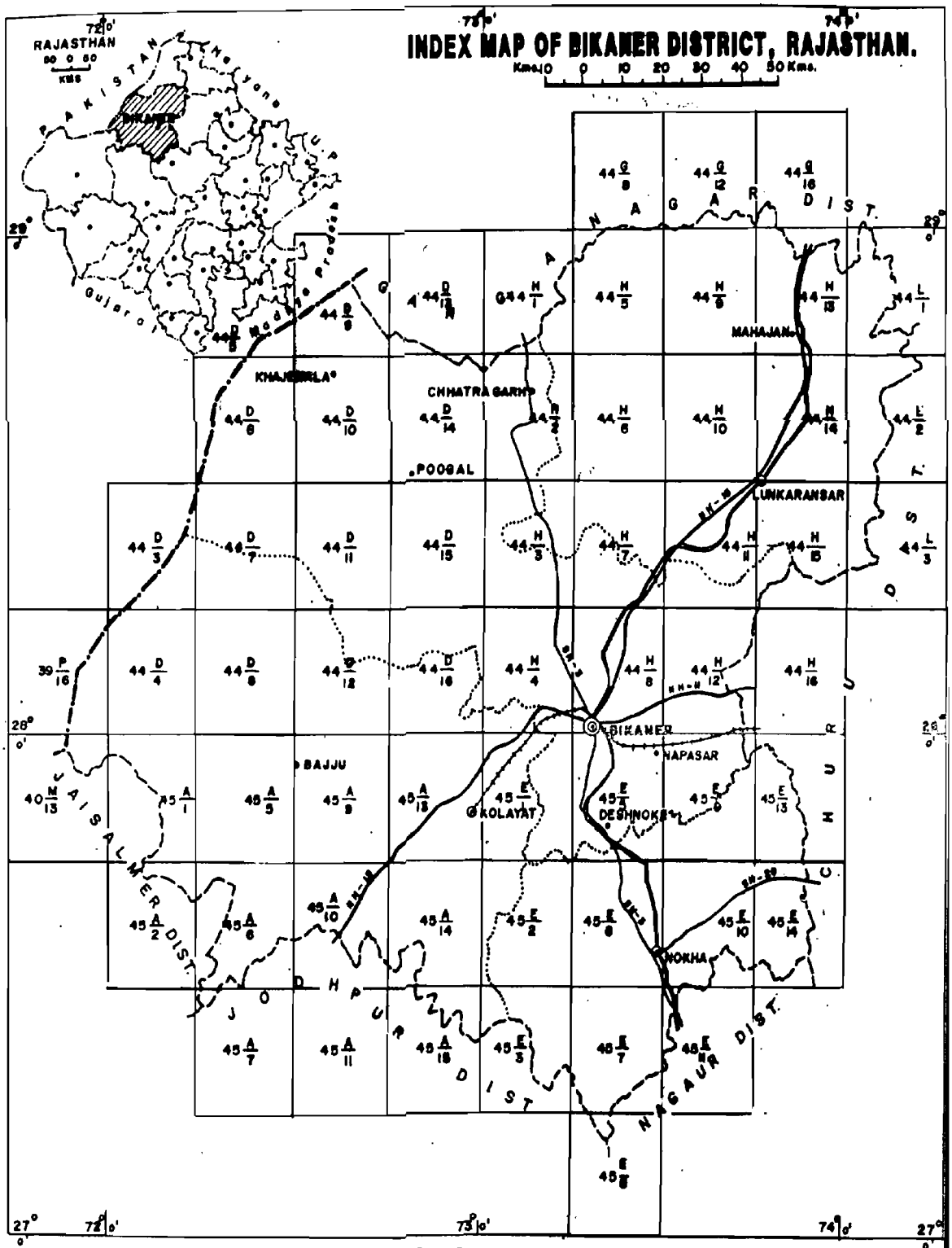

INDEX MAP OF BIKANER DISTRICT, RAJASTHAN.
Kms. 0 10 20 30 40 50 Kms.
RAJASTHAN
50 0 50
Kms
PAKISTAN
HARYANA
U.P.
Gujarat
M.P.
GANGANAGAR DIST.
HANUMANGARH
MAHAJAN
KHAJUWALA
CHHATRAGARH
POOGAL
LUNKARANSAR
BIKANER
NAPASAR
BAJJU
KOLAYAT
DESHNOKE
NOKHA
JAISALMER DIST.
JODHPUR DIST.
NAGAUR DIST.
NH-15
NH-11
NH-65
NH-89
72° 0'
73° 0'
74° 0'
29°
28°
27°

FIG. 1.

constitute 39.7 per cent concentrated in seven towns viz., Bikaner, Napasar, Gangashahar, Deshnokh, Kolayat, Lunkaransar and Nokha while rural population comprises 60.3 per cent lives in 580 inhabited villages in the district while 67 villages are uninhabited. The 86.8 per cent population is based on agriculture while remaining 13.2 per cent people engaged in other works like, government service, industries and other household industries. Total livestock in the district as per 1992 livestock census are 25,31,365 which provides better opportunity to the people for their enhancement of economic condition.

3. GEOGRAPHICAL DESCRIPTION

The western, south western, northern and north eastern part of the district are largely covered with dunes of different types and magnitude with flat to undulating interdunal plains. The central, eastern and southern parts of the district constitute largely the flat and undulating aggraded alluvial plains. There are no hills, and no rivulets or streams of any significance. Small ephemeral streams flow in the vicinity of Kolayat and Gajner. Natural inland depressions which retain some water during the summer are located near Lunkaransar, Kolayat, Jamsar and Nal. The general elevation of the district plain varies between 152 to 300 metres above mean sea level sloping generally towards north-west. The sand dunes, range in height from 6 to 45 metres, suggesting the ribbed appearance of a seashore. Construction of Indira Gandhi canal in its western parts had led to activation of the stable dune field to a large extent. The migrating sand is, however, threatening the canals and roads, besides spreading eastwards. At places salinity hazards and undesirable rise of water table are also developing in the canal command area.

3.1 CLIMATE

Climate of the district ranges from arid in the east to extremely arid in the west and is characterised by large extremes of temperature, erratic and low rainfall with high evaporation. The mean annual rainfall of the district is 247 mm varying from 300 mm in the east to 180 mm in the west bordering Pakistan. The bulk of rainfall occurs from June to September, maximum occurring in the month of August. The usual onset of active monsoon is in the month of July. The rainfall variability in the district from year to year is high and standard deviation from normal annual exceeds 100 mm particularly at all stations with coefficient of variability ranging from 50 to 65% for different recording stations.

Winter temperatures in the district are fairly low and there is a probability of frost occurrence once in the three years and sometimes temperature come down to -2° in the month of January.

High temperatures in the district starts from April onward and May and June are the hottest months of the year. During this period, dry hot winds and dust storms occur frequently. From April to June temperatures exceed 40°C in most of the years and in some years temperature above 47°C have been recorded. The wind regime during the hot months is from the direction of west and south-west and wind speeds increase from average of 6.5 km/h in March to 13.5 km/h in June.

With the onset of monsoon in late June or early July, the day temperatures fall to 38°C in July to 36°C in August and September. The diurnal variation in the temperature during the season is about 10°C. Wind direction during monsoon is mainly from south westerly direction with mean speeds decreasing from 12.8 km/h in July to 9.4 km/h in September with 24 to 28% as coefficient of variability.

3.2 GEOLOGY

The district of Bikaner is a vast sandy tract. Three of its four tehsils, namely, Bikaner, Lunkaransar mostly, Nokha and part of Kolayat are covered with sand. Rocks locally known as Magra are found in the south-western portion of the district, which is part of Kolayat tehsil. In other parts of the district, sand layer has been found while digging extensive and deep wells upto a depth of 45 metres. In the hard or the Magra area, various types of sand stone, clay and lime stone have been revealed at different levels. At a depth of 32 m horizontal beds of various rocks belonging to the Eocene age have been found which shows that this area was subjected to sedimentation of sand stones for a pretty long time. Similar sedimentary formations of the same age have been found in the south-western part of Pakistan also. The geological formations of Eocene age are well represented in the neighbourhood of Bikaner city. The strata consists of thick white and buff lime stones and shales. Lignite and beds of fuller's earth occur in these formations.

3.3 SOILS

Soils of the district are predominantly light textured, weak structured and well drained. Soil distribution in the district is related to landforms. Moderately deep to very deep, loamy sands, sandy loam and loam soils occur on the flat aggraded older alluvial plains and flat interdunal plains. Deep to very deep, fine sandy to fine loamy sand occur on the undulating sandy aggraded older alluvial plains and undulating interdunal plains and very deep fine sands on the dunes. All the soils are calcareous, amount of calcium carbonate increases with depth merging at lower depths with lime concretionary zone particularly in the flat aggraded older alluvial plains and the flat interdunal plains. The arid climate in the district has resulted largely in physical weathering of parent material giving rise to more of coarse fraction than fine clay material in the soils.

3.4 VEGETATION

The vegetation of Bikaner district falls under the natural division of deciduous forest. The trees and bushes which grow there are insufficient even to fulfil the local requirements for construction of houses, making agricultural implements and for fuel purposes. The most common tree found in the district is khejri (*Prosopis cineraria*). Other trees are : rohira (*Tecomella undulata*), ber (*Ziziphus jujube*) and jal or pilu (*Salvadora oleoides*). Some other trees found on embankments in the vicinity of tanks or in the gardens are shisham (*Dalbergia sissoo*), ber (*Ficus bengalensis*), pipal (*Ficus religiosa*), siris (*Albizzia lebbek*), etc. Among the shrubs found in the region mention may be made of aak (*Calotropis procera*), jhar beri (*Ziziphus nummularia*), phog (*Calligonum polygonoides*), bui (*Aerva pseudotomentosa*), pala (*Ziziphus rotundifolia*) and ker (*Capparis decidua*) while in some scattered pockets hiloxlon is also available in sufficient quantity. The grass community which is prevalent in the district are *Lasiurus sindicus, Panicum turgidum* and *Cenchrus barbatus*, etc. and are available throughout the district. The saline depressions and saline interdunal areas are dominated by halophytic scrub vegetation with *Sporobolus marginatus-Eleusine compressa* as grass community.

4. DATA USED

The study of wasteland mapping was conducted with the help of geo-coded IRS-LISS-II and LISS-III False Colour Composite (FCC) data of January 1998 and October 1998, Survey of India topographical maps of 1:50,000 scale and supported with limited ground truth collection. Beside this, available and existing resource inventories like Land Revenue Record data which were collected from district headquarters and forest data collected from DFO, Bikaner. Administrative boundaries like district, tehsil and village boundaries, their village names and code numbers were incorporated from the district census handbook of Bikaner district 1991. The major roads like National Highway, State Highway and other important roads which are connecting the medium to big size of villages are also taken from the district road map from PWD. The Watershed Atlas of India was used for taking the boundaries of region, basin, catchments and sub-catchments and further mini and micro watershed boundaries are delineated taking into account the slope, elevation and local heights provided in the SOI topographical maps. The final data and statistics generated through the GIS as per detailed methodology given in Wasteland Manual prepared by NRSA.

FLOW CHART FOR GENERATING DIGTAL DATA BASE FOR WASTELANT USING VISUAL INTERPRETATION TECHNIQUES

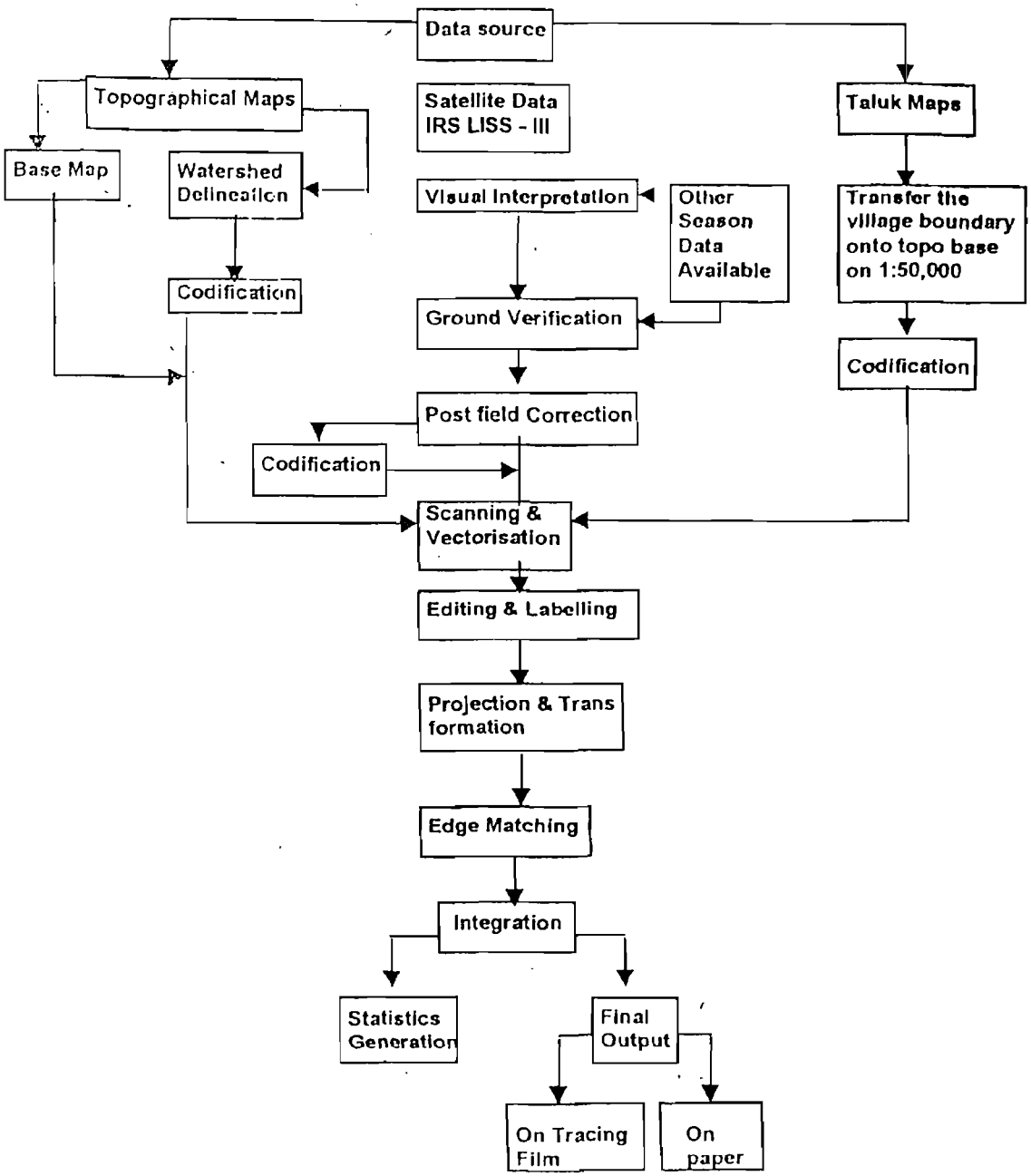


FIG. 2 : Visual Methodology

5. METHODOLOGY

Wasteland mapping of Bikaner district was carried out by visual interpretation and GIS techniques as described in the Manual of Procedure for Preparation of Wasteland Digital Data Base using Remote Sensing and GIS Techniques (1997). False Colour Composite (FCC) on 1:50,000 scale made from IRS-LISS-II and LISS-III, combined bands 2, 3 and 4 February 1997, January 1998, October 1998, and SOI Topographical Maps on 1:50,000 scales were used as base material to prepare the toposheet wise wasteland maps for the year 1998. Study is more based on shape, size, tone, texture and pattern of the different wasteland categories. The spatial distribution and extent of each wasteland categories are shown in the maps and their area statistics generated through the GIS output. Bikaner district covering 49 effective coverage on 1:50,000 scale were prepared in four layers i.e. wasteland layer, base layer, administrative layer and watershed layer. Therefore, the final maps have the detailed wasteland informations. The base details are taken from SOI topographical sheets and village boundaries from district census handbook of 1991 and codified. The region, basin and catchment boundaries were delineated and codified as per Watershed Atlas of India. Based on terrain and heights micro and mini watersheds were also delineated. The ground truth information of query points of all representing categories were recorded and field photographs were also taken. The land revenue record data were also collected from district headquarters, Bikaner.

The data base including digitizing, editing, labelling, projection and transformation, edge matching, overlaying and statistics generation, boundaries of watersheds and their types and also provided the administrative layer on 49 coverage through the ARC/INFO GIS system. The flow chart for generating digital data base for wasteland mapping given in Manual of Wasteland Mapping (1997) was followed in complete GIS system (Fig. 2).

6. CATEGORYWISE SPATIAL DISTRIBUTION OF WASTELANDS

The statistics generated through the GIS reflects that largest area among all the major wasteland categories has been mapped under sand desertic (sandy waste) i.e. 10.01% followed by land with or without scrub, degraded pastures/grazing land, under utilised/degraded forest land, gullied land, waterlogged land, mining wasteland and land affected by salinity which covers 8.23%, 2.47%, 0.29%, 0.27%, 0.13%, 0.05% and 0.01% of the total district area, respectively. The area under different wasteland categories are given in Table 1, 2 and Fig. 3.

Distribution of Wastelands in Bikaner District

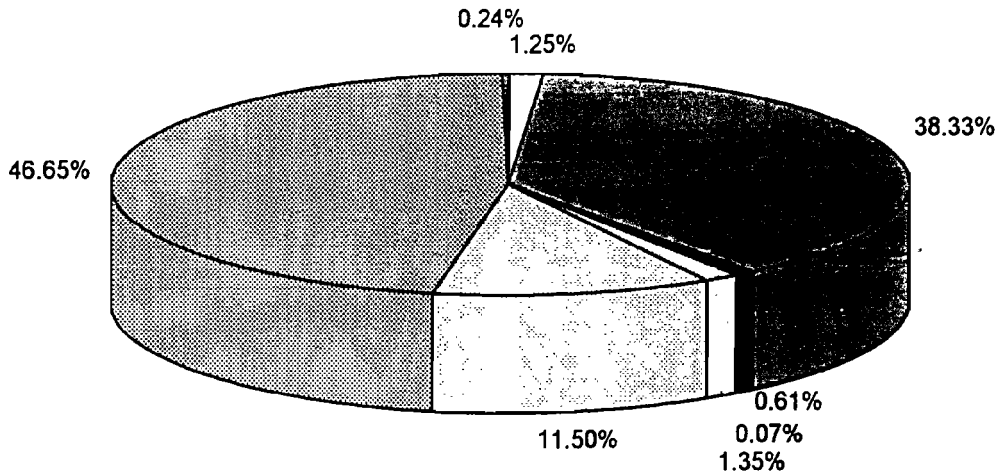


Fig. 3

The detailed wasteland statistics of the district for the year 1997-98 is given in Table 2 and their spatial distribution has been shown on 49 coverage of 1:50,000 scale attached with the report. Watershed-wise distribution of wastelands is given in Table 3. Brief description of the wasteland categories and their characteristics are as under.

6.1 GULLIED LANDS (Plate 1 and 2)

This category of wastelands covers 0.27% of the total geographical and 2.16% of the total wastelands. It occurred mostly around Kolayat upland and gravelly region where there are only a few small rock outcrops of vindhyan sandstone of about 1-2 metres height in the region. Few local short intermittent and ephemeral channels originated and have formed the gullies in the north-east of Bithnok, north of Madhogarh and west of Kotri area. The land has been incised by water into gullies of different depth and width. The large areas around Mal, Gajner and Kolayat which is aggraded older alluvial plain and eroded rocky and gravelly surface of Kolayat upland region and have potential getting runoff into Kolayat and Gajner tank and in some depressional areas where gullies are formed as a result of localised surface runoff has affected the unconsolidated material resulting in the formation of perceptible channels and caused undulating terrain. Around Kolayat and Golri area at some places murram, fuller's earth and soft white stones are also mined which are locally used for making limestone and for house building material. Vegetations are very sparse and occur along runnets and pockets of soil accumulation. *Prosopis juliflora, Acacia tortilis, Capparis decidua, Calotropis procera, Tephrosia purpurea* and *Grewia tenax* form the sparse vegetation community. Grasses are very poor due to hard surface, shallow soil and low rainfall.

6.2 LAND WITH OR WITHOUT SCRUB (Plate 3 and 4)

This category of wastelands constitutes about 8.23% of the district and 38.33% of the total wasteland area. Without scrub part of this category is more associated with upland, gravelly and shallow soil lands which are devoid of vegetation. The lands with scrub have been mapped in hummocky areas, sandy undulating terrain and in stabilised high dunes where density of vegetation or scrub is high. Such type of lands occur near Kolayat towards north of National Highway, north of Pitharon ki Dhani, around Nokhra, north of Navagaon, south-west of Diyatra, north of Gura and south of Khari Charna in a gravelly areas. Largest pocket of this category with scrub have been delineated in west of Mahajan village around Meusar, Hindov, Kanolai, Buala (covering 34 villages under firing range toposheet no. 44 H/5, 6, 9, 10 and 13) and other large and small scattered pockets in north-western part of the district near Tarsula Toba, Kalewa Toba and along the Pakistan border near Sasad Kund Bhagawala, north of Chhamb, south of Bithnok, Shekhawali ki Dhani, south and east of Deli, east of Chhilan, Gulam Aliwala and around Randhisar. Gravelly and shallow soil areas are mostly without scrub, dunes

and sandy undulating areas are having some vegetations and scrubs like *Capparis decidua, Crotalaria burhia, Calotropis procera, Calligonum polygonoides, Zizyphus nummularia, Acacia jacquemontii, Aerva pseudotomentosa, Leptadenia pyrotechnica, Cenchrus biflorus, Aristida funiculata* and *Panicum turgidum* are the common bushes and grasses. In this category the grass cover is very poor, otherwise it can be better utilised for grazing purposes. Low and erratic rainfall are the major constraints to develop this land into grazing lands.

6.3 WATERLOGGED LAND (Plate 5 and 6)

This category comprises of 0.13% of the total geographical and 0.61% area of the total wastelands of the district. Two large pockets have been delineated and mapped along the main I.G. canal south of Gegra at 507 RD and west of Amarpura at 750 RD. Besides, several small pockets of this category occur along some canal distributaries i.e. south-east of Rawatwali Dhani and east of Chhamb area. At RD 507 and RD 750 the excess water of canal has been drained out through the weirs in interdunal and depressional areas to just save the canal from damage by excess overflow water. But this inunded water in interdunal and in depressional areas have created the problem of water logging. These pockets have been easily delineated from IRS data giving black tone in an irregular shape in interdunal areas. Due to gypicious hard strata stagnated water from a long period has created a problem of marshy land and salinity in fields of fringe areas and lowered the crop productivity. In near future surrounding fields may be converted into saline pockets. Before diverting the excess canal water in these interdunal areas and in depressional areas, these were good cultivated fields in kharif as well as in rabi seasons, but now these areas have been converted into water logged areas which are wastelands. Due to constant standing water several valuable trees and shrubs have been damaged and mainly mesophytic and hydrophytic species consisting of *Typha angustata, Imperata cylindrical, Arundo donax* and *Saccharum spontaneum* have come up.

6.4 LAND AFFECTED BY SALINITY (Plate 7 and 8)

This category of wastelands identified and mapped only in north of Lunkaransar and covers about 0.01% of the geographical area and 0.07% of the total wastelands of the district. It is easily identified on the imagery of LISS-III FCC of October 1998 giving in dark blue tone in rainy season due to stagnated water. This is a natural saline depression. This land is located in a depression and unproductive and bare of vegetation and looks like a whitish due to salinity in summer season. But some salt loving plants like *Prosopis juliflora, Salvadora persica* and *Sporobolus marginatus, Eleusina compressa* and some unpalatable grasses come up in the rainy season. In dry season a whitish crystal layers of salt is visible but salt extraction is uneconomic.

6.5 UNDERUTILISED/DEGRADED NOTIFIED FOREST (Plate 9 and 10)

Forest area in this district are deciduous and are highly in degraded condition because of erratic and low rainfall, extremes of temperature and high evaporation loss of moisture, converting the district into a typical arid tract. Hence, whatever plantations are done either dried up without water or has been eaten by the animals. In this category only one area has been mapped as a degraded notified forest i.e. BIR in between Udramsar, Surdhana, Godhwana and Gharisar covering an area 0.29% of the district and 1.35% of the total wastelands of Bikaner. It is in highly degraded condition having very scattered trees and bushes like *Prosopis cineraria, Zizyphus jujube, Calotropis procera* and scattered *Capparis decidua* are the common trees and bushes.

Forest Department has undertaken various departmental programmes and plantations have been done at several places like Nal, Gajner, Kolayat, along the highway Bikaner to Mahajan village these areas are not included in the notified forest. These are in highly degraded condition due to open grazing having very scattered trees and bushes like *Zizyphus jujube, Prosopis cineraria, Calotropis procera* and *Capparis decidua* are the common trees and bushes. The plantations are done along the main canal and its distributaries are flourishing well as a shelter belts but these areas have not yet been included under notified forest, and hence area under notified forest is very negligible.

6.6 DEGRADED PASTURES/GRAZING LANDS (Plate11 and 12)

This category of wastelands comprises of 2.47% of the total geographical and 11.50% of the total wastelands of the district. This category of wastelands includes the permanent pastures, *orans, agor, bir*, and land under tanks and *nadis* and roadside strip lands which are common property resources under the direct control of village panchayat or Government. Almost all the villages have the common grazing lands. The village tanks/nadis also invariable exist in these grazing lands. Due to constant and uncontrolled grazing and increasing livestock pressure these grazing lands are in highly degraded condition. Mostly this category has been delineated and mapped around the settlements, tanks and temples in the south-east part of the district having distinct boundaries and light red tone of October imagery and at some places give light whitish tone on the IRS data due to its degradation. The pressure of livestock population is very high and carrying capacity of this land is very low.

These lands are distributed throughout the district in small to large in size because every villages have some area under common pasture lands. Large pockets of this category occur in villages like Deshnokh, Jajju, Hadda, Akasar, Bholasar, Uditpur, Lakhansar, Bikanpur, Gariyala, Gura, Kolayat, Khari-Charna, Girajsar, around Gangapura, north of Sevra, Kalu, Kalasar, west of Bikaner city, Shobhasar, Jaimalsar, Karnisar, Sarunda, Napasar, Himatsar and SW of Gangasahar. In rainy season only seasonal grasses

come up in natural way and grazed in a short period. Removal of plant cover accelerated the process of soil erosion and siltation of water tanks.

The herbaceous ground flora in the grazing lands is in extremely poor condition and is represented by lower level successional species like *Eragrostis, Oropetium thomaeum, Eleusine compressa, Panicum turgidum, Aristida funiculata, Crotalaria burhia* associated with non-palatable thorny species of *Fagonia cretica, Corchorus depressus, Tephrosia purpurea, Lepidagathis trainervis* and *Euphorbia granulata*, etc. The sparse and scanty vegetation cover of these degraded grazing lands is not adequate to meet the grazing demand of livestock population. Orans are in comparatively better condition due to their religious sanctity, but these too do not have optimum grass cover as there is no control on grazing of livestock. They are only having the stands of trees and shrubs since their cutting is prohibited.

6.7 SANDY AREA (DESERTIC) (Plate 13 and 14)

Stabilised, semi-stabilised, dissected and active sand dunes 8 to 45 m height and undulating sandy plains with high hummocks and fence line ridges where cultivation is not possible have been classified and mapped under this category. It covers largest area amongst the wasteland categories i.e. 10.01% of the geographical area and 46.65% of the total wastelands of the district. Due to higher reflectance sand dunes and sandy hummock appear in light yellowish and sometimes light greenish tone on the IRS data. Most of the lands are allotted and private property of farmers but due to low and erratic rainfall and wind velocity in the region, these lands are not cultivated. Moreover, high dunes in accessible for cultivation. Mostly, crest of the dunes are devoid of vegetation and wind erosion/deposition is the dominant hazard. Some vegetations have been observed on the low sloping side of windward side and foot of the dune in leeward side. Large pockets of this category have been mapped south of Khajewala, south of Rasubai, east of Deli, north of Bhanipura, around Aangneu, around Sunesal and north of Chhilan, while small to medium in size scattered pockets are distributed throughout the district. Common vegetation on this category are *Leptadenia pyrotechnica, Calligonum polygonoides, Acacia jacquemontii, Aerva pseudotomentosa, Crotalaria burhia, Cenchrus biflorus, Aristida funiculata* and *Panicum turgidum*, etc. The density of *Calligonum polygonoides* is declining day by day and this specie is endanger due to its large scale cutting by villagers for fuel purpose.

6.8 MINING WASTELANDS (Plate15 and 16)

This category of wastelands comprises 0.05% of the total geographical area and 0.24% of the total wastelands of the district. This category is associated with gypsum available under the shallow soil depth and earlier it was under mining but at present it is out of use. This unit has been delineated and mapped near Jamsar, south of Dhirera Railway Station and east of Utamdesar, Bharu gypsum area in north of Badrasar and east of

Kawani village. Earlier these pockets were rich in gypsum production but now this mineral is almost at finishing stage and pits and heap of residue waste materials are turned upside down and vegetation cover completely destroyed and mine spoils represent complete desertized sites in whitish tone in degraded condition with shallow soil on the imagery in interdunal flat areas. The *Acacia tortilis, Aerva pseudotomentosa, Leptadenia pyrotechnica, Cenchrus biflorus, Aristida funiculata, Crotalaria burhia* and *Fagonia cretica* are the scattered and scanty plant species in degraded condition due its lost fertility status in these pockets. Moreover, due to climatic and prevailing edaphic constraints large to small mining muck heaps are devoid of any biological activity. Actually the mining activity should start with a planning of revegetation of the spoiled site/mining dumps and their subsequent maintenance and management. In the past almost all the open mined areas were left to the mercy of nature. Low rainfall, high temperature and wind speed in summer, low water holding capacity of soil, deep and brackish/saline groundwater has further aggravated their degradation.

7. RECOMMENDATION FOR WASTELAND RECLAMATION AND MANAGEMENT

7.1 GULLIED WASTELANDS

These lands are located in gentle to moderate slope of Kolayat and Gajner upland area. The land has been incised by the water into gullies of different depth and width. For such lands, the control measures suggested including gully plugging, stream training and providing suitable vegetation cover to check the further degradation of these lands. For gully plugging grasses like *Cynodon dactylon* and *Desmostachya bipinnata*, should be grown on gully slopes and banks. Trees like *Acacia tortilis, A. senegal, Acacia nilotica* and shrubs suited to that area like *Balanites aegyptiaca, Prosopis juliflora* and *Zizyphus nummularia* should be grown. Dead wood and tings of trees may be erected at certain interval in gully to slow down of running water. Such type of plantations in the gullied lands will check the further degradation of these areas and ultimately ameliorate local environmental condition and provide fuelwood and timber resource to the local people.

7.2 LAND WITH OR WITHOUT SCRUB

The rocky/stony and gravelly upland occurs in the surrounding of Kolayat, Gajner, Nal, Khari Charna, around Randhisar, Nokhra and Diyatra area in eroded topography without scrub and in scattered pockets of this unit in north-western part have been mapped with scrub. These lands are recommended for fast growing trees and on the rocky gravelly uplands shrubs and trees can be planted with the halfmoon terrace and/or in contour

trenches depending on the situation. The moisture conservation measure recommend for these lands are halfmoon terrace and contour trenching at the interval of 15 to 20 m depending upon the slope of the lands. The recommended energy plant species are *Acacia bivenosa, Prosopis cineraria, Prosopis juliflora, Euphorbia caducifolia, Acacia tortilis, Eucalyptus, Acacia senegal, Zizyphus nummularia, Capparis decidua* and *Maytenus emarginata*. The plant species will check the further degradation of these lands and will provide fuelwood and top leaf for fodder. These type of energy plantation will ultimately ameliorate the local environmental condition and enrich the fuel wood and timber resource for the local people. It shall also save cowdung for the use as an organic manure.

The areas of lands with scrub have been mapped in the north-western part of the district near Kundal, east of Beriyanwala, north of Khajuwala, south of Bariya, west of Ranjeetpura, north of Pabni Toba, west of Bhaguwala Toba and Ghulam Aliwala villages. These lands are associated with semi-stabilised sand dunes, hummocky undulating plains, scattered transverse dunes and sandy flat older alluvial plains with different types of vegetative cover. The sparse shrubs and grasses like *Calligonum polygonoides, Acacia jacquemontii, Leptadenia pyrotechnica, Aerva pseudotomentosa, Haloxylon salicornicum, Calotropis procera, Zizyphus nummularia* and grasses like *Lasiurus sindicus* and *Panicum turgidum* are in degraded state. Major constraints are very low rainfall, open grazing and cutting of trees and shrubs for fuel purpose and high wind erosion/deposition. Therefore, this category should be revegetated and rehabilitated with suitable sturdy plants and grasses with soil moisture conservation measures and brought into silvipasture system. The open grazing should be controlled and tree and plant cutting should be prohibited. These should be developed in rangelands so that fodder problem can be solved for the increasing pressure of livestock in the region.

7.3 WATERLOGGED AREAS

The excess water drained out through the weirs and seepage from Indira Gandhi main canal system and its distributaries has created waterlogging problem in parts of the command area. The most grazing examples are at RD 507 and 750 and in some scattered pockets in the district. These waterlogged areas are currently infested with obnoxious weeds like *Arundo donax, Saccharum spontaneum, Typha angustata*, etc. and are without any use. If the weeds are removed and pisciculture is introduced the ecology of the waterlogged depressions may improve. Moreover, these two major areas are located at RD 507 and 750 of main IG canal and well connected with canal side road and good transport network. Hence, these can be easily supplied to the available market in the state. This pisciculture practices will give higher economic returns to the state government.

These areas need immediate remedial measures like dewatering of ponded water, perforated PVC pipe line of drainage and reclamation of the degraded land. Suggested efficient delivery and on-farm utilisation of irrigation water holds key to realise maximum benefit from the costly imported water. Seepage from erected earthen bunds around the waterlogged areas in cultivated fields should be checked through the masonry structures so that agricultural fields could be saved from rising salinity.

7.4 LAND AFFECTED BY SALINITY

In the natural salt affected lands near Lunkaransar it is highly saline and are devoid of vegetation. However, the margins or fringe areas have slightly less saline environment, where some salt tolerant bushes grow. Such areas may be planted with shrubs like *Prosopis pallida, Prosopis tamarugo, Prosopis chinensis* and *Atriplex* sp. Which are fast growing and can withstand high salinity. Other salt tolerant species like *Tamarix diocia* and *Salvadora oleoides* may also be planted. These species have high value for fuelwood.

7.5 UNDERUTILISED/DEGRADED NOTIFIED FOREST LAND

This category is in highly degraded condition and looks like a scrub forest in the field. The tree species are very negligible except *Prosopis cineraria* which is also available in scattered form. More dominant plant species are *Zizyphus jujube, Zizyphus nummularia, Capparis decidua, Calligonum polygonoides, Leptadenia pyrotechnica* and *Aerva pseudotomentosa* which are not in the category of trees. Therefore, replantation should be initiated with choosing the right species, planting of sturdy stocks in time and deep, timely replacement of casualties and after care. Cutting and lopping should be strictly prohibited with proper watch and ward. Presently fencing is broken at several places and grazing is being done by the surrounding villagers. Therefore, area needs fencing of barbed wire and grazing should be stopped and replantation should be done with proper soil and water conservation measures. Major plant species suitable for this land are *Acacia senegal, Prosopis cineraria, Capparis decidua, Ziziphus jujube, Parkinsonia oculeata, Salvadora oleoides, Azadirachta indica, Grewiz tenax, Albizzia lebbeck, Maytenus emarginata, Acacia tortilis* and *Tecomella undulata*.

7.6 DEGRADED PASTURES/GRAZING LAND

Village grazinglands and pastures occur in scattered pockets throughout the district small to large in size in highly degraded condition and often suffer from wind erosion/deposition. The browse resources have been severely exploited, while the grazing resources are almost non-existent. Such lands have been recommended for grass reseeding and tree/shrub plantation. Depending on the occurrence these may have varied landform and soil types. Therefore, before adopting the recommendations site specific situation should be kept in mind.

The main objective is to provide a palatable vegetation cover on these lands and regeneration of the degraded vegetation cover by providing suitable soil and moisture conservation measure and the protection. The approach should be ecologically suitable and acceptable to local people. The species suitable for grazing requirement and also as per requirement of the habitat are selected. Local vegetation surrounding the rehabilitation site can be taken as an indicator for selection of suitable species. Since most of the pastures/grazinglands/orans are associated with village tanks/nadis at their downslope end, the dégradation and encroachment of these lands lead to more inflow of sediments in the tanks/nadis. Therefore, first of all it is necessary to provide fencing and plantation of *Acacia tortilis* around these lands for effective control of animals and then revegetation and rehabilitation should be done with the sturdy shrub and grass species. The high yielding perennial grasses like *Lasiurus sindicus, Cenchrus ciliaris, Cenchrus setigerus* and *Panicum turgidum* should be grown with the onset of monsoon. These species are more suitable for these lands and will provide nutritious fodder to the livestock of this region. After two years establishment of these grasses, the pasture land may be opened for deferred rotation grazing or only cutting of grass may be allowed for sustained forage production.

The techniques of CAZRI given for the development of desert area should be adopted. Contour furrows, 60 cm wide and 25 cm deep are constructed in grasslands at a distance of 10-15 m apart, across the slope of the land. In an another technique of inter-row water harvesting (IRWH) system in which 30 cm wide ditch alternate legumes/shrubs are grown on the edge of the ditch. The grass seeds are pelleted by mixing grass seed, clay, FYM and sand in 1:30:5:5 in a pellet making device. Pellets of 0.5 cm diameter are prepared and sown in the either in contour furrows or in IRWH system. The seed rate varies from 2.5 to 7.5 kg/ha for direct seed sowing of different types of grasses. For planting trees in the grazing land/oran lands piting-discing technique should be followed. Unmanaged grazing should be stopped for better forage production.

The district falls in the zone of 150 to 300 mm rainfall where after 3 years of protection and controlled grazing the degraded conditions of grasslands can be improved and their yield may be increased two to three times. The yield of these grazing lands further can be increased significantly after adopting soil and moisture conservation measures, reseeding and proper silvipastoral management system. CAZRI recommended that under this rainfall zone trees *P.cineraria, Zizyphus* species, *C.mopane, H.binata, A.senegal* and *A.tortilis* showed great adaptability with *L.sindicus, C.ciliaris* and *Cymbopogon* grass species on marginal and submarginal lands and also check the movement of sands towards the agricultural lands.

7.7 SANDY AREA (DESERTIC)

This category of wastelands sprawled over throughout the district small to large in size of scattered pockets. These areas of dunes like crest,

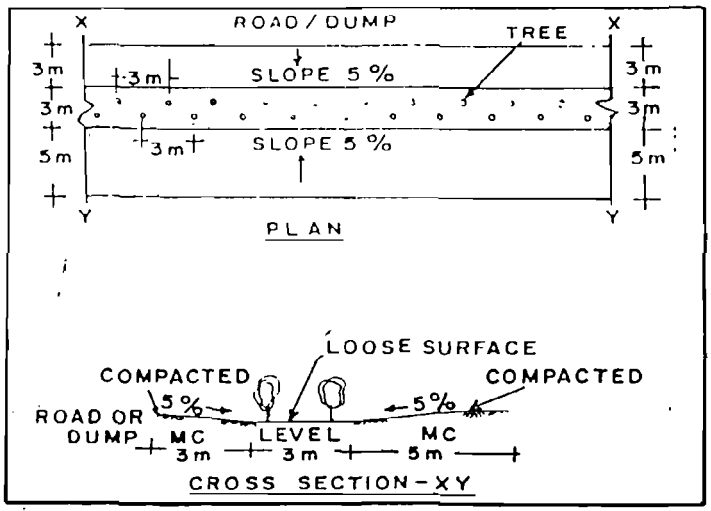
top and side flanks are bare and devoid of vegetation due to high wind velocity, scanty rainfall, sandy soil texture with loose single grained structure, extreme variation of diurnal and annual temperatures, evaporative demand of the atmosphere and biotic interference have resulted into reactivation and wind erosion hazards. Wind erosion is doubly harmful as both areas, from where the soil is removed and where it is deposited, lower the crop productivity of the surrounding cultivated fields. Therefore, sandy waste in the form of sand dunes need immediate remedial measures like sand dune stabilisation practices. Sand dune control measure will not be successful until and unless it ensures stabilisation of the sandy landscape upwind of the dunes proper. Often the downwind nasal part of the dunes are considered for stabilisation, while the other parts are left to uncontrolled grazing and cultivation. Such practices also lead to failure of the control programme. It is, therefore, suggested that the sand dune stabilisation programme may be more wide-based, and include stabilisation of upwind plains by fixing barriers in parallel strips or in chessboard pattern using locally available shrubs, etc. to act as micro-wind breaks.

CAZRI suggested that grasses and shrubs are most suitable for sand dune stabilisation, instead of trees in the arid region. Local available plant species may be given preference in the programme. In the north-western part *L.sindicus, P.turgidum* and *E.compressa* grasses, as well as *Z.nummularia, Calligonum polygonoides, Haloxylon salicornicum, Acacia jacquemontii, Aerva pseudotomentosa* and *Leptadenia pyrotechnica* shrubs are dominant, while in southern part *L.sindicus, E.compressa, Crotalaria burhia, Aristida funiculata* and *Fagonia cretica* grasses occur with *L.pyrotechnica, A.pseudotomentosa, Z.nummularia, C.decidua* and *Calotropis procera* shrubs. These and other local grasses and shrubs and *Citrullus colocynthis* creeper may be used for sand dune stabilisation, but controlled grazing of dune forests is of utmost importance.

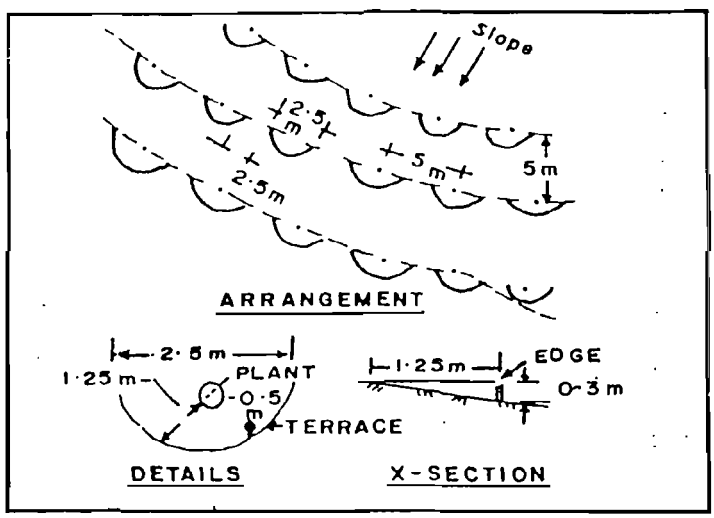
The most durable and economic approach to stabilise the active and fresh sand dunes is through the establishment of vegetative cover in which three major steps are : (i) protection from biotic interference, (ii) establishment of micro-wind breaks, and (iii) revegetation of sand dunes with strict watch and ward arrangements. Sand dune plantation forests have largely been justified on protective consideration; however, with increase in population, such plantations are considered an important source of woody biomass and fodder. Protection of dune forests from pests and disease is an important part of overall management.

7.8 MINING WASTELANDS

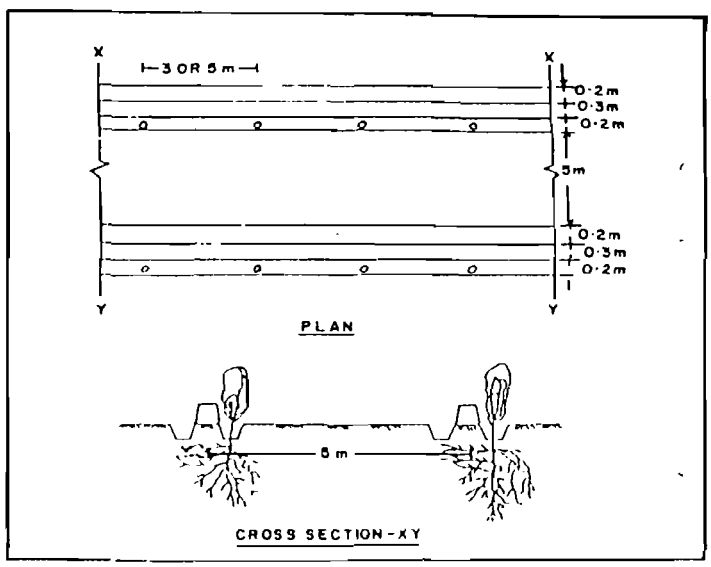
In Bikaner district, the mining activity is carried out by opencast mining method of the non-metallic minerals like gypsum, fuller's earth and white clay. Out of these gypsum mining covers the largest part and this activity inflict damaged the large area of land surface. In these opencast mining the environmental degradation is evidently unavoidable. In mining process the



MICRO-CATCH. WATER HARVESTING



HALF-MOON TERRACES



RIDGE & FURROW WATER HARVESTING SYSTEM

FIG. 4

lands have been turned upside down, the vegetation cover completely destroyed, fertility status of the area reached to zero level which caused total loss of biomass. Therefore, rehabilitation of mined wastelands should be taken up taking into account the characterisation of spoils and hydrological features, etc. The productivity of rehabilitating site should either be equal to or exceed that of pre-mining stage. The revegetating material should include the productive and protective plant cover of such species which are well adapted to the terrain and climatic conditions of the area. Hence in the characterisation of vegetation, the neighbouring areas adjacent to mined site, may be surveyed to evaluate the suitable species of trees, shrubs and grasses, etc., which could be easily and successfully be grown on the mine spoils.

In gypsum mined wastelands CAZRI recommended several trees, shrubs and grasses which are most suitable for development of such areas in arid lands with proper soil and water conservation measures. The trees like *Acacia tortilis, A.senegal, Prosopis juliflora, Albizzia amara, P.cinerania, Salvadora persica, Pithecellobium dulce* and *Tamarix aphylla*, while the shrubs are *Parkinsonia aculeata, Dichrostachys nutans, Cercidium floridum, Colophospermum mopane, Capparis decidua* and grasses like *Desmostachys bipinnata, Cenchrus ciliaris, Cymbopogon jwarancusa*, etc. These shrubs and trees can be planted with half moon terrace and/or in contour trenches depending on the situation (Fig. 4).

8. CONCLUSION

The study of wasteland mapping reveals that about 584574 ha or 21.46% land is under different categories of wastelands and land with or without scrub, pastures/grazing lands and sandy area (desertic) are sprawled over throughout the district while gullied land, waterlogged, land affected by salinity, degraded notified forest and mining wastelands are occurred in limited pockets. Among all the wasteland categories, sandy waste covers the largest land i.e. 10.01% of the total geographical area of the district followed by land with or without scrub (8.23%), degraded pastures (2.47%), degraded notified forest (0.29%), gullied land (0.27%), waterlogged land (0.13%), mining wasteland (0.05%) and land affected by salinity (0.01%). All the categories are under degraded state. Moderate to severe wind erosion and deposition, constantly increasing waterlogging and salinity, large scale removal of natural vegetation and over utilisation of pastures are major problems of the region. Therefore, for their development some measures and technologies have also been suggested. Waterlogged areas near by irrigated fields are further deteriorating the agricultural lands. Therefore, in this case further detailed study using high resolution remote sensing data is required.

REFERENCES

CAZRI, 1974. Report on Basic Resources of Bikaner District (Rajasthan).

Census of India, 1991. District census handbook of Bikaner district (Rajasthan).

Gheesa Lal, 1990. Report on landuse/land cover of Bikaner district (Raj.). CAZRI, Jodhpur.

Gupta, J.P. and Sharma, A.K. 1997. Agroforestry for Desertification Control in Arid Ecosystem. *Desertification Control* (Eds. Surendra Singh & Amal Kar).

Harsh, L.N. and Tewari, J.C. 1997. Stabilisation of sand dunes and their management in Indian arid zone. *Desertification Control* (Eds. Surendra Singh & Amal Kar).

Joshi, D.C. and Dhir, R.P. 1997. Waterlogging and salinisation in Indian arid region. *Desertification Control* (Eds. Surendra Singh & Amal Kar).

NRSA, 1997. Manual of procedure for preparation of wastelands digital data base using remote sensing and GIS techniques.

NRSA, 1998. Wasteland manual, 75 steps for preparation of digital database.

Saxena, SS.K., Sharma, K.D. and Sharma, B.K. 1997. Rehabilitation of mined wastelands in Indian arid ecosystem. *Desertification Control* (Eds. Surendra Singh & Amal Kar).

Singh, K.C. and Sharma, S.K. 1997. Management of degraded grassland in the Indian arid ecosystem. *Desertification Control* (Eds. Surendra Singh & Amal Kar).

Table 1. Distribution of wastelands in Bikaner district

Wasteland categories	Total area (ha)	Per cent to total district area	Per cent to total wasteland
1. Gullied and/or ravinous land	7319	0.27	1.25
2. Upland with or without scrub	224059	8.23	38.33
3. Waterlogged and marshy land	3588	0.13	0.61
4. Land affected by salinity/ alkalinity (inland)	405	0.01	0.07
5. Under utilised/degraded notified forest land	7884	0.29	1.35
6. Degraded pastures/ grazing land	67238	2.47	11.50
7. Sand desertic	272704	10.01	46.65
8. Mining/industrial wastelands	1377	0.05	0.24
Total	**584574**	**21.46**	**100.00**

Table 2. Toposheet-wise distribution of wastelands in Bikaner district, Rajasthan

(Area in hectares)

S No	Toposheet	Gullied and/or ravinous land	Upland with or without scrub	Water-logged and marshy land	Land affected by salinity/ alkalinity- coastal/ inland	Under-utilised/ degraded notified forest land	Degraded pastures/ grazing land	Sands - desertic/ coastal	Mining/ industrial waste-lands	Total
1.	45 A/1+2	-	-	-	-	-	682	6765	-	7447
2.	45 A/5	-	-	-	-	-	726	3975	-	4701
3.	45 A/6+7	-	245	-	-	-	2283	822	-	3350
4.	45 A/9	248	609	-	-	-	3282	3913	-	8052
5	45 A/10	-	5214	-	-	-	2443	244	-	7901
6.	45 A/13	4799	5661	-	-	-	4908	588	-	15956
7.	45 A/14	-	1588	-	-	-	1334	979	-	3901
8.	45 A/15	-	-	-	-	-	447	690	-	1137
9.	44 D/3	-	4012	-	-	-	108	7493	-	11613
10.	44 D/4	-	84	-	-	-	1104	30197	-	31385
11.	44D/6+5+2	-	14322	-	-	-	-	4979	-	19301
12	44 D/7	-	11367	-	-	-	1879	14303	-	27549
13.	44 D/8	-	2216	-	-	-	428	9203	-	11847
14.	44 D/9	-	1607	-	-	-	-	406	-	2013
15.	44 D/10	-	6039	-	-	-	22	22438	-	28499
16.	44 D/11		765	-	-	-	414	20159	-	21338
17.	44 D/12	-	4070	375	-	-	549	12050	-	17044
18.	44D/14+13	-	1510	-	-	-	1242	23967	-	26719
19.	44 D/15	-	1540	1726	-	-	612	19611	-	23489
20.	44 D/16	-	5144	572	-	-	2591	8828	-	17135
21.	45 E/1	1790	5105	-	-	-	3007	1023	-	10925
22.	45 E/2	-	-	-	-	-	3431	1739	-	5170
23.	45 E/3	-	-	-	-	713	-	3587	-	4300
24.	45 E/5	401	-	-	-	7171	5363	123	-	13058
25.	45 E/6	-	-	-	-	-	2636	1135	-	3771
26.	45 E/7+8	-	54	-	-	-	1691	4758	-	6503
27.	45 E/9	-	-	-	-	-	1698	447	-	2145
28.	45 E/10	-	-	-	-	-	1052	2778	-	3830
29.	45 E/11	-	-	-	-	-	-	156	-	156
30.	45 E/13	-	-	-	-	-	510	246	-	756
31.	45 E/14	-	-	-	-	-	338	1706	-	2064
32.	44 H/1	-	-	543	-	-	68	2393	-	3004
33.	44 H/2	-	-	-	-	-	544	11188	-	11732
34.	44 H/3	-	8629	-	-	-	1705	13990	-	24324
35.	44 H/4	-	8036	-	-	-	2991	5369	131	16527
36.	44H/5+44G/8	-	13627	372	-	-	799	3290	-	18088
37.	44 H/6	-	29530	-	-	-	1343	3025	-	33898
38.	44 H/7	-	24	-	-	-	2768	3981	90	6863
39.	44 H/8	81	730	-	-	-	3113	2501	348	6773
40.	44H/9+44G/12	-	66006	-	-	-	53	103	-	66162
41.	44 H/10	-	22665	-	139	-	1235	412	-	24451
42.	44 H/11	-	-	-	137	-	1956	241	808	3142
43.	44 H/12	-	-	-	-	-	1063	937	-	2000
44.	44H/13+44G/16	-	3660	-	-	-	1018	573	-	5251
45.	44 H/14	-	-	-	122	-	1008	1029	-	2159
46.	44 H/15+44L/3	-	-	-	7	-	1893	1073	-	2973
47.	44 L/1	-	-	-	-	-	436	-	-	436
48.	44 L/2	-	-	-	-	-	445	-	-	445
49.	39P/16+40M/13	-	-	-	-	-	-	13291	-	13291
Total	**2724400**	**7319**	**224059**	**3588**	**405**	**7884**	**67238**	**272704**	**1377**	**584574**
Percent to total area		0.27	8.22	0.13	0.02	0.29	2.47	10.01	0.05	21.46
Percent to wasteland		1.25	38.33	0.61	0.07	1.35	11.50	46.65	0.24	100.00

Table 3. Watershed-wise distribution of wasteland

S.No.	Watershed No.	Watershed area	Wasteland area	Percent to total wasteland
1.	6 B (ED)	329515	29364	5.02
2.	6 C (ED)	2189814	481288	82.33
3.	6 D2 A1	127934	52714	9.02
4.	6 D2 A3	27535	3432	0.59
5.	6 C 00001	5965	1566	0.27
6.	6 C 00002	2058	149	0.03
7.	6 C 00003	5681	648	0.11
8.	6 C 00004	7574	770	0.13
9.	6 C 00005	4057	1583	0.27
10.	6 C 00006	2353	547	0.09
11.	6 C 00007	3197	740	0.13
12.	6 C 00008a	602	536	0.09
13.	6 C 00008b	779	194	0.03
14.	6 C 00008c	682	134	0.02
15.	6 C 00008d	678	376	0.06
16.	6 C 00008e	493	247	0.04
17.	6 C 00008f	932	812	0.14
18.	6 C 00008g	1416	1369	0.23
19.	6 C 00009a	1511	395	0.07
20.	6 C 00009b	1123	1055	0.18
21.	6 C 00009c	910	825	0.14
22.	6 C 00009d	748	557	0.10
23.	6 C 00009e	3420	2975	0.51
24.	6 C 00009f	2860	656	0.11
25.	6 C 00009g	722	7	0.00
26.	6 C 00009h	1841	1635	0.29
	Total	**2724400**	**584574**	**100.00**

Table 4. List of toposheets covered in Bikaner district, Rajasthan

S.No.	Toposheet No.	S.No.	Toposheet No.
1.	39 P/16	31.	44 H/11
2.	40 M/13	32.	44 H/12
3.	44 D/2	33.	44 H/13
4.	44 D/3	34.	44 H/14
5.	44 D/4	35.	44 H/15
6.	44 D/5	36.	44 L/1
7.	44 D/6	37.	44 L/2
8.	44 D/7	38.	44 L/3
9.	44 D/8	39	45 A/1
10.	44 D/9	40	45 A/2
11.	44 D/10	41.	45 A/5
12.	44 D/11	42.	45 A/6
13.	44 D/12	43.	45 A/7
14.	44 D/13	44.	45 A/9
15.	44 D/14	45.	45 A/10
16.	44 D/15	46.	45 A/13
17.	44 D/16	47.	45 A/14
18.	44 G/8	48.	45 A/15
19.	44 G/12	49.	45 E/1
20.	44 G/16	50.	45 E/2
21.	44 H/1	51.	45 E/3
22.	44 H/2	52.	45 E/5
23.	44 H/3	53.	45 E/6
24.	44 H/4	54.	45 E/7
25.	44 H/5	55.	45 E/8
26.	44 H/6	56.	45 E/9
27.	44 H/7	57.	45 E/10
28.	44 H/8	58.	45 E/11
29.	44 H/9	59.	45 E/13
30.	44 H/10	60.	45 E/14

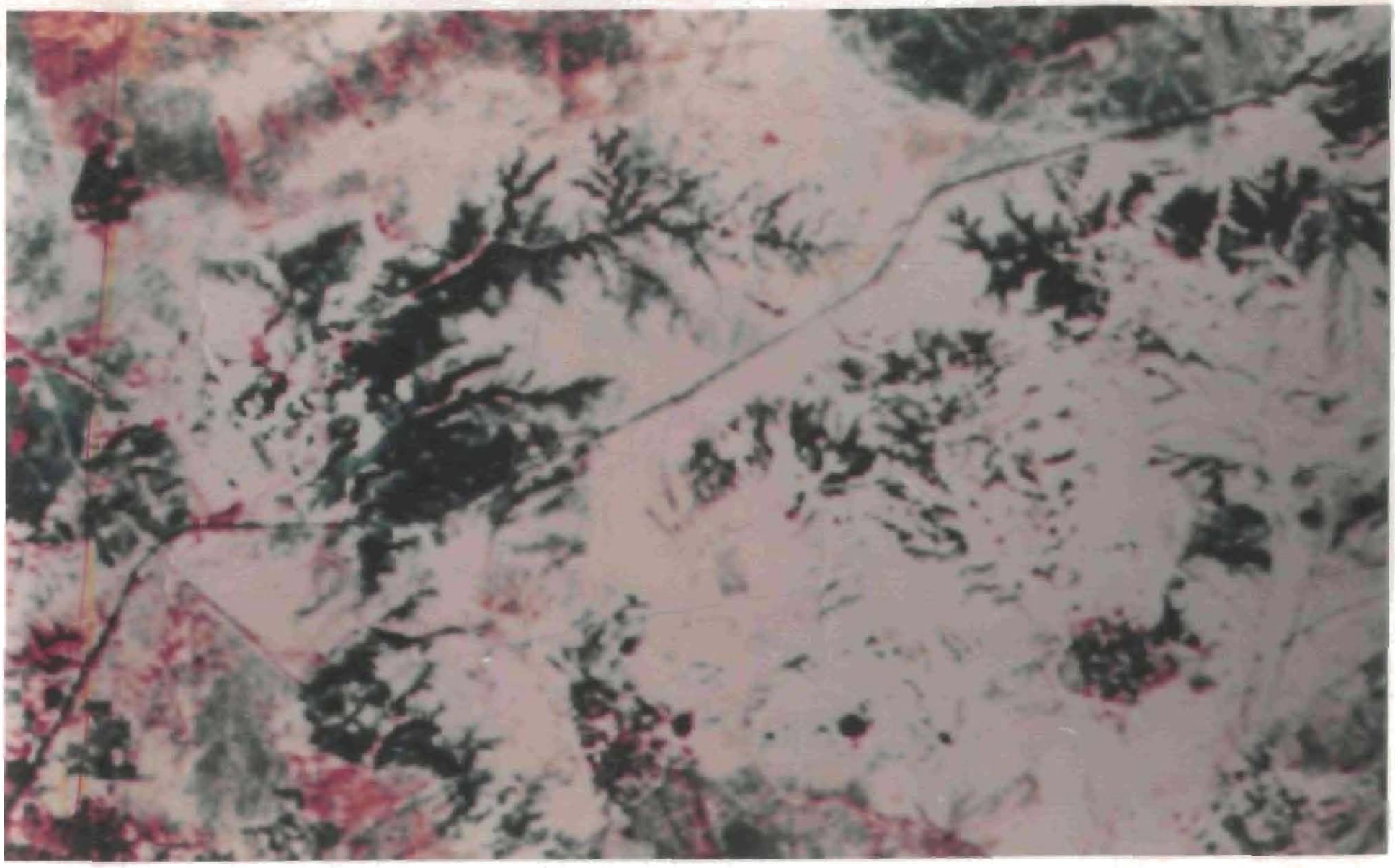


Plate 1. Part of IRS-LISS III FCC of December - Gullied land.

Plate 2. Gullied land - South-east of Gura village.

Plate 3. Part of IRS-LISS III FCC of February - Land with or without scrub.

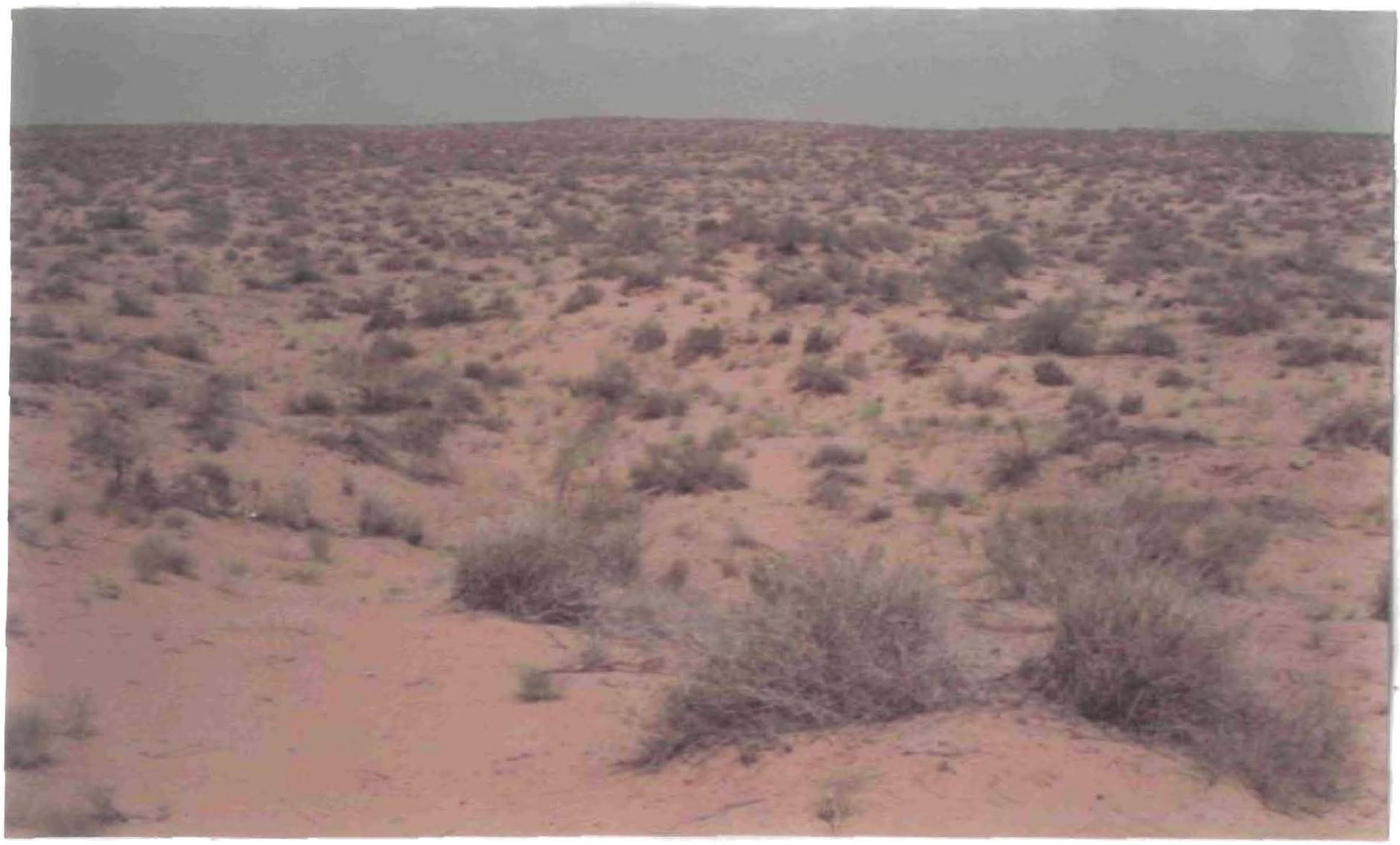


Plate 4. Land with or without scrub - NE of Beriyanwala village.

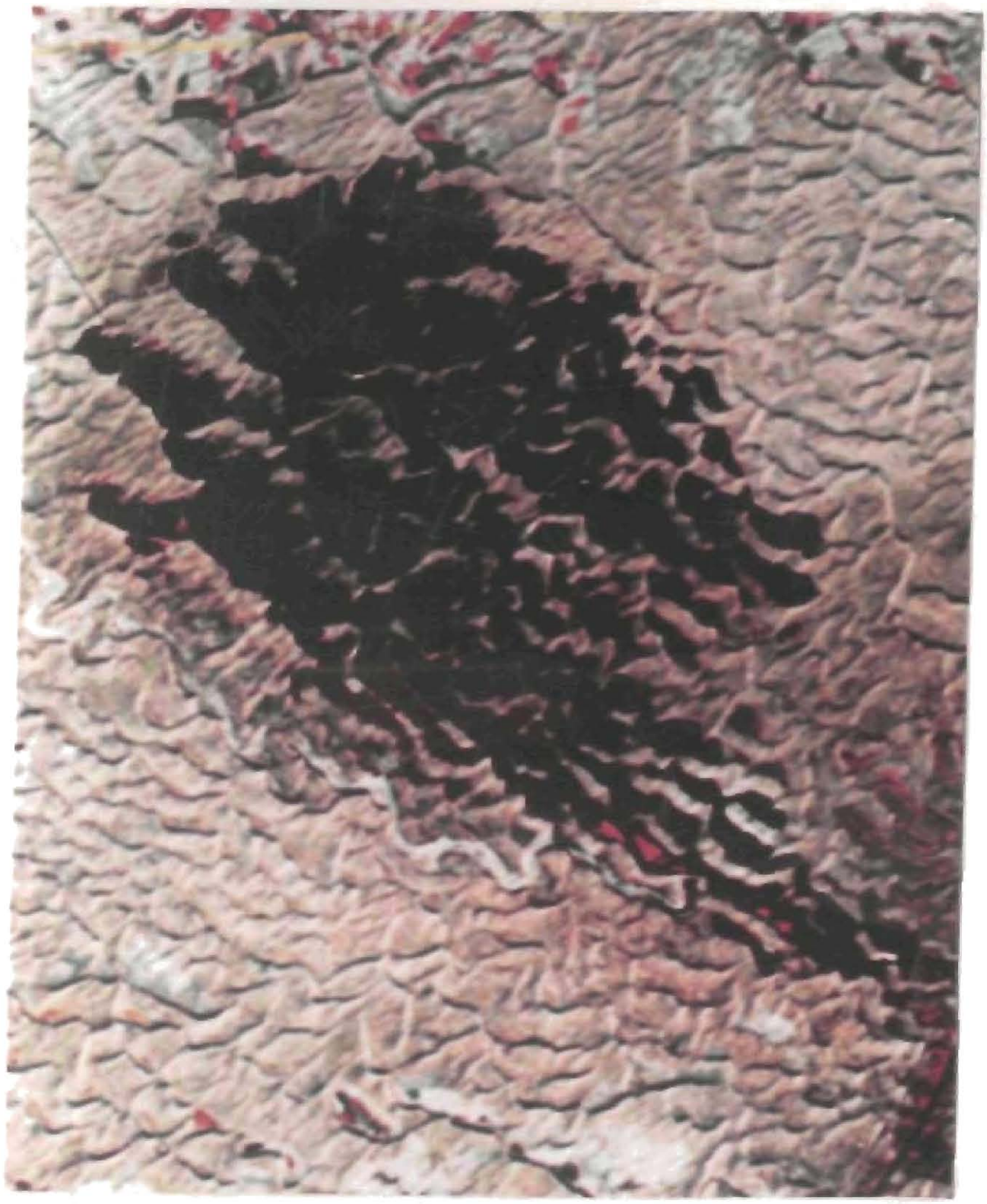


Plate 5. Part of IRS-LISS III FCC of January - Waterlogged area.

Plate 6. Waterlogged area at RD 750 - West of I.G. main canal.

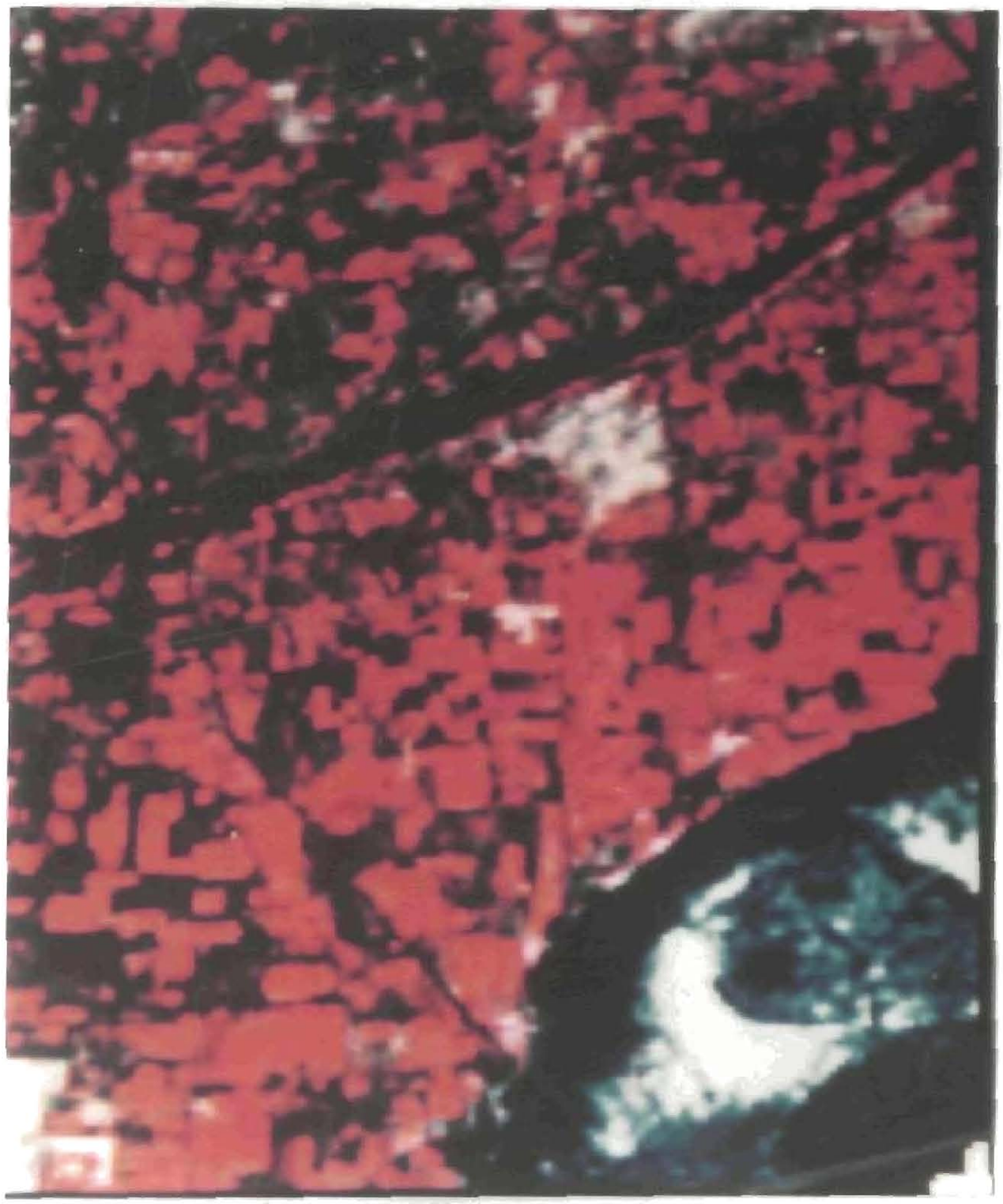


Plate 7. Part of IRS-LISS-III FCC of January - Land affected by salinity.

Plate 8. Land affected by salinity - North of Lunkaransar village.

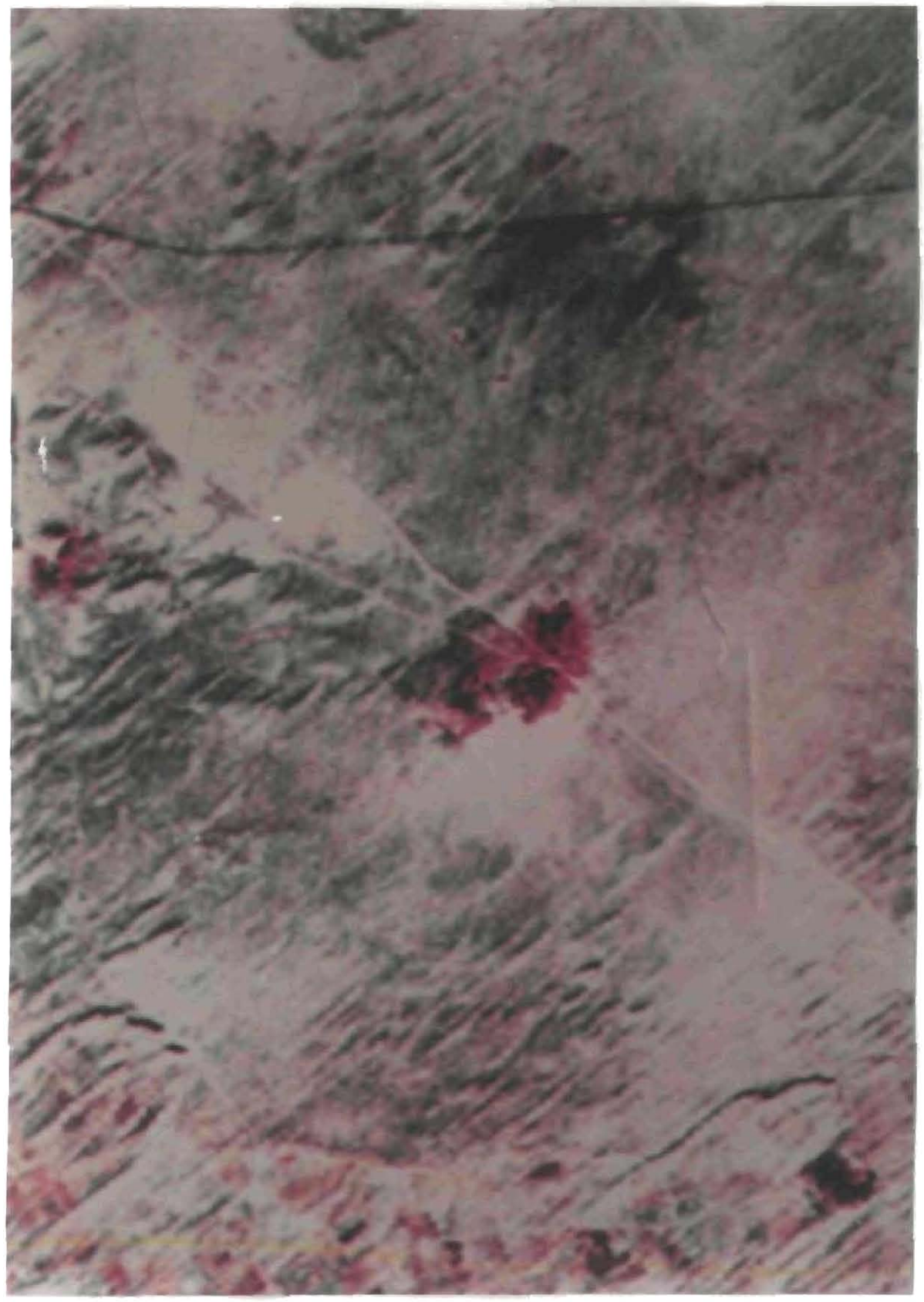


Plate 9. Part of IRS-LISS III FCC of December - Degraded notified forest.

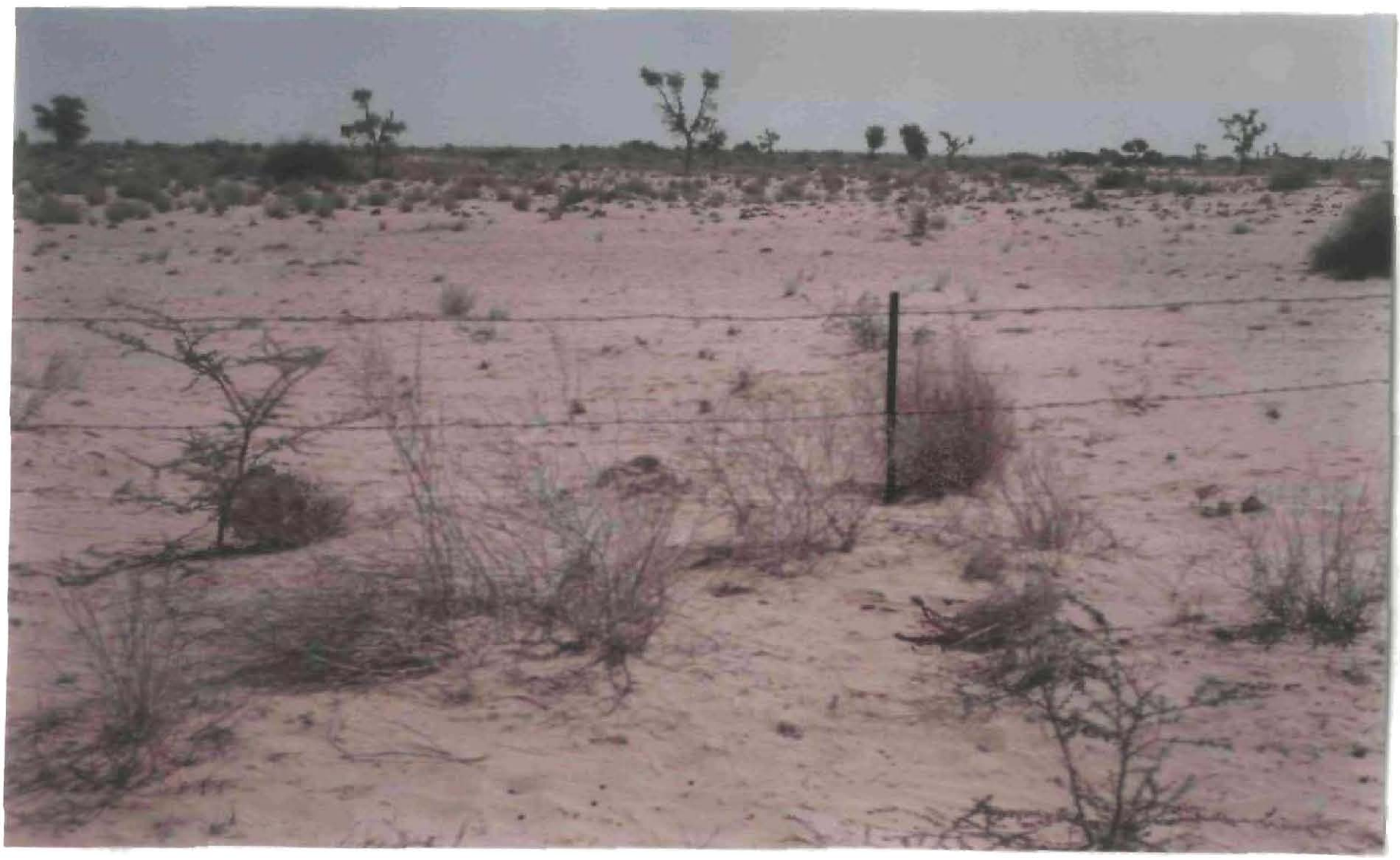


Plate 10. Degraded notified forest - West of Godhwala village

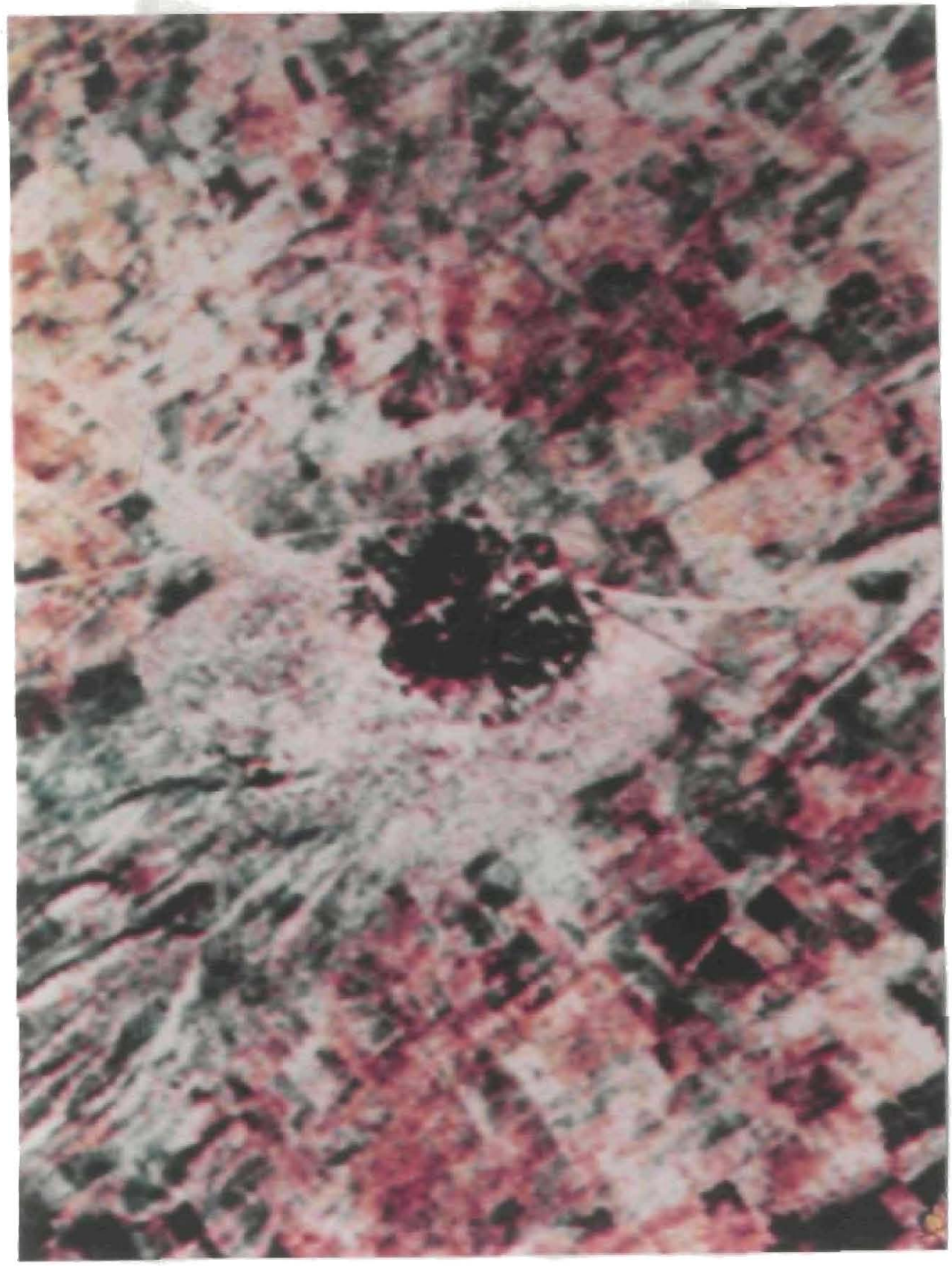


Plate 11. Part of IRS-LISS III December - Degraded pasture.

Plate 12. Degraded pasture near Girajsar village

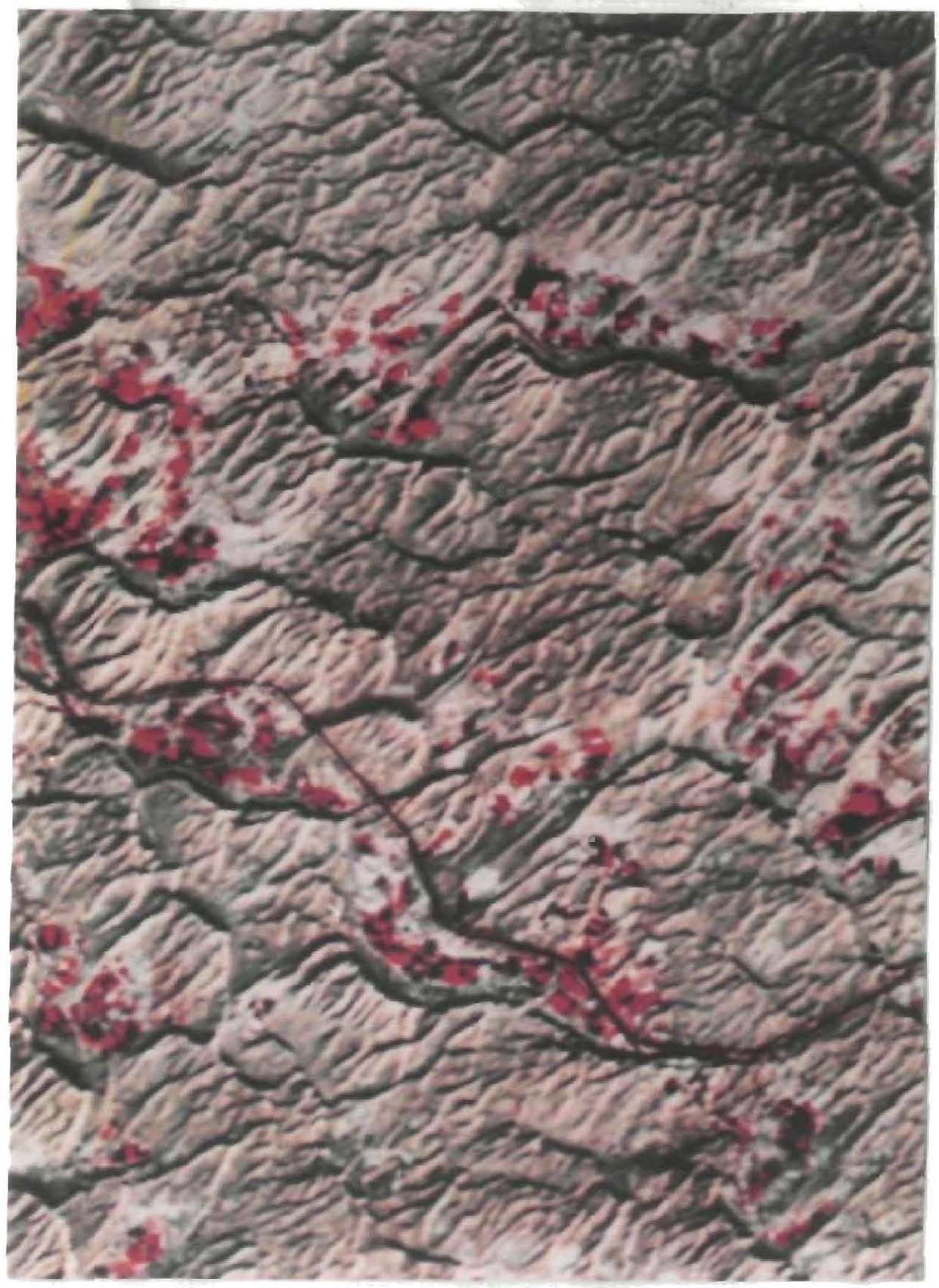


Plate 13. Part of IRS-LISS III of January - Desertic sand.

Plate 14. Desertic sand - North of Jodhasar.

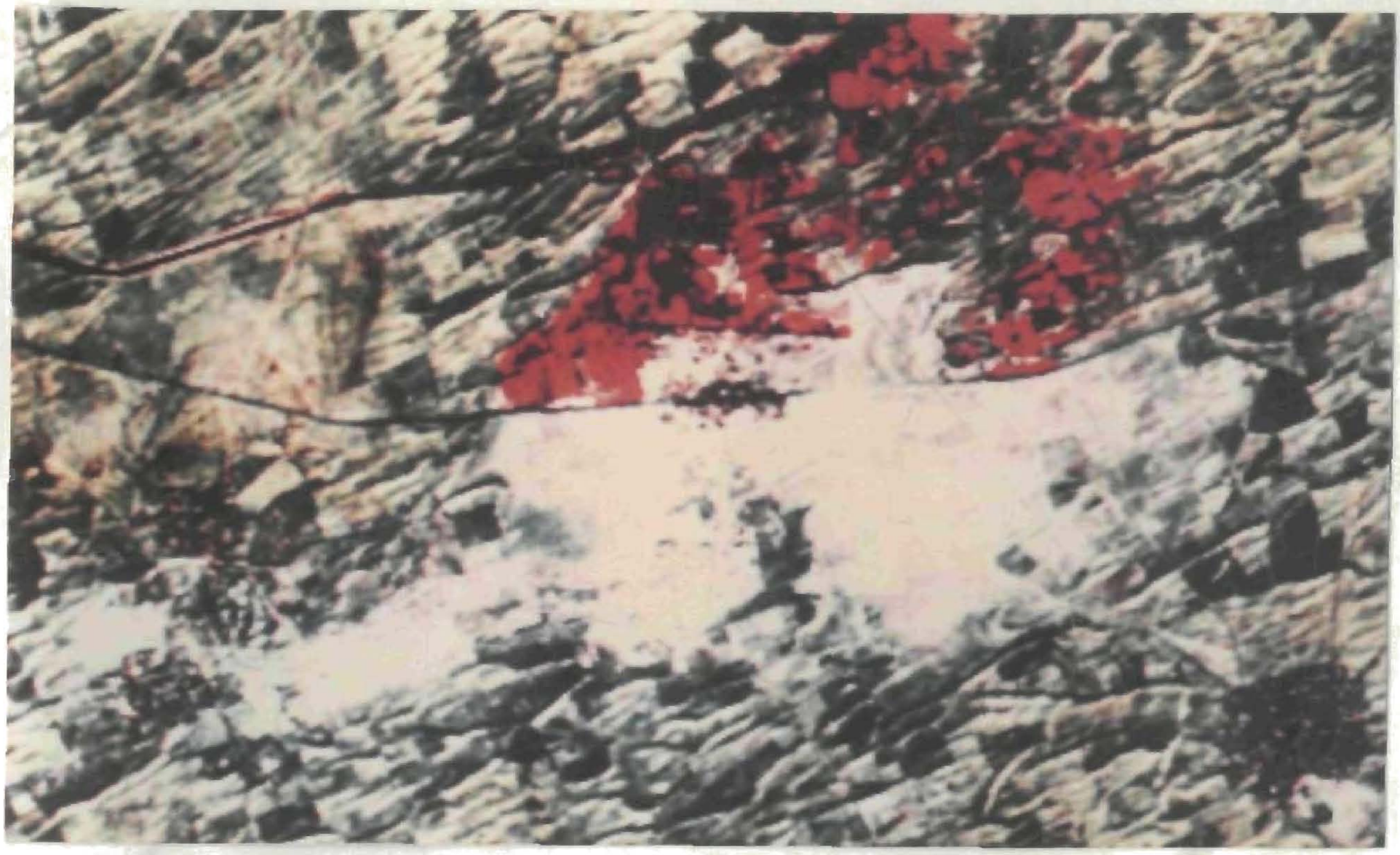


Plate 15. Part of IRS-LISS III of February - Mining wasteland.

Plate 16. Mining wasteland - South of Dhirera Rly. Station.