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INTEGRATED NATURAL AND HUMAN RESOURCES APPRAISAL OF JAISALMER DISTRICT

Edited by
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FOREWORD

The largest and driest district in the country—Jaisalmer, is endowed mainly with a sandy habitat. The region has very low potential for natural resources, resulting in low biological productivity. The system can not sustain the increasing biotic pressure. Inventory and appraisal of the basic resources is the first step towards an overall process of resource management of the region. This is why the emphasis is being laid on the detailed analysis of the existing and potential resources and formulation of scientific plans for their development and sustained productivity. A multidisciplinary team of scientists undertook this challenging task and came out with the present volume for undertaking the developmental programme, mostly in the areas not to be covered by the Indira Gandhi Nahar Pariyojana Command. On request from the Desert Development Commissioner, Jodhpur, a detailed report on the natural resources of the Sam Development Block has been prepared and appended. Moreover, as per the guidelines provided by our Honourable Prime Minister to carry out district-wise planning, it is hoped that this report will be of immense value to the district development authorities.

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September 29, 1989

PREFACE

Jaisalmer district, located in the extremely hot arid part of India, is now on the verge of change. Although its production potentials in terms of agriculture are extremely poor due to its inherent climatic and other constraints, the gradual introduction of the Indira Gandhi Canal network within the district will lead to fast changes in not only its agrarian situation, but also in other related spheres of activities, including the socio-economic set-up. However, the history of irrigated agriculture in the deserts of the world point to the fact that limited water use, alongwith a better understanding of the facets of the land and its problems, are of utmost necessity for sustained agricutural growth under such circumstancess. Moreover, even under the extremely arid situation there are certain useful plants in the district which can attain climax state under slight range care, and help maintaining, not only the equilibrium of the fragile terrain, but also the ecologically sustainable livestock population of the region. The crucial factor for consideration before choosing the options is, therefore, an inventory of the resources of the district, both biotic and abiotic. Since unplanned growth of human and livestock populations in the extremely fragile environment of the district are leading to acceleration of the problems in many areas, the studies on the natural, human and animal resources, their dynamism and their interrelations will also help in suggesting the appropriate methods and sites for development, as well as control measures. The data base will also help in monitoring and evaluating the changes that are currently taking place. The Institute, therefore, carried out a multi-disciplinary survey on the natural, human and animal resources of the district during 1982-86, under the able guidance of the then Directors.

The data from survey were analysed and mapped disciplinewise and then integrated, on the basis of which specific recommendations were formulated. The report contains the salient findings of that survey, alongwith small scale maps. Detailed report on each discipline, alongwith detailed maps, could be had from the concerned disciplines on request.

It is hoped that the report will be helpful in formulating the plans for development in the district.

(J. Venkateswarlu)
Director

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It would have been impossible to bring out this report on the "Integrated Natural and Human Resources Appraisal of Jaisalmer District" in time, without the active support and cooperation of several organisations and individuals. We would like to place on record our sincere thanks for all of them.

We express our sincere gratitude and thanks to Dr. J. Venkateswarlu, Director, CAZRI, for his keen interest, constant guidance and encouragement in brining out this report in time.

The Collector and District Magistrate, Jaisalmer, very kindly arranged to supply the land revenue data and the village maps of the tehsils, for which we express our sincere thanks to him. Information on ground water potential zones has been collected from the published reports of Rajasthan Ground Water Department (Government of Rajasthan), while the geological information is based on the reports of Geological Survey of India. The sources are thankfully acknowledged.

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CHAPTER I

INTRODUCTION

Jaisalmer, the largest district of Rajasthan state, covers an area of 38,401 sq. km., in the extreme western part of the State along Indo-Pakistan border. While the district has a common boundary with Jodhpur district in the east, in the north it is flanked by Bikaner district and in the south by Barmer district. In its west the district has a long boundary with Pakistan (Fig. 1).

Spanning about 2 degrees of latitude between 26°1'N and 28°2'12" N and about 3 degrees of longitude between 69°30'E and 72°20'30"E, the district experiences the most arid climate of the country. While its eastern margin receives about 200 mm of annual rainfall, the western margin receives less than 100 mm of it. The occurrence and distribution of the rainfall are highly erratic. Evaporation far exceeds the precipitation. The maximum temperature during the summer months often sores above 47°C, while during winter the daily minimum temperature sometimes goes down to the freezing point.

Under such extremely arid situation the terrain features assume a barren and faceted look. Streams are very few and insignificant. Water erosion is negligible. In contrast the aeolian processes are highly efficient, producing vast areas of sand dunes and sandy hummocks. In fact, sand dunes, interdune plains and other sandy undulating terrain cover more than 60% area of the district, except in the central tract where the terrain is distinctly rocky and shallow gravelly, with occasional hills, and in the south-central part where there are vast stretches of gravel-strewned surfaces. Soil cover is generally very thin, except in the sandy terrain. Natural vegetation consists mainly of grasses and shrubs of 'poor' condition. Trees are rare. Yet, some areas, especially in the north have excellent and almost undisturbed stands of *Lasiurus* grass, which suggests the potentiality of the land to sustain the types of vegetation which are highly adaptable to this xeric environment. It is but natural that availability of water is at a discount. Generation of surface run-off is unpredictably low and potable subsurface water sources are confined to a few aquifers.

Inspite of such harsh realities the district has a population of 243,082 (1981 census), the density of population being 6 per sq. kilometre. More than 85% of the

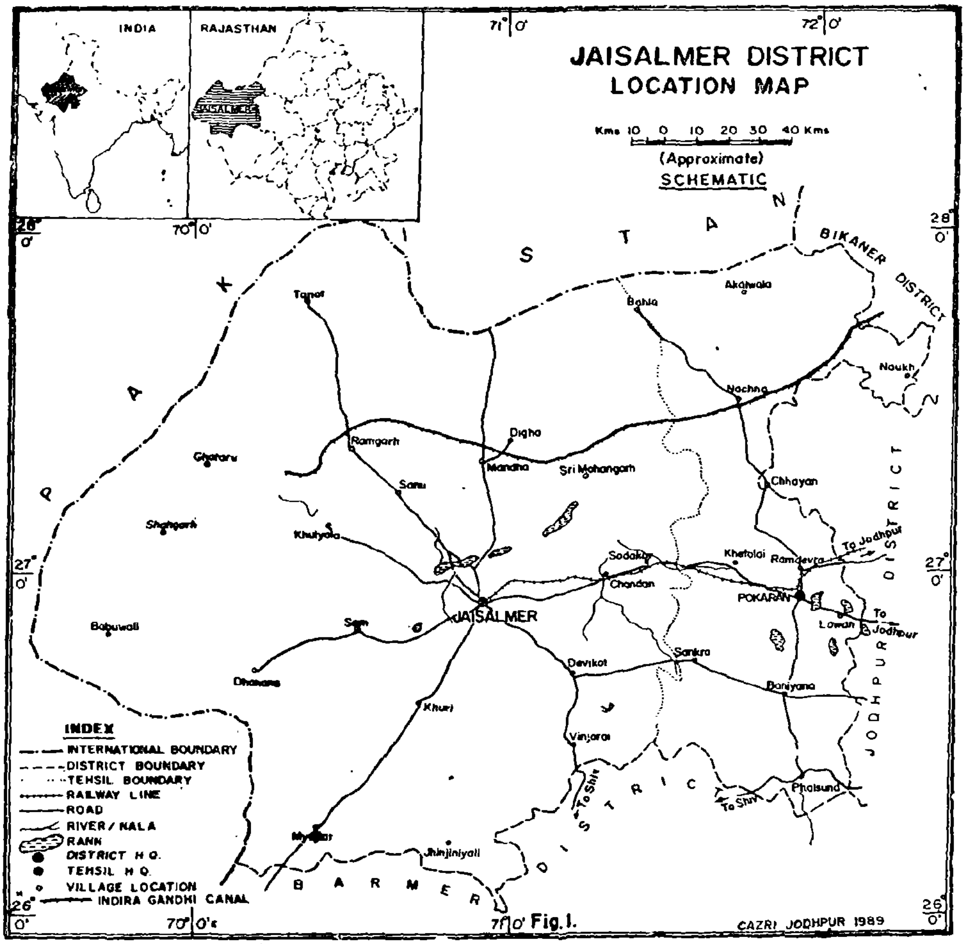

JAISALMER DISTRICT
LOCATION MAP
(Approximate)
SCHEMATIC
INDIA
RAJASTHAN
JAISALMER
PAKISTAN
BIKANER DISTRICT
JODHPUR DISTRICT
BARMER DISTRICT
INDEX
INTERNATIONAL BOUNDARY
DISTRICT BOUNDARY
TEHSIL BOUNDARY
RAILWAY LINE
ROAD
RIVER / NALA
RANN
DISTRICT H.Q.
TEHSIL H.Q.
VILLAGE LOCATION
INDIRA GANDHI CANAL
JAISALMER
POKARAN
Ramgarh
Ramdevra
Chhayan
Nachna
Khuri
Devikot
Chandan
Fig. I.
CAZRI JODHPUR 1989

Fig. 1.

total population is rural, inhabiting 515 villages under two tehsils, namely Jaisalmer and Pokaran (Fig. 2; Appendix I). Only 36.3% of the total population is considered as workers, engaged as cultivators (18.77%), agricultural labourers (1.07%), household manufacturers (0.83%), other workers (11.42%, especially as livestock rearers) and marginal workers (4.22%). The rest 63.69% population is considered as non-workers (1981 census).

The low percentage of cultivators and agricultural labourers in the district is due to the severe environmental constraints for agricultural operation. Much of the land is not fit for agriculture, because of climatic, terrain and soil constraints. Yet, over the centuries people have evolved a system of moisture and rainwater conservation for agriculture, locally known as *Khadin*. Animal husbandry is practised on a large scale, due to the capability of much of the land to sustain grasslands alone. According to the 1983 livestock census the district harbours 1.6 million heads of livestock, mainly consisting of sheep and goats.

Since the environment is highly fragile and the resources are scarce and mostly in degraded state, introduction of any technology for development within the district should be preceded by an inventory of all its resources, both biotic and abiotic, and careful analysis of relationship between the resources, the state of their exploitation, the key problems and problem areas and the expected changes in the resources under induced conditions. To fulfill these objectives a multi-disciplinary resources survey was carried out by the Central Arid Zone Research Institute, Jodhpur, during 1982-85. The present report summarises the findings, supplemented by small-scale resources maps, and highlights the resource patterns, the problems and the recommended practices.

Additionally, the resource potentials and problems of Sam Panchayat Samiti, occupying the westernmost part of the district, have been highlighted in an appendix. The Samiti is in the extremely arid part of the district and has a sparse population. Much of the terrain is still in a less disturbed state, but in some parts activities connected with Indira Gandhi Canal have just started. The present data base will not only help in monitoring the changes brought about by these activities, but will also help in fixing the priorities for development.

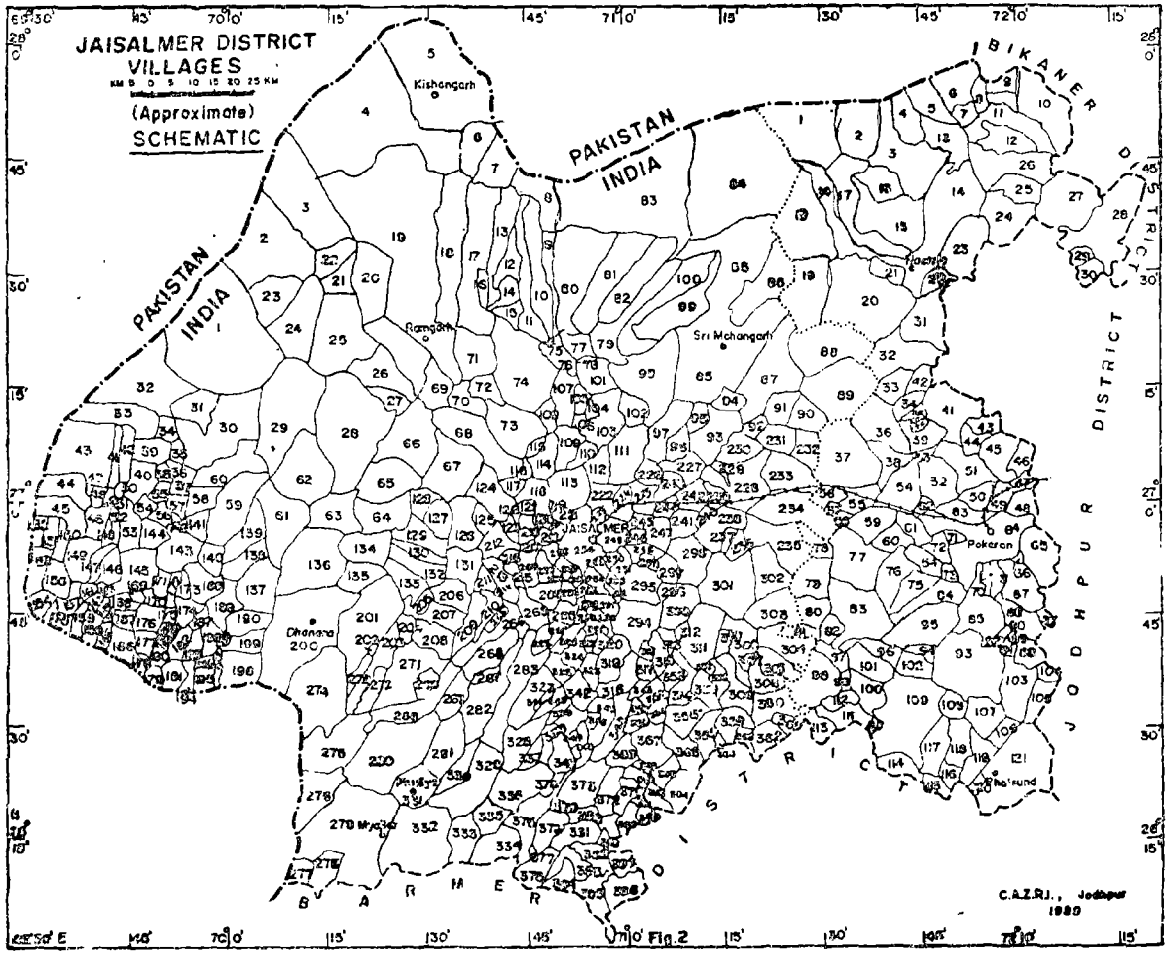

JAISALMER DISTRICT
VILLAGES
(Approximate)
SCHEMATIC
PAKISTAN
INDIA
PAKISTAN
INDIA
BIKANER
DISTRICT
JODHPUR
DISTRICT
BARMER
Kishangarh
Ramgarh
Sri Mohangarh
Pokaran
Phalsund
Dhanana
JAISALMER
C.A.Z.R.I., Jodhpur
1980
Fig. 2

Fig. 2.

CHAPTER II

CLIMATIC FEATURES

a) General climatic characteristics

Climatically Jaisalmer district, with annual normal rainfall of 200 mm or less over much of its area (Fig. 3a) and extremes of temperature (Fig. 3b), comes under the extreme arid climate with mean moisture index of -90.7. The rainfall normal, based on the data for the years 1949-1980 at Jaisalmer is 188 mm (Table 1). May and June are the hottest months with the mean maximum temperature of about 41°C. In some individual years the average may cross 45°C due to severe heat waves. Similarly during winter the average minimum temperature is less than 10°C. Occasionally, the minimum temperature is below freezing point under the influence of severe cold waves which cause frost damages. Generally the monsoon sets in during the first week of July and starts receding by the end of August or in the first week of September (Fig. 4a). A strong wind regime prevails from March onwards, with average wind speeds of more than 10 kmph upto September and strong dusty winds during May, June and July. The peak values of potential evapotranspiration (PE) are observed during hot and windy periods. The annual PE values range from 1900 mm in the southeast of the district to more than 2200 mm in the west (Fig. 4b). Relative humidity ranges between 60 and 66 per cent. Dust storms and dust raising wind due to seasonal low pressure over north India is a common feature during summer and the average number of dust storms that occur in Jaisalmer is two per year.

The extremes of monthly climatological data of Jaisalmer are presented in Table 2. Rainfall in the area is recorded during the strong monsoon months of July and August. The highest recorded rainfall was 394 mm in the month of August. Mean monthly temperatures range between 4.6°C and 43.3°C and relative humidities between 5% and 93%. The monthly mean winds in certain years are as strong as 36 kmph. The lowest recorded monthly mean wind speed was 3 kmph.

(b) Rainfall characteristics

There are six rain gauge stations in Jaisalmer district (Table 3) for which rainfall data is available for a period varying from 24 years at Pokaran to 80 years at

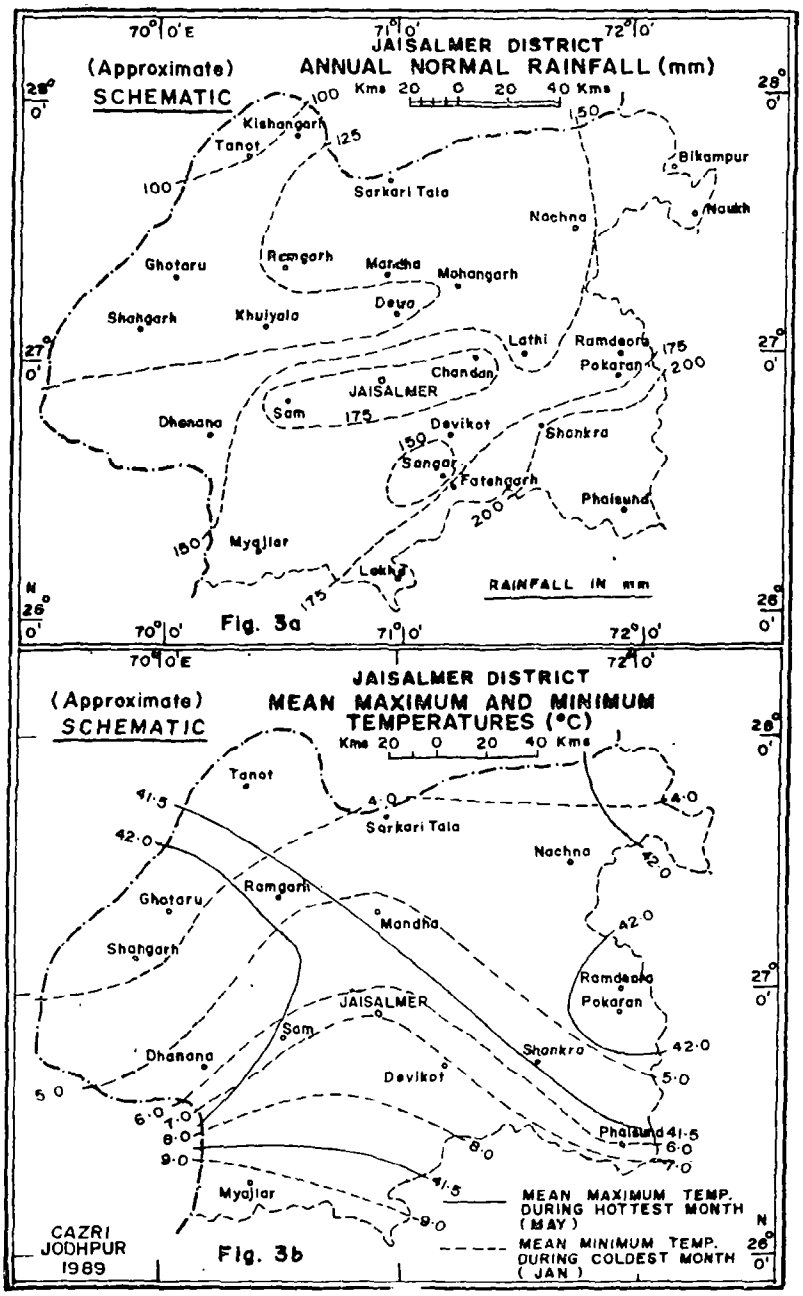

JAISALMER DISTRICT
(Approximate)
SCHEMATIC
ANNUAL NORMAL RAINFALL (mm)
Kms 20 0 20 40 Kms
Kishangarh
Tanot
Sarkari Tala
Nachna
Bikampur
Naukh
Ghotaru
Ramgarh
Mandha
Mohangarh
Shahgarh
Khuiyala
Deva
Lathi
Ramdeora
Pokaran
Chandan
JAISALMER
Sam
Dhanana
Devikot
Shankra
Sangar
Fatehgarh
Phalsund
Myajlar
Lathi
RAINFALL IN mm
Fig. 3a
JAISALMER DISTRICT
(Approximate)
SCHEMATIC
MEAN MAXIMUM AND MINIMUM TEMPERATURES (°C)
Kms 20 0 20 40 Kms
Tanot
Sarkari Tala
Nachna
Ghotaru
Ramgarh
Mandha
Shahgarh
JAISALMER
Ramdeora
Pokaran
Sam
Dhanana
Shankra
Devikot
Phalsund
Myajlar
MEAN MAXIMUM TEMP. DURING HOTTEST MONTH (MAY)
MEAN MINIMUM TEMP. DURING COLDEST MONTH (JAN)
CAZRI JODHPUR 1989
Fig. 3b

Fig. 3.

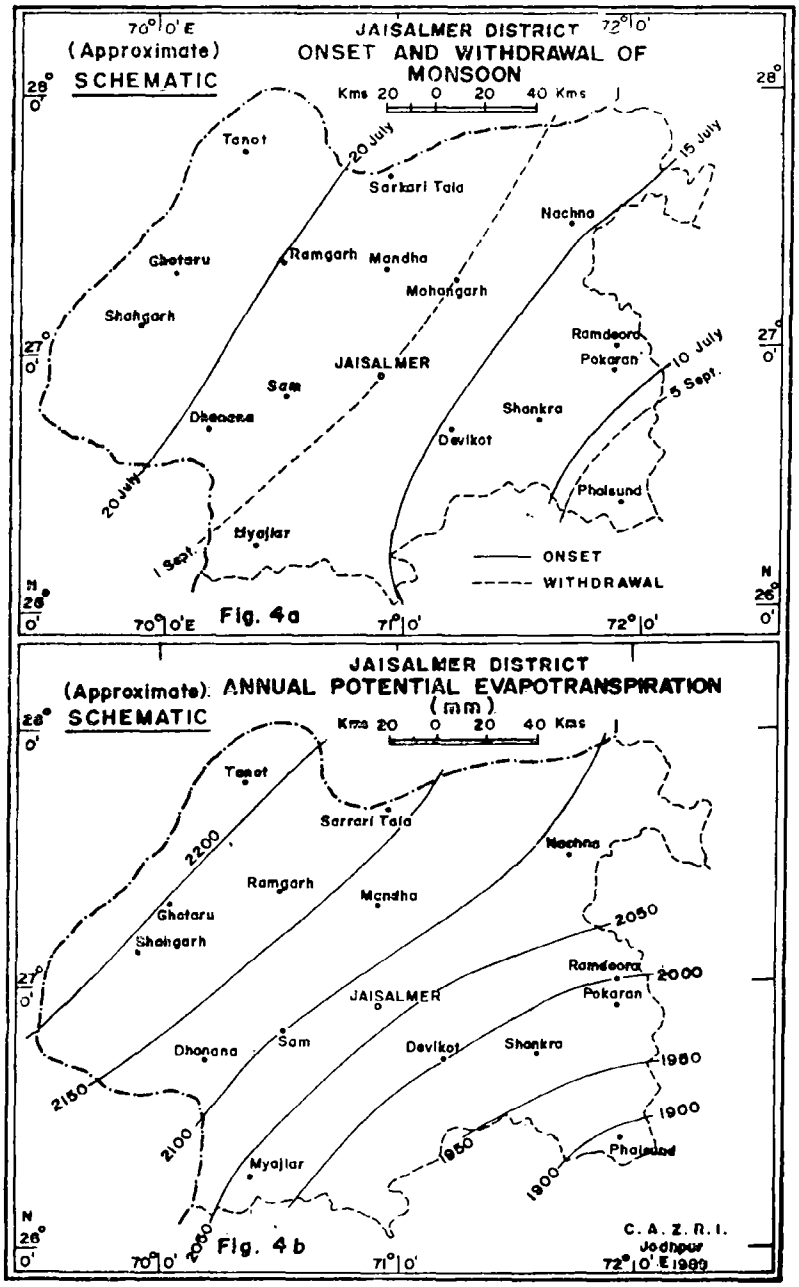

JAISALMER DISTRICT
(Approximate) SCHEMATIC
ONSET AND WITHDRAWAL OF MONSOON
Kms 20 0 20 40 Kms
70°0'E
72°0'
28°0'
27°0'
26°0'
N
Tanot
Sarkari Tala
Nachna
Ghotaru
Ramgarh
Mandha
Mohangarh
Shahgarh
Ramdeora
Pokaran
JAISALMER
Sam
Dhanana
Shankra
Devikot
Phalsund
Myajlar
20 July
15 July
10 July
5 Sept.
1 Sept.
ONSET
WITHDRAWAL
Fig. 4a
JAISALMER DISTRICT
(Approximate) SCHEMATIC
ANNUAL POTENTIAL EVAPOTRANSPIRATION
(mm)
Kms 20 0 20 40 Kms
2200
2150
2100
2050
2000
1950
1900
1850
C.A.Z.R.I.
Jodhpur
Fig. 4b

Fig. 4.

Tabte 1. Normal climatological data of Jaisalmer

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual total/ Mean
Rainfall, mm	2.7	4.7	3.3	2.1	6.7	15.6	56.4	66.4	23.3	1.5	1.5	1.9	188.1
Maximum temperature, °C	23.5	27.6	32.8	38.0	41.4	40.9	37.7	35.9	36.6	36.1	30.9	25.5	
Minimum temperature, °C	7.1	10.3	15.8	21.4	25.2	26.8	26.4	25.2	23.2	19.9	13.1	8.3	
Relative humidity, % 0830 h	60	53	48	48	54	64	73	77	72	56	48	58	
Relative humidity, % 1730 h	36	34	29	28	25	31	47	55	46	34	34	35	
Wind speed, kmph	7.9	8.5	10.3	12.2	17.6	24.8	21.1	18.8	14.6	7.8	5.9	6.2	
Potential evapotranspiration, mm	71	92	153	204	281	317	248	211	192	147	84	64	

Table 2. Extremes of monthly climatological data of Jaisalmer

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Rainfall, mm	Highest	37 9	45.5	43.9	33.8	84.6	63.3	185.7	394.0	196.3	76.2	28.4	32.8
	Lowest	0	0	0	0	0	0	0	0	0	0	0	0
Temperature, °C	Highest	26.5	37.1	36.0	40.4	43.3	43.0	40.9	39.2	38.2	38.6	32.7	27.7
	Lowest	4.6	6.9	9.0	16.8	22.9	23.8	24.6	23.8	22.1	17.5	10.2	4.9
Humidity, %	Highest	78	78	70	68	79	80	89	91	93	80	82	86
	Lowest	13	5	16	13	15	12	32	36	27	23	11	22
Wind speed, kmph.	Highest	24.9	27.8	27.4	29.0	35.6	35.9	36.0	27.7	22.0	27.2	23.8	24.0
	Lowest	4.8	4.9	6.8	4.4	11.1	12.0	11.8	10.5	8.9	6.1	3.1	3.0

Table 3. Mean annual and extreme rainfall in Jaisalmer district and its variability

Station	Normal annual rainfall, mm	Number of rainy days	Standard devitation, mm	Coefficient of variation	Extremes of annual rainfall, mm					
					Highest			Lowest		
					Amount, mm	Year	% of normal	Amount, mm	Year	% of normal
Jaisalmer	188.1	12.0	123.0	65.4	583.1	1944	310	0.0	1918	0.0
Ramgarh	133.8	6.1	97.8	73.2	584.0	1917	437	2.0	1969	1.5
Fatehgarh	157.4	7.4	105.8	67.2	447.8	1931	285	0.0	1968	0.0
Sam	210.7	8.6	147.7	90.9	633.5	1961	388	7.0	1980	3.3
Pokaran	171.9	11.7	83.7	48.7	363.0	1976	211	29.0	1969	16.9
Nokh	164.6	8.1	98.8	60.0	464.0	1936	282	45.0	1968	27.3

Jaisalmer and Ramgarh. The bulk of the annual rainfall at these stations are received during July, August and September months and the highest at most of the stations occurs generally in the month of August. The annual rainfall varies from 134 mm at Ramgarh to 211 mm at Sam and the total number of rainy days varies between 6 (Ramgarh) and 12 (Jaisalmer and Pokaran). Winter rainfall is very uncommon in the district.

The coefficient of annual rainfall varies from 49 per cent at Pokaran to 91 per cent at Sam. Most of the stations in the district have annual rainfall with a coefficient of variation above 60 per cent. The highest recorded annual rainfall was from 363 mm at Pokaran to 634 mm at Sam.

The highest one day observed rainfall ranged from 71 mm at Pokaran to 178 mm at Ramgarh (Table 4). Similarly the range of the highest observed weekly rainfall was between 190 mm at Pokaran and 396 mm at Sam. The highest weekly rainfall is generally recorded in the last week of July or in the first week of August, thereby indicating late arrival of monsoon in this extreme western part of India. Generally the onset of monsoon is associated with heavy showers. A second maxima of weekly rainfall is also observed at many stations, associated with the withdrawal of monsoon. The longer wet spells recorded in the district so far are of 4 to 8 days' duration.

Defining a flood year as a year receiving rainfall of 150 per cent or more of normal rainfall and a drought year as a year receiving rainfall of 50 per cent or less than the normal value, the percentage frequency of flood and drought years at different stations in the district are given in Table 4. The percentage of flood years varies from 13 at Pokaran to 23 at Fatehgarh. The frequency of severe drought years is more common than the flood years in the district. The severe rainfall deficit years prevailed for 17 to 46 per cent of the total period in the district.

(c) Wind pattern and dust storms

Jaisalmer region experiences the highest wind speeds in the arid western Rajasthan. While the post-monsoon and cold weather period (Oct.—Mar.) winds are

Table 4. Peak rainfall, flood and drought frequency in Jaisalmer district

Station	Highest one day rainfall, mm	Maximum weekly rainfall, mm	Longest wet spell		% frequency of flood years	% frequency of drought years
			in days	in mm		
Jaisalmer	130.0	267.6	8	111.5	16.3	21.3
Ramgarh	177.8	228.6	6	88.0	18.9	23.0
Fatehgarh	165.0	259.0	7	223.6	23.1	25.0
Sam	—	395.7	5	395.7	16.7	45.8
Pokaran	71.1	189.6	6	189.0	12.5	16.7

generally light and variable (5 to 11 kmph), winds normally build up from April and continue to remain strong till the end of September. Peak wind speeds are observed in June which records a mean monthly wind speed of 27.2 kmph. The maximum daily wind velocity in the area frequently reaches 30-45 kmph during June and July, with peak winds of upto 100 kmph during severe dust storm period. The wind in the area is predominantly from the north east or northerly direction in winter, while during the rest of the year it is mostly south-westerlies to west-south-westerlies. These high winds during April to September favour formation of dust storms. Interestingly the average frequency of dust storms in the region is the lowest (2 per year) in the western Rajasthan, but during severe drought years upto 15 dust storms are recorded.

(d) Agroclimatic features

The mean annual rainfall within Jaisalmer district varies from 130 mm to 210 mm, with a crop growing season of about 4 to 6 weeks only and, therefore, the region is not suitable for crop production. The growing season available for pastures is 8 to 10 weeks under normal conditions of rainfall and the grasslands are subjected to drought conditions once in four years during the growing phase, affecting the forage production. The forage production in good rainfall years (7.96 million metric tons) is three times more than the production under normal rainfall conditions (2.66 million metric tons). During severe drought years, the forage production decreases drastically (by about 86%), compared to the production during a normal year.

The crop production under rainfed conditions in the district is confined mainly to the south eastern part where the mean annual rainfall is around 200 mm. The pearlmillet is grown under 80 per cent of the net sown area in the district, inspite of poor yields and regular crop failures. The average yield is 113 kg/ha. with a coefficient of variation of 89 per cent in the yield. Rainfall is inadequate even for sowing in 20 to 30 per cent of the years.

The percentage frequency of occurrence of agricultural drought in Jaisalmer district varies from 4% of the period under early commencement of sowing rains, 18% under normal and 78% under late commencement of sowing rains. With late commencement of sowing rains, the area under pearlmillet decreases from 128 to 97 thousand ha and the grain yield from 128 to 99 kg/ha. The percentage probabilities for occurrence of agricultural drought is very high (about 88%).

CHAPTER III

GEOLOGICAL FRAMEWORK

The different geological formations within the district range from pre-Cambrian to Quaternary in age. The major part of the district is covered with wind blown sand (Recent) in the form of dunes which attain considerable height in the north-west. There are series of ridges and rocky plateau around Jaisalmer and in the southern part there are granite hillocks near Khora Kunda. Near Pokaran and Gomat there are hills of Jodhpur sandstone.

On the basis of exposed rock formations and subsurface data the sedimentary sequences of Jaisalmer district could be classified into four major basins, viz. Jaisalmer basin, Lathi basin, Birmania basin and Nagaur basin.

The Mesozoic sequences comprising of Jaisalmer formation, Parewar formation and Abur formation (Cretaceous), and the Cenozoic sequences, comprising of Sanu formation (Eocene), were laid down in the main Jaisalmer basin.

The fresh water sandstones, siltstones and conglomerates, belonging to Lathi formation, were deposited in the Lathi basin. A small Birmania basin towards the south of Jaisalmer includes Randha Sandstone and Birmania Limestone (Cambrian) which are equivalent to Jodhpur Sandstone and Bilara Limestone of Nagaur basin.

The periphery of Nagaur basin commences near Pokaran where Pokaran boulder beds rest over Malani rhyolites. The Jodhpur Sandstone, overlying Pokaran boulder beds, form a few outcrops near Pokaran and to its south. A cap of Bap boulder bed, with underlying marine Bhadaura Sandstone (Permocarboniferous), overlie the sedimentary sequences of Nagaur basin.

The generalised stratigraphic sequence of different rock formations of Jaisalmer district is as follows :

	Recent	Wind blown sand
Quaternary		younger alluvium
	Sub-recent	Older alluvium
		Shumar grits
	.....*major*	unconformity.....
Cenozoic	Eocene	Bandah Limestone

Cenozoic		Khuiala Sandstone
		.....
	Palaeocene	Sanu Sandstone
	.....major	unconformity.....
	Cretaceous	Abur Limestone
Mesozoic		Pariwar Sandstone
		.....
	Jurassic	Bedesar Sandstone
		Baisakhi Shales
		Jaisalmer Limestone
		.....
		Lathi Sandstone
	.....major	unconformity.....
	Permocarboni-	Bap boulder beds
Palaeozoic	ferous	Bhadaura Sandstone
		.....
	Cambrian	Birmania Limestone
		Randha Sandstone
		Jodhpur Sandstone
		Pokaran boulder beds
	.....major	unconformity.....
	Pre Cambrian	Malani rhyolite and granites

CHAPTER-IV

GEOMORPHOLOGY

Jaisalmer district, because of its location in the extremely arid part of the Indian desert, has terrain features which are distinctly arid in nature, with areas of either dominantly sandy forms or the barren rocky-gravelly forms, punctuated with areas of shallow *in situ*/transported depositional forms. Because of extreme paucity of rainfall, high insolation and higher wind speed the land forming processes are dominantly aeolian. Effects of fluvial processes are negligible, although the dry valleys in the central rocky part bear testimony to the efficacy of the spasmodic discharge during rare cloud-bursts. In the central rocky part the Tertiary and pre-Tertiary continental to marine sedimentary beds are also acted upon by numerous ground level weathering processes, although the effects of dominant aeolian processes are noticed in the typical modifications to the rock fragments.

Because of such climatic and terrain features the streams are very few, ephemeral in nature and confined mostly to the rocky part. The most notable among these are the Lik, showing its appearance from a low rhyolite hill range near Bhaniyana and flowing southwards; the Sukri, having its distinct course from near Pokaran and flowing westward; another Sukri, originating from near Sankra and flowing northwestward to meet the other Sukri; the Ramgarh nala, originating from near Ramgarh and flowing northwards; and the Vikharan nai, originating from near Khuiyala and flowing northwestward. The streams hardly record any flow, have gravelly or coarse sandy bed, except in the case of the Lik which has slightly finer sandy alluvium along its course, and are either truncated by sand dunes or are desiccated by aridity. Broadly the area between Pokaran-Mohangarh-Ramgarh-Sam-Fatehgarh-Rajmathai-Lawan is dominantly rocky-gravelly, while the area beyond is dominantly sandy with different types of sand dunes. The sandy forms, consisting of the dunes, interdunal plains and other undulating plains, cover the largest area of 23, 305.0 sq.km (or 60.68% of the total area). Other depositional plains cover 11,715.4 sq.km area (30.52% of the total area), of which only 694.2 sq. km (1.81%) area is under alluvial plains and the rest is shallow, associated with rocky/gravelly units. The exposed rocky/gravelly surfaces cover 3380.6 sq.km area (8.8% of the total area).

There are eleven major land form units within the district (Table 5; Fig. 5) their location, characteristics and potentials are as follows.

Table 5. Landform units in Jaisalmer district

S.No.	Landform units	Unit area in sq.km	% of district area	Subunit area in sq. km	% of district area	% of unit area
1.	Hills	360.0	0.94			
2.	High level rocky structural plains	1314.6	3.42			
3.	Rocky/gravelly pediments	1353.2	3.52			
4.	Gravelly pavements	352.8	0.92			
5.	Flat buried pediment/ pavements/structural plains	10895.8	28.38			
	a) Non saline			10830.0	28.21	% of (a)
	i) Associated with structural plains			2713.4	7.07	24.95
	ii) Associated with rocky/gravelly pediments			4577.2	11.92	42.50
	iii) Associated with gravelly pavements			5539.4	9.22	52.55
	b) Saline flat buried pediments			65.8	0.17	
6.	Sandy undulating buried pediments	1751.4	4.56			
7.	Flat older alluvial plains	694.2	1.81			
	a) Moderately deep alluvial plains			342.6	0.89	
	b) Deep alluvial plains			351.6	0.92	
8.	Sandy undulating older alluvial plains	1300.2	3.38			
9.	Sand dunes	17192.4	44 77			
10.	Interdunal plains	3061.0	7.97			
	a) Flat sandy ,,			2444.6	6.36	
	b) Rocky ,,			56.7	0.15	
	c) Sandy undulating ,,			559.7	1.46	
11.	Saline depression	125.4	0.33			
	Total	38401.0	100.00			

a. Landforms and their characteristics

1. *Hills* (360.0 sq. km) : Covering 0.94% of the total district area, the hills occur scatteredly, especially between Pokaran and Bhaniyana (dominantly rhyolite),

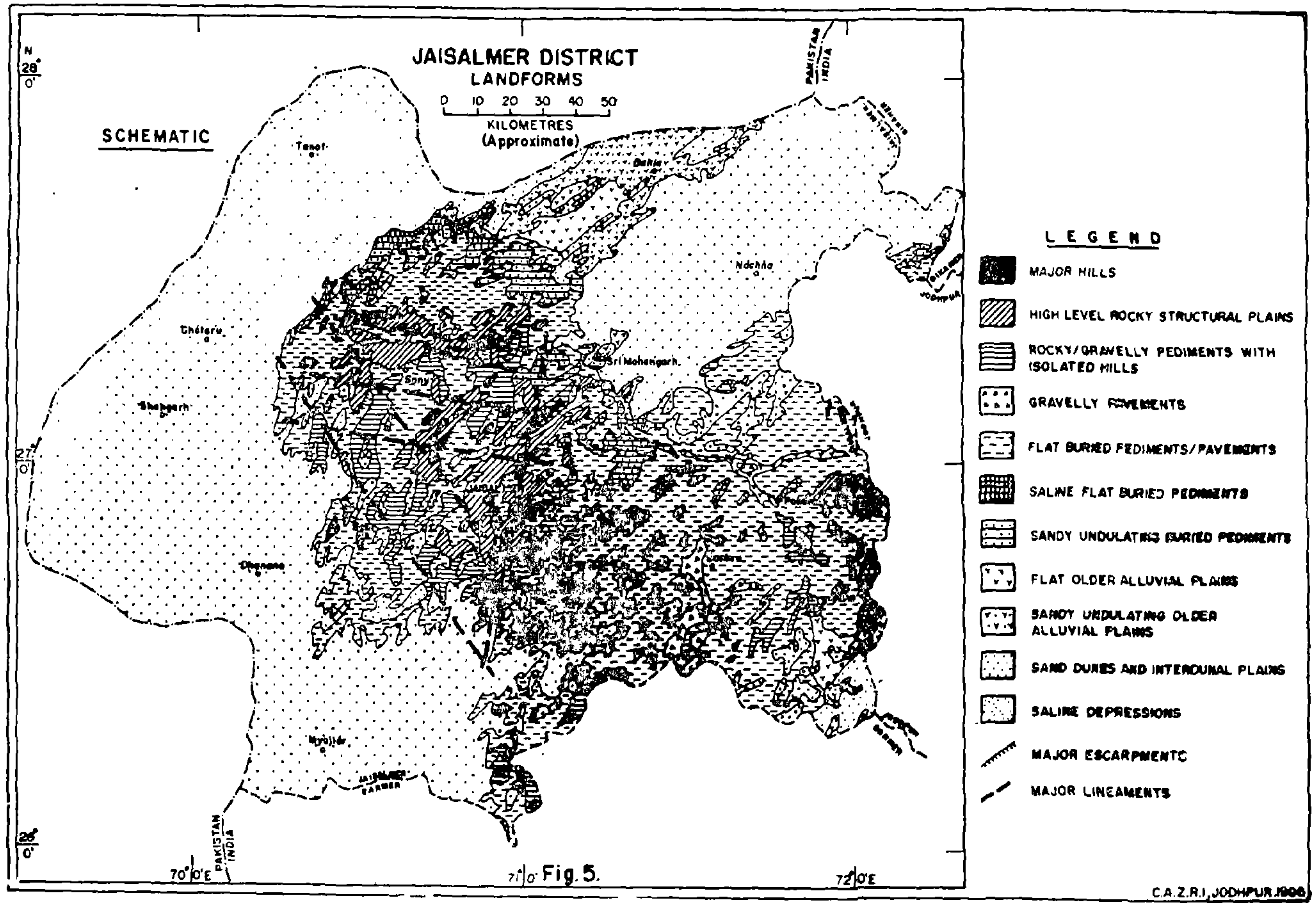

JAISALMER DISTRICT
LANDFORMS
0 10 20 30 40 50
KILOMETRES
(Approximate)
SCHEMATIC
LEGEND
MAJOR HILLS
HIGH LEVEL ROCKY STRUCTURAL PLAINS
ROCKY/GRAVELLY PEDIMENTS WITH ISOLATED HILLS
GRAVELLY PAVEMENTS
FLAT BURIED PEDIMENTS/PAVEMENTS
SALINE FLAT BURIED PEDIMENTS
SANDY UNDULATING BURIED PEDIMENTS
FLAT OLDER ALLUVIAL PLAINS
SANDY UNDULATING OLDER ALLUVIAL PLAINS
SAND DUNES AND INTERDUNAL PLAINS
SALINE DEPRESSIONS
MAJOR ESCARPMENTC
MAJOR LINEAMENTS
PAKISTAN
INDIA
Sri Mohangarh
Ndchha
70°0'E
71°0'
72°0'E
28°0'
27°0'
26°0'
Fig. 5.
C.A.Z.R.I, JODHPUR 1986

Fig. 5.

around Randha and Lakhan (mainly granite), and between Ramgarh-Joga Kanod line in the north and Sam-Shipal-Rama-Rasla line in the south (sandstone and limestone). Hills formed or capped by sandstone are mainly in the form of mesas and buttes, while the limestone hills provide a low rounded profile. The rhyolite and granite hills stand out as inselbergs and domal inselbergs. Some of the hills, especially between Thayat, Mohangarh, Danwar and Damodara are in the form of cuestas and hog backs because of a slight northwestward tilt of the rock beds. The hills are barren and almost devoid of lengthy talus slope. In the south the slopes of many isolated hills between Chhatangarh, Devra and Bhopa have been partly covered by sand dunes.

2. *High level rocky structural plains or hamadas* (1314.6 sq. km) : Over much of the rocky terrain the Tertiary and pre-Tertiary beds of sandstone, limestone and shale with their typical near-horizontal or gently dipping disposition, have been sculpted into high level rocky structural plains (or the *hamadas*), bounded by steep escarpments where the softer beds underneath are exposed. In the case of slightly tilted beds the hamadas appear like broad cuestas with steep southeast facing escarpments and gentler 1° to 5° dip slope northwestward. A number of minor drainage lines originate along the dip slope, maintain their courses on the rocky hamada and die out after a certain distance beyond. The Kankni and the Masurdi near Jaisalmer and the Sam Nadi near Khuiyala are the best examples. The surface is generally rocky throughout (e.g. around Pokaran on Jodhpur Sandstone, around Jaisalmer on Jaisalmer Limestone and near Mokal on Bedesar Sandstone), but where the siliceous bouldery Khuiyala limestone forms the parent rock, especially between Khuiyala, Habur, Sanu, Joga and Biprasar, it provides a much rougher surface. Similarly the gritty layers of Sanu Sandstone and the fossiliferous Bandah Limestone do also provide some roughness.

The usual landform sequence from the escarpment towards the dip slope is a cuesta or a hogback (rarely), followed by a narrow serir plain where ephemeral channels from the cuesta's dip slope converge, and then a broadly convex hamada, the continuation of which is broken by another escarpment.

3. *Rocky/gravelly pediments* (1353.2 sq. km) : The isolated hills and the escarpment side of some hamadas are flanked by rocky/gravelly pediments. The unit covers 3.52% of the total area and occurs widely in Damodara-Kinoi-Habur-Mokal-Chhatrel area and in Sam-Nibh Dungar-Khuri-Bida area where sandstone and limestone are the chief constituents. In the south and east these have been formed on rhyolite and granite. Because of insufficient moisture and run-off, the processes of weathering and erosion are very limited and hence angular and blocky rock fragments, many of them ventifacted or varnished, abound the surface. At places the surface has scattered distribution of polished sandstone balls and smaller nodules, produced by the long

period of physico-chemical weathering and wind-assisted rolls. The slope seldom exceeds 1° of inclination within this unit.

4. *Gravelly pavements* (352.8 sq. km) : A vast area between Pokaran, Chandan, Devikot, Ola, Bandewa, Rajmathai and Nananiyai is occupied by patches of exposed gravelly surfaces with slightly convex outline. Formed almost exclusively of quartz and quartzite pebbles and boulders these surfaces qualify for the term gravelly pavements. In between these outcrops stretches of sand sheets have veneered the gravelly surfaces. The gravels generate from a thick, loosely cemented, conglomeratic bed, associated with the Lathi Sandstone. The thickest deposit has been encountered around Ola, Sankra and Madasar, from where the gravels travel short distance along small channels and with sheet wash. Almost all the pebbles are subrounded to rounded and many are cleaved due to high insolation weathering and dirt cracks. Average slope of this unit is from 1° to 3°C. Such gravel spreads do also occur scatteredly in other parts of the district, especially near Hamira and to the east of Sadhan.

Over much of the area the profile shows a surficial concentration of gravels, followed by an appreciable thickness of sandy and silty material mixed with gravels and then the parent formation.

5. *Flat buried pediments/pavements/structural plains* (10895.5 sq km) : Covering 28.38% of the district's area, this unit is associated with rocky/gravelly pediments, pavements and hamadas. The non-saline subunit of it covers an area of 10830.0 sq. km area (28.21% of the district area). Of this the maximum area of 4577.2 sq. km 11.92% of the district) is associated with the pediments and 3539.4 sq. km (9.22%) is associated with the pavements. The rest 2713.4 sq. km area (7.07%) is associated with the hamadas. Almost every where the average depth of the colluvial sediment is 30-60 cm, composed of fairly polished/varnished angular to sub-rounded fragments and aeolian sand, indicating extremely limited chemical weathering and fluvial erosion, but highly efficient aeolian process. Because of such limitations these plains between Bandah-Ramgarh-Sultana-Khinsar-Joga-Habur have abundant quantity of little weathered fossil nummulitic fauna, generated from the parent rock formation and mixed with aeolian and other finer deposits. Even many of the recent mobile dunes formed on these plains have extensive fossil remnants. The particles of 0.25 to 0.15 mm size and those of 1 to 2 mm size are dominant everywhere. As in the case of pavements, surficial concentration of coarser fragments, in comparison to finer sub-soil, has been noticed in the buried pediments also.

In the case of the buried pavements the dominant coarser particles are of the sizes of cobbles and pebbles, followed by the sand of 0.25 to 0.15 mm size. In some low-lying areas within the units, especially in the areas of *Khadin* cultivation, slightly finer deposits upto 90 cm or sometimes more could be encountered, because of

centripetal drainage and associated inflow of sediments. The average slope varies from 0° to 1°.

The mappable area of *saline flat buried pediments* (65.8 sq. km) occurs amidst hills and pediments around Modha and Sirwa to the west of Devikot, where the salinity is principally due to the exposure of a salt-releasing bed of the Fatehgarh Sandstone and waterlogging. The surface is strewned with rock fragments, but has 30 to 40 cm thick finer deposit below, partly formed *in situ* from the siltstone bed of the formation. Inspite of the hazard, *Khadin* cultivation is tried in this unit.

6. *Sandy undulating buried pediments* (1751.4 sq. km) : Around the margins of the rocky desert and also within it low mobile barchans and other small sand ridges and hummocks create an undulating topography with shallow aeolian deposits in the swells (4.56% of district's area). Within the rocky area this unit occurs mainly along the dry channels and in areas of topographical low. In most cases the aeolian sand is followed at depth by rock. Chief occurrences are around Pokaran, Ujlan, Chacha, Bhairwa and to the north and west of Sultana-Ramgarh-Bandah line.

7. *Flat older alluvial plains* (694.2 sq. km): This unit occurs mainly along the dry bed of the Sukri through Ramdeora, Odhaniya and Chandni, along the Lik to the south of Bhaniyana, in the north between Bahla and Brahmanwala Tibba, and also between Odhaniya and Nananiyai. The unit has been further subdivided into moderately deep and deep. In the case of the moderately deep subunit the sediment thickness varies between 60 and 90 cm, has layered deposits of medium to fine sand and coarse pebbles, and is followed by a riverine conglomeratic sequence at depth. Along the Lik the unit is affected by slight salinity-alkalinity hazard, because of the saline formation within the alluvium. The deep subunit is more than 90 cm deep, occurs mainly along the Lik south of Dantal and has the problem of salinity/alkalinity. The slope varies from 0° to 1°. While the former subunit covers 342.6 sq.km (0.89%) area, the latter subunit covers 351.6 sq.km (0.92%) area.

8. *Sandy undulating older alluvial plains* (1300.2 sq.km) : Covering 3.38% of the total district area, this unit occurs mainly in the south eastern part and to the east of Bahla in the north, where sandy hummocks and ridges of 2 to 5 m height and sand sheets have covered the alluvial plains. The slope is irregular and varies from 1° to 3°. In the southeast the area is relatively well vegetated with trees and is regularly cultivated, but the hummocks in the north are highly unstable, less vegetated (by grasses only) and create more problems under slight biotic pressure.

9. *Sand dunes* (17192.4) : The sand dunes cover the maximum area of the district (44.74%) and occur mainly in the north, west and southwest. In the east they have relatively scattered distribution. There are seven major types of sand dunes (Fig. 6), of which five are relatively stable, but are reactivated to various degrees. These are the

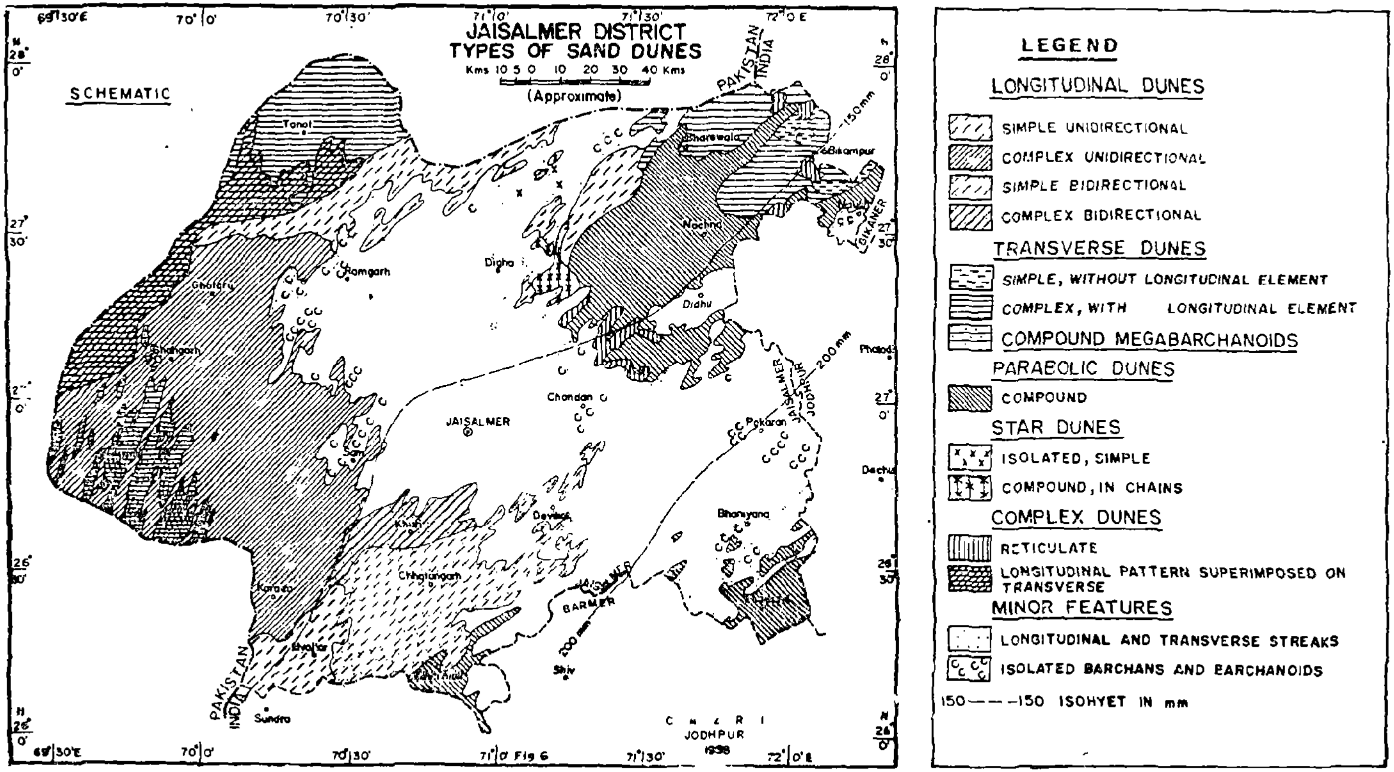

JAISALMER DISTRICT
TYPES OF SAND DUNES
Kms 10 5 0 10 20 30 40 Kms
(Approximate)
SCHEMATIC
PAKISTAN
INDIA
Tanot
Ramgarh
Ghotaru
Shahgarh
Digha
Nachna
Didhu
Sharewala
Bikampur
BIKANER
JAISALMER
Chandan
Pokaran
JODHPUR
Phalodi
Dechu
Bhaniyana
Devikot
Khuiri
Chhatangarh
Karada
Sundra
Shiv
BARMER
150 mm
200 mm
C A Z R I
JODHPUR
1978
LEGEND
LONGITUDINAL DUNES
SIMPLE UNIDIRECTIONAL
COMPLEX UNIDIRECTIONAL
SIMPLE BIDIRECTIONAL
COMPLEX BIDIRECTIONAL
TRANSVERSE DUNES
SIMPLE, WITHOUT LONGITUDINAL ELEMENT
COMPLEX, WITH LONGITUDINAL ELEMENT
COMPOUND MEGABARCHANOIDS
PARABOLIC DUNES
COMPOUND
STAR DUNES
ISOLATED, SIMPLE
COMPOUND, IN CHAINS
COMPLEX DUNES
RETICULATE
LONGITUDINAL PATTERN SUPERIMPOSED ON TRANSVERSE
MINOR FEATURES
LONGITUDINAL AND TRANSVERSE STREAKS
ISOLATED BARCHANS AND BARCHANOIDS
150 — — —150 ISOHYET IN mm

Fig. 6.

longitudinal, transverse, parabolic, star (fern leaf pattern) and complex (reticulate and longitudinal pattern superimposed on transverse) dunes with heights of 10 to 60 m. Among the dune fields (encompassing the sand dunes and interdunal plains) the longitudinal covers the maximum area of 11062.6 sq.km, followed by transverse (4058.0 sq. km.), parabolic (3437.5 sq.km), complex (1495.9 sq km) and star (199.4 sq. km).

The most notable feature of the longitudinal dunefields is the changing shape of the dune from west to east. While in the west most of them are unattached feathered and maintain singularity unless joined by similar form along same trend line, in the east they change gradually from feathered longitudinals to the inverted Y-junctured ones where two or more short longitudinals are noticed at the upwind end of a longitudinal and then 5 to 8 longitudinals converging at an acute angle without much downwind prolongation (i.e. beginning of the transitional zone to parabolics).

The majority of the mobile dunes are either the simple barchanoids of 8 to 10 m height, the isolated barchans of 2 to 8 m height and other minor sand streaks of 2 to 6 m height, which are of shifting nature and have been included in the sandy undulating units, or the compound megabarchanoids (980.0 sq. km) of 15 to 40 m height. While in the case of stable dunes the sand grains are predominantly of 0.15 to 0.125 mm size, in the case of the mobile dunes and reactivated crest of the stable dunes the dominant size is 0.25 to 0.18 mm. Bimodality of sand is a characteristic feature of the stable complex transverse dunes in the northwest.

10. *Interdunal plains* (3061.0 sq.km): Within the duny areas there are some large, mappable interdunal plains. Of these the flat sandy subunit covers 2444.6 sq.km (6.36%) area, the sandy undulating one 559.7 sq. km (1.46%) and the rocky subunit 56.7 sq.km. (0.15%) area. The shape of the interdunal plains is guided by the orientation of the dunes. The flat interdunes in the transverse dunefield of the northwest (e.g. Tanot-Kishangarh area) have distinctly fine loamy texture with more of silt fraction, but elsewhere these interdunes have variable thickness of loose aeolian sand. In the west, especially in Tanot-Ghotaru-Shahgarh-Babuwali tract the dunes and interdunes are copiously vegetated with shrubs and grasses, because of the former courses of Saraswati through the area. The rocky interdunal plains occur mainly in the northeast, while the sandy undulating ones are scatterdly distributed. To the east and north of Mohangarh the interdunes are floored at many places by a gypsiferous hard layer at 60 cm to 150 cm depth. Sand grains of 0.15 mm to 0.125 mm are dominant everywhere.

11. *Saline depressions* (125.4 sq. km) : These *'ranns'* occur scatterdly within the rocky part, especially at Lawan, Pokaran, Ujlan, That and between Jaisalmer and Mohangarh, covering 0.33% area of the district. All the ranns are fed by minor

channels, are flooded after heavy cloud bursts and had outlets formerly, which are now chocked by sand. The Lik had its origin in the ranns of That and Ujlan, while the ranns between Jaisalmer and Mohangarh had an outlet northwards. The surface of the ranns is flat and hard when dry.

b. Assessment of natural hazards and their effects

Because of extreme paucity of rainfall and high wind energy the dominant hazard within the district is of aeolian deposition, affecting 31153.5 sq. km area (81.13% of total area), especially in the sandy tract and along the margins of the rocky tract (Fig. 7). The hazard is of severe proportion mainly around the settlements and in the southwest. The inter-dunal areas are generally affected by slight or moderate wind depositional hazard. Slight water erosional hazard is present in only 348.7 sq.km (0 91%) area, especially in the pavemented southcentral part, and the salinity/alkalinity has affected 108.2 sq.km (0.54%) area, through encrustation mainly in and around the ranns. Thus 6690.6 sq. km (17.42% of the total) area is left with no apparent hazard, especially in the central rocky area and in parts of the flat older alluvial plains, yet it is mostly sterile.

Due to such constraints imposed by the climatic and terrain characteristics agriculture is hazardous in most parts of the district. In many parts there is a dearth of effective soil depth, while at others ploughing, especially through tractors, results in moderate to high reactivation of the sandy layer.

Deep ploughing of some cultivated fields through tractors (e.g. at Loharki and Ramdevra) and uprooting of the natural grasses from the sandy plains (e.g. at Chandan) resulted in a loss of 10 to 15 cm thick top soil in a single year (1985) and created aeolian problems downwind. The formation and movement of barchans along well developed lanes of vortices and their transformation into longitudinal dunes, or the formation of barchanoid crest of the reactivated longitudinal dunes and their advancement through a series of growth sequences have implications for trafficability in the region of such dune formation. The terrain in the sandy tract or the rocky margin is so fragile that slight disturbance to the system leads to sand reactivation and slight unevenness becomes the focii of sand deposition during the high wind regime of the summer months. The surroundings of the settlements are, therefore, severely affected by mobile dune forms, leading in some cases to vast fields of barchanoids (e.g. Lunar).

The gradual introduction of the Indira Gandhi Canal into the district's northern part through Madasar, Nachna and Mohangarh will create better environment for agriculture in the interdune plains of the area. However, the earth work connected with canal construction has already created immense problem of reactivation of erstwhile stable dunes and threatened the roads, canal networks and settlements. Severe erosion

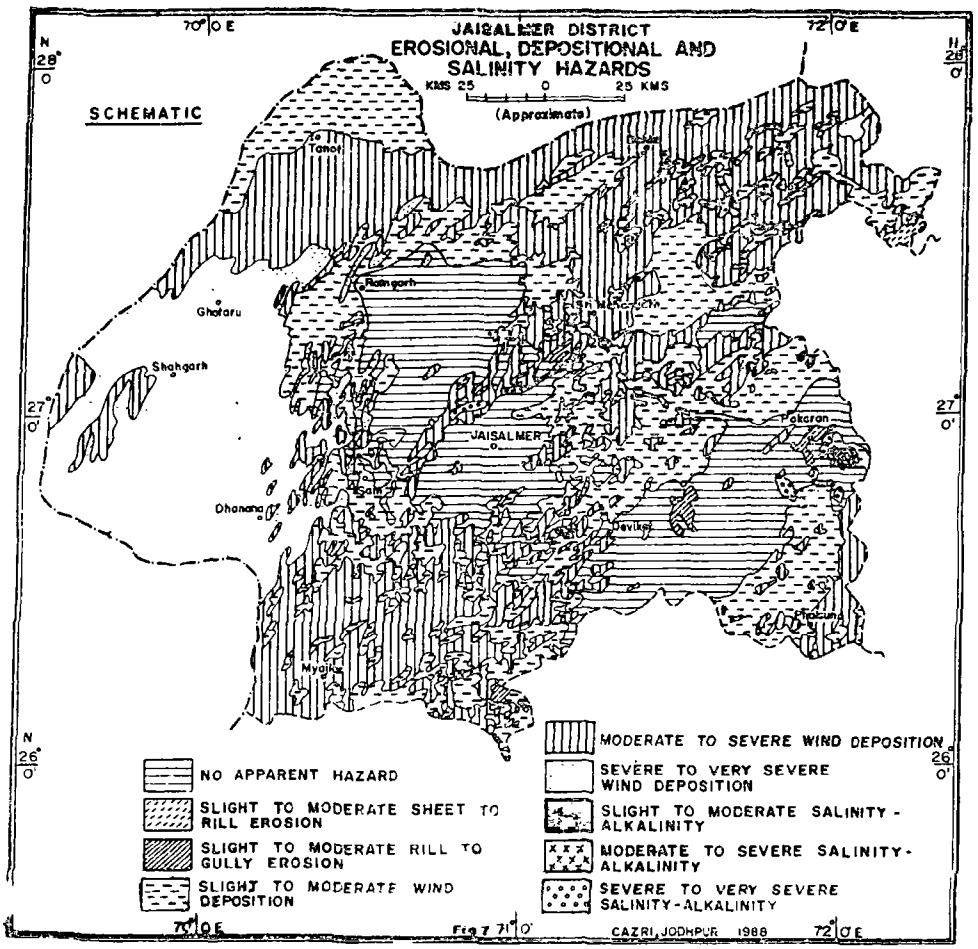

JAISALMER DISTRICT
EROSIONAL, DEPOSITIONAL AND SALINITY HAZARDS
SCHEMATIC
(Approximate)
Tanot
Ramgarh
Ghotaru
Shahgarh
JAISALMER
Pokaran
Dhanana
Devikot
Myajlar
NO APPARENT HAZARD
SLIGHT TO MODERATE SHEET TO RILL EROSION
SLIGHT TO MODERATE RILL TO GULLY EROSION
SLIGHT TO MODERATE WIND DEPOSITION
MODERATE TO SEVERE WIND DEPOSITION
SEVERE TO VERY SEVERE WIND DEPOSITION
SLIGHT TO MODERATE SALINITY - ALKALINITY
MODERATE TO SEVERE SALINITY - ALKALINITY
SEVERE TO VERY SEVERE SALINITY - ALKALINITY
CAZRI, JODHPUR 1988

Fig. 7.

of the canal bank exposed to the dominant SW wind is also a major problem during the summer months. Away from the canal digging activities the dunes have remained much less affected. Another major source for acceleration of the aeolian hazard in the canal command area is devegetation of the dunes and interdunes for bringing more land under irrigated agriculture. Without the assured supply of water such devegetated plots may tremendously increase the rate of sand movement and affect the potentials of surrounding areas.

The salinity-alkalinity hazard is mainly dominant in and around the *ranns*, but the limitation of gypsiferous hard pans at shallow depth in the canal command area is likely to aggravate the problem in near future, especially around Panna, Lakheri, Madasar, Awai, Nachna, Ghantiali and Mohangarh, unless there is adequate water management. The salinity problem has already set in between Madasar and Awai due to seepage from the canal.

Water erosion in the district is negligible as streams hardly flow. People, therefore, seek subsurface sources of water. Most of the former buried channel courses are, however, not very promising because of insufficient catchment and/or relation with saline ranns (Fig. 8). The obliterated course of the Lik, the buried stream course through Naukh and Madasar in the north east or the course traced north of Mohangarh are all linked with saline ranns. Another former channel network with courses originating from the Chattangarh and Randha hills and flowing westward through Jhinjhiniyali and Antiya do not have sufficient valley fill, but still could be explored. The best promising buried courses are, however, those of the Saraswati in the extreme west, through Dharmi Khu, Ghantial and west of Ghotaru, Shahgarh and Babuwali in the dune country (Fig. 8), which yield sweet water. However, because of very narrow interdunes and high reactivated sand dunes the source could only be tapped for drinking water supply. A lineament traced to the south of Jaisalmer through the vicinity of Bhu, Narsingh ki Dhani, Ugawa and Binjota, and having possible linkage with the one further south through the east of Nagraja, Letha, Tejmalta and the Randha hills, has thick semi-consolidated deposits and could be a promising zone. A number of other lineaments could also be identified from satellite images of the rocky terrain (Fig. 5) and need to be verified. In the Khuiyala limestone terrain there are numerous evidence of karsting which control not only the fewer surface channels on it, but also the movement of ground water.

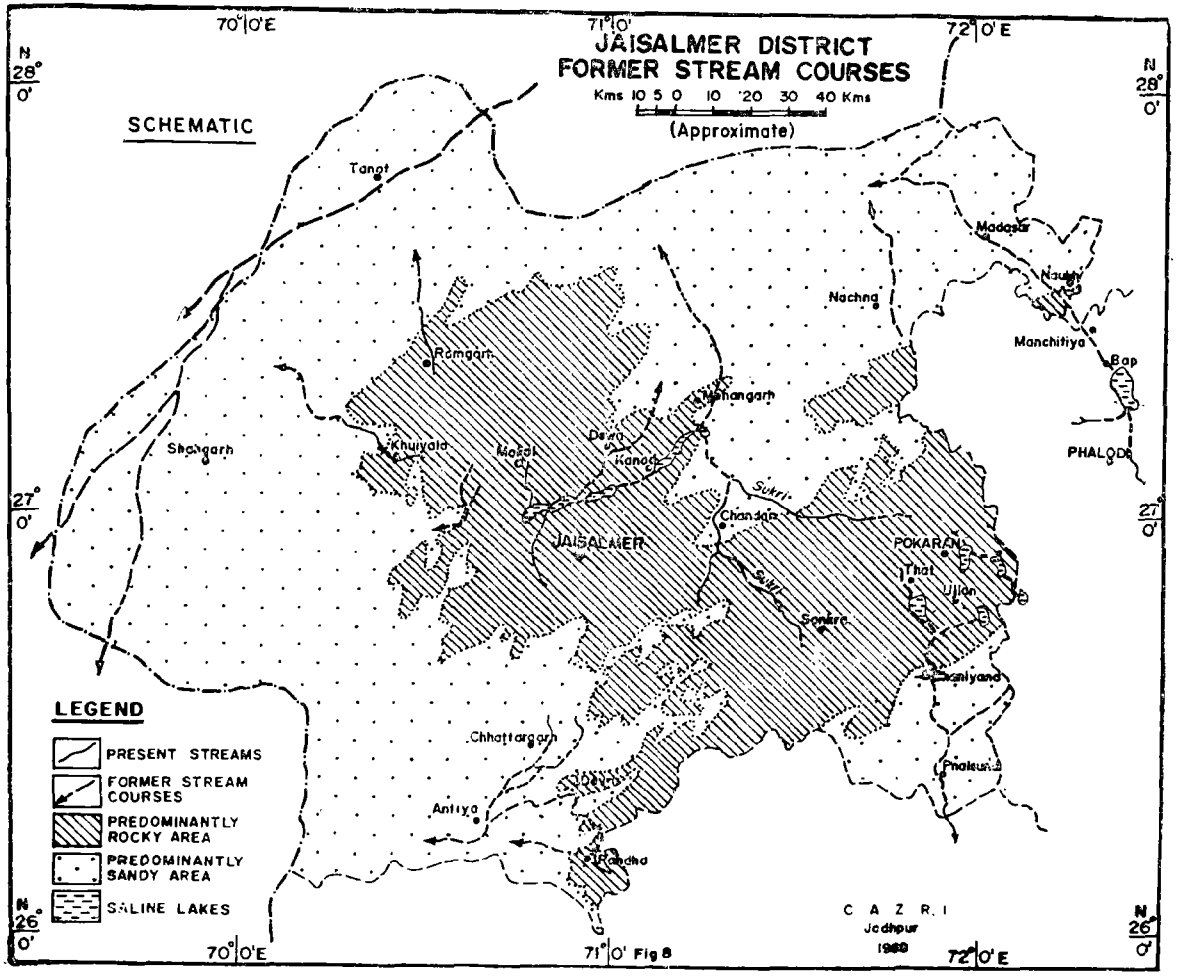

JAISALMER DISTRICT
FORMER STREAM COURSES
Kms 10 5 0 10 20 30 40 Kms
(Approximate)
SCHEMATIC
70°0'E
71°0'
72°0'E
N 28° 0'
N 27° 0'
N 26° 0'
Tanot
Madasar
Nachna
Manchitiya
Bap
PHALODI
Ramgarh
Pokhangarh
Shahgarh
Khuiyala
Mohar
Dewa
Kanoi
Sukri
Chandan
JAISALMER
POKARAN
That
Ujlan
Sonara
Kanlyana
Chhattargarh
Phalsun
Antiya
Kandha
LEGEND
PRESENT STREAMS
FORMER STREAM COURSES
PREDOMINANTLY ROCKY AREA
PREDOMINANTLY SANDY AREA
SALINE LAKES
C A Z R I
Jodhpur
1980
Fig 8

Fig. 8.

CHAPTER-V

SOILS AND LAND USE CAPABILITY

Jaisalmer district, inspite of its high aridity and moisture deficiency, has an immense variability of soil. Sediments from different rock sources and varied history of landscape evolution have given rise to a wide range of soils, like the coarse aeolian sandy soils, the dune soils, the interdune soils, the moderately fine textured clay loam soils, the gravelly skeletal soils and the bare rocky outcrops.

Based on the morphological characteristics of soils, like texture, structure, colour, lime concretions, thickness of solum and soil depth, the major soils of the district have been mapped into 26 soil series. Considering the various phases within the series, like soil depth, extent of hummockiness, dune or interdune terrain, etc., the total soils mapping units are 55.

For this report the soil series have been grouped into broad textural classes and a major soil group map has been prepared (Fig. 9). Their major characteristics and distribution have been summarised in Table 6 and are described below.

1. Coarse textured soils

i) *Coarse textured soils of dune complex and interdunes :* These soils are composed of very fine aeolian sand, deposited in the form of sand dunes and interspersed with interdunal plains. These are very deep soils of uniform profile characteristics, varying in colour from light yellowish brown (10 YR 6/4) to reddish brown (7.5 YR 4/4). They generally comprise of 2 to 6% clay, 1.7 to 3.3% silt, 72 to 85.3% fine sand and 9.3 to 15.1% coarse sand. The interdunal areas often have deep aeolian sands and are prone to high wind velocity.

ii) *Coarse textured soils of sandy plains :* These soils have wide spatial variability with respect to colour, particle size distribution, underlying strata, etc. Therefore, these have been divided into various series like Madasar, Shergarh, Thar, Dabla, Bhojka, Sam, Myajlar, Parewar and Chirai. While Madasar, Myajlar and Shergarh have negligible coarse sand, Parewar, Bhojka and Dabla have appreciable proportion of medium to coarse sand. In general these soils are sandy at the surface and either sandy or loamy sand in sub soil, underlain at variable depth by weakly developed or moderately developed lime concretionary zone, or weathered rock or gravels/ pebbles. Generally most of these soils are prone to wind erosion/deposition and hence, the surface at many places is highly hummocky.

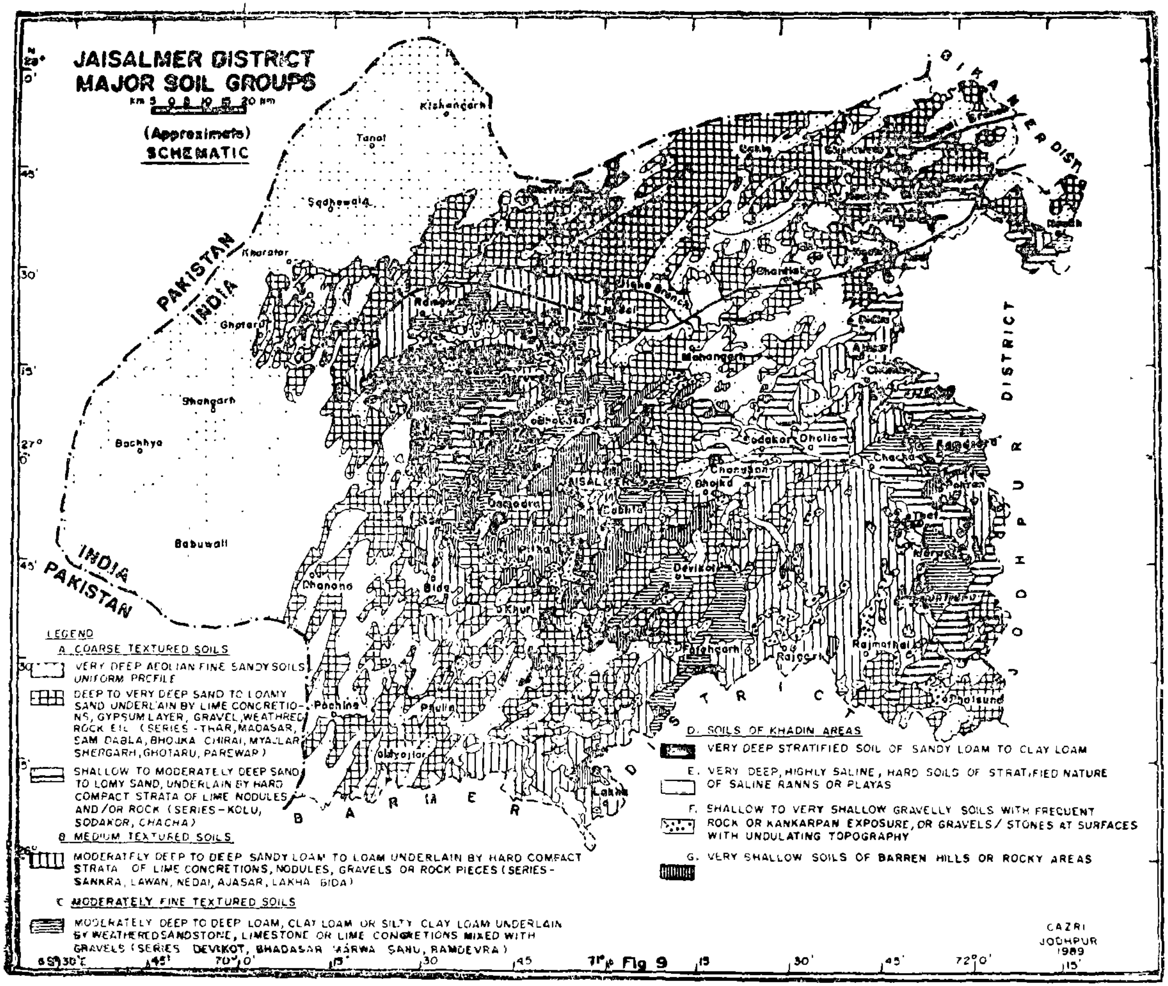

JAISALMER DISTRICT
MAJOR SOIL GROUPS
(Approximate)
SCHEMATIC
PAKISTAN
INDIA
BIKANER DIST.
JODHPUR DISTRICT
BARMER DISTRICT
Kishangarh
Tanot
Sadhewala
Kharatar
Ghotaru
Shahgarh
Bachhya
Babuwali
Mohangarh
Sodakor
Dholia
Chandhan
Bhojka
Dabla
Chacha
Devikot
Fatehgarh
Pokran
Rajmathai
Pachina
Phulia
Bida
Khuri
Lakha
Dhanana
LEGEND
A. COARSE TEXTURED SOILS
VERY DEEP AEOLIAN FINE SANDY SOILS UNIFORM PROFILE
DEEP TO VERY DEEP SAND TO LOAMY SAND UNDERLAIN BY LIME CONCRETIONS, GYPSUM LAYER, GRAVEL, WEATHRED ROCK ETC (SERIES - THAR, MADASAR, SAM DABLA, BHOJKA CHIRAI, MYAJLAR SHERGARH, GHOTARU, PAREWAR)
SHALLOW TO MODERATELY DEEP SAND TO LOMY SAND, UNDERLAIN BY HARD COMPACT STRATA OF LIME NODULES AND/OR ROCK (SERIES - KOLU, SODAKOR, CHACHA)
B. MEDIUM TEXTURED SOILS
MODERATELY DEEP TO DEEP SANDY LOAM TO LOAM UNDERLAIN BY HARD COMPACT STRATA OF LIME CONCRETIONS, NODULES, GRAVELS OR ROCK PIECES (SERIES - SANKRA, LAWAN, NEDAI, AJASAR, LAKHA BIDA)
C. MODERATELY FINE TEXTURED SOILS
MODERATELY DEEP TO DEEP LOAM, CLAY LOAM OR SILTY CLAY LOAM UNDERLAIN BY WEATHEREDSANDSTONE, LIMESTONE OR LIME CONCRETIONS MIXED WITH GRAVELS (SERIES DEVIKOT, BHADASAR MARWA SANU, RAMDEVRA)
D. SOILS OF KHADIN AREAS
VERY DEEP STRATIFIED SOIL OF SANDY LOAM TO CLAY LOAM
E. VERY DEEP, HIGHLY SALINE, HARD SOILS OF STRATIFIED NATURE OF SALINE RANNS OR PLAYAS
F. SHALLOW TO VERY SHALLOW GRAVELLY SOILS WITH FREQUENT ROCK OR KANKARPAN EXPOSURE, OR GRAVELS/ STONES AT SURFACES WITH UNDULATING TOPOGRAPHY
G. VERY SHALLOW SOILS OF BARREN HILLS OR ROCKY AREAS
CAZRI
JODHPUR
1989
Fig 9

Fig. 9.

(iii) *Shallow coarse textured soils :* Wherever the coarse sandy soils have depth limitation due to occurrence of a reasonably hard strata close to the surface, made up of either hard, cemented lime concretions, nodules or gravels, these have been mapped under the series Sodakor, Rajgarh, Ghotaru and Chacha, depending upon their profile characteristics and morphology. These soils are also prone to wind erosion.

Potentials and limitations : Most of the coarse textured soils are composed of sand and at places have loamy sand texture in the subsoil, with predominantly fine sandy component. These are devoid of any stable structure and therefore are loose and very friable. Often the soils are single grained and have very low water retention capacity (50 to 70 cm water per metre depth).

Since vegetation cover on these soils is almost negligible these are highly susceptible to wind erosion. In fact, these soils serve as a source of dust during the summer months.

With respect to fertility the soils are very poor in organic carbon (0.01 to 0.07%), poor in available phosphate (6 to 17 kg/ha), but have medium to high available potash (140-477 kg/ha). Yet the contents appear to be sufficient for sustaining the natural vegetation. The soils are, therefore, best suited for natural pastures, or developed pastures, especially *Lasiurus sindicus* grass. Plants like *Ziziphus nummularia, Capparis decidua* and *Leptadenia pyrotechnica* are most common on these soils.

Agriculture without irrigation is not recommended.

Distribution : These soils occupy 74.1% area of the district and occur in most parts, but have less occurrence in Pokaran tehsil.

2. Medium textured soils

Soils of this group are formed of sediments from somewhat fine grained rock types. These soils are generally comprised of sand to loamy sand texture at the surface, grading to sandy loam texture in subsoil and underlain by variable materials like weathered fragments of sandstone, limestone, granite or conglomerate. Therefore, their colour, particle size distribution, calcareousness and amount of free lime or kankar differ widely. Among the series the Lawan, Lakha, Bida and Ajasar are reddish brown with their colour ranging from 7.5 YR to 2.5 YR. Ajasar has high proportion of coarse sand, while Lawan and Lakha have less of coarse sand and more of fine sand. While Lawan and Ajasar soils have developed on sediments from red sandstone, Lakha and Sankra are associated with pink granite. Bida soils are associated with limestone. Rajgarh and Nedai soils of very old land surfaces are associated with conglomeratic material and assorted gravels, along with lime nodules. Thus, these soils are morphologically highly variable.

Though these soils are sandy to loamy sand at surface, they have sandy loam texture in subsoil, indicating little more of clay and silt in subsoils. The clay content ranges from 9.9 to 15.8%, while the silt content ranges from 8.9 to 12.1%. Coarse sand ranges from 11.2 to 27.9%, and fine sand from 47.3 to 68.2%. Thus, there is appreciable rise in clay and silt content and reduction in sandy compenent. Most of these soils are highly calcareous and their subsoils have weak to moderately developed structure.

Potentials and limitations : These soils, having little more clay and silt component in subsoil and a weakly to moderately developed subangular blocky structure, retain 90 to 110 mm of water per metre depth, which is slightly more than that of sandy soils of earlier group. The soils are slightly less susceptible to wind erosion, although deposition of aeolian sand from adjoining units is creating low sandy hummocks which need stabilization. The soils contain 0.04 of 0.24% organic carbon, 11 to 20 kg/ha of phosphate and 190 to 465 kg/ha of potash. Thus, these soils are low in nitrogen and phosphate, but medium to high in potash.

Although otherwise suitable for agriculture, the location of the soil in the extremely arid climate, discourages rainfed agriculture. However, agriculture with irrigation would be more suitable on these soils. Otherwise, there is scope for developing pasture lands with suitable species and land management. *Eleusine compressa, C. decidua, Ziziphus nummularia* and *Calotropis procera* occur naturally on these units.

Distribution : These soils occupy 10.53% area of the district, especially around Bida, Lakha, Sankra, Rajgarh, Lawan, Ajasar and Nedai villages.

3. Medium to moderately fine textured soils

Most of the soils of this group are formed of either fine sediments or over weathering zone of fine grained rocks. The soils are fine textured and well aggregated. Therefore, these are subject to slight to moderate sand deposition. With the variation in parent lithology the soils differ in colour, particle size distribution, extent of calcareousness, depth and underlying strata, necessitating identification of series like Sanu, Marwa, Devikot, Ramdevra and Bhadasar.

Generally they range in texture from sandy loam to loam at surface and loam to clay loam in subsurface layers over gravelly strata of either fine grained pink sandstone or shale material or fine grained limestone or compact lime concretion. The colour ranges from yellowish brown (10 YR 5/4) to dark reddish brown (5 YR 4/4). Clay content in the subsoil ranges from 16.8 to 36.0%, silt from 8.3 to 26 3%, fine sand from 14 to 56% and coarse sand from 6.6 to 15.4%. Thus, the subsoil texture ranges from loam to clay loam, silty clay loam and gravelly clay loam. Marwa,

Ramdevra and Devikot series generally have deep phases and Bhadasar series has moderately deep to deep phases.

Potentials and limitations : These soils have appreciable structural development and form good soil peds when ploughed. Being fine textured with better structural development, these soils have better water retention capacity (110-190 mm water per metre depth). However, soils shallower than a metre may hold less water in profile.

The soils are poor in organic carbon, ranging from 0.04 to 0.36% and so are poor in nitrogen. Available phosphate is also poor, the range being 10 to 18 kg/ha. Available potash, however, is enough, its range being 215 to 514 kg/ha. These nutrients, however, are seen to be sufficient to support natural vegetation and grasses of the region.

Due to the climatic constraints rainfed agriculture is hazardous. However, if potential runoff catchment are available nearby, these soils could be developed as good 'khadin' areas. Therefore 'khadin' type runoff agriculture can profitably be developed on such soils.

Distribution : These soils collectively occupy about 5.32% of the district and are scattered around Devikot, Fatehgarh, Sanu, Bhadasar, Ramgarh, Damodara, Marwa and Ramdevra.

4. Soils of Khadin area

'Khadin' is a typical, age-old land use system of run-off agriculture in Jaisalmer area, wherein runoff water from adjoining rocky catchments is collected and impounded on low lying farm land for subsequent *rabi* cropping. Thus, it is a site-specific land use. Due to the regular settlement of fine sediments, brought down by water on the farm land and prolonged moist conditions which favour better weathering in the farm soils, khadin soils are medium to fine textured and stratified with better aggregation and clod formation. They are generally very deep, with sandy loam to loam at surface and loam, clay loam and silty clay loam in the subsoils. Colour, particle size distribution, calcareousness, etc. differ with the rock type. Being medium to fine textured and well structured, these soils hold 130-220 mm water per metre depth. Fertility status is better than in many soils of the region.

Organic carbon content ranges from 0.26 to 0.70%. Available phosphate ranges from 24 to 68 kg/ha. Available potash varies from 240 to 920 kg/ha. Thus, these are the most fertile soils of the region. Because of the availability of runoff water, these are also the suitable sites for rainfed agriculture and especially the rabi crops.

Potentials and limitations : Proper development of the khadin catchment and channelisation of the runoff water to the 'khadin' are necessary for best results. There is also need to frequently level the farm lands and to maintain khadin bunds, for uniform distribution of water over the farm land.

New khadins could be developed on medium to fine textured soils if proper catchments exist in the proximity.

Distribution : Although small khadins of 1-5 ha are scattered in the district, those could not be mapped at small scale. Large, mappable khadins occupy 0.7% of the district. A number of new khadins are also coming up.

5. Shallow gravelly/rocky soils of piedmont zones

These miscellaneous types of soil occur in nearly level to gently undulating rocky or hilly situations. The surface of these soils is strewn with gravels and pebbles to the extent of 5 to 20 per cent, although patches having gravels as high as 70 per cent are also found.

The 10 to 40 cm deep solum is usually mixed with gravels and the underlying strata is often gravelly or concretionary and indurated.

The gravel-free soil in the solum has a texture of sand to fine sandy loam, with clay content of 7 to 13 per cent and silt of 6 to 11 per cent. Soils can retain only 15 to 35 mm of moisture in the solum. These soils have reasonably good amount of plant nutrients to support natural vegetation. The soil tends to form crust. This factor, together with gravel component, generate significant runoff even under low intensity rains, which can be collected for better utilization. These soils are suitable for pasture development with suitable species and soil working.

Distribution : These soils occupy 3.17% area of the district and cover large area around Pokaran, Jaisalmer, Rajgarh and Ramgarh.

6. Salt -affected soils

Salt affected soils largely occur in the saline 'playas' (or the *Ranns*) like the Khara Rann, Mitha Rann, Pokaran Ka Rann, That Ka Rann, Jhalaria Ka Rann, Phulasar Ka Rann, Lawan Ka Rann, Kanod Ka Rann, etc. The soils vary from sand to loamy sand, sandy loam, clay loam and silty clay loam. Although these are highly charged with soluble salts, the salt content varies spatially as well as in profile. The electrical conductivity ranges from 100 mmhos to as high as 2, 200 mmhos. The soils are, therefore, unsuitable for agriculture and prohibit growth of natural vegetation. As such, most of these areas are practically barren.

Potentials and limitations : Although the soils are highly saline, at suitable sites with fairly low salt concentration suitable land layout, like making ridges and ditches or raised beds or bunds, etc. can help in plantation of highly salt tolerant species of grasses and trees.

Distribution: These soils occupy nearly 0.51% area of the district.

7. **Soils of rocky hills and plateaus**

This unit comprises of hills, dissected plateaus and other uplands on sandstone, limestone, granites, etc. The soil cover is very scanty and thin. At plaees the western flanks are covered with aeolian sand and form good media for natural vegetation.

Problems and potentials: These areas, due to lack of soil cover and soil depth, support very little vegetation, but can form good runoff potential areas for harvesting runoff.

Distribution : This unit occupies nearly 5.71% area of the district.

Table 6. Major soil types of Jaisalmer district and their characteristics

Major soil type	Major characteristics	Potentials and/or limitations	Precent area
1. Coarse textured sandy soils of duny complex			
a) Dunes and interdunes	Very deep, very fine, calcareous aeolian sands, single grained	Highly susceptible to wind erosion; poor moisture retention; rolling topography; very deep rooting zone	43.04
b) Very deep soils of sandy plain (Madasar, Shergarh, Thar, Dabla, Bhojka, Sam, Myajlar, Parewar, Chirai series)	Very fine sand to loamy fine sand in subsoil; very deep with slight to highly hummocky phases; very weak structured	Highly susceptible to wind erosion; poor moisture retention; often hummocky relief; very deep rooting zone.	11.18
c) Moderately deep soils of sandy plains (Sodakor, Rajgarh, Kolu, Ghotaru, Chacha series).	Same as above	Same as above, but underlain by moderate to well developed lime kankar zone within 40-70 cm depth; limited rooting zone	12.84
2. Moderately coarse textured soils			
a) Deep to very deep (Lawan, Lakha, Ajasar, Nedai series)	Very deep loamy sand to sandy loam; often with slight to moderate hummocky phases	Susceptible to wind deposition; slightly better moisture retention	3.59
b) Moderately deep soils (Bida, Sankra, Nedai, Rajgarh series), Ajasar Lakha, Lawan, Bhojka and Rajgarh varient	Moderately deep soils of loamy sand with sandy loam at subsoil underlain by hard strata	Root zone limitation; low moisture retention; susceptible to wind deposition	6.94

(Contd.)

(Contd.)

Major soil type	Major characteristics	Potentials and/or limitations	Percent area
3. Medium to moderately fine textured soils (Sanu, Marwa, Devikot, Ramdevra, Bhadasar series)	Moderately deep to deep soils of loam to clay loam texture in subsoil underlain by hard strata	Better water retention; not susceptible to wind erosion, but often sand deposit on surface	5.32
4. Deep soils of 'Khadin' area	Deep alluvial soils of local sediments, medium to moderately fine textured	Good for ensured rainfed cropping	0.74
5. Shallow gravelly, rocky soils of piedmont zones	Very shallow gravelly soils with variable lithology and texture	Poor water retention; undulating to sloping land; gravels and stones strewn on surface	3.13
6. Salt affected soils	Very deep moderately fine textured stratified soils of low depressions and Ranns	High salinity; sometimes inundated; barren	0.52
7. Soils of rocky hills and plateaus	Rocky, sloping areas with pockets of shallow skeletal soils	Exposed rocky surface; high runoff potential	5.71

Land use capability classes

Considering the extreme climatic constraints like high evaporative demand and very low and erratic precipitation, none of the soils are considered to be suitable for regular rainfed farming. Dry farming is impossible without supplemental irrigation. Therefore, no land, despite somewhat better soil cover, is assigned a land use capability class better than class IV. The only exceptions are the khadin areas which, due to their regular runoff agriculture during Rabi season, are assigned class III. Altogether the following five classes have been identified and mapped in the district : III, IV, VI, VII and VIII (Table 7, Fig. 10).

Table 7. Land capability classes in Jaisalmer district

Class	% area	Major characteristics/limitations
III	0.73	Major Khadin areas of runoff farming
IV	6.49	Very deep coarse to medium textured soil in more than 250 mm rainfall areas.
VI	42.68	Moderately deep to very deep soils of coarse to medium texture in the less than 250 mm rainfall zone.
VII	35.60	Very shallow to moderately deep sandy, gravelly soils with 3 to 5% slopes and sand dune complex
VIII	14.50	Steep hills, rocky areas, highly saline ranns and barchan dune.

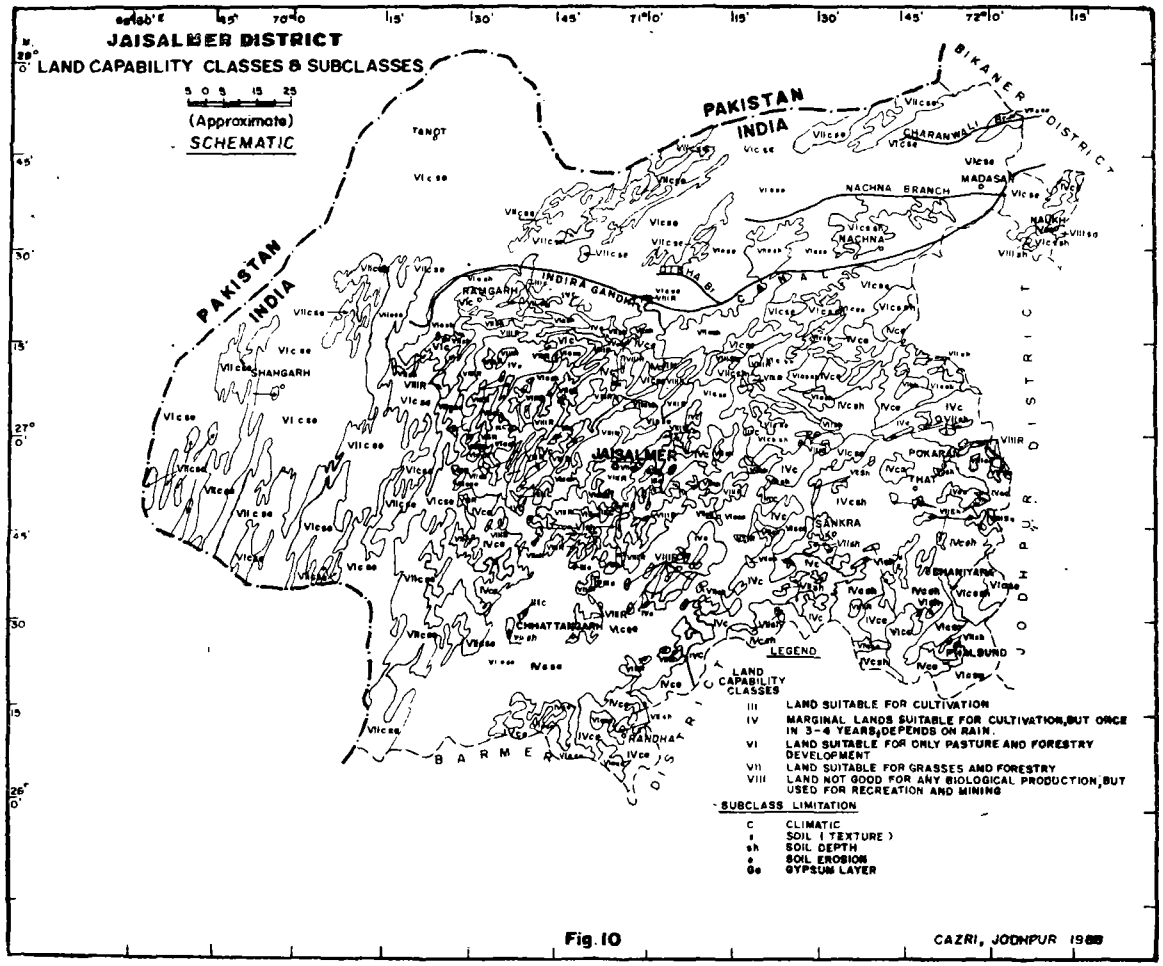

JAISALMER DISTRICT
LAND CAPABILITY CLASSES & SUBCLASSES
(Approximate)
SCHEMATIC
PAKISTAN
INDIA
BIKANER DISTRICT
JODHPUR DISTRICT
BARMER
JAISALMER
POKARAN
SANKRA
CHANDAN
LEGEND
LAND CAPABILITY CLASSES
III LAND SUITABLE FOR CULTIVATION
IV MARGINAL LANDS SUITABLE FOR CULTIVATION, BUT ONCE IN 3-4 YEARS, DEPENDS ON RAIN.
VI LAND SUITABLE FOR ONLY PASTURE AND FORESTRY DEVELOPMENT
VII LAND SUITABLE FOR GRASSES AND FORESTRY
VIII LAND NOT GOOD FOR ANY BIOLOGICAL PRODUCTION, BUT USED FOR RECREATION AND MINING
SUBCLASS LIMITATION
c CLIMATIC
s SOIL (TEXTURE)
sh SOIL DEPTH
e SOIL EROSION
Ge GYPSUM LAYER
Fig. 10
CAZRI, JODHPUR 1988

Fig. 10.

CHAPTER VI

VEGETATION

Trees are rare in Jaisalmer district. Hence the terrain gets a look of sparse grassland with sprinkling of shrubs and small trees, many of which have forage value (Fig. 11). The distribution and characteristics of grasses, shrubs and trees on different habitats are described below.

(a) Major communities

1. Grasslands

Four major grassland types have been identified in Jaisalmer district. These are : (1) *Lasiurus sindicus* type, occurring over 80% of the geographical area of the district; (2) *Dactyloctenium sindicum - Eleusine compressa*, occupying 8.64% area; (3) *Aristida-Oropetium thomaeum*, covering 6.06% area; and (4) *Sporobolus marginatus-Eleusine compressa* on 3.5% area. *Lasiurus sindicus* has two subtypes : (a) *Lasiurus sindicus - Eleusine compressa*, dominating on sandy plains (on 25% area) (Fig. 11), especially in the northwest and (b) *Lasiurus sindicus - Panicum turgidum*, occupying 55% area, mainly on dunes and interdunes in the northeast and southwest. *Aristida - Oropetium* type occurs on rocky/gravelly surfaces and lower slopes of the central rocky uplands of the district. *Sporobolus marginatus - Eleusine compressa* type is restricted to the saline depressions. *Dactyloctenium sindicum - Eleusine compressa* appears on thin soil mantles in the south eastern part of the district.

Average dry forage yield was maximum in *Lasiurus sindicus* type (687 kg/ha), followed by *Sporobolus marginatus - E. compressa* (650 kg/ha). *D. sindicum - E. compressa* (275 kg/ha) and *Aristida - Oropetium thomaeum* (180 kg/ha). Similar trend is also observed in their average carrying capacity (Table 8). Total dry matter yield and carrying capacity is maximum in *Lasiurus sindicus - P. turgidum* type, followed by *L. sindicus - E. compressa* and S. *marginatus - E. compressa* types. Estimates show that potential forage yield, which is the maximum possible yield under protection, can be increased four times per year. The existing average dry forage yield of 27.36 lakh tonnes is estimated to have carrying capacity of 12.5 lakh ACU/year. The actual livestock population, as per 1981 gazetter is 4.38 lakh ACU/year. The district has, therefore, a surplus of 14.27 lakh tonnes of dry forage yield (Table 9) which can support double the present livestock population.

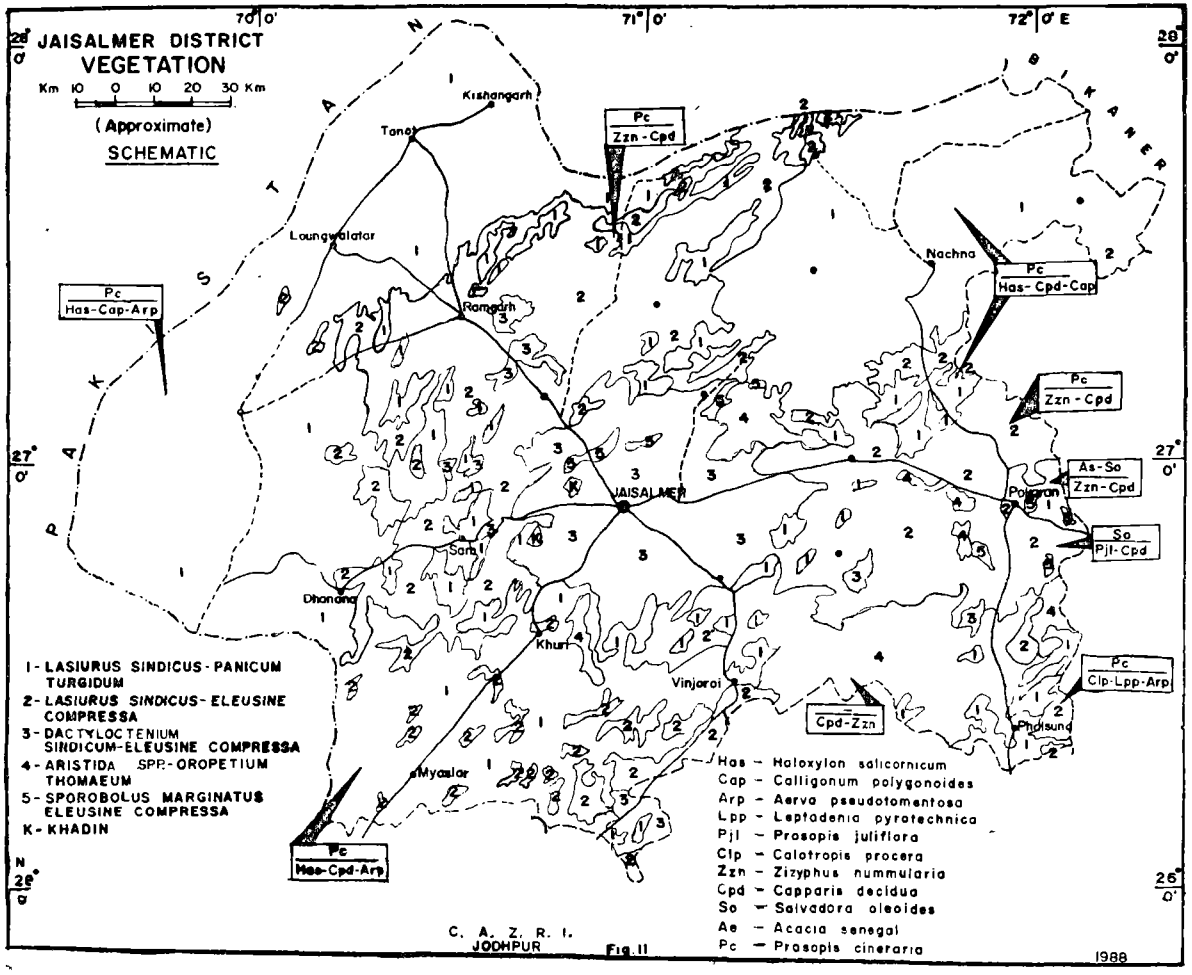

JAISALMER DISTRICT
VEGETATION
Km 10 0 10 20 30 Km
(Approximate)
SCHEMATIC
70° 0'
71° 0'
72° 0' E
28° 0'
27° 0'
26° 0'
N
Kishangarh
Tanot
Loungewalatar
Ramgarh
Nachna
Pokaran
JAISALMER
Sam
Dhanana
Khuri
Vinjorai
Phalsund
Myajlar
Pc
Zzn - Cpd
Pc
Has-Cap-Arp
Pc
Has-Cpd-Cap
Pc
Zzn - Cpd
As-So
Zzn-Cpd
So
Pjl-Cpd
Pc
Clp-Lpp-Arp
Cpd-Zzn
Pc
Has-Cpd-Arp
1 - LASIURUS SINDICUS - PANICUM TURGIDUM
2 - LASIURUS SINDICUS - ELEUSINE COMPRESSA
3 - DACTYLOCTENIUM SINDICUM-ELEUSINE COMPRESSA
4 - ARISTIDA SPP.-OROPETIUM THOMAEUM
5 - SPOROBOLUS MARGINATUS ELEUSINE COMPRESSA
K - KHADIN
Has - Haloxylon salicornicum
Cap - Calligonum polygonoides
Arp - Aerva pseudotomentosa
Lpp - Leptadenia pyrotechnica
Pjl - Prosopis juliflora
Clp - Calotropis procera
Zzn - Zizyphus nummularia
Cpd - Capparis decidua
So - Salvadora oleoides
Ae - Acacia senegal
Pc - Prosopis cineraria
C. A. Z. R. I.
JODHPUR
Fig. 11
1988

Fig. 11.

Table 8. Grassland types, their forage yield and carrying capacity in Jaisalmer district

Grassland types	Area (sq. km) (% in brackets)	Av. dry forage yield (kg/ha)	Total dry forage yield (lakh t.)		Carrying capacity ACU/year	
			Existing	Potential	Existing	Potential
1. *Lasiurus* type						
A. *Lasiurus sindicus-Panicum turgidum*	22849.05 (54.83)	450	21.13	79.97	7.24	27.38
B. *Lasiurus sindicus-Eleusine compressa*	10470.79 (25.12)	925	4.71	23.03	1.61	7.88
2. *Dactyloctenium sindicum-Eleusine compressa*	3599.31 (8.64)	275	0.98	4.32	0.33	1.48
3. *Aristida* spp.-*Oropetium thomaeum*	2525.83 (6.06)	180	0.45	0.57	0.15	0.19
4. *Sporobolus marginatus-Eleusine compressa*	145.21 (0.35)	650	0.09	0.23	0.03	0.07
Total area under grasslands	39590.59 (95.0)		27.36	108.12	9.36	37.00
Cropped area	2083.71 (5.0)					

Table 9. Balance sheet of grassland forage supply-demand in Jaisalmer district

Area under grassland (thousand sq. km)	Existing av. dry forage yield (lakh tonnes)	Existing carrying capacity (lakh ACU/year)	Existing animal population as per livestock Census 1981 (lakh ACU/yr)	Total forage need (lakh tonnes) of the existing livestock	Surplus	
					Lakh ACU per year	Forage (lakh tonnes/ year)
39.48	27.36	9.36	4.38	12.79	4.98	14.57

As per livestock Census 1981, the break up is 2,60.230 cattle; 1,082 buffaloes, 8,74,527 sheep, 3,05,437 goat, total 16,15,789 or 4,38,306.6 ACU (1 sheep or goat=0.15 cattle), computed daily forage intake (a) 2.5% per 250 kg body weight of adult cattle

Besides, *Bordi (Ziziphus nummularia)*, *Khejri (Prosopis cineraria)* and *Lana (Haloxylon salicornicum)* are important browse yielding shrubs and trees. While *Bordi* abounds on the rocky/gravelly habitats in the south east, *Lana* is abundant on the sandy plains of the north west, making the entire district self sufficient in *Bordi* and *Lana* browse.

2. Tree-shrub cover

Trees and shrubs on various habitats and their density (no/ha; figures within brackets following each species) are described below. The average density and frequency of occurrence of trees, shrubs and grasses in different habitats are also given in Table 10.

i) Piedmont areas : *Salvadora oleoides* (43 plants/ha), *Capparis decidua* (40) and *Grewia tenax* (27) were major trees and shrubs, respectively on such habitats. Because of heavy exploitation the population of *Commiphora wightii* (20) has been greatly affected. *Euphorbia caducifolia* (70) and *Acacia senegal* (170) were dominant on rocky surfaces while on colluvial surfaces *Prosopis cineraria* (45) and *Ziziphus nummularia* (66) gained dominance. On sandy colluvial surfaces *Calotropis procera* (15), *Aerva pseudotomentosa* (170) and *Lasiurus sindicus* do also appear.

ii) Buried pediments : *Ziziphus nummularia* (81 plants/ha, 70% frequency of occurrence) and *Capparis decidua* (58 plants/ha; 85% frequency of occurrence) formed the dominant shrub cover, while *Grewia tenax* (15 plants/ha), *Lycium barbarum* (30 plants/ha) and *Aerva pseudotomentosa* (48 plants/ha) were the major associates. Among the trees *Salvadora oleoides* (30 plants/ha) and *Prosopis cineraria* (10 plants/ha) were dominant and *Acacia senegal* was the associate. *Haloxylon salicornicum* (250 plant/ha) had an exclusive dominance on buried pediments in the northwest.

iii) Ranns (saline depressions) : The middle of the ranns were bare due to recurring inundation and high salinity. The peripheral areas had predominant shrubs of *Tamarix dioica* (40 plants/ha) and *Ziziphus nummularia* (40 plants/ha) and also *Salvadora oleoides* (261 plants/ha) trees. Away from the ranns and with gradually increasing sand cover *Calligonum Polygonoides* (50 plants/ha), *Aerva pseudotomentosa* (723 plants/ha) and *Lasiurus sindicus* (554 plants/ha) become dominant in the sequence mentioned.

iv) Dunes and interdunes : These habitats in the southeastern part support *Calligonum polygonoides - Calotropis procera - Aerva pseudotomentosa* shrub cover, while in the northwest *Calligonum polygonoides - Haloxylon salicornicum - Leptadenia pyrotechnica* become dominant. *Salvadora oleoides* and *Prosopis cineraria* occur sporadically in the interdunes only. *Ziziphus nummularia* and *Capparis decidua* do also occur, but in less number (10-36 plants/ha).

Table 10. Average density (No/ha) and frequency of occurrence of trees, shrubs and perennial grasses on different habitats of Jaisalmer district.

Species	Piedimont		Buried pediment		Older alluvial plain		Rann	
	Freq.	Density	Freq.	Density	Freq.	Density	Freq.	Density
1	2	3	4	5	6	7	8	9
Salvadora oleoides	50.00	43	28.57	30	10	35	57.1	261
Grewia tenax	66.67	27	17.86	15	—	—	—	—
Euphorbia caducifolia	16.67	70	5.36	15	—	—	—	—
Commiphora wightii	16.67	20	—	—	—	—	—	—
Bonamia sp.	33.33	85	—	—	—	—	—	—
Sericostema pauciflorum	33.33	420	5.36	10	20	27	—	—
Aerva persica	16.67	140	—	—	10	240	14.3	340
Calotropis procera	33.33	15	42.86	25	40	50.5	28.6	35
Capparis decidua	66.67	40	85.71	58	60	81	14.3	20
Leptadenia pyrotechnica	16.67	40	7.14	15	—	—	14.3	10
Haloxylon salicornicum	16.67	160	12.50	250	10	20	—	—
Lasiurus sindicus	66.67	995	51.79	1596	30	1765	85.7	554
Cymbopogon jwarancusa	33.33	480	—	—	—	—	14.3	20
Ziziphus nummularia	50.00	66	69.64	81	70	95.7	14.3	40
Prosopis cineraria	33.33	45	21.43	10	20	75	14.3	7
Lycium barbarum	33.33	125	37.50	30	20	15	14.3	210
Panicum turgidum	16.67	190	16.07	35	—	—	71.4	287
Acacia senegal	16.67	150	7.14	180	—	—	—	—
Crotalaria burhia	16.67	20	3.57	235	—	—	28.6	20
Mimosa hamata	16.67	10	5.36	10	—	—	—	—
Aerva pseudotomentosa	33.33	110	48.21	44	80	437.5	71.4	723
Calligonum polygonoides	—	—	—	—	10	310	14.3	50
Dipterygium glaucum	—	—	—	—	10	4260	—	—
Acacia jacquemontii	—	—	—	—	—	50	—	—
Panicum antidotale	—	—	—	—	—	—	57.1	54
Salvadora persica	—	—	—	—	—	—	42.8	19
Tamarix dioica	—	—	—	—	—	—	28.6	40
Sporobolus marginatus	—	—	—	—	—	—	71.4	420
Salvadora oleoides	7.09	16.0	—	—	—	—	60	103
Calotropis procera	18.11	120.0	15.38	61 0	37.5	22	50	348
Capparis decidua	14.17	36.0	50.0	62.3	62.5	63	50	61
Leptadenia pyrotechnica	12.60	17.5	11.54	13	25.0	17	—	—
Haloxylon salicornicum	43.31	66.0	34.81	390	50.0	354	—	—
Lasiurus sindicus	81.89	431.2	88.8	1720	87.5	643	70	820
Cymbopogon jwarancusa	—	—	—	—	—	—	10	250
Ziziphus nummularia	6.30	10.0	23.07	39.2	37.5	28	20	63
Prosopis cineraria	8.66	10.0	23.07	36.0	—	—	60	154
Lycium barbarum	7.09	9.5	—	—	12.5	150	20	55
Panicum turgidum	61.42	363.0	26.92	97.0	62.5	1665	50	429
Acacia senegal	—	—	—	—	—	—	—	—

(Contd.)

(Contd.)

1	2	3	4	5	6	7	8	9
Crotalaria burhia	—	—	—	—	25.0	65	10	30
Mimosa hamata	—	—	—	—	—	—	20	58
Aerva pseudotomentosa	84.25	405.2	46.15	715	100.0	469	80	862
Calligonum polygonoides	69.29	201.6	15.38	162.5	—	—	—	—
Dipterygium glaucum	—	—	—	—	25.0	490	—	—
Acacia jacquemontii	1.57	20.0	—	—	—	—	—	—
Panicum antidotale	—	—	—	—	—	—	10	300
Salvadora persica	—	—	—	—	—	—	—	—
Tamarix dioica	—	—	—	—	—	—	40	46
Sporobolus marginatus	—	—	—	—	—	—	—	—
Heliotropium nerifolium	—	—	—	—	—	—	20	15
Acacia nilotica	—	—	—	—	—	—	20	13

v) Interdunal plains : Tree cover was represented by *Prosopis cineraria* (10-100 plants/ha), while shrub cover comprised of *Capparis decidua - Ziziphus nummularia* and *Haloxylon salicornicum* (40-400 plants/ha). *Aerva pseudotomentosa* became dominant (715 plants/ha) upon degradation of sites. *Calligonum polygonoides* (162 plants/ha) occurs on hummocks.

vi). Older alluvial plains : *Capparis decidua* (81 plants/ha) and *Ziziphus nummularia* (95 plants/ha) formed the dominant plant cover, while *Aerva pseudotomentosa, Calotropis procera* and *Lycium barbarum* occupied sandy hummocks on these habitats.

vii) Sandy undulating plains : These had predominance of *Haloxylon salicornicum* (354 plants/ha), *Aerva pseudotomentosa* (469 plants/ha) and *Capparis decidua* (65 plants/ha).

viii) Khadins : Vegetation along the rim of Khadins was rich with vegetal elements of both sandy and alluvial habitats. *Prosopis cineraria* (154 plants/ha), *Salvadora oleoides* (103 plants/ha) and *Acacia nilotica* (13 plants/ha) were dominant trees and *Tamarix dioica* (46 plants/ha), *Ziziphus nummularia* (63 plants/ha), *Capparis decidua* (61 plants/ha), *Indigofera oblongifolia* and *Sesbania sesban* were dominant shrubs.

(b) **Crop area weeds**

Weeds of crop fields are mostly graminaceous and legumes. Their importance value of over 50% indicated the severity of weed infestation. Dry matter of weeds were 2 to 7 tonnes more than that of the crop. In the process the crops lost the nutrients, water and space to the weeds.

(c) **Evaluation of vegetation cover**

Only Bhadriya and Ramdevra have typical relict vegetation which bear a semblance of forest stand of *Z. nummularia* and *Capparis decidua*. Barabagh near Jaisalmer town also has good stand of trees, but by and large trees are badly cut, browsed and lopped, until they ultimately disappear. Range condition analysis at 114 sites revealed that only 13% of the grasslands belonged to 'good' class; 14% to 'fair' class and 73% to 'poor' and 'very poor' classes. Protection and range reseeding can bring these grasslands to 'good' class status.

CHAPTER VII

SURFACE WATER

Jaisalmer district, because of its low and erratic rainfall, is a chronically water-scarcity district. Because of deep ground water over most parts, the people generally rely on village tanks (nadis), *tankas* and *Khadin* system of water conservation for cultivation. These practices aim to collect maximum rainfall water and to use the same either for human and livestock drinking or for bed cultivation. However, there are serious problems of water loss through seepage and evaporation, and sedimentation in these traditional structures. The streams in the district are short, ephemeral and carry flow during abnormally high rain storms.

(a) Dependable rainfall for surface water structures

Analysis of rainfall (1961-87) of six raingauging stations at Jaisalmer, Pokaran, Nachna, Ramgarh, Sam and Fatehgarh indicated that the average rainfall varies from 99.5 mm at Fatehgarh to 173.3 mm at Jaisalmer (Table 11). At Jaisalmer the rainfall was less than 150 mm in 51.85 percent of the 27 rainfall years. Designing of any water harvesting structure on the basis of such an average rainfall may be misleading. Therefore, the 60% probability curves for each raingauging station were drawn for prediction of the dependable rainfall for drinking water harvesting structures and the return period of such rainfall years (Fig. 12). The 60 percent probability was worked out through Log Pearson Type III distribution. Dependable rainfall at 60 percent probability level for designing of drinking water harvesting structures worked out to be 107 mm, 130 mm, 105 mm, 87 mm, 90 mm and 52 mm for Jaisalmer, Pokaran, Nachna, Sam, Ramgarh and Fatehgarh, respectively and their surrounding areas. For other structures in the district, like earthen dams, the amount of rainfall may be considered having a return period of one in 10 years, while for masonry structures the return period is one in 5 years (Table 12).

(b) Present surface water resources

(1) *Village tanks (nadis)* : Nearly 60.68% area of the district is covered with high to medium sand dunes, interdunes and sandy undulating plains where surface water potentiality is very meagre due to the absence of potential drainage channels (Fig. 13). However, short drainage channels occur on gravelly and rocky surfaces, but carry very little runoff during normal rainfall period and disappear at short distances in sandy areas (Fig. 14).

Table 11. Rainfall pattern (1961-87) in Jaisalmer District

Name of rain-gauging station	Average rainfall (mm)	Standard deviation	Co-efficient of variation (%)
1. Jaisalmer	173.3	124.2	72
2. Pokaran	169.5	89.9	53
3. Nachna	144.0	66.2	46
4. Ramgarh	124.1	80.6	65
5. Sam	152.6	148.0	97
6. Fatehgarh	99.5	105.7	106
Overall average	143.83		

Table 12. Designed storm at various probability levels for Jaisalmer District

Return period (years)	Proba-bility	Designed rainfall					
		Jais-almer	Pokaran	Nachna	Sam	Ram-garh	Fateh-garh
1.01	99	21	44	26	28	20	—
2.0	50	130	150	125	110	90	67
5.0	20	251	230	220	230	200	172
10.0	10	355	300	300	242	280	275
20.0	5	470	360	400	465	385	460
50.0	2	645	450	520	680	485	620
100.0	1	800	510	620	870	590	870

There are 1822 nadis in the district, capable to store 38.377 mcm of water during normal rainfall year (Fig. 13). Out of these only 277 nadis are large (I5 .20%; capacity greater than 0.03 mcm); 364 are medium (19.97%; capacity 0.01-0.03 mcm) and 1181 are small (64.83%; capacity ranging from 0.005 to 0.01 mcm). Almost all the villages have atleast one nadi of large to medium size, except in the sandy areas where nadis are of small capacity. Large capacity nadis are located in the gravelly or stony catchments which generate more runoff. Some of the villages having more number of large nadis are Seu, Ramgarh, Kathori, Dedha, Khuri, Dabhala, Jaisalmer town, Morha, Randha, Nimbli, Mohangarh, Machhera and Khetolai. Small capacity nadis are situated in interdune areas. Their drawbacks are: (a) the stored water is available from 1 to 6 months of the year, mainly due to heavy seepage and evaporation losses; (b) deposition of sediments, and (c) deposition of blown sand. The deposition of sediments and blown sand decrease the capacity of nadis every year. Therefore, the villages depending only on the surface water resources are facing acute scarcity of drinking water.

(2) *Tanka*: The water harvesting through tanka system plays an important role in mitigating the drinking water requirement, particularly for people living in scattered settlements on dunes, interdunal plains and undulating sandy plains. Tanka pro-

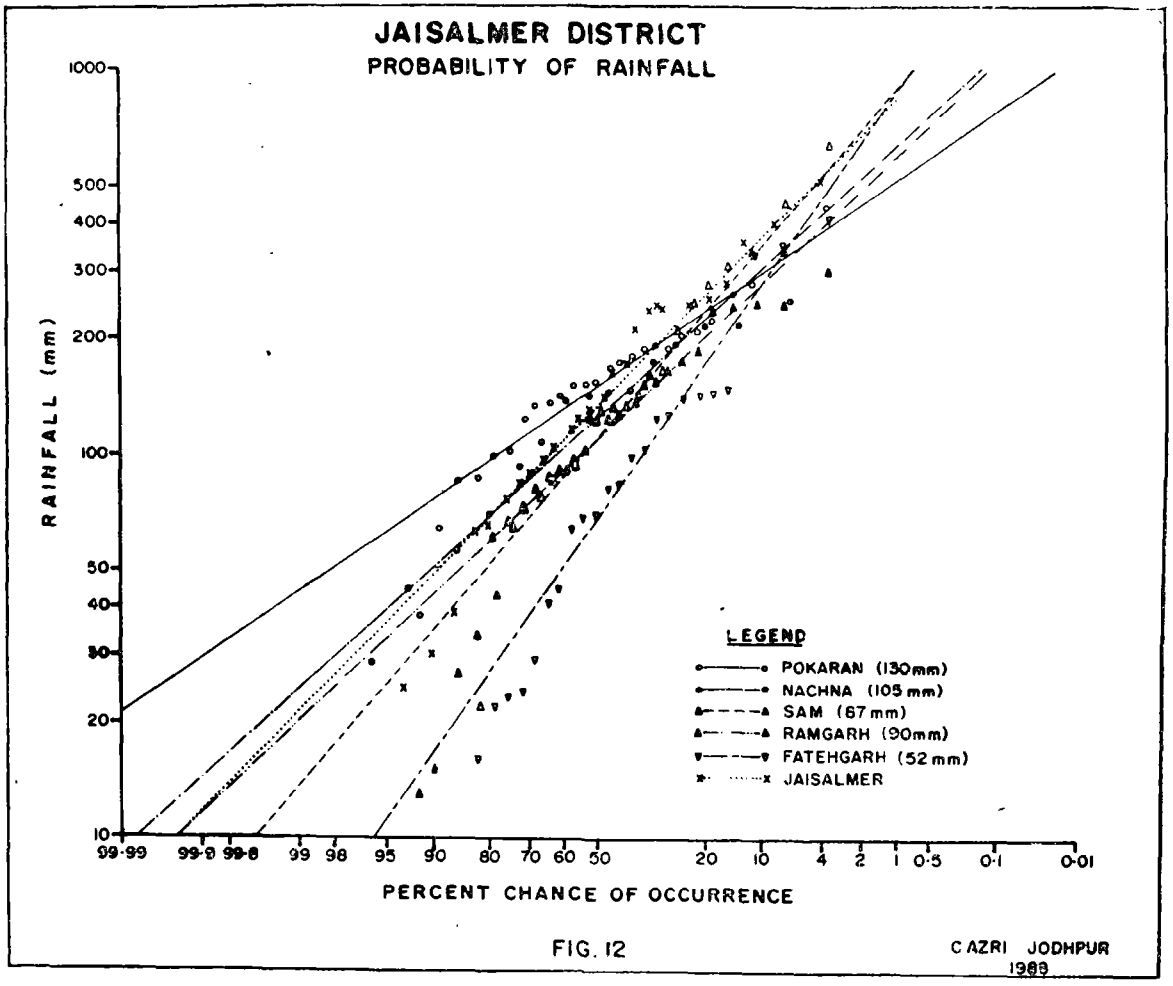

JAISALMER DISTRICT
PROBABILITY OF RAINFALL
RAINFALL (mm)
1000
500
400
300
200
100
50
40
30
20
10
99·99
99·9
99·8
99
98
95
90
80
70
60
50
20
10
4
2
1
0·5
0·1
0·01
PERCENT CHANCE OF OCCURRENCE
LEGEND
POKARAN (130mm)
NACHNA (105 mm)
SAM (67 mm)
RAMGARH (90mm)
FATEHGARH (52 mm)
JAISALMER
FIG. 12
CAZRI JODHPUR
1989

Fig. 12.

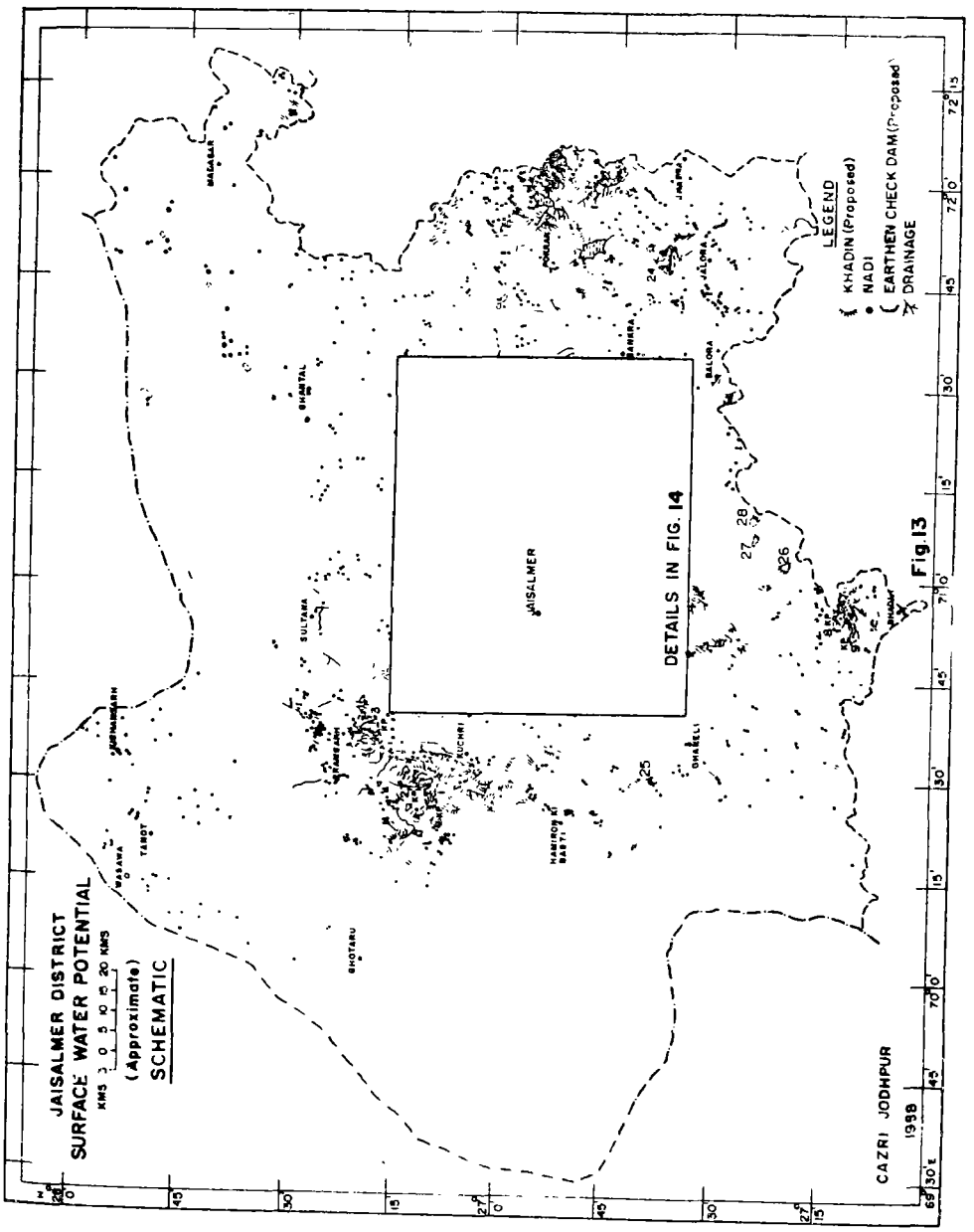

JAISALMER DISTRICT
SURFACE WATER POTENTIAL
KMS 2 0 5 10 15 20 KMS
(Approximate)
SCHEMATIC
LEGEND
KHADIN (Proposed)
NADI
EARTHEN CHECK DAM (Proposed)
DRAINAGE
DETAILS IN FIG. 14
JAISALMER
Fig.13
CAZRI JODHPUR
1988

Fig. 13.

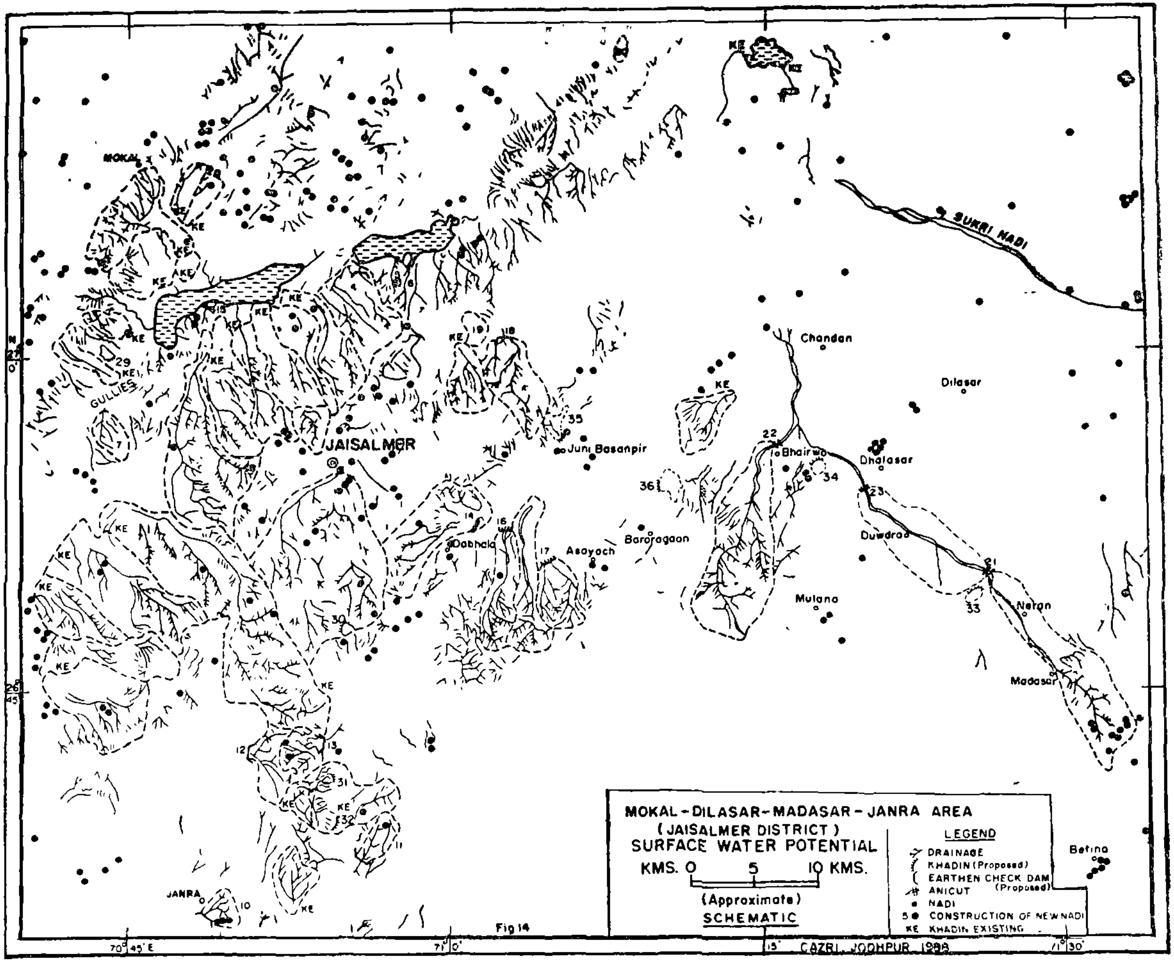

MOKAL - DILASAR - MADASAR - JANRA AREA
(JAISALMER DISTRICT)
SURFACE WATER POTENTIAL
KMS. 0 5 10 KMS.
(Approximate)
SCHEMATIC
LEGEND
DRAINAGE
KHADIN (Proposed)
EARTHEN CHECK DAM (Proposed)
ANICUT
NADI
CONSTRUCTION OF NEW NADI
KE KHADIN EXISTING
SUKRI NADI
JAISALMER
MOKAL
JANRA
GULLIES
Chandan
Dilasar
Dhalasar
Bhairwa
Duwdrao
Neran
Madasar
Mulana
Betina
Barorogaon
Asayach
Dabhala
Juni Basanpir
70°45' E
71°0'
15'
71°30'
26°45'
27°0'
Fig 14
CAZRI, JODHPUR 1998

Fig. 14.

vides reliable safe drinking water to consumers. In almost every village the tankas are constructed on individual household basis or on community basis. Those constructed on individual household basis do not ensure adequate supply of water throughout the year. This is mainly because the artificial catchments provided for generating runoff are not enough for the prevalent lean rainfall years. Further, the structures constructed by local practices need modification in constructional details and in preparation of artificial catchments so that the availability of water is ensured throughout the year, even in below-normal rainfall years.

(3) *Khadin* : Runoff harvested in low-lying areas from the surrounding rocky catchments for practicing agriculture (or khadin system) have great significance in the district. In some cases the runoff water is diverted through small channels to farm lands in lower reaches. Bunds constructed across the slope and farm lands lying between the ridges of the catchment are normally inundated with water during monsoon period, but on drying the *rabi* crops are sown. During drought years, such fields are put under *kharif* crops.

About 84 *khadins* have been constructed by the Irrigation Department, Government of Rajasthan. The catchment areas of these *khadins* vary from 2.5 to 51.0 sq. km with storage capacity ranging from 0.028 to 2.33 mcm. The total storage capacity at F.T.L. is about 11.91 mcm. Apart from these, there are several privately owned *khadins*, constructed by cultivators on their farms. This practice of water harvesting on farmland is thus gaining popularity in the district.

(c) **Water requirement and dependency on sources**

Following is the annual water requirement under different uses in the district.

1.	Drinking water for human population	5.680 mcm
2.	Drinking water for livestock population	5.114 mcm
	Total	10.794 mcm
3.	Irrigation by surface water	Practically nil
4.	Kharif crops (optimum production)	
	(a) Sown area (2467.41 sq. km)	986.964 mcm
	(b) Culturable waste (30021.98 sq. km)	12008.792 mcm
	Total	12995.756 mcm

Thus the total annual wate requirement in the district is 13,006.55 mcm.

Drinking water requirement for human and livestock is met partly from groundwater and partly from surface water storage structures. Irrigated crops are practically nil and *kharif* crops are rainfed. During an average rainfall year (143.83 mcm) the district generates 5520.76 mcm of water which clearly indicates that there is water deficiency for optimum production of crops and even drinking water. Nearly

85.27% villages of Jaisalmer tehsil and 90.52% villages of Pokaran tehsil therefore, depend on dug wells, tubewells, hand pumps alongwith nadi and tanka water (Table 13). Hence, to reduce the stress on ground water resources suitable measures to augment the surface water conservation practices are necessary. The list of villages facing acute drinking water problem is provided in Appendix II.

Table 13. Depcndency of drinking water sources in Jaisalmer district

Drinking water source	Tehsil				Total in district	Percentage in district
	Jaisalmer		Pokaran			
	No. of villages	Percen-tage	No. of villages	Percen-tage		
1. Wells, nadis and tankas	133	38.49	52	44.83	185	40.04
2. Wells and tankas	101	29.19	16	13.79	117	25.32
3. Tubewells, taps and hand pumps	58	16.76	37	31.90	95	20.56
4. Tankas only	14	4.04	1	0.86	15	3.25
5. Nadis, beris and tankas	9	2.60	—	—	9	1.95
6. Nadis	13	3.76	—	—	13	2.82
7. Nadis and tankas	15	4.33	10	8.62	25	5.41
8. Wells	3	0.83	—	—	3	0.65
Total	346	100.00	116	100.00	462	100.00

CHAPTER VIII

HYDROGEOLOGICAL CONDITIONS

The ground water in Jaisalmer district occurs in almost all formations, but the quality and quantity vary considerably in different rock types. A number of perched aquifers, containing good quality of ground water, support domestic and livestock requirements through shallow open dug wells, known as 'berris'. Lathi Sandstone and Parewar Sandstone form very promising ground water aquifers wherein it occurs under semi -confined and unconfined conditions. In Jaisalmer Limestone and crystalline igneous formations groundwater occurs in limited quantity under water table conditions.

Hydrogeological units

Eleven major hydrogeological units have been delineated (Fig. 15) and depth to water in them have been worked out (Fig. 16). The details are as follows:

(1) *Crystallines—Rhyolites and Granites:* The Malani rhyolites form shallow aquifers in the eastern part of the district where these are exposed near Pokaran, Bhaniana, Kelawa, Phalsund, Phulasar, Lawan etc. The ground water occurs in limited quantity under water table conditions. The yield of wells is restricted due to limited thickness of weathered and fractured zones.

The granites form hydrogeological unit around Sankra, Modardi, Chok, Khuhra, Kunda, Bhadli and Lakera. It forms fresh to potable water aquifers and ground water movement is through fractures and joint planes under water table conditions. Depth to water varies from 15.00 m (Ratdiya) to 68.06 m (Sada).

(2) *Jodhpur Sandstone* : Jodhpur Sandstone forms aquifer towards eastern part of the district around Gomat, Pokaran, Bhakri, Ratdiya, Padroda, Jhabra, Sangram Singh Ki Dhani, Baiteena and Khelana. The depth to water in these formations is generally shallow, the minimum being at Pokaran (6 20m) and the maximum at Jhalaria (21.70m). These formations yield low to moderate discharge, varying from 2.0 to 12.0 cubic metres per day. The quality of groundwater is generally potable.

(3) *Lathi Sandstone:* Lathi Sandstone forms the most extensive and productive aquifers in the district due to high permeability and transmissivity of the formation. A number of tubewells have been drilled in this formation around Dabla, Lathi, Chandan, Bhojka, Sodhakor, Devikot, Fatehgarh etc.

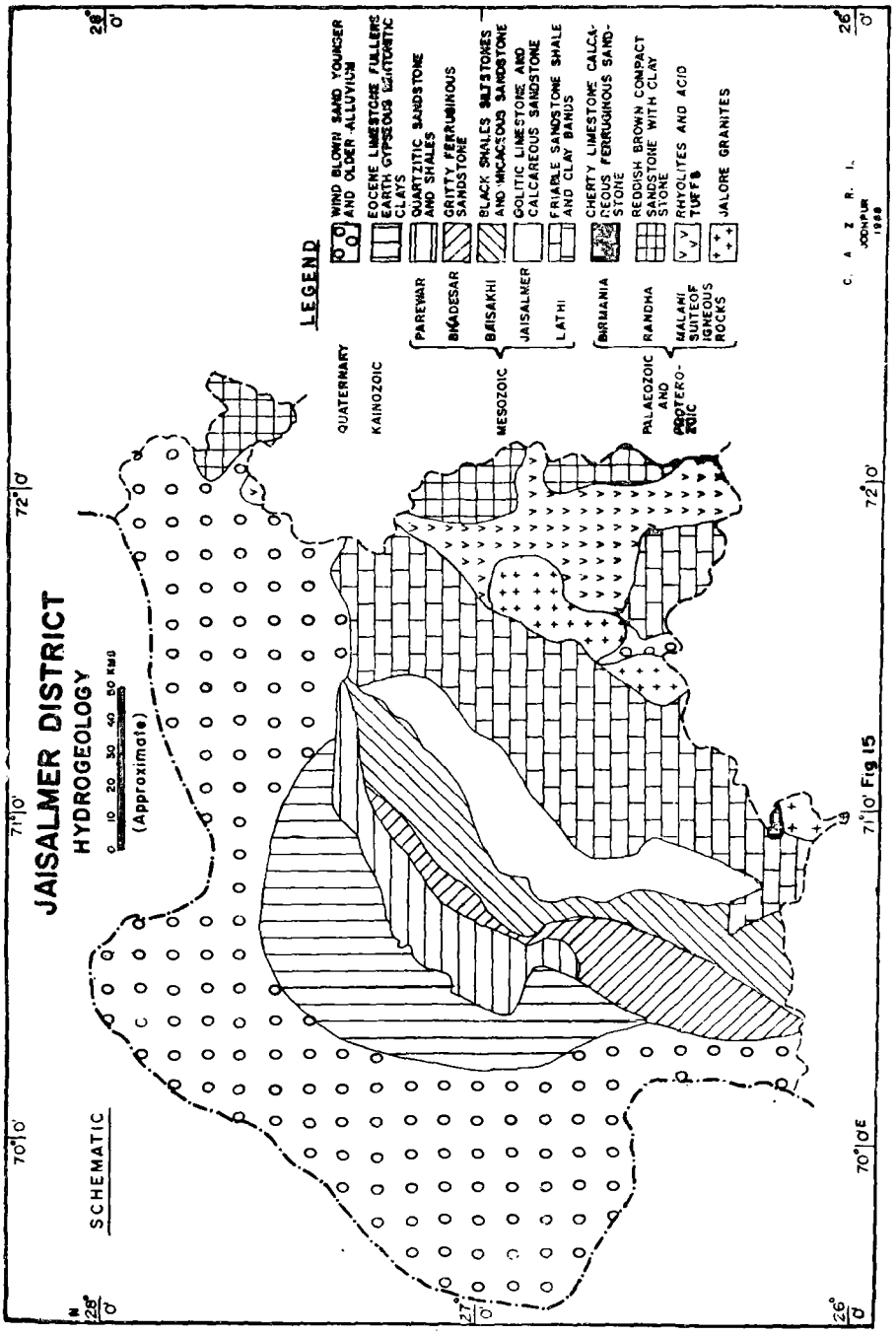

JAISALMER DISTRICT
HYDROGEOLOGY
SCHEMATIC
(Approximate)
0 10 20 30 40 50 Kms
LEGEND
QUATERNARY
WIND BLOWN SAND YOUNGER AND OLDER ALLUVIUM
KAINOZOIC
EOCENE LIMESTONE FULLER'S EARTH GYPSEOUS ISOMONTIC CLAYS
PAREWAR
QUARTZITIC SANDSTONE AND SHALES
BHADESAR
GRITTY FERRUGINOUS SANDSTONE
MESOZOIC
BAISAKHI
BLACK SHALES SALTSTONES AND MICACEOUS SANDSTONE
JAISALMER
OOLITIC LIMESTONE AND CALCAREOUS SANDSTONE
LATHI
FRIABLE SANDSTONE SHALE AND CLAY BANDS
BARMANIA
CHERTY LIMESTONE CALCAREOUS FERRUGINOUS SANDSTONE
PALAEOZOIC AND PROTEROZOIC
RANDHA
REDDISH BROWN COMPACT SANDSTONE WITH CLAY
MALANI SUITE OF IGNEOUS ROCKS
RHYOLITES AND ACID TUFFS
JALORE GRANITES
C. A. Z. R. I. JODHPUR 1988
72°0'
71°0'
70°0'
28°0'
27°0'
26°0'
70°0'E
71°0' Fig 15
72°0'

Fig. 15.

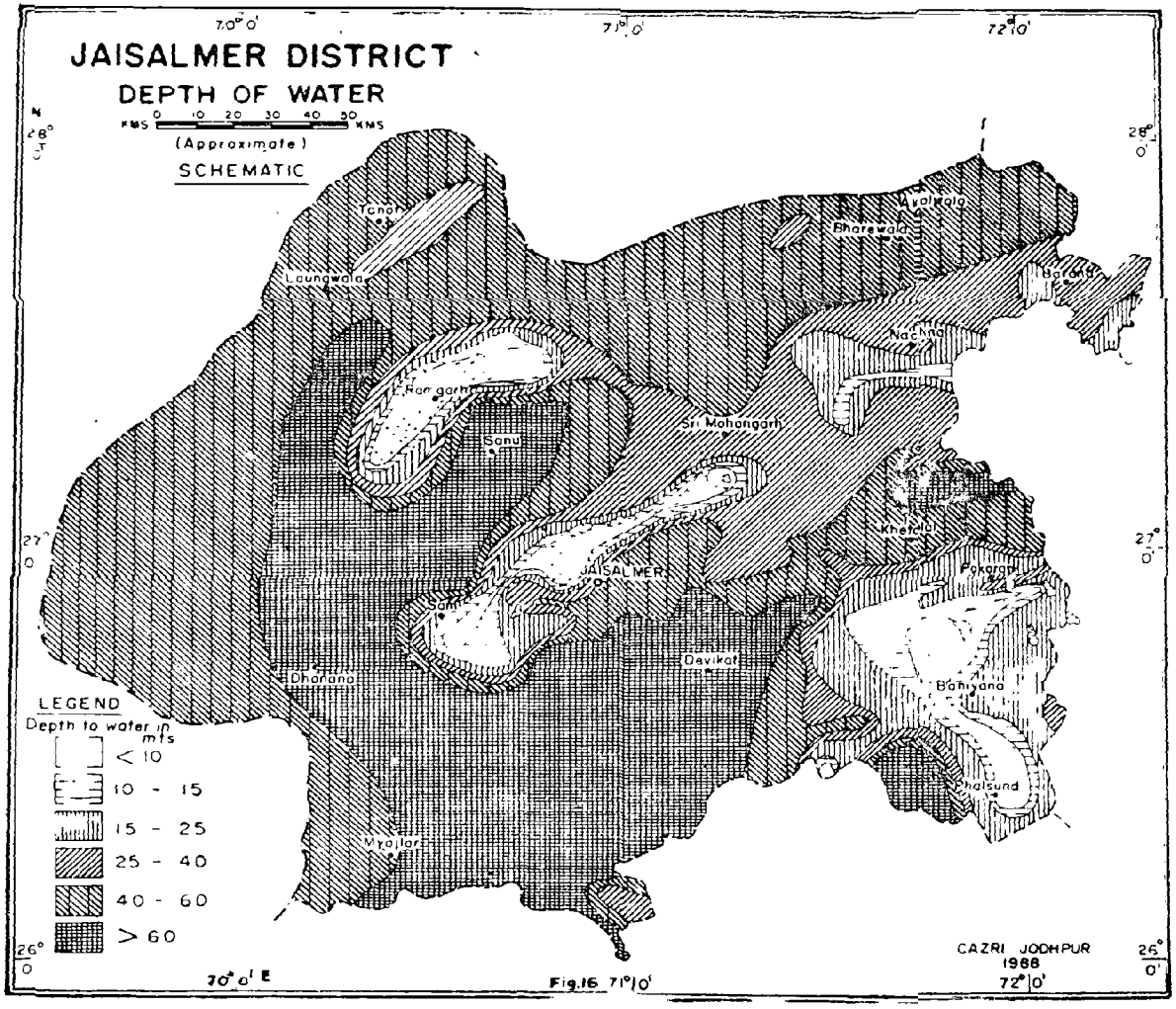

JAISALMER DISTRICT
DEPTH OF WATER
KMS 0 10 20 30 40 50 KMS
(Approximate)
SCHEMATIC
70° 0'
71° 0'
72° 10'
28° 0'
27° 0'
26° 0'
Tanot
Longewala
Akal Kala
Bhaiewala
Nachna
Ramgarh
Sri Mohangarh
Sanu
Khetlai
Pokaran
JAISALMER
Sam
Dhorana
Devikot
Bahriyana
Chalsund
Myajlar
LEGEND
Depth to water in mts
< 10
10 - 15
15 - 25
25 - 40
40 - 60
> 60
CAZRI JODHPUR
1988
70° 0' E
Fig.16
71° 0'
72° 0'

Fig. 16.

The depth to water in Lathi Sandstone varies considerably, the minimum being at Tadana (14.0 m) and the maximum at Bhakrani (129.0 m). The total soluble salt content varies from 640 ppm at Dholia to 5120 ppm at Bhojka.

(4) *Jaisalmer Formation*: This formation is composed of calcareous sandstones with arenaceous limestones and is intercalated with shales. Groundwater movement is through pore spaces and joint planes. Depth to water ranges from 8.00 m at Deunga to 78.00 m at Pithala. The total soluble salt content varies from 608 ppm at Dhawa to 4480 ppm at Bhojasar. The highest TSS content was noted at Kunjal Ki Dhani i.e. 16380 ppm. Discharge in these formations is meagre and at a few places like Amar Sagar, Badabad, etc., groundwater occurs in perched water condition, which supply limited ground water through shallow open dug wells.

(5) *Baisakhi Formation:* This formation is composed of black shales with siltstones and micaceous sandstone and does not form any promising aquifer due to lack of sufficient granular zones. Ground water generally occurs under perched water conditions. Depth to water varies considerably and ranges from 17.00 m at Chhatrel to 101.00 m at Bersiala. Total soluble salt content varies from 1440 ppm at Dewa to 9600 ppm at Khariya. At Chaudhariya the total soluble salt is the highest i.e. 13,760 ppm. The yield of tube wells, drilled in this formation, varies from 2.5 lps at Satto to 10 lps at Khuri.

(6) *Bedesar Formation*: These are gritty ferruginous sandstones intercalated with shale bands and gypseous clay beds. These form productive aquifers at some of the places like Myajlar where coarse grained sandstones yield moderate discharge, though the quality is slightly saline. Depth to water in these formations varies from 51.00 m at Boa to 128.40 m at Bida. The total soluble salt content varies from 960 ppm at Ugawa to 5120 ppm at Myajlar. The highest total soluble salt content has been noted at Salkha (10, 880 ppm). Perched water conditions are also found within the formation e.g. at Kanoi where depth to water is 13.70 m and the quality of ground water is also good, containing total soluble salts of 640 ppm.

(7) *Parewar Formation:* This formation comprises of felspathic and ferruginous sandstones which form an important aquifer around Sanu and Parewar where a number of tubewells are yielding good quality of ground water. The depth to water varies from about 68.00 m at Joga to about 125.00 m at Mokal. The yield of tubewells drilled near Parewar village is 72.64 cubic metres per day, whereas at Sanu the yield is 360 cubic metres per day. The quality of ground water is generally potable, but at Deega the quality of ground water is highly saline, where total soluble salt content is 12, 160 ppm.

(8) *Eocene Formations:* These include the Khuiala and the Bandah formations. The Khuiala formation comprises of coarse grained sandstones, greenish or yellowish

brown gypseous clay and chalky and fragmental limestone. The Bandah Limestone comprises of gypseous bentonite clay, marly layers, fragmental and crystalline limestone. The ground water in these formations generally occur at shallow depth. Due to limited saturated thickness of granular horizons these formations do not form promising aquifers. Depth to water in these formations varies from 22.00 m at Sam to 67.00 m at Joga. The total soluble salt content ranges from 608 ppm (Khuiyala) to 5800 ppm at Sultana. The discharge is generally low and meagre. It varies from 2.5 lps to 3.5 lps.

(9) *Older alluvium*: The older alluvium comprises of sand, gravel and clay intercalations, alongwith *Kankar* pans. These form hydrogeological unit along the north-eastern part of the district. Depth to water ranges from 15.26 m (Awai) to 46.0 m (Tawariwala). The total soluble salt content varies from 1984 ppm at Panna to 3968 ppm at Panchewala tala.

(10) *Younger alluvium*: The sediments belonging to younger alluvium comprises sand, gravel and clays, generally deposited along stream courses. The depth to water in these formations is shallow, ranging from 9.0 m at Ola to 25.88 m at Bhaisra. The quality of ground water is generally fresh to potable, varying from 640 ppm (Banara) to 2560 ppm (Rajgarh).

(11) *Wind blown sand*: Over major part of the district aeolian sand attains considerable thickness and forms important aquifer to support domestic and livestock requirements. Open dug wells are generally located at the base of the dunes to tap water. The depth to water ranges from 17.60 m at Rehrund to 84.0 m at Asutar. The total soluble salt content ranges from 768 ppm at Girdhuwala to 7040 ppm at Moharanwala. The discharge of wells varies from 2.5 lps at Sarkaritala to 3.8 lps at Asutar.

Ground water recharge, draft and surplus in different aquifer zones are provided in Table 14.

Quality of groundwater

In Jaisalmer district the ground water quality ranges from C_2 class to C_8 class (Fig.17). About 59.0% area of the district belongs to C_5 class, i.e. total soluble salt content ranging from 3200-5000 ppm. Ground water of this class is generally found all along the western and northernmost part in wind blown sand aquifer. In the central part of the district ground water belonging to C_5 class is generally found in Jaisalmer formation and along outer peripheral area of Lathi basin. The older alluvial formation in the northeast also contains ground water of this class.

Quality of ground water belonging to C_4 class, i. e. total soluble salt content ranging from 1500 to 3200 ppm, forms immediate peripheral zone of Lathi basin and is generally found in all hydrogeological units.

Table 14. Ground water recharge, draft and surplus in different aquifer zones of Jaisalmer district

Zone		Area	Recharge in mcm	Draft in mcm	Surplus in mcm
Alluvium	Q_1	Asutar	32.0243	0.1438	31.8805
		Kishangarh	7.7159	0.0644	7.6615
	Q_2	Nachna	3.8566	0.0155	3.8411
		Nokh	17.7080	0.1011	17.6069
		Murar	9.9915	—	9.9915
		Longewala	11.2520	0.0311	11.2209
Tertiary	T_2	Askandra	2.4497	0.0311	2.4186
		Bhuvana	11.9915	—	11.9915
Parewar	P_1	Sanu	8.2384	0.2672	7.9712
	P_2	Koria	6.6097	0.0972	6.5125
Bhadasar	Bd_1	Myajlar	1.5396	0.1619	1.3777
	Bd_2	Dhaneli	1.0221	0.1552	0.8669
Lathi	L_1	Rajmathai	9.3939	0.0777	9.3162
		Ajasar	1.2052	0.0485	1.1567
		Chandan	48.4594	1.6069	46.8525
		Jhinjhiniyali	9.2475	0.0324	9.2151
	L_2	Devra	18.5329	0.0466	18.4863
Jodhpur	J_1	Ramdevera	5.4458	0.0181	5.4277
		Rataria	2.9808	0.0052	2.9756
	J_2	Sangram Singh Ki Dhani	2.4941	0.0052	2.4889
		Total	212.1589	2.8990	209.2599

The C_3 class of quality of ground water, i.e. containing 500-1500 T.S.S. in ppm, forms very prominent and promising aquifers of Lathi Sandstone, Parewar Sandstone, part of Khuiyala formation (perched water bodies) and very limited zones in wind blown sand, rhyolites and Jodhpur Sandstone.

The quality of groundwater belonging to C_1 and C_2 classes, i. e. total soluble salt content of less than 180 ppm and from 180 to 500 ppm, respectively, are not found in any of the hydrogeological units, except at very localized places at Ganga in Khuiyala formation and Ghantial in wind blown sand. These could be perched water bodies. However, even the perched water aquifers located in Shumar, Bandah and Khuiyala formations have also ground water quality belonging to C_3 and C_4 classes, i.e. total soluble salt content ranging from 500 to 1500 and 1500 to 3200 ppm, respectively.

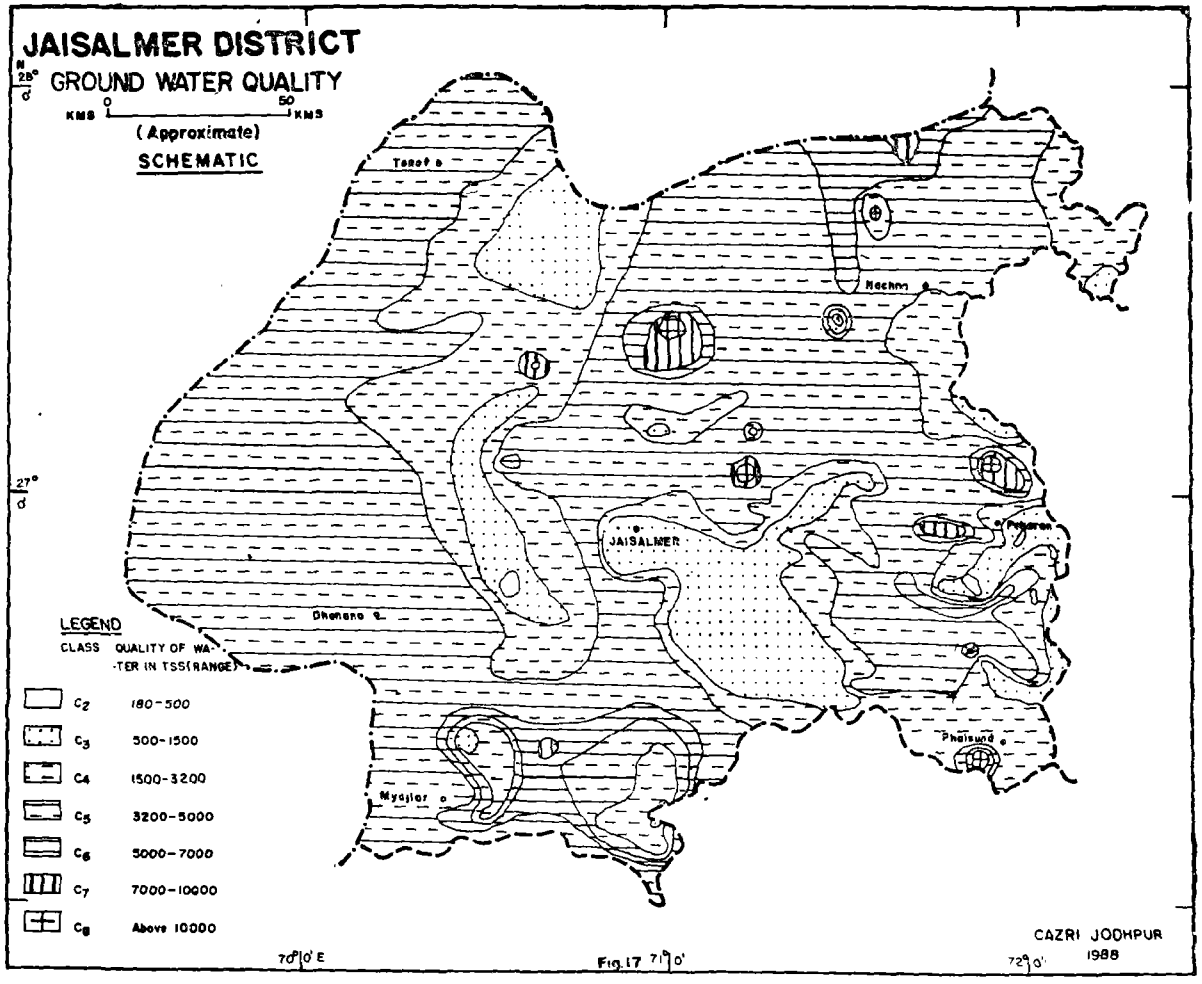

JAISALMER DISTRICT
GROUND WATER QUALITY
0
50
KMS
KMS
(Approximate)
SCHEMATIC
Nachna
JAISALMER
Pokaran
Dhanana
Pholsund
Mystar
LEGEND
CLASS QUALITY OF WATER IN TSS(RANGE)
C2 180-500
C3 500-1500
C4 1500-3200
C5 3200-5000
C6 5000-7000
C7 7000-10000
C8 Above 10000
70°10' E
Fig.17
71°0'
72°0'
CAZRI JODHPUR
1988

Fig. 17.

CHAPTER IX

MINERAL RESOURCES

Jaisalmer district has considerable reserve of gypsite/gypsum, clay, phosphate and limestone, which are being quarried since long. The district has also been explored for natural gas and petroleum reserves by the Oil and Natural Gas Commission (ONGC) and Oil India Ltd (OIL) with some positive indications for availability of natural gas.

Limestone : The limestone deposits of the district are associated with the Jaisalmer limestone and Khuiyala Limestone. The former forms ridges, mounds and hillocks near Jaisalmer, from Pithal to Hamira and Jethwai, near Amar Sagar, etc. The Limestone bands extend over 100 kms in NNE-SSW direction. The total thickness varies from 15 m to 145 m. The Khuiyala Limestone forms an arcuate shaped hill range to the west of Habur.

The Jaisalmer and Habur Limestones found their places as ornamental building stones due to their colour and abundant small fossils.

Clay deposits : Pockets of clay occur within Lathi Sandstone and Mandai Sandstone at Chhor and Mandai, respectively. A clay bed of 1 to 2 m thickness occurs at Chacha. It appears to be the weathered product of an impure dolomite. This clay is used as a filler and is being quarried extensively.

Phosphorite : Phosphorite or rock phosphate associated with limestone, chert, black shale and sandstone has been located at Birmania. These phosphatic rocks are calcareous or arenaceous. Phosphate pellets have also been reported in the Baisakhi Shales near Rupsi and Nibh Dungar. But the phosphorite deposits were not found to be of commercial grade as their P_2O_5 content ranges from 5 to 20 percent only in Birmania deposits.

Gypsum : Gypsum is extensively quarried near Mohangarh where it is found at shallow depth. Selenite associated with gypsite is also found in the Mohangarh area, The entire production from Mohangarh quarries is used by the Fertilizer Corporation of India.

Oil and Natural Gas : Extensive exploration in the northern and north western parts of the district, near Asutar, Ghotaru, Kishangarh and Sadhewala has proved the existence of favourable structure for natural gas. In some of the bore holes drilled by ONGC near Ghotaru, commercial gas has been found.

CHAPTER X

PRESENT LAND USE

Jaisalmer district, because of its climatic and terrain constraints, is principally composed of vast arid wastelands. The wastelands of different categories cover about 89.0% area, while cultivation (rainfed single cropping) is practised in 6.4% area and the rest 4.6% area is under miscellaneous land uses (Table 15). The following landuse units have been identified and mapped (Fig18).

Table 15. Present land use in Jaisalmer district

Land use units	Area (ha)	% of total area
A_{11} (Double cropped area)	157	—
A_1 (Single cropped-intensity 80-100%)	I54346	4.02
A_2 (.....” .....60-80%)	57161	1.49
A_3 (.....” .....40-60%)	31894	0.83
A_5 (.....” .....10-20%)	3286	0.08
Miscellaneous Landuse		
(a) Forest	59600	1.55
(b) Settlement and water features	55800	1.45
(c) Orans and permanent pastures	59800	1.56
Wastelands		
B_1 (Sandy waste)	864225	22.50
B_1X (Sandy waste with open scrubs)	924840	24.08
B_2 (Saline waste)	13065	0.35
B_3 (Rocky and stony waste)	108881	2.83
B_4 (Stony and gravelly waste)	582954	15.18
B_4X (Stony and gravelly waste with open scrubs)	924031	24.08
	3840100	100.00

A_{11} lands (Double cropped) : Irrigated and double cropped lands are negligible and cover only 157 ha area of the district. Small pockets of this units occur at Moolsagar and Amarsagar near Jaisalmer town and some small fields near Pokaran town, but these are not of mappable size.

A_1 lands (Single cropped-intensity 80 to 100%) : Kharif cropping pattern is dominant in the district. The total cultivated area in the district is 6.43%, out of

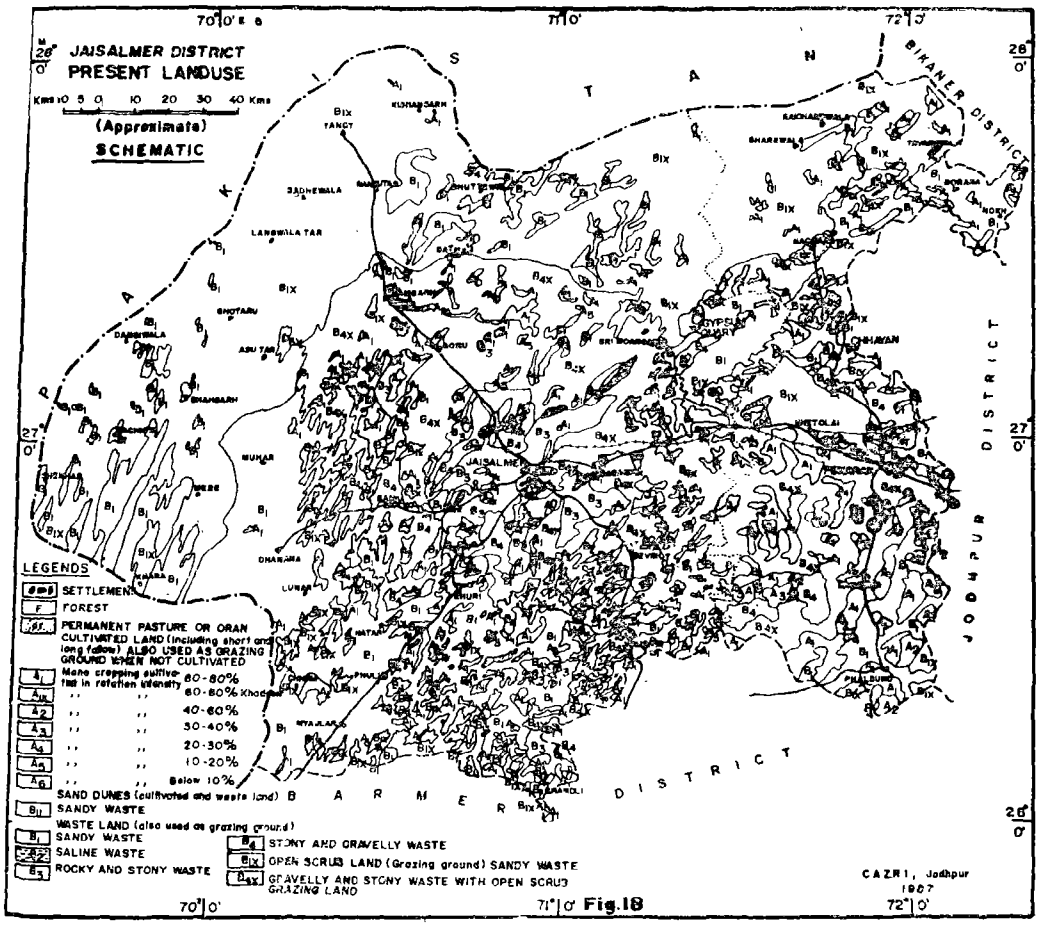

JAISALMER DISTRICT
PRESENT LANDUSE
(Approximate)
SCHEMATIC
Kms 10 5 0 10 20 30 40 Kms
INDIA
PAKISTAN
BIKANER DISTRICT
JODHPUR DISTRICT
BARMER DISTRICT
JAISALMER
LEGENDS
SETTLEMENT
FOREST
PERMANENT PASTURE OR ORAN CULTIVATED LAND (including short and long fallow) ALSO USED AS GRAZING GROUND WHEN NOT CULTIVATED
Mohe cropping cultivated in rotation intensity 60-80%
60-80% Khadin
40-60%
30-40%
20-30%
10-20%
Below 10%
SAND DUNES (cultivated and waste land)
SANDY WASTE
WASTE LAND (also used as grazing ground)
SANDY WASTE
SALINE WASTE
ROCKY AND STONY WASTE
STONY AND GRAVELLY WASTE
OPEN SCRUB LAND (Grazing ground) SANDY WASTE
GRAVELLY AND STONY WASTE WITH OPEN SCRUB GRAZING LAND
CAZRI, Jodhpur 1967
Fig.18

Fig. 18.

which A_1 unit covers 4.02% (154346 ha) area of the district. The unit is scatteredly distributed. There is more concentration towards the south-east, around Ramdevra, Odhaniya, Ujlan, Bhaniyana, Sankra, Rajmathai, Badoragaon, Askandra, Jhinjiyali, Phuliya, Devikot and Khuri in the interdunal and *Khadin* areas. Around Jaisalmer the A_1 lands are mostly isolated small *khadins*.

A_2 lands (Intensity 60-80%) : This unit covers about 1.5% (57161 ha) area of the district. Areas of this unit have been mapped towards southeast of Pokaran near Sakariya, Charno Ki Dhani and Lalpura, to the west of Sam near Meghwalon ki Dhani, and in some scattered pockets near Satto, Khetolai and Awai. The principal crops are bajra, moth, moong, guar and til. The unit is mostly covered with sandy hummocks and sand sheets. Production of crops is less here than in the A_1 unit.

A_3 lands (Intensity 40-60%) : This unit occurs in the southeast towards Phalsund and Shergarh and adjacent to the districts of Barmer and Jodhpur. It covers about 0.8% (31894 ha) area and is mainly covered by sand sheets and dunes. Cultivation is done in 2, 3 or more years of rotation, but in the years of favourable rainfall there is good yield of bajra.

A_5 lands (Intensity 10-20%) : This unit occurs around Lanela to the west of Jaialsmer and near Bharewala, Bahla, Panna, Madasar and Naukh in the northeast, covering only 0.08% (3286 ha) area of the district. The terrain comprises high dunes and is cultivated only during the favourable rainfall years. Although these are marginal lands sometimes bajra is cultivated with musk-mellon and water-mellon. Such land is not recommended for cultivation.

Miscellaneous land uses: This unit includes forests, settlements (with water features) and *orans* or permanent pastures, covering 1.55% (59600 ha), 1.45% (55800 ha) and 1.56% (59800 ha) area, respectively of the district.

Wastelands: Wastelands of different kinds cover 89.02% area of the district. Although these lands are not generally suitable for cultivation, rocky and saline wastes are used for mining. Many of the wastelands are grazing or pasture lands also.

B_1 (Sandy waste): This comprises 22.5% (864224 ha) area of the district. The major occurrences are in the north, northwest, northeast and southeast, where stable and unstable dunes with or without vegetation and sandy undulations are dominant.

B_1x (Sandy waste with open scrub lands): These are also sandy wastes, but are covered with scattered shrubs and wild grasses which, however, do not survive for more than a few months after the rains. This unit covers 24.1% (924840 he) area of the district, and inculdes undulating sandy plains, interdunal plains and medium to small dunes. It includes an area of more than 550 sq. km from Sultana to Asutar

where *Lasiurus sindicus* (Sewan grass) grows naturally and provides ample fodder to livestock of the district.

B_2 (*Saline waste*): The major saline ranns like Mitha and Khara ranns, Kanod ka rann, That ka rann, Jhalariya ka rann, Pokaran ka rann and Lawan ka rann are included in this unit. These are saline flats and not suitable for cultivation, but often their margins are used for grazing. Some *ranns* are used for extracting salts. This unit covers 0.35% (13065 ha) area of the district.

B_3 (*Rocky and stony wastes*): These are the hills and the sloping hill sides or pediments, mostly in Jaisalmer tehsil, and covers about 2 84% (108881 ha) area of the district. The major occurrences are near Lanela, Dedha, Damodara, Rupsi, Kanod ka rann, Gomat and west of Bhaniyana.

B_4 (*Stony and gravelly wastes*): This unit occurs with the B_3 unit, especially in the foothills and associated gravelly lands and covers 15.2% (582954 ha) area, especially around Damodara, Rupsi, Jaisalmer, Lathi, northeast of Pokaran, Dedolai and Rathra.

B_4X (*Stony and gravelly wastes with open scrub lands*): It occurs in a belt between Jaisalmer, Mohangarh and Ramgarh and around Pokaran, Devikot and Ludrava, covering about 24% (924031 ha) area of the district. It is a *magra* land for pasture and grazing. Although agriculturally waste it provides grass for the livestock.

Khadins: More than 500 khadins are located in the different isolated depressional areas surrounded by *magra* lands, and cover about 12500 ha area. When the khadins become dry after the rains, jowar, wheat and gram are grown in their bed without irrigation. In few cases like Rupsi and Bhuj khadins of Jaisalmer tehsil, the water stored in the upper khadins is supplied by channels to the lower khadins for cultivation. In the year of adequate rainfall almost all the khadins are cultivated. The larger khadins are at Bhuj (1600 ha), Daiya (800 ha), Komal (800 ha), Jaitsar (160 ha), Patan (143 ha), Olabundh (125ha), Saran (100 ha), Novada I (96 ha), Ugata (80 ha), Mungri (80 ha), Sagra (76 ha), Barkhanwala (73 ha), Kansi I (88 ha) and Lunakhurd (83 ha). These khadins are highly productive. It is reported that in the years of favourable rain, 10 to 14 quintals of wheat per hectare have been produced by the farmers. These khadins are the important sources of rabi crops without irrigation in this district. The names of the khadins do not necessarily reflect the names of the villages, nor do all the khadins exist in the vicinity of the village settlements.

CHPTER XI

SOCIO-ECONOMIC CONDITIONS

Out of the 462 inhabited villages of Jaisalmer district, about 7 percent villages were randomly selected for socio-economic investigation.

Enumeration of all the households of the villages was done and the households were further stratified according to various caste groups. From each caste stratum 10 percent of the total heads of households were selected and 547 schedules were filled in through random sampling procedure. Relevant secondary data were also collected from various available sources, i.e. census reports, records at Jaisalmer Tehsil office and at the district headquarters.

Demographic and social aspects

Over 80% of the respondents expressed preference of male child, rather than female child, to increase the earning members, for support in old age, for socio-religious requirements, patrilineal pattern of society and to gain higher social status. About one fourth of the respondents preferred small size of family with 1-3 children, and over one third preferred a medium size of family with 4-5 children. More than 40%, however, preferred a large family with more than 6 children for economic benefits and security. Maximum number of girls (60% to 100%) were married during childhood age (below 18 years). The age of marriage ranged from 5-18 years in a Rajput dominated village and 2-20 years in a Sindhi Muslim dominated village.

The overall growth rate of population increased by 221.75% during 1901-1981. During 1971-81 the district recorded the highest growth rate of 43.4%, as compared to 36.3% in Rajasthan State. The chief reasons were in-migration of population with the introduction of Indira Gandhi Canal, influx after the 1971 Indo-Pak war, change in social values and urbanisation and tourism. In addition, customary practices of early marriage and remarriage in lower castes like Meghwals and Muslims, illiteracy, especially among the female members, high regards for a married person and belief in more hands for higher income in a family were the contributing factors.

The district is chiefly inhabited by pastoral communities and is dominated by Rajputs, Sindhi Muslims and Meghwals, followed by few Malis and other servicing castes in Jaisalmer Tehsil. Non-existence of other servicing castes related to agriculture is due to less complementary functions of the predominant livestock rearing castes in

the area. The Rajputs and the Sindhi Muslims comprise more than three fourth of the total households and inhabit the dune and inter - dunal plains. The Purohits, Paliwals, Brahmins, Malis and a sectarian group of Bishnois comprise more than 45% of the households, inhabiting dunes and buried pediments. Meghwals, Suthars and Kumhars, the traditional crafts households, inhabit alluvial plains and buried pediments, while other caste groups occupy rocky and buried pediments, alluvial plain and saline depressions.

Caste composition revealed predominance of Rajputs (80%), followed by others (20%)in the rocky-cum - buried pediment. In sandy buried pediments Rajputs (50%) and others were numerically equal in proportion, whereas in the sandy undulating units Sindhi Muslims (100%) were the only inhabiting community. Supporting castes to Rajputs were Bheel and Sindhi Muslims in rocky areas, while socio-religious castes (Swami, Gurda), occupational (Suthar, Meghwal) and others (Darji, Sindhi Muslim) were supporting the Rajput community in sandy buried pediments. No supporting caste to Sindhi Muslim was found in sandy undulating areas. For agro-livestock services Sindhi Muslims depended on occupational castes of the nearby villages.

Joint family system was dominant in Jaisalmer district. Of the households surveyed, 57% were found to be joint and 43% nuclear households. Low density of population, scattered settlements, and extended family clans compelled the villagers to live jointly for security. Imbalanced male-female ratio, i.e. 830 females/1000 males in 1981, late marriage among males because of prevalence of high bride price and exchange marriage system are also responsible. Moreover, livestock rearing requires more number of persons which a joint family can provide.

Literacy rate is extremely low and almost nil among the female rural population. In rural sector the overall literacy rate was about 10%, while among males and females it was 17% and less than 2%, respectively during 1981 census.

The settlements were compact, scattered (*dhani* settlement) and compaet-cum-scattered. Of all the households surveyed, 47% resided in compact and 42% in scattered settlements. More than 10% of the household were in compact settlement during non-cultivating season and in *dhani* during cultivating season. In village Sankra of Pokaran tehsil hardly 10% of the total households lived in the village core, and 90% resided in *dhanis*. The distance of *dhani* settlement from the village core varies from O.5 to 13 km.

Man-land relationship

The land utilization statistics (1983 - 84) of Jaisalmer district indicate a very high proportion (76%) of barren and culturable wastelands. The uncultivable lands accounted for 14%area and comprised of forests (O.5%), usar and uncultivable land

(9%), land used for purposes other than cultivation (1.6%), and permanent pastures and other than cultivation (2.8%). Hardly 8% of the total area was under rainfed cultivation. Agriculture is followed by only one fifth of the total population as compared to about three fourth in other districts of the desert. On an average a household of Jaisalmer area possessed the highest size of landholding (10 ha) with lowest number of fragments (2), as compared to the situation in other arid districts of Rajasthan. Among the different castes a household of pastoral community (Rajput, Sindhi Muslims) owned a holding of 19 ha; agricultural community (Bishnoi, Purohit, Mali and Paliwal) owned 15 ha; craftsman's household (Suthar, Meghwal, Kumhar) owned 13 ha; others (Mahajan, Bheel, Nai, Sonar and Darji), rendering services to village community, owned 11 ha and the socio-religious castes 10ha. Of the various *kharif* crops grown in the district during 1983-84, bajra, followed by fodder guar, were the most predominant rainfed crops. About half of the total area under *kharif* crops was occupied by bajra and more than half by the fodder guar. Areas under pulses and other *kharif* crops were almost negligible because of drought. About 1.3% of the total area sown had *Rabi* crops, grown under Khadins. Among the *rabi* crops wheat, oilseed crops and gram were dominant. Only 96 ha of land was under irrigated cultivation.

Animal-human relationship

Animal husbandry is the main occupation, engaging about half of the total earners. Livestock population in the district was 1616 thousand according to the 1983 animal census, or 6.7 per capita, the highest for the arid zone of Rajasthan. Sheep and goats together constitute about 80% of the total livestock, whereas cattle constitute 16%. Density of adult cattle units per 100 ha of permanent pastures (including other grazing lands) and cropped area was found to be 13, 501 and 168, respectively.

On an average a household owned 65 heads of total livestock, out of which 40 were sheep, 7 goats, 15 cattle and 3 camels and others. In sample villages the Rajputs owned highest number of liveslock (143) per household, followed by the Mali (74), Sindhi Muslim (71) and Meghwal (-2). Irrespective of the caste status, donkey is kept as an ecological necessity. It is most widely used for carrying water from far off distances, as transporter to *khadins*, for carrying newly born lambs and goat kids to far off grazing lands and for carrying household goods during migration.

Livestock migration was chiefly prevalent among agro-livestock rearing communities of the sample villages. Sindhi Muslims, followed by the Rajputs, and the Rawna Rajputs practised such migration most. Castes like Meghwal, Darji, Gurda and Sadh also practised migration during droughts and famines. On an average a migratory herd contains 130 heads of livestock and 4 persons which include the owner, his sons, relatives and village friends. The routes followed by their ancestors are still followed, though many express difficulties.

The migration cycle takes 3 to 10 months' time and the distance covered varies from 30 km to 1500 km, both within and outside the State. The pattern was also noticed during the severe drought of 1980s.

Cottage industries, crafts and other sources of livelihood

About 29.61 percent of the total enumerated caste households belonged to the craftsmen communities. Among the vairous castes *Meghwals* (78.83 percent) were engaged in spinning wool, wool weaving and leather craft, *Kumhar* (10 94 percent) in cultivation and pottery and *Suthars* (20.21 percent) in craft of timber and wood-work. The craftsmen groups were closely associated with the agricultural castes than with the pastoral communities.

Crafts articles have a local market for 3 to 5 villages, covering the distance of 5 to 30 kms. The means of transportation and communication are the major constraints.

Wool weaving and spinning are the predominant cottage industries associated with sheep rearing in the area. On an average 16% of the total surveyed households was engaged in wool spinning and weaving in the district. This being their chief subsidiary, supplements their economy to the extent of Rs. 2390/- per household per annum.

Leather work, a subsidiary craft industry, was followed by about 7% households. On an average a household earned Rs. 1666/- per year.

The income generated from the crafts per household was carpentry: Rs. 6,722, leather and shoe: Rs. 2,923, spinning and weaving: Rs. 3,330, spinning of wool by the females: Rs. 1,250. In case of capital investment the carpenter and the shoemaker invested Rs. 4,000, whereas other craftsmen invested Rs. 100 to 300 annually.

Due to socio-cultural transformation and technological advancement the traditional artisan crafts are dwindling. More than 50% of the households of Meghwal community, traditionally engaged in leather work, have discontinued their shoe-making occupation. However, with the introduction of Khadi Gram Udyog, wool weaving and spinning have gained popularity. Irrespective of caste status, wool spinning is done bythe females of households to supplement their earnings. Carpentry has received a setback. The other sources of livelihood are camel cart driving, casual labour in stone mines and masonry works, and government and private services. Mean annual income per household, from these sources was about Rs. 1480. On an average a housholde earned the maximum from casual labours during a year.

Rural credit and indebtedness

Indebtedness is widespread among the rural population. Unlike other arid districts, Jaisalmer district is significantly less indebted, perhaps due to the higher

income stability of livestock breeders. The loans seem to be incurred for little productive purposes (buying of seeds, fertilizers, tractors, animals), but mainly to meet daily domestic needs in scarcity periods, or for socio-religious purposes.

On an average more than half of the surveyed house holds (57%) were indebted and their extent varies from 41% in buried pediment-hill-rocky structural plains complex to 79% in older alluvial and sandy undulating plains. The extent of overall indebtedness per household ranged from Rs. 2080 to Rs. 5641 per year. The average indebtedness per household in the sampled villages was Rs. 3944.

Institutions of credit

The principal public credit institutions in the district are the primary credit cooperatives for short-term loans and the land development banks for long-term loans both of which have performed quite poorly in the area. The reasons of poor performance are their refusal to give loans for non-productive purposes and their credit procedures, which are totally unadapted to the peculiarities of arid zone agriculture.

Comparative advantages and disadvantages reported by the villagers about the traditional and modern agencies engaged in rural credit and indebtendess are given below.

(a) Due to scattered form of settlements, banking institutions located at far off places, especially in towns or in Panchayat Samiti or Tehsil Headquarters, are not easily accessible. (b) Difficulties are faced to cope up with the banking formalities for getting loans. (c) Village money lenders are easily approachable as and when necessary for getting loans. (d) It is easy to mortgage gold/silver ornaments with the village money lenders, rather than the banks. (e) Bank recoveries are in cash, whereas the village money lenders postpone recovery during droughts or famines. (f) Village money lenders provide very long term loans, (g) To mortgage a land is considered a social stigma. (h) Banks keep secrecy of the borrowers, whereas the village money lenders keep it open. (i) Illiteracy of the people puts the borrowers sometimes in trouble.

CHAPTER XII

STATUS OF LIVESTOCK

Trends of livestock population in Jaisalmer district

During the last 81 years since 1901 Jaisalmer district experienced 10 mild, 22 moderate and 10 severe droughts. The harsh climatic conditions and its location in one of the remotest parts of the country have allowed the breeding and multiplication of only those animal types which can withstand the rigours of the environment, besides ensuring the maintenance of the purity of the breeds. This is mainly the reason why the animals presently found in Jaisalmer district are not only among the hardiest, but also of the purest types in the country.

According to the 1983 livestock census Jaisalmer district harbours 1.6 m heads of livestock. There was a 92% increase in total livestock population between 1956 and 1983 (Table 16). The district had only 0.85 m heads of livestock in 1956. During this period, minimum change was recorded in the number of donkeys and ponies (+3.0%), followed by cattle (+12.0%). The maximum gain of 153% was among the camel population. In 1956, the district supported 0.23 m cattle, while in 1983 the number increased to 0.26 m heads. The cattle population of Jaisalmer district has been widely fluctuating since 1956 (Table 16). Between 1956 and 1961 there was a 26% increase in cattle population, followed by a 17% increase during 1961-66. The cattle population then decreased drastically by 81% during 1966-1972, followed by massive increases during 1972-77 (89%) and 1977-83 (111%). The recorded reduction in cattle population during 1966 and 1972 was mainly due to the heavy losses caused by severe droughts.

Since 1956 the buffalo population in the district fluctuated more than the cattle population. It had slightly decreased (3%) during 1956-1961 and registered some 3% increase during 1956-1966. Later on the buffalo population was drastically reduced (76%) during 1966-1972. During 1977-1983, the buffalo population increased by 63%. While most livestock species in the district recorded increase in their number during 1956-1983, buffaloes were reduced in number (23%) during the same period, the highest reduction (61.1%) having been recorded in the population of buffalo-bulls, followed by she-buffaloes (25.7%). However, during this period the number of buffalo calves increased by 33.8%.

The district had a goat population of 0.19 m in 1956, which rose to 0.29 m in 1961 and 0.30 m in 1966. A series of fluctuations in goat number followed : 0.19 m

Table 16. Livestock population (x 1000) changes with time in Jaisalmer district

Livestock type	Census year						% changes during
	1956	1961	1966	1972	1977	1983	1956-1983
Cattle (total)	233	294 (25.9)	344 (17.1)	65 (-81.1)	124 (89.7)	261 (111.4)	12.0
Male, above 3 years	27	33 (25.9)	49 (46.4)	06 (-87.2)	16 (148.0)	20 (28.2)	25.2
Female, above 3 years	132	172 (29.9)	191 (11.0)	36 (-81.0)	65 (79.9)	143 (119.6)	8.0
Less than 3 years	74	87 (17.6)	104 (18.9)	23 (-78.2)	43 (89.5)	98 (128.9)	32.5
Buffaloes (total)	1.38	1.34 (-2.6)	1.38 (3.1)	0.33 (-76.1)	0.66 (99.1)	1.7 (62.9)	-23.0
Male, above 3 years	0.48	0.31 (-34.3)	0.41 (32.4)	0.10 (-75.1)	0.25 (141.7)	0.19 (-25.7)	-61.1
Female, above 3 years	0.54	0.62 (-13.7)	0.61 (-0.7)	0.14 (-77.4)	0.28 (100.7)	0.40 (45.1)	-25.7
Less than 3 years	0.36	0.41 (14.7)	0.36 (-13.5)	0.89 (-75.1)	0.13 (47.2)	0.48 (268.7)	33.8
Goats	189	286 (51.5)	304 (6.3)	193 (-36.6)	437 (126.9)	417 (-4.7)	120.9
Sheep	395	467 (18.3)	591 (26.6)	313 (-47.0)	678 (116.4)	876 (29.3)	122 0
Horses and Ponies	0.66	0.78 (17.0)	0.99 (27.2)	0.24 (-76.0)	0.43 (82.7)	0.68 (58.0)	3.0
Donkeys and Mules	11	11 (3.3)	17 (53.6)	3 (-83.0)	15 (437.6)	23 (48.7)	117.0
Camels	20	29 (40.8)	41 (43.0)	38 (-8.6)	46 (21.1)	52. (13.5)	152.9
Pigs	—	—	—	—	—	—	—
Total	850	1089 (28.1)	1299 (19.4)	612 (-52.9)	1300 (112.5)	1631 (25.4)	91.9

The values in parenthesis represent the percent change in population during the period between two successive census years.

Source : Gazetteer of India, Rajasthan, Jaisalmer, (1973); Statistical Abstracts, Jaisalmer district, 1982; Statistical Abstracts, Rajasthan, 1984.

in 1972, 0.44 m in 1977 and 0.42 m in 1983. The overall gain in goat population during 1956-1983 was of the order of 121 per cent.

The sheep population in the district is generally showing increases since 1950, except for the period 1966-1972 when a sizeable reduction (47%) was recorded. The overall growth rate of the sheep population during 1956-1983 was similar to that of goats, i.e. 121 per cent.

The number of horses and ponies in the district increased since 1956, except during 1966-1972 when their number was drastically reduced (76%). Between 1956 and 1983 a marginal increase of 3% was recorded in the population of these animals, probably due to their decreasing use as draught animals. Their use as modes of transportation has also become limited due to the increasing use of mechanised vehicles. The donkey and mule populations in the district increased by 117% during 1956-1983. Their numbers are steadily increasing since 1956, except during 1966-1972 when a severe reduction (83%) in their population was recorded due, perhaps, to the severe drought of 1969. Infact, the 1969 drought adversely affected the population of all livestock species in the district, including goats and camels. The donkey is unquestionably the animal of choice for the economically weaker sections of the rural population of the district and is used, like camel, as a multipurpose animal. However, unlike the sheep and goat owners of Barmer district, the sheep owners of Jaisalmer district do not keep the donkey and are not seen taking the donkies on migration along with their sheep. This difference in the attitude of sheep and goat owners in the two districts could be due to the difference in social castes of the sheep owners. The sheep owners of Jaisalmer district are mainly Rajputs, whereas in Barmer, Jodhpur and Jalor districts people of the Raika and Jat communities generally rear these animals.

The camel population of Jaisalmer district recorded the highest increase of 153% during 1956-1983, except during 1966-1972 when population declined by 8.6% due to drought. There is no mention of pig in the animal census of the district uptil 1983.

Characteristics of livestock species

Cattle : The cattle of Jaisalmer district mainly belong to the dual purpose Tharparkar breed. These animals are characterized by a medium size with a deep frame : strong, straight and clear limbs, fine bones, strong ankles and hard feet. Their body, though not compact, is muscular and stockily built. The young animals usually have a white or light grey line over the spine, depending upon the colour of the animal. The head is broad, with a straight, bulging forehead and a long face. Their ears are medium to large and horns short and upright, but not coarse. Their legs are short, strong and well built. The tail is long and almost reaches the ground. The coat colour in these animals generally varies from white to grey. The average

height of the bull is from 131 cm to 137 cm and that of the cow is from 127 cm to 132 cm. Bullocks of the Tharparkar breed are good draught animals and the cows are relatively good milk yielders. The average daily milk yield from a Tharparkar cow is only 2.3 to 3.2 kg which may increase to 4.5 kg during the monsoon. Stall-fed cows may yield upto 11.2 kg milk/day. The average milk yield from well maintained stall-fed Tharparkar cows in Jaisalmer district is 1,361 kg during the lactation period of 6 to 8 months. In some cases it is as high as 2,268 kg.

Cattle of the Rathi breed are also found in the north-eastern part of the district. It is a milch breed. The Rathi cows are good dairy animals, but the bullocks are low and relatively poor in draught power. Rathi cattle are medium sized, with a heavy head and moderate-sized, coarse, small, thick horns. They have a comparatively broad face with a heavy hump and dewlap, and a pendulous sheath. They have dropping ears and a deep, compact frame of rounded quarters. The legs are short, massive and wide and the udders are quite capacious. The animals are wedge shaped, with an average height of 125-132 cm in the case of males and 109 cm to 127 cm in the case of females. The colour of Rathi cattle varies from red to dark red, sometime with a white spot on the dewlap and the udder and even on the body. A combination of red and white or black and white coat colours is also found. The average milk production of Rathi cow ranges between 6.5 and 8 kg per day A well maintained, stall-fed Rathi cow can yield upto 13.6 kg milk per day, with an average production of 1,588 to 1,814 kg of milk during a lactation period that lasts generally for 10 months.

Considering the importance of Jaisalmer district as the principal source of germplasm for Tharparkar breed of cattle, Rajasthan Government established, in 1964, a 250 ha Cattle Breeding Farm at Chandan for the improvement of Tharparkar cattle. Genetically pure Tharparkar bulls are bred here, maintained and distributed among the farmers.

Goats : Goats constitute about 26% of the total livestock population of the district and belong mainly to the long, black haired, meat type Marwari breed. These are not good milk yielders. Goats of another meat type, the Lohi breed, are also found. The Marwari goats of Jaisalmer and other arid districts of western Rajasthan, are in great demand in other parts of the country. Goats from the district are regularly transported to Bombay for slaughter.

Sheep : Sheep in Jaisalmer district mainly belong to the Jaisalmeri breed and constitute about 54% of the total livestock population of the district. Jaisalmeri sheep is a heavily built animal, with a black face and characteristically long ears and a roman nose. The average body weight of the ewes is 29 kg to 30 kg and that of rams 32 kg. The average per capita wool production is about 2.12 kg per annum. The

wool, which is white in colour, is of medium grade, though some flocks produce fine grade wool as well. Sheep are clipped twice a year.

Buffaloes : Because of their high water requirement buffaloes constituted only 0.1% of the total livestock population of the district during the year 1983.

Camels : The camel is perhaps the most useful domestic animal in the district. The Jaisalmeri camels, forming a specific breed called Jaisalmeri, are considered to be fast runners and are famous for their speed, hardiness, endurance and easy paces. There are lighter in weight and are also lighter in colour than the Bikaneri camels. Jaisalmeri camels, unlike the Bikaneris, do not have a bunch of black hairs on the inner side of pinnae, nor do they have the big hairy eye lashes, typical of the Bikaneri camel. However, these animals have a long cluster of hairs at the lower part of the neck, which is generally absent in the Bikaneri camel. They can go over long distance without food or water, subsisting for days on a little unrefined sugar (Jaggery) and alum which are carried in the saddle bags. The better animals of this breed are smaller and finer in head and neck than the ordinary camels of western Rajasthan, and can cover 129-161 km during a single night if the need arises. The camels are used both for pleasure rides and for a host of useful purposes like ploughing and harrowing the land, for bringing home the harvest and for carrying wood and water. Camel milk is also consumed by the rural population. Its hair is used for making *Durris* (rough carpets) and ropes and the hide for making shoes.

Donkeys : Among all the livestock types of Jaisalmer district, the donkey, perhaps, makes the highest contribution as the beast of burden, carrying a variety of loads like water, fodder and fuel wood and providing transportation to the human population. They are also used for ploughing the fields during the monsoon.

Animal products-based cottage industries

Since sheep and camel rearing are important in the district, the wool industry here is provided with a rich resource base. It is the only cottage industry worth the name in the district. Unprocessed wool is generally exported out of the district and processed wool is used for making shawls or lois, blankets, carpets and *namdahs*. The articles are made in two shades, white and black. Camel and goat hairs are also used for making carpets and large bags for carrying fodder. Ropes made of camel and goat hairs are also in demand.

Livestock fairs

Although no cattle fair of importance is held in the district, yet a couple of local cattle fairs are arranged by the Panchayat Samities. One such fair is held at Naukh during April-May. Animals are also brought to the Ramdeora fair, for purchase and sale of camel, bullocks and cows.

Animal diseases

One of the most common livestock diseases in the district is Avitaminosis, caused by the non-availability of good pasture or green fodder. Foot and mouth disease is also common. Mastitis in cattle is not very common.

Fodder situation

During the days of princely administration, Jaisalmer kept reserved tracts of grass to meet milder fodder scarcities. Some such tracts were at Dawa, Khaba and Devikot. Arrangements were also made to store enough hay and fodder. Presently, fodder are grown generally in areas where tube well facilities are available. The major fodder crops include *guar (Cyamopsis tetragonoloba)*, *rizka* (lucerne), *jowar* (Sorghum), and *bajra* (Pearl millet), growing mainly in Pokaran tehsil. According to one estimate, during 1963-64, 1964-65, 1965-66, 1966-67 and 1967-68 fodder crops were grown on 20,136 ha, 24,414 ha, 21, 070 ha, 20,081 ha and 22,573 ha of land, respectively in Jaisalmer district.

Considerable efforts have been made by CAZRI to mitigate the fodder scarcity conditions in Jaisalmer district and to improve and nurture the natural rangelands. Apart from the Government's and the farmers' efforts to mitigate the fodder scarcity conditions the extensive areas of naturally growing *Lasiurus sindicus* provide permanent pasture.

The major constraints for utilising such grazing areas are lack of water and shade. The fodder, when its requirement is maximum during summer, becomes highly fibrous (neutral detergent fibre content : 79.5%) and may contain as little as 2.7% of crude protein. During the summer of 1986, the cattle owners of Shiv, Gunga, Deva and Jhinjhiyali villages took their animals to Pali-Digga and let them loose on this pasture. As no water sources were available near this grazing area, the cattle owners were forced to take their livestock every alternate day to the nearest watering point at Sultana village, about 12-20 km from the various cattle camps. According to one estimate, during the summer of 1986 about 40,000 cattle camped in this area and in some of the cattle herds the mortality rate was as high as 45-55 per cent during their stay in this grazing area.

During the drought year of 1987, a total of 119 cattle camps were organised at various sites in Jaisalmer district and a total of 655, 775 heads of cattle were benefitted through these camps.

CHAPTER XIII

WILD LIFE AND RODENT PESTS

Wild Life

The district is an endless stretch of sandy plain interspersed with innumerable sand dunes and at places with rocky areas and hillocks. Due to the arid environment, it supports a very scanty vegetation and a low density of trees and shrubs which reflects upon the carrying capacity of land. Yet it is amazing that quite a variety of wildlife is found in this xeric environment. The Indian gazelle, locally known as Chinkara (*G. gazella*) is fairly common, whereas the desert hare (*Lepus nigricollis*) is sparsely distributed all over the district. The porcupine (*Hystrix indica*) occurs in the hilly habitat. The carnivores, desert fox (*Vulpes V. pusilla*) and desert cat (*Felis lybica*) are occasionally seen, but jackal (*Canis aureus*) and the wolf (*Canis lupus*) have almost vanished from the scene.

Among the birds, the most significant and spectacular species found in fair number in this region is the Great Indian bustard (*Adreotis nigriceps*). It is especially common in the western part of Jaisalmer and north western part of Barmer district. Part of the region has been declared as a Desert National Park. The Patridge (*Francolinus pondicerianus*), the common sandgrouse (*Pterocles exustus*) and few quails are the common species of wildlife interest. During the winter season several birds migrate into this region. Among them the Houbara (*Chlamydotis undulata*) and the Imperial sandgrouse (*Pterocles oritendalis*) are the main species of wildlife interest.

A number of reptiles inhabit the sandy plain. Among them the more important ones are the spiny-tailed lizard, commonly known as sanda (*Uromastix hardwickii*), the desert monitor lizard (*Varanus griseus*) and the venomous viper (*Echis carinatus*). In the *sewan* (*Lasiurus sindicus*) grasslands there is a great scope of conserving the wildlife species, if the grass can be maintained in green condition throughout the year by meagrely irrigating it through sprinkler.

Rodents

Rodents are a menace. They destroy standing food and fodder crops, stored foodgrains and other properties worth millions of rupees. In addition, they spread atleast 20 kinds of diseases among human beings. In the desert region their density per unit area is much higher than in any other habitat in India. The damages inflicted by the field rodents to *kharif* as well as *rabi* crops, to grasses and to the tree

plantations make it all the more essential that adequat econtrol operations are adopted before sowing any crop or taking up any afforestation programme.

In Jaisalmer district a survey to study the species composition and habitat selection of field rodents were taken up in 4 major land types.

(1) *Sandy habitat:* A community of *Lasiurus sindicus--Cenchrus biflorus* and *Blepharis sindicus* was recorded on this habitat which supports shallow soil, deposited either on gravels or on rocky substratum. *Capparis decidua* scrubs on such situations are evenly distributed, having a frequency of about 66 percent. The herbaceous ground flora had a comparatively high basal cover of 7.9 percent because of enclosure. Most of the rodent burrows were recorded from the sandy hummocks formed under *Capparis decidua* bushes. At the time of study a very low number of rodents was, however, recorded (trap index being 0.034). In an earlier study conducted in the same habitat a much larger number was recorded. It is worth mentionig that *Meriones hurrianae* could not be collected even during 3000 trap hours in this habitat and only three species of rodents viz. *Gerbillus gleadowi, G. n. indus* and *Funambulus pennanti* were collected, the latter being collected in the traps situated near *Tecomella undulata* trees.

The species composition was found to be as follows:

Species	*Percent frequency*
Funambulus pennanti	33.3
Gerbillus nanus indus	33.3
Gerbillus gleadowi	33.3
Meriones hurrianae	*Few*
Rattus gleadowi	*Few*

(2) *Rocky habitat:* In the studied rocky area *Cymbopogon jawarancusa-Eleusine compressa-Oropetium thomaeum* formed the main plant community, associated with *Commiphora wightii* plants. The soil depth was almost nil. The number of rodents trapped here was low and only 4 *R. C. cutchicus* were trapped. This may be due to the extreme drought prevailing at the time of study and the thin veneer of soil mantle.

The species composition was found to be as follows:

Species	*Percent frequency*
Hystrix indica	Rare
Rattus c. cutchicus	100

(3) *Gravelly habitat*: The vegetation in the gravel plains was found to be very sparse and was chiefly composed of *Salvadora oleoides, Commiphora wightii* and

Acacia senegal. The other components were *Tephrosia purpurea* and *Capparis decidua* and at certain localities *Acacia jacquemontii* and *Prosopis cineraria.* Rodent population was found to be very low in this habitat. The species, collected in this habitat, were *M hurrianae, Tatera indica. R. Gleadowi* and *Mus platythrix.*

(4) *Village complex*: Ruderal habitat (village complex) can be seen on any landform, mainly depending upon the availability of water and forage for human and livestock population. Typical plants in this habitat are *Azadirachta indica, Prosopis cineraria, Tamarindus indica, Ficus religiosa, F. bengalensis, Ficus retusa, Salvadora oleoides, Zizyphus mauritiana,* etc. which are planted for shade and to serve as top feed for the animals during the periods of fodder scarcity. Hedges around the hutments and crop fields are chiefly composed of dried twigs and thorns of *Zizyphus nummularia, Prosopis juliflora* and *Calligonum Polygonoides* which serve as the outer boundary wall. Adjoining to these village hutments and occasionally in the village itself, crop fields are found where rainfed crops like millets and legumes (*Phaseolus aconitifolius, P. aureus, Cyamopsis tetragonoloba*) and oil crops like sesame are mainly cultivated. Under such conditions the rodents were trapped in the village outskirts, particularly along the hedge lines.

The species composition was as follows:

Species	*Percent frequency*
G. gleadowi	78.0
Tatera indica	7.0
Meriones hurrianae	14.0

CHAPTER XIV

MAJOR LAND RESOURCES UNITS CHARACTERISTICS AND ASSESSMENT

The mapping, evaluation and correlation of the data generated in respect of different land attributes within the district led to the recognition of certain patterns of homogenity in the spatial distribution of the different attributes (resources), and hence, of eertain units which have been named as the Major Land Resources Units (MLRU). Each of these has its own set of characteristics in respect of geomorphology, soils, land capability, vegetation, surface and subsurface water, land use, etc., and also ccrtain problems and potentials.

Ten Major Land Resources Units have been recognised and mapped within the district (Fig. 19). Their characteristics and assessment are as follows:

UNIT

1. Hills (360.0 sq. km)

Geomorphology: Formed of sandstone, limestone, granite and rhyolite; shape conical, monoclinal and flat- topped; almost no talus; obstacle dunes against some; long, rectilinear slope; faceted in areas of hard cap: very few channel.

Soils and land capability : Rocky; VIII.

Vegetation: *Salvadora oleoides, Capparis decidua, Aristida, Oropetium thomaeum.*

Surface water: Insignificant infiltration; run-off better than in sandy areas, but not sufficient.

Ground water: Nil

Present land use: Mainly rocky waste.

Assessment : Suitable for quarrying of aggregate resources. Runoff from the rocky slopes could be collected either in the foot-hills or beyond.

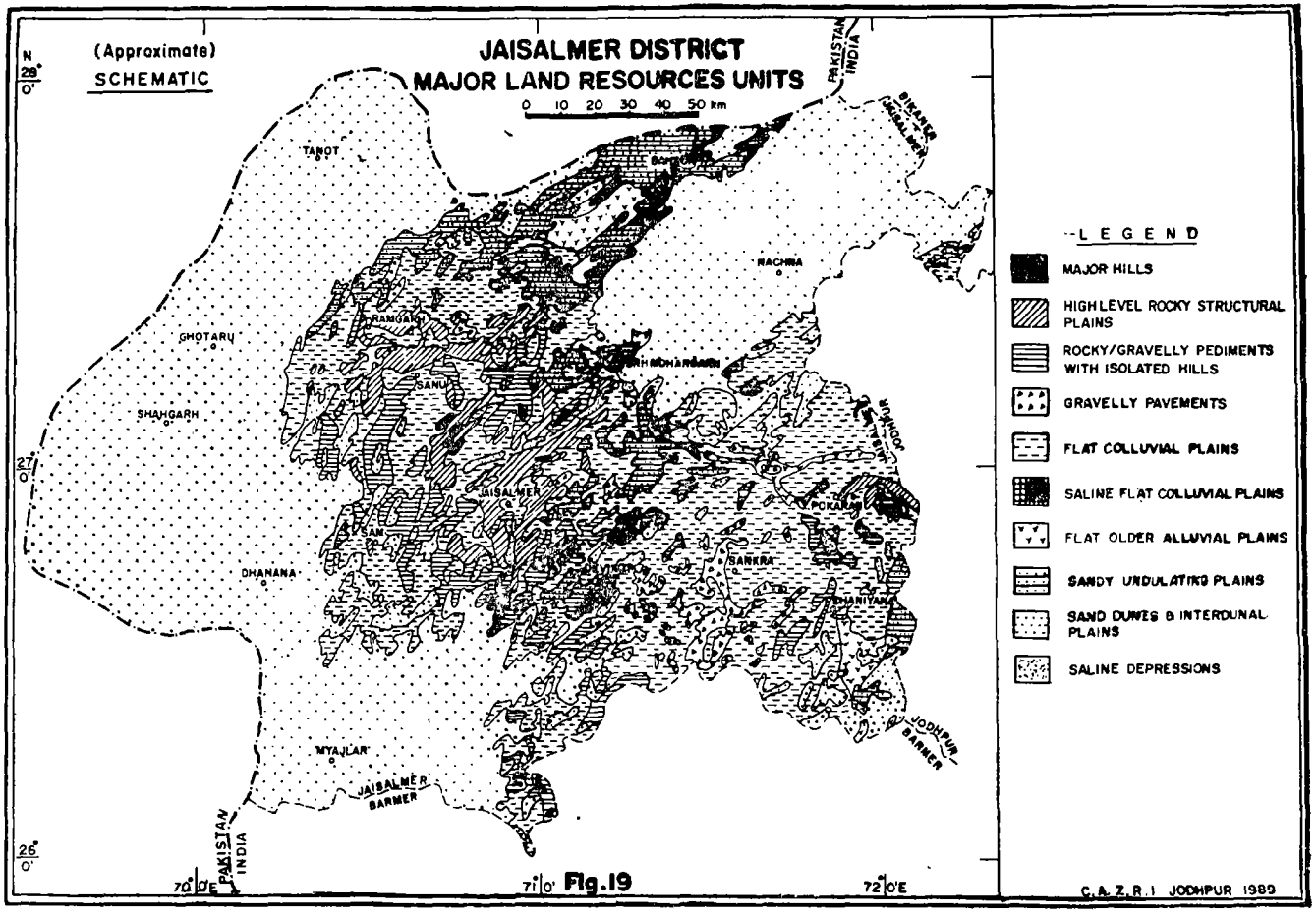

(Approximate)
SCHEMATIC
JAISALMER DISTRICT
MAJOR LAND RESOURCES UNITS
0 10 20 30 40 50 km
N
28° 0'
27° 0'
26° 0'
70° 0' E
71° 0'
72° 0' E
PAKISTAN
INDIA
TAROT
GHOTARU
SHAHGARH
DHANANA
RAMGARH
SANU
JAISALMER
SAM
MOHANGARH
RACHNA
POKARAN
SANKRA
DHANIYANA
MYAJLAR
JAISALMER
BARMER
JODHPUR
BARMER
BIKANER
JAISALMER
LEGEND
MAJOR HILLS
HIGH LEVEL ROCKY STRUCTURAL PLAINS
ROCKY/GRAVELLY PEDIMENTS WITH ISOLATED HILLS
GRAVELLY PAVEMENTS
FLAT COLLUVIAL PLAINS
SALINE FLAT COLLUVIAL PLAINS
FLAT OLDER ALLUVIAL PLAINS
SANDY UNDULATING PLAINS
SAND DUNES & INTERDUNAL PLAINS
SALINE DEPRESSIONS
Fig.19
C.A.Z.R.I JODHPUR 1989

Fig. 19

2. High level rocky structural plains (1314.6 sq. km)

Geomorphology: Mostly with south facing escarpments; 1°-3° long dip slope towards NW; channels mostly along dip slope; parallel to dendritic pattern; karsting on some limestone hamadas, wind erosion is dominant.

Soils and land capability: Miscellaneous shallow, gravelly/rocky; VIII, sh, r.

Vegetation: *Euphorbia caducifolia, Acacia senegal, S oleoides, Commiphora wightii, Aristida, O. thomaeum.*

Surface water : Insignificant infiltration; run-off during occasional cloud-burst; better potential along the long dip slope.

Ground water: Nil

Present land use: Mainly rocky/stony wastes with open grazing lands.

Assessment: Suitable for quarrying of aggregate resources; catchments along the dip slope could be developed for harnessing the run-off from this unit more efficiently for khadin cultivation downslope. *Commiphora wightii* is severely degraded, especially around Jaisalmer, but has tremendous potentiality. *Euphorbia* and *Acacia* species need encouragement. The Eocene Khuiyala Limestone, forming the unit to the west of Habur, has excellent flux grade limestone reserve of about 350 million tonnes.

3. Rocky/gravelly pediments (1353.2 sq km)

Geomorphology: Flat, 0° to 1° slope; often armoured with angular, varnished fragments and/or a veneer of aeolian sand; very few shallow channels.

Soils and land capability: Rocky/gravelly, with occasional shallow, miscellaneous deposits; VII c, sh; VIII r.

Vegetation: *A. senegal, Zizyphus nummularia, S. oleoides, C. decidua, Aristida, O. thomaeum, Dactyloctenium sindicum, Eleusine compressa.*

Surface water: Insignificant infiltration; better run-off potential during occasional cloud burst; numerous *nadis*, water available for 1 to 6 months.

Ground water: Generally not explored, but exploited in some cases of Lathi, Bhadasar and Parewar aquifers.

Present land use: Rocky and stony wastes with open scrub grazing lands.

Assessment: Degradation of scarce vegetation resource, especially through uncontrolled open grazing and destruction of shrubs for fuel, etc., are favouring faster sand movement along the margins of the sandy desert. Sedimentation in the *nadis*, especia-

lly aeolian sand deposition, is a problem. To minimize the sand movement through this unit range care is neoessary over it and in the surrounding sandy units.

4. Gravelly pavements (352.8 sq km)

Geomorphology: Slightly convex outline; 1°-3° slope; surficial concentration of cleaved or subrounded quartzite and other cobbles and pebbles, mixed with sand; subsurface contact with parent formation is either direct, or through a finer, sandy layer.

Soils and land capability: Heterogenous gravelly soils; gravel-free solum has sand to loamy sand texture; reasonably good amount of plant nutrients; tendency to form crust; VII, sh.

Vegetation: C. decidua, Z. nummularia, Aristida, O. thomaeum.

Surface water: Moderately high infiltration, lesser than in sandy areas, but higher than in rocky units; many nadis.

Ground water: Exploited in Lathi Sandstone aquifer; TSS ranges from 500 to 3200 ppm; Av. depth to water more than 60 m.

Present land use: Gravelly wastes with open grazing lands.

Assessment: Suitable for quarrying of aggregate resources and pasture development.

5. Flat colluvial plains (10830.0 sq. km)

Geomorphology: Flat, 0°-1° slope; average colluvial depth 33 to 60 cm, plains associated with pediments dominated by 0.15 to 0. 25 mm size near-surface sediments, alongwith parent rock fragments; gravels and pebbles dominate in pavemented areas; less of fluvial transport; slow in-situ weathering.

Soils and land capability: Generally medium to fine textured in areas associated with pediments and structural plains in the west; sandy loam to clay loam; good structural development; medium textured in pavemented areas of east; sandy loam; weak to moderately developed subangular blocky structure; medium to fine textured in *Khadin* areas; stratified soils, better aggregation and clod formation; sandy loam to loam and clay loam; IV, C, sh, s; VI c, s, sh.

Vegetation: S. oleoides, Prosopis cineraria, Z. nummularia, C. decidua, Tamarix dioica (in Khadin), Acacia nilotica (in Khadin); L. sindicus, E. compressa.

Surface water : Slow infiltration; moderately high run-off potential; numerous nadis and tankas; *khadin* system of run-off harvesting for agriculture in favourable

areas with appreciable soil depth and rocky catchment in the surroundings. Catchment size for *khadins* generally varies from 2.5 to 51 sq.km; storage capacity varies from 0.028 to 2.33 mcm.

Ground water : Lathi Sandstone, Bhadesar Sandstone and Parewar Sandstone provide the potential aquifers in most areas; Jodhpur Sandstone is the potential aquifer to the east of Pokaran and Ujlan. Depth to water more than 60 m in most cases, but between 15 and 40 m in the east. Most of the potential aquifers have water of less than 3200 TSS, while some have upto 5000 TSS. Unconsolidated Quaternary deposits along channels are the sources of perched water at favourable sites after occasional good rains; water tapped through shallow dug-wells (beries).

Present land use : Khadin cultivation in favourable locations through conservation of rain water-also a source of rabi cropping; otherwise usual monocropping of kharif crops in rotation; also permanent pastures (*orans*).

Assessment : Most of the cultivated lands of the district occur within this unit. Although it contains a wide range of soil texture, the soil depth is a limitation almost everywhere. Traditional khadin system of cultivation in favourable areas has proved to be immensely successful, but requires better management, improvement and propagation. Permanent pastures are in various states of degradation; also there is shrinkage of their area, leading to further degradation of the marginal lands. Moderate to very high risk of aeolian hazard, especially along the margin of dune-covered and other sandy undulating areas.

6. Saline flat colluvial plains (65.8 sq.km)

Geomorphology : Flat, 0°-1° slope; morphological characteristics are same as in the case of flat colluvial plains. However, the surface is saline, mostly due to the nearness of the gypseous clay beds associated with the Baisakhi Shale formation (e.g. near Sirwa and Modha). Mappable areas are limited, although there are several pockets of such salinity within the rocky areas.

Soils and land capability : Generally fine textured soils; associated with pedimented areas; loam to clay loam; moderately developed subangular blocky structure; saline soil; VI sa, s, c.

Vegetation : S. oleoides, Tamarix dioica, P. juliflora, Sporobolus marginatus.

Surface water : Slow infiltration; moderately high run-off potential.

Ground water : Not very promising.

Present land use : Very poor monocropping of kharif crops in scattered locations; otherwise miscellaneous wastelands.

Assessment : These areas could be developed through forest plantation, especially through plantation of naturally occurring species of *P. juliflora, S. oleoides, Tamarix dioica*, etc. The limited soil depth and salinity/alkalinity are the major hindrances for agricultural development.

7. Flat older alluvial plains (694.2 sq. km)

Geomorphology : Flat, 0°-1° slope; mainly along the dry beds of the Sukri and the Lik; average thickness over hard pan is 60 to 100 cm; medium to fine sands dominate; lime-coated riverine conglomerate is often the limit; problems of salinity-alkalinity in the south-east, as the Lik has its source in the *ranns*.

Soils and land capability : Moderately deep to deep sandy loam to loam, underlain by lime concretions and gravels; finer particles dominant in the subsoil; weak to moderately developed structure; IV c, VI c, s, ga.

Vegetation : C. decidua, Z. nummularia, Calotropis procera, Aerva pseudotomentosa, L. sindicus, E. compressa.

Surface water : Slow to moderate infiltration; numerous nadis and tankas. Khadin system of run-off harvesting for agriculture.

Ground water : Lathi Sandstone and rhyolite form the major aquifers; few cases of alluvium aquifer; Depth to water generally between 15 and 40 m; TSS ranges from 1500 to 5000; perched water along the channels are tapped in beries after the rains.

Present land use : Monocropping of kharif crops dominate, intensity 60% to 80%; permanent pastures are fewer than in other units.

Assessment : Limitations of soil depth, salinity/alkalinity and adequate potable water preclude much development under the existing set-up. Deep ploughing with tractor has led to the problem of accelerated wind erosion in many parts (e.g. between Ramdevra and Loharki, near Bhaniyana), as monsoon rainfall is totally uncertain and SW wind energy is high, even in July-August. Yet, it contains some of the potentially good agricultural lands within the district.

8. Sandy undulating plains (3051.6 sq. km)

Geomorphology : Thick, undulating aeolian sand over either a colluvial surface (dominant), or sandy alluvium; 1 to 5 m high, mobile barchans, barchanoids and sand streaks are the major constituents.

Soils and land capability : Moderately deep to deep sand to loamy sand, underlain by lime concretions, gypsum layer, gravel or rock, generally no stable structure; fine sand in the substratum; VIc, s, sh and VII c, s, e.

Vegetation : *Haloxylon salicornicum, A. pseudotomentosa, C. decidua, L. sindicus, E. compressa.*

Surface water : High infiltration; low runoff potential; many tankas with artifical catchment; few nadis.

Ground water : Lathi Sandstone provides the potential aquifer; depth to water varies from 40 m to more than 60 m; TSS ranges from 1500 to 5000.

Present land use : Mainly sandy waste ; also used as open grazing lands.

Assessment : Very high risk of aeolian hazard. The low density grasses and shrubs are being excessively exploited near the settlements, leading to more degradation in those areas. In the north the unit has excellent coverage of natural *Lasiurus sindicus* grasses, but due to recurrent drought and absence of any range care practices much of it has become almost a dead stock. Yet, there is potentiality for development of natural grassland with minimum range care.

9. Sand dunes (17192.4 sq. km)

Geomorphology : Seven major types; the megabarchanoids of the south-west, the smaller barchans and other sandy streaks are mobile; others are relatively stable and vegetated, yet highly vulnerable; formation and movement related to dominant SW wind; mobile dunes and reactivated dune crests are dominated by 0.25 to 0.18 mm sand. Buried courses of the former Saraswati river beneath the dune and interdune sediments in the west.

Soils and land capability: Light yellowish brown to reddish brown, very deep fine calcareous aeolian sand; no structure; poor moisture retention; VI c, s, e.

Vegetation: Leptadenia pyrotechnica, Calligonum polygonoides, C. procera, A. pseudotomentosa, L. sindicus, P. turgidum, E. compressa.

Surface water: Very high infiltration; almost no potential.

Ground water: Potential Quaternary alluvial aquifer beneath the dunes and interdunes in the west; depth to water varies from 40 to 60 m; TSS ranges from 3200 to 5000.

Present land use: Mainly sandy waste; also used as open grazing lands.

Assessment: Inspite of very high vulnerability the stable dunes can support adequate grass and shrub cover under undisturbed condition; this helps in reduction of the aeolian hazard. However, excessive exploitation of the resources near settlements and earthwork connected with I. G. canal construction in the north and west have

created numerous mobile forms and associated problems. Programmes for stabilization of the dunes through plantation have now been taken up on a massive scale in the canal command area, especially along the main canal. Mobile dunes are most numerous in the western part, affecting settlements, roads, etc. but are transient in nature.

10. Interdunal plains (3061.0 sq. km)

Geomorphology: Mostly flat and sandy undulating; few rocky; shape guided by orientation of sand dunes; dominant grain size varies from 0.12 to 0.15 mm. Buried courses of the former Saraswati river beneath the aeolian sediments in the west; problems of aeolian erosion and deposition.

Soils and land capability: Light yellowish brown to reddish brown, deep to very deep fine calcareous sand; no structure; also underlain by lime concretion, gypsum, weathered rock fragments, etc. at depth; IV c, VI c, s, e.

Vegetation: P. cineraria, C. decidua, C. polygonoides, Z. nummularia, L. sindicus, H. salicornicum, A. pseudotomentosa.

Surface water: Infiltration rate variable according to the nature of the deposits; *tankas* numerous; also *nadis*, especially in flat and rocky interdunes.

Ground water: Most potential aquifer is the Quaternary alluvium in the west; depth to water varies from 40 to 60 m; TSS ranges from 3200 to 5000.

Present land use: Mainly sandy waste; also monocropping of *Kharif* crops, especially in the eastern part; open grazing land.

Assessment: With the introduction of canal water many of the interdunal plains in the I. G. Canal command area will be transformed into good agricultural lands. However, the subsurface barriers, especially of gypsum hard pan or amorphous layers may encourage waterlogging and salinity- alkalinity build-up and hence, may prove to be a deterrent factor in the near future. The terrain is also highly vulnerable to aeolian hazard. Hence, devegetation operation for agriculture or deep ploughing, without assured supply of water may lead to aeolian erosion and new mobile dune formation. The vast *L. sindicus* grassland in the west and northwest is ecologically most adapted, but recurrent drought and lack of management have degraded the species and taken a great toll of the existing stands. The vegetation resources in the east and south are also severely degraded, leading to aeolian hazards.

11. Saline depressions (125.4 sq. km)

Geomorphology: Flat, saline, hard surfaces when dry, pools of saline water after the rains and softer ground; mainly the areas of internal drainage, having bounding

rocky cliffs and/or steep slopes; however, always with an outlet at one end, through which water very rarely drains during exceptionally wet period; few sandy hummocks or barchans move across the flat surface; sandy hummocks more numerous near the outlets; near-surface sediments within the depressions have aeolian sand mixed with finer silt and clay.

Soils and land capability: Deep, fine textured saline soils; high pH; barren.

Vegetation: Only around the rim of the depression, especially where there is a sand cover; *Tamarix dioica, S. oleoides, Z. nummularia, Sporobolus marginatus, E. compressa.*

Surface water: Low infiltration, not potential due to salinity.

Ground water: Highly saline ground water at shallow depth; not potential; however, a rim of brackish ground water around the depression.

Present land use: Mainly saline waste, but few are used for commercial exploitation of salt.

Assessment: Efforts are being made to plant *P. juliflora* and other salt tolerant species along the margins for fuelwood purposes; shall mainly remain a waste, except for commercial exploitation of salt at few sites.

The list of the villages associated with above units is given in Appendix I.

CHAPTER XV

RECOMMENDATIONS

Depending upon the resource characteristics within the district and their assessment in respect of vulnerability and potentials, some broad recommendations could be framed for development planning. These are as follows:

1. Need for controlling the aeolian hazard

i) Because of extreme aridity and highly efficient aeolian processes the sandy terrain, especially the stable sand dunes, interdune plains and sandy undulating plains, have high risk of being reactivated through mobile dune formation, under the slightest biotic pressure/mismanagement. The surroundings of villages and the canal construction sites have already been affe.ted to a large extent. To control the problem of sand movement atleast 10 to 13 per cent grass and/or shrub cover is necessary. Restricted grazing and maintenance of stubbles and other plant residues help in checking the erosion to some extent. In the canal construction sites in the north and west of the district the stable dune ecosystem should bc restored at the earliest, so that the mobile dunes do not engulf larger areas. The canal bank, exposed to the SW wind, needs more protection through plantation than the other bank.

ii) Deep ploughing, without assured water supply, is to be discouraged in the sandy plains and in the inter-dunes as it encourages faster erosion of finer sediments, leaving a coarser lag deposit.

iii) The movement of barchans create problems of trafficability along the southern margin of the rocky tract and in the west. Yet, these move fast unless obstructeda rtificially. The average rate of movement is between 30 and 45 m/year. On the contrary, any obstruction across their path leads to the attraction of more sand and engulfing of the obstructing structure. Hence, such mobile bedforms should be allowed to pass, rather than attempting to check them. Avoidance of the barchan path is more economical than trying to counter their advances.

iv) The most severe problem of aeolian sand deposition along the highways are created by the heaps of stone chips and other aggregate materials stored along the roads for future use. During the dry summer months the strong sand-laden winds deposit their load to thc lee of these obstructions as elongated sand mounds, thus

partly or fully obstructing sections of the roads. To control this hazard the dominant SW wind should not be allowed to form any such depositional form across the road. If the aggregates are to be stored along the road, these could be heaped on the side which allows the SW wind to sweep clear the road. The depositional forms will then take shape beyond the road. A margin of about 5 m to 6 m is suggested between the road and the aggregate heaps. The small sand mounds in the immediate vicinity of the roads facing the SW wind should be levelled, so that these do not become the sites of sand accumulation during the sandstorms. Major bushes along the most vulnerable road sections may be replaced by a permanent grass cover. Creepers like *tumba* may also be encouraged, so that the sand movement is checked. The immediate vicinity of the vulnerable road stretches could also be paved to allow faster sand transportation.

v) The road-side plantation sites in the loose sand-covered plains of the district are sometimes sought to be protected through long, porous barriers. During the sandstorms, however, such porous barriers become the sites of sand accumulation, burying the small plants and creating new elongated sand ridges instead. Such barriers should, therefore, be discouraged in the vulnerable stretches.

vi) The introduction of water in the canal command area will encourage the farmers of the command area for land levelling and destruction of natural vegetation cover as a prelude to irrigated agriculture. Since land levelling in this dune covered area means levelling of the low dunes and sandy hummocks, thereby loosening the sand of a wider area, and since destruction of natural vegetation along the slopes of the dunes also leads to loosening of sand in the highly vulnerable tract, such activities without the assured supply of water to the disturbed lands will lead to more reactivation of sand, formation of new barchans and barchanoids and engulfing of newer flat areas with such mobile forms. It is, therefore, suggested that such disturbances to the terrain should be allowed only in those plots where there is an assured supply of canal water.

vii) Since all such problems are site-specific the detailed control measures need to be based on an understanding of the geomorphology of the sites and wind pattern.

2. Better uses of the soil resources

i) The coarse textured soils of the district have a poor fertility status, but the contents are adequate for sustaining natural vegetation. Hence, these soils are best suited for development of pastures, especially the *Lasiurus sindicus* grass in its natural habitat. Agriculture without irrigation is not recommended.

ii) The medium textured soils, inspite of their better status of clay and silt content, could not be properly used for rainfed agriculture due to its adverse climatic

situation. However, agriculture with irrigation is recommended. Otherwise, the soils have good scope for developing pasture lands.

iii) The medium to moderately fine textured soils could be developed as good *khadin* areas, if potential run-off catchment is available. Yet, in many cases the soils are poor in organic carbon, nitrogen and available phosphate. The nutrients are, however, sufficient to support natural vegetation which could be encouraged through range care in areas not fit for agriculture. In the established *khadins* the nutrient status is now better, indicating the type of change that can occur after land treatment. It is, therefore, recommended that the *khadin* system of cultivation be encouraged in all the favourable sites within the medium to moderately fine textured soils.

3. Suitable plant species for sand dune stabilization in the Canal Command area*

In the Indira Gandhi Canal command area within the district the vegetation on the sand dunes is in a severely degraded state and require urgent stabilization. Some of the sand dunes along the canal are now being stabilized, especially through the plantation of *Acacie tortilis*. However, continuous movement of animals on the dunes still loosen the sandy surface. Therefore, a better remedy could be additional plantation of grasses, shrubs and undershrub species.

i) *Stabilization :* There are two options for the stabilization of these sand dunes. One is protection by providing exclosure through barbed wire fencing or live hedge, while the other approach is to do plantation without any protection. In the first case highly productive and palatable grasses and top feed-cum-multipurpose species of shrubs and trees are to be raised, while in the second case only nonpalatable species of indigenous origin could be used.

Since water is available from the canal, non-palatable, but economic, grass species like *Saccharum munja* (Munj) can be transplanted all along the peripheries of the sand dunes in close spacing through root slip technique. In two years' time these grasses will provide an impenetrable wall-like structure. Once these grasses are established *Lasiurus* and/or *Cenchrus* grasses with *Prosopis, Tecomella* and *Calligonum* can be raised through sprinkler irrigation. Other suitable species for live hedge are *Opuntia elatior, Calotropis procera, Agave americana, Leptadenia pyrotechnica* and *Prosopis juliflora*. The chess board system of brushwood compartmentalization, developed for sand dune stabilization by CAZRI, may also be adopted. Plantation and/or seed broadcasting of nonpalatable, drought hardy, indigenous species could be taken up on the dunes. During the monsoon the reactivated loose segments of the dunes provide an opportunity for quick stabilization, because of good moisture regime. Indigenous species are deep rooted and adapted to minimal water requirement and

* Contributed by S.K. Saxena. Division of Resource Survey and Monitoring, CAZRI.

fertility, and hence thrive very well. Presently, these species are used for stabilizing the sand dunes. The majority of shrubs and undershrub species mentioned below are multibranched from their base and hence will be effective in checking the sand movement.

Suitable non-palatable species

Shrubs : Calotropis procera (Ak), *Leptadenia pyrotechnica* (Khimp), *Clerodendrum phlomoides* (Arni), *Balanites aegyptiaca* (Hingota), *Cassia auriculata* (Anwal), *Tamarix erecoides* (Jhau), *Withania somnifera* (Asgandh) and *Haloxylon salicornicum* (Lana).

Undershrubs : Aerva persica (Bui), *A. pseudotomentosa* (Baribui), *Crotalaria burhia* (Sannia), *Datura innoxia* (Dhatura), *Cassia italica* (Sonali), *Tephrosia purpurea* (Dhamasia), *T. falciformis* (Mansa), *Agave americana* (Sisal)**, *Opuntia elatior* (Thor)**.

Grasses: Cymbopogon jwarancusa (Burgas), *Desmostachya bipinnata* (Dab), *Panicum turgidum* (Murut), *Saccharum munja* (moonj), *S. spontaneum* (Kans) and *Sorghum halepense* (Baru).

Creepers : Citrullus colocynthis (Tumba), *Dactyloctenium welvitschii* (Ankh phutni bel).

Trees : Holoptelia integrifolia (Pitpapri), *Tamarix articulata* (Jhau), *Prosopis juliflora* (Vilayati babool), *Salvadora oleoides* (Jal).

Multipurpose trees and shrub species to be provided with exclosure include indigenous and exotic species like :

Trees : Acacia tortilis (Israeli babool), *A. senegal* (Kumat), *Prosopis cineraria* (Khejri), *Tecomella undulata* (Rohida), *Leucaena leucocephala* (Su-babool), *Acacia nilotica* sp. *Cupressiformis* (Khajoor Babool).

Shrubs : Calligonum polygonoides (Phog), *Dichrostachys nutan* (Kolai), *Colophospermum mopane* (Mopane), *Zizyphus nummularia* (Bordi).

Grasses : Lasiurus sindicus (Sewan), *Cenchrus ciliaris* (Anjan), *C. setigerus* (Dhaman).

It is emphasized that many of the species suggested for the command areas are of much wetter regions and have high water requirements. Hence, these species are to be planted only in areas where water is available for their sustenance.

** Exotic, but naturalized.

Nursery of such species should be raised during February and transplantation could be carried out during the monsoon. The shrub species may be raised with 3 m spacing. In between the two shrub rows grass species could be raised through root slip or seed sowing at 1 m spacing. The undershrubs may be tried at 1.5 m spacing with 0.75 m spacing of grasses. Such establishment of vegetation enhances the micro-flora and the fertility of the soil.

ii) *Shelterbelts and wind breaks :* Shelterbelts reduce the wind velocity within a certain area in the leeward side and improve the micro-climate in the sheltered part. This influences the growth and productivity of the crops in the sheltered fields. In the dry sandy tract of the canal command area of the district wind erosion from the agricultural fields and soil moisture loss due to evapotranspiration could be minimized through raising multirows (5 to 10) of trees/shrubs across the prevailing SW wind, all along the main canal and its distributaries.

Single row of trees and/or shrubs, when grown across the wind direction or around the field boundary/farm/orchard/garden, is generally termed as wind break. In the canal command area within the district wind breaks of single row are required on each *Murabba*+. The divided Murabba area should also be protected from the harsh climate through micro-wind breaks. When a crop is to be raised and sheltered from the hot wind, plants taller than the crop are to be provided for protection. Planting a few lines of the annuals as micro-shelterbelts a few days ahead of sowing the main crop, but harvested after the main crop, can also provide extra revenue by way of fodder/seed/fibre, etc. These annuals do not have any root competition with the main crop.

The plants suitable for shelterbelts and wind break in the area are as follows. The majority of the species are drought-hardy, disease resistant and fairly fast growing. They also have deep root systems and have longer life cycle.

Trees

Acacia nilotica (Babool)	*Hardwickia binata* (Anjan)
A. cupressiformis (Khajoor babool)	*Holoptelia integrifolia* (Pitpapri)
A. tortilis (Israeli babool)*	
Albizzia lebbek (Siris)	*Leucaena leucocephala** (Su-babool)
*A. amara**	*Prosopis cineraria* (Khejri)
Azadirachta indica (Neem)	*P. juliflora* (Tree type)
Cassia siamea (Kala siris)	(Angreji babool)
Dalbergia sissoo (Shisham)	*Tecomella undulata** (Rohida)
Eucalyptus camaldulensis (Safeda)	*Zizyphus mauritiana* (Ber)

+ 1 Murabba=25 Bigha.

* The species are susceptible to waterlogging and hence, should be avoided in shallow, hard pan areas.

Shrubs

Parkinsonia aculeata * (Angrezi babool)
Dichrostachys cinerea (Kolai)
D. nutans * (Nutan)
Clerodendrum phlomoides (Arni)
Zizyphus nummularia (Bordi)

Plants suitable for micro-shelterbelts are :

Annuals

Sorghum vulgare (Chipta)
Pennisetum typhoides (Bajra)
Ricinus communis (Arandi)
Zea mays (Makai)
Sesbania aegyptiaca (Ikar)
Crotolaria juncea (Sann)

Perennials for orchard:

Dedonea viscosa (Relia)
Clerodendrum phlomoides (Arni)
C. aculeatum (Jhurmuta)
Vitex negandu (Sambhalu)
Lawsonia inermis (Mehndi)
Nerium oleander (Kaner)
Saccharum bengalense (Moonj)

4. Suitable plant species for sand dune stabilization in non-command areas

Grasses and shrubs are well adapted to the dry environment of Jaisalmer district. Hence, the local grasses and shrubs should be given preference in stabilization of the dunes in the district. The dominant grasses in the north, west and southwest area are *L. sindicus*, *P. turgidum*, *E. compressa*, while the dominant shrubs are *Capparis decidua* and *Z. nummularia* in the north, *Haloxylon salicornicum*, *Calligonum polygonoides* and *A. pseudotomentosa* in the west and *Calotropis procera*, *Leptadenia pyrotechnica*, *C. decidua* and *A. pseudotomentosa* in the southeast. These local species could be tried for stabilization of the sand dunes in the district. Additionally, creepers like *Citrullus colocynthis* could be encouraged, as it is a good sand binder and has economic importance. The chess board system of compartmentalization of the dune surface for seeding/planting is most appropriate.

5. Improving the grasslands

i) Since grassland-based animal husbandry is the best landuse in Jaisalmer district grasslands need to be scientifically managed for sustained and optimum production, especially when 73% of the surveyed sites recorded 'poor' condition class.

* The species are susceptible to waterlogging and hence, should be avoided in shallow, hard pan areas.

ii) Both the quality and quantity of browse resources deserve improvement. Special attention must be paid to *Haloxylon salicornicum* (Lana), *Prosopis cineraria* (Khejri), *Z. nummularia* (Bordi) and *Acacia tortilis* as their percent cover on different habitats is much less than the desired level.

iii) Under-utilized and under-exploited plants like *Citrullus colocynthis*, *C. lanatus* for seed oil, *Commiphora wightii*, *Tribulus alatus* and *Arnebia hispidissima* having clinical importance, should be encouraged for systematic exploitation.

iv) The carrying capacity of the grasslands can be increased four times by proper range care. Even the surplus at present level can be used for hay making. Scientific grazing, like deferred and rotational systems, should be followed.

v) Natural pastures of *Lasiurus sindicus* (Sewan) and *Haloxylon salicornicum* (Lana) should be preserved in the Indira Gandhi Canal Command area, because flood irrigation may totally eliminate this natural vegetation and salinity may increase. It is important, therefore, that cropping in this region should be judiciously practiced at selected places.

6. Development of surface water resources and related management

The density of human population in the rural area of Jaisalmer tehsil is 4 per sq.km, whereas in Pokaran tehsil it is 11. To provide drinking water through piped water supply schemes to such widely scattered and thinly populated settlements is very costly and also difficult to manage. Hence, the villages facing acute scarcity of water must be provided with alternate permanent sources of water supply through cheap water harvesting structures. The conditions of the existing nadis, tankas and khadins need also to be improved. The people of the district mainly depend on animals for their livelihood. However, due to climatic constraints and mismanagement the condition of rangelands is poor, leading to regular migration of animals out of the district. Soil and water conservation practices in the rocky habitats can slightly improve the situation. Keeping in view the above problems the following soil and water conservation practices are recommended.

i) *Contour furrows* : Mostly the grazing lands consist of either gravelly, rugged surface or deep sandy soils. On gravelly surfaces, with slopes of 0.5 to 1.0 percent, water retention is negligible and cause sheet erosion. To control it and to increase the moisture status for grassland improvement, contour furrows must be constructed and maintained properly. Studies in other parts of western Rajasthan indicate that the contour furrows constructed at 5-6 m horizontal spacing and with cross section area of 0.046 sq.m. are most effective in conserving moisture and improving the grass production. Such measures will also reduce the sediment load in the nadis in the low reaches. Two such sites, (1) north of Hameera (625 ha) and west of Jaldhari (187 ha), have been identified.

ii) *Wind break baffle walls* : Stony wastelands, although generating substantial runoff for the *khadins*, are mostly barren. To make them productive the sand-laden south-westerly wind of the summer months could be obstructed through the construction of stagerdly stone baffle walls, built with the help of cheaply available local stone. The obstructed wind will deposit the sand on rocky surfaces and will ultimately promote some natural vegetation. The staggered baffle walls may be 0.30 to 0.60 m high and 3 to 5 m long, in curved alignment against the slope. Such structures will harvest small quantity of runoff, but will not significantly affect the existing *khadins*.

iii) *Khadins*: The construction of *khadins* have played a major role in the agriculture development of the district and needs to be extended in other areas where suitable sites are available. However, the existing *khadins* need also to be improved on the basis of sound scientific considerations. In some of the existing *khadins* the stored water is in excess of what the crops need and hence, is drained out at the time of rabi crop season. Moreover, such excess storage leads to evaporation losses from wider water surface area. The water could have been utilized in lower reaches wherever cultivation is possible. The data needed for designing any *khadin* should be based on the relation between catchment area needed for generating runoff and the area of bed cultivation. The following equation can be adopted to find out the ratio between the two.

$$\text{Runoff} = \text{Ac. P.C} = \text{Af (d+Esdi)}$$

where, Ac = Catchment area
P = Average rainfall
C = Coefficient of runoff
Af = Bed cultivation area of khadin
d = Depth of water needed for single crop for optimum production
Esdi = Evaporation and seepage losses.

With the help of following data of Jaisalmer district the relationship is worked out as :

P = 171.4 mm (Jaisalmer & Pokaran tehsils)
C = 0.2 for average catchment condition. For good catchment condition the value of C can be taken as 0.30 - 0.35.
Af = Unit area of bed cultivation
d = 400 mm or 40 cm
Esdi = Total losses, i.e. evaporation losses for 4 months : 100 cm and seepage losses assumed to be one half of evaporation, i.e. 50 cm.

Therefore, $\text{Ac} \times 0.171 \times 0.2 = 1(0.4+1.5)$

$$\text{Ac} = \frac{1.9}{0.171 \times 0.2}$$

Catchment = 55.55 or 56 unit

Hence, the ratio is 1:56, i.e. for one ha of bed cultivation under Jaisalmer condition, the average catchment area required for generating the runoff is 56 ha.

Similarly, for better catchment areas the ratio has been worked out as 1:37. However, if rainfall at 60% probability (118.5 mm) is considered, the ratio will be much higher.

Apart from improving the conditions of the present *khadins*, there is scope for construction of 21 new *khadins* (Appendix III). These 21 sites with catchment areas of 45 ha to 3750 ha will generate 7.83 mcm of water which will be utilized by crops in 412.07 ha.

iv) *Earthen check dams, gully control structures and anicuts*: Inspite of the adverse rainfall and terrain conditions in the district a few small rocky catchments could be treated for augmenting the water potentiality, through recharge to the groundwater and as sources of drinking water. For this the construction of small earthen check dams is proposed at 6 sites, anicuts at 3 sites and gully control structures at 2 sites. Near Bhaniyana a channel which is contributing 1.75 mcm of saline water to the existing *nadi* should be diverted for better use of stored water. The list of structures and sites is given in Appendix IV. These structures with a total catchment area of 293.1 sq. km are expected to store runoff of 25.66 mcm.

v) *Nadis:* The present status of *Nadis* in the district is not commendable because of sediment inflow and loss of stored water through evaporation and seepage. Moreover, maintenance is very poor. The condition of the existing *Nadis* could be improved by way of dredging of sediments every year and renovating the structures based on the designs developed by CAZRI. The adoption of the designs will reduce the seepage and evaporation losses and sediment inflow. These also ensure drinking water free from pollution. The renovation cost will be nearly Rs. 3.30 per 100 lit. of stored water in the first year. The design and constructional details of the *nadis* are as follows:

Designs and constructional aspects of *nadis* depend on various parameters, such as characteristics of catchment which include catchment class, slope area, type of soil, vegetation cover and rainfall. From these parameters, one can assess the expected runoff potential to be stored. Nadi being a source of drinking water, assured rainfall at 60 percent probability for each particular site should be considered. Essentially, before starting construction of structure a survey should be carried out for delineating the catchment area, slope and assessment of the soil and vegetation cover. Also the infiltration studies will be helpful for assessing the threshold rainfall capable to generate runoff.

Evaporation losses being overwhelming it should be minimised. At present, no successful measure is known to control the evaporation losses from surface water

bodies, but to some extent losses can be reduced by optimising the relation between depth and surface area. In the sandy plains the optimised depth (m) and surface area (m^2x10^3) works out to be 2.0 and 27.1, respectively, whereas in duny complex the figures are 2.5 m and 29.1 $m^2 x10^3$, in younger alluvium 5 m and 161.0 m^2x10^3, in older alluvium 3.0 m and 96.3 m^2x10^3 and in rocky/gravelly pediments 6 m and 126.5 m^2x10^3, respectively.

Design developed by this Institute is attached (Fig. 20). Its capacity is nearly 18,100 cum. Stored water is sufficient for 500 presons and their livestock throughout the year. The structure is circular, having diameter of 74 m. The width of earthen mount around water body is 7 m. To avoid entry of animals in the nadi, angle iron barbed wire fencing with eight strands of barbed wire is provided. The structure has been provided proper inlet and outlet. The outer edge of inlet is nearly 20 m and the inner edge is 10 m, with little regular slope towards water storage side. The complete inlet will be of dry stone-like normal pitching on earthen bund. Silt trap is provided at the entry of inlet and inward slope is given to pitching for proper flow of water in the nadi. This system will reduce the sediment load in the *nadi*. The outlet will be of similar material having slope to the outer edge. Separate entry is provided for men to draw water from *nadi*. Also animal trough is to be constructed outside the water body, which may be filled by manpower or one windmill can be provided for filling up the trough. By checking the animal entry and reducing the sediment load, the problem of water pollution will be avoided.

To avoid seepage from the bottom and vertical surfaces of the structure, the provision for laying of LDP sheeting (250 micron) has been kept. The laying of LDP sheet needs much care, so as to avoid any perforation in the sheets. Before laying of LDP sheets all grasses and weeds should be uprooted, along with spraying of weedicide. To avoid perforation, LDP lining should be overlain on the 5 cm thick sand cushion. Vertical side-surfaces may be excavated in the form of steps for placing of LDP sheets and covered with fine sand upto the bottom surface. There should be proper anchoring of LDP sheets at the ground level. Estimated cost of the structure, based on 1986 BSR schedule of rates, will be nearly Rs. 3,50,000.

vi) *Tankas*: There are 55 villages facing the crisis of drinking water and need to be provided with *tanka* structures as reliable source of drinking water. The structures could be built either on natural catchments or with artificial catchment. A tank of 21 cum capacity, costing nearly Rs. 11,000/- and having an artificial catchment, will provide water to a family of 5-6 persons throughout the year. A *tanka* of this capacity is most suitable for individual *dhanis* (Fig. 21). However, a tanka of 200 cum capacity, developed by CAZRI (Fig.22), may be constructed for schools, Primary Health Centres Panchayat halls, etc. and will cost nearly Rs. 60,000/. The natural rocky or gravelly catchment area needed is 2-3 ha. The area needed for an artificial catchment depends

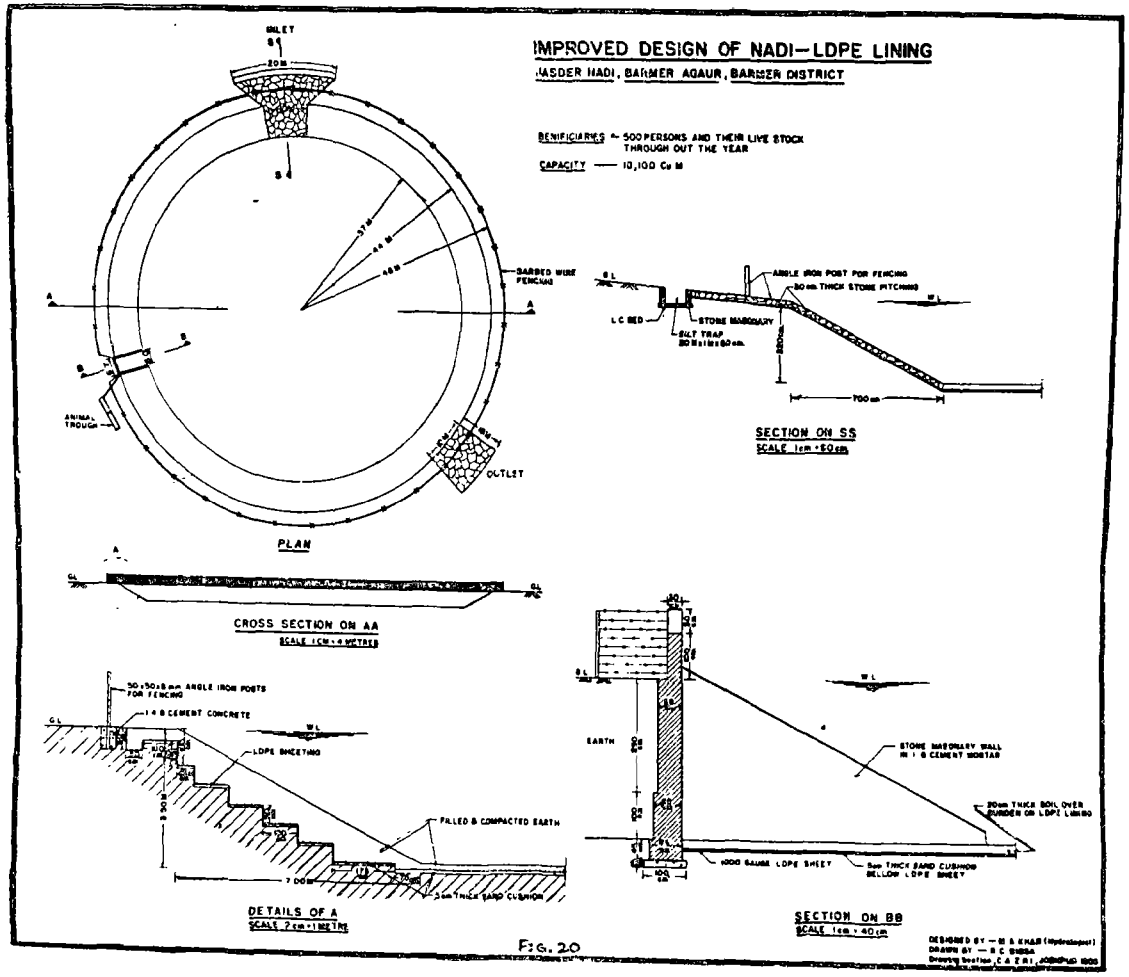

IMPROVED DESIGN OF NADI–LDPE LINING
BENIFICIARIES — 500 PERSONS AND THEIR LIVE STOCK THROUGH OUT THE YEAR
CAPACITY — 10,100 Cu M
PLAN
SECTION ON SS
SCALE 1cm = 50cm
CROSS SECTION ON AA
DETAILS OF A
SCALE 2cm = 1 METRE
SECTION ON BB
SCALE 1cm = 40cm
OUTLET
ANIMAL TROUGH
BARBED WIRE FENCING
ANGLE IRON POST FOR FENCING
50 mm THICK STONE PITCHING
LC BED
STONE MASONARY
SILT TRAP
700 cm
1:4 CEMENT CONCRETE
LDPE SHEETING
FILLED & COMPACTED EARTH
EARTH
STONE MASONARY WALL IN 1:6 CEMENT MORTAR
1000 GAUGE LDPE SHEET
5cm THICK SAND CUSHION BELLOW LDPE SHEET

Fig. 20

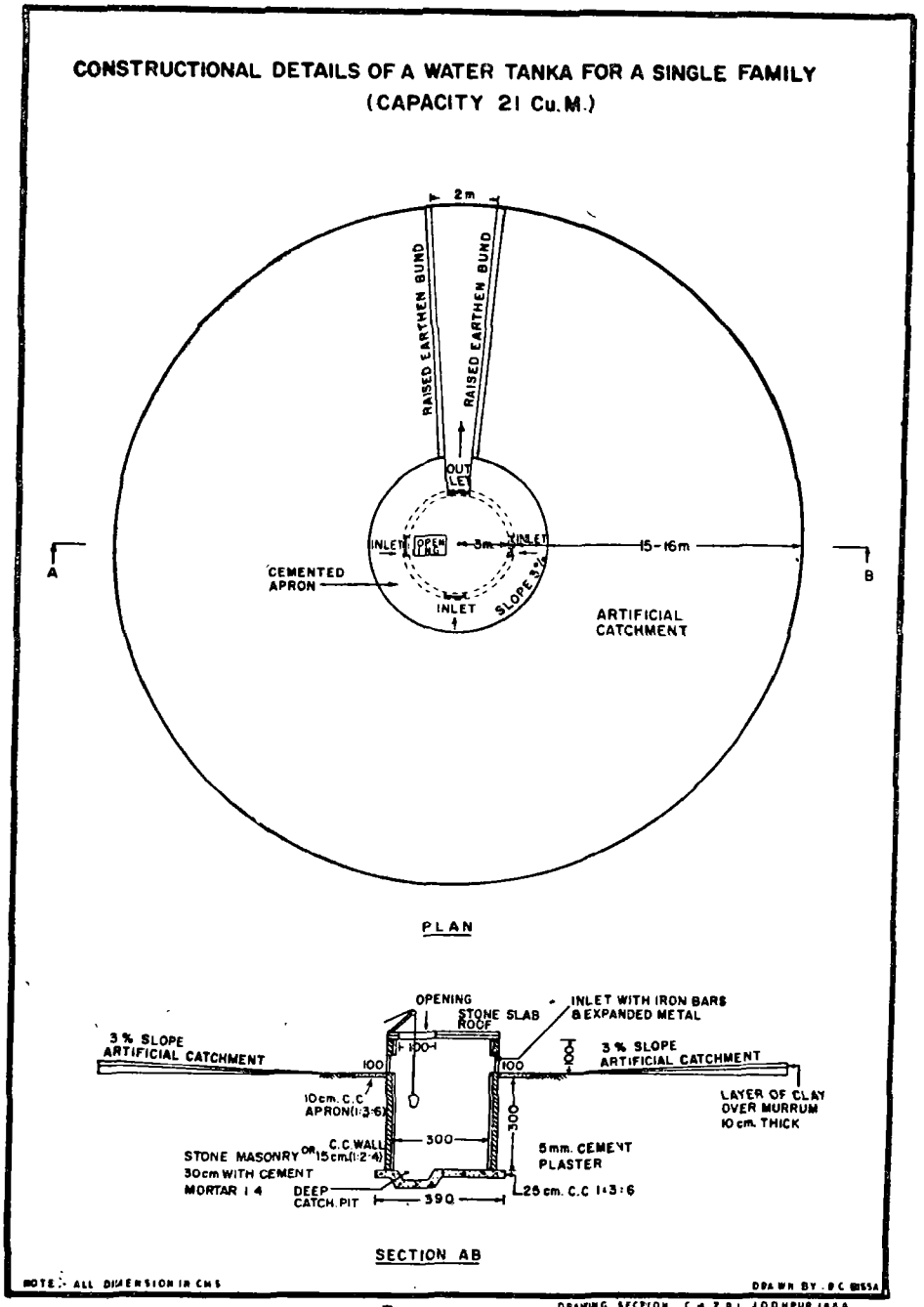
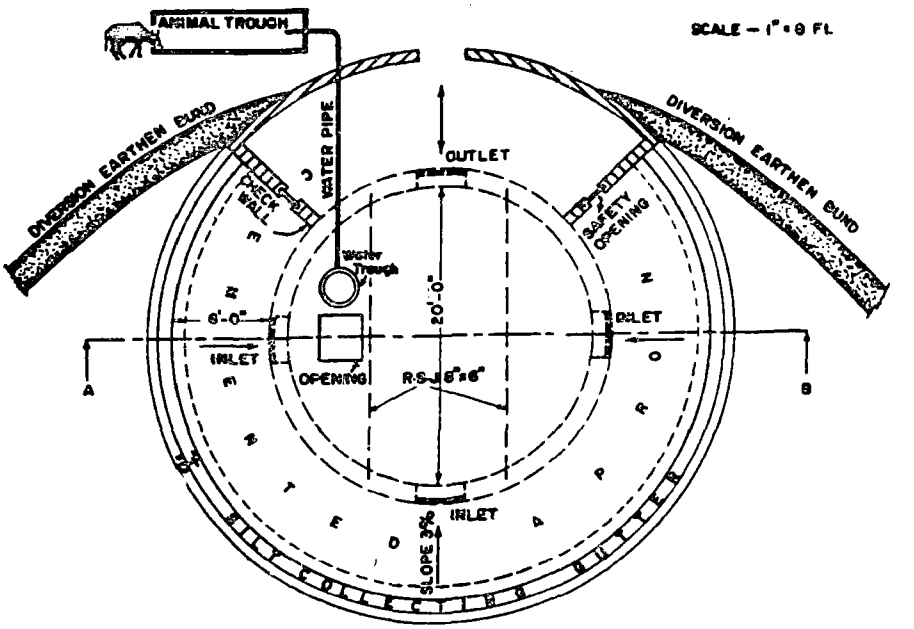

CONSTRUCTIONAL DETAILS OF A WATER TANKA FOR A SINGLE FAMILY
(CAPACITY 21 Cu.M.)
2m
RAISED EARTHEN BUND
RAISED EARTHEN BUND
OUT LET
INLET
OPEN
3m
INLET
15-16m
A
B
CEMENTED APRON
INLET
SLOPE 3%
ARTIFICIAL CATCHMENT
PLAN
OPENING
STONE SLAB ROOF
INLET WITH IRON BARS & EXPANDED METAL
3% SLOPE ARTIFICIAL CATCHMENT
3% SLOPE ARTIFICIAL CATCHMENT
100
100
100
100
10cm. C.C APRON(1:3:6)
LAYER OF CLAY OVER MURRUM 10 cm. THICK
300
300
C.C WALL OR 15cm.(1:2:4)
STONE MASONRY 30cm WITH CEMENT MORTAR 1:4
5mm. CEMENT PLASTER
DEEP CATCH PIT
390
25cm. C.C 1:3:6
SECTION AB
NOTE :- ALL DIMENSION IN CMS
DRAWN BY - P.C. MISSA
DRAWING SECTION C.A.Z.R.I. JODHPUR, 1968

Fig. 21

Fig. 21.

CONSTRUCTIONAL DETAILS OF A WATER TANKA

(CAPACITY 200 Cum)



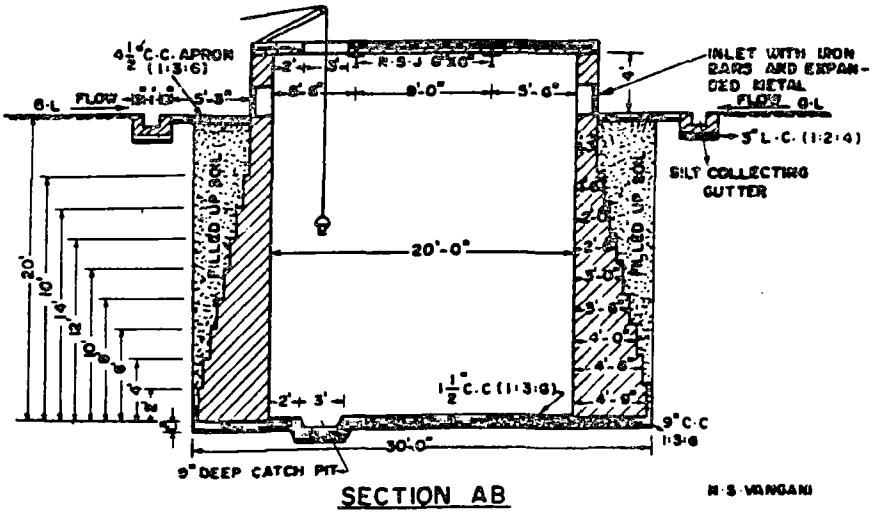


Fig 22

on the 60 percent of dependable rainfall in the particular part of the district. However, based on the rainfall data of Jaisalmer, the catchment area works out to be 1030 sq. m. If the catchment area is circular, the *tanka* diameter should be 32 m.

The catchment area required for the two types of tanka can be worked out with the help of the following equation.

$$Ac.\ Pd.\ C = m.d.\ Ao$$

where, Ac = catchment area
Pd = runoff coefficient, 0.20 for an average catchment class, 0.30-0.35 for good catchment class and 0.60-0.70 for treated catchment
m = Storage coefficient - unity for tanka
d = depth of tanka
Ao = cross sectional area of the tanka

Further, based on the assumption that evaporation and other losses from storage are negligible, per capita consumption from catchment is calculated by

$$C = \frac{Y}{N}$$

where, C = per capita consumption, litres/m^2/day
N = number of persons served by the catchment
Y = mean daily catchment yield, litres/m^2, i.e.

$$\frac{\text{dependable rainfall x runoff coefficient}}{365}$$

From the above equations, it has been calculated that from a treated catchment of 500 sq.m with dependable rainfall (175 mm), 21 cum stored water in a tanka can serve a family of 6 members throughout the year. Designs developed by this Institute are discussed below.

Tanka of 21 cum capacity

Specifications: The designed tanka is circular in shape, having 3 m diameter and a depth of 3 m. Circular shape is most economical and is found to be more stable as the pressure exerted by water is uniform with radial pressure in all directions on the diametrical plane, right angle to the curved surface. The main structure can be built up with cement concrete (1:2:4) walls, 15 cm thick with minor reinforcement, or with stone masonry 30 cm thick with cement mortar 1:4. At the base 25 cm thick cement concrete (1:3:6) is sufficient to bear the dead load and weight of water. Beneath the opening at the top, deep catchment pit is provided at the base to draw the minimum available water from the tanka. Roof is covered with stone slabs, with opening of 100x 100 cm which ultimately is to be covered with iron lid for drawing of water. Three inlets and one outlet are provided. In case of excess inflow than the capacity, the

outlet will drain out the surplus water and will save the structure. Outlets and inlets are made of angle iron frame with expanded wire mesh These restrict the unwanted materials flowing with water. An apron, consisting of 10 cm cement concrete (1:3:6), 1 m wide, must be constructed around the tanka at ground level for smooth inflow of water. In case of natural catchment a silt collecting gutter around the tanka is also to be provided. Artificial catchment is made in circular saucer shape, having nearly 3% slope. This can be made by ramming a layer of murrum on the top or some impermeable treatment materials. All inner surfaces are to be cement plastered.

Tanka of 200 cum capacity

Specification : The tanka is circular in shape, having 6 m depth and 6 m diameter. Such a structure is normally constructed on community basis, such as for Panchayat halls or schools or Primary Health Centres. For optimum use of water, cooperation of all concerned is needed for such structures. Usually these are constructed on natural catchment. The catchment area of average class, free from vegetation, having slope of 2-3 percent and area of about 2 ha, is sufficient to generate runoff to its capacity. Walls are built with stone masonry in cement mortar 1:4, resting on floor of cement concrete (1:3:6) 25 cm thick. A catch pit is also provided in floor. Extra excavated space around masonry structure should be filled with only fine sand and compacted with the help of a rammer after sprinkling water. At ground level cemented apron-12 cm thick (1:3:6) - of 2 m width is constructed around the tanka, which will protect the seepage towards outer faces of walls. The function of silt collecting gutter is to reduce the velocity of runoff and allow the suspended sediments to drop before reaching the inlet point. Two baffle walls, nearly 30 cm high with safety opening, are provided nearer the outlet for collecting water in case of need or to open the safety opening in case of excess runoff. To restrict the entry of animals to tanka, animal trough is constructed at the back of diversion earthen bund, which is connected by G.I. pipe to water trough constructed on top of tanka roof. Inner surface of tanka is plastered with cement mortar. One percent of washing soap solution may be added to act as water proofing material.

Maintenance and after care

Atleast once in a year cleaning of a tanka, ramming of its catchment and painting of the inlets and the outlets are must for keeping the tanka in good condition. Desilting of the tanka is also necessary and may be taken up before the onset of the monsoon. Periodical use of oxidising agents like potassium permanganate will prevent the growth of microscopic organisms and development of bad taste, odour and colour of the water. Alum helps in settling the dirt in suspension. *Atleast a few cm of water columu should always be maintained* in the tanka to avoid development of cracks, etc.

7. Ground water potential areas for development

The potential areas within the district are shown in Fig. 23. Their characteristics are provided in Table 17. The following is a brief account of the potential zones.

i) Among the rocky aquifers the Lathi Sandstone formation is the most productive, due to its high permeability and transmissivity. There are five potential areas within this formation. These are (1) Ajasar area (61.12 sq.km), (2), Rajmathai area (412.50 sq.km), (3) Chandan area (3213.24 sq. km), and (4) Jhinjhiniyali area (376.00 sq.km area), where the quality of ground water is tolerably good (EC 1000-4000 μ/ mhos), while (5) the Devra area (753.54 sq.km) in the south, has slightly saline water. The depth to water generally varies between 50 and 110 m.

(ii) The Parewar Sandstone formation is much less potential, covering a total of 694.20 sq.km area around Sanu and Koria. The EC of water varies from 1000-6000 μ mhos in the Sanu area and from 4000 to 6000 μ mhos in Koria area. The average depth to water is 105 m.

iii) The Bhadasar formation has two potential areas. The one near Myajlar has fresh quality water (2000-6000μ mhos) and covers 327 sq.km area. The other around Dhaneli covers only 135 sq. km area and has slightly saline water (4000-6000 μ mhos). The average depth to water is between 75 m and 105 m.

iv) The Jodhpur formation has two smaller potential aquifers around Ratdiya (139.75 sq.km area) and Ramdevra (255.31 sq.km area) where the water quality is tolerably fresh, and one slightly saline water aquifer around Sangram Singh Ki Dhani (116.93 sq.km area). The average depth to water is between 20 m and 25 m.

v) In contrast the Tertiary formations have not yielded so far any fresh quality aquifer. The one around Askandra, with an extent of about 200 sq.km, has slightly saline quality water.

vi) The Quaternaries, however, have good potentialities in the extreme west, especially along the buried courses of the Saraswati, as has been suggested earlier. The potential zones appear to be around Kishangarh (409.37 sq.km) and Asu Tar (781.25 sq.km) with fresh quality water; and around Longewala (274.50 sq.km), Muhar (243.75 sq.km), Nachna (159.50 sq.km) and Naukh (455.12 sq.km) where the quality is slightly saline. The depth to water varies from 30 m to 50 m.

8. Improving the land use system

i) The introduction of canal water in the northern part of the district will enlarge the agricultural activities in that part. However, irrigated agricultural land use may not be the best system in the long run everywhere, because of several physi-

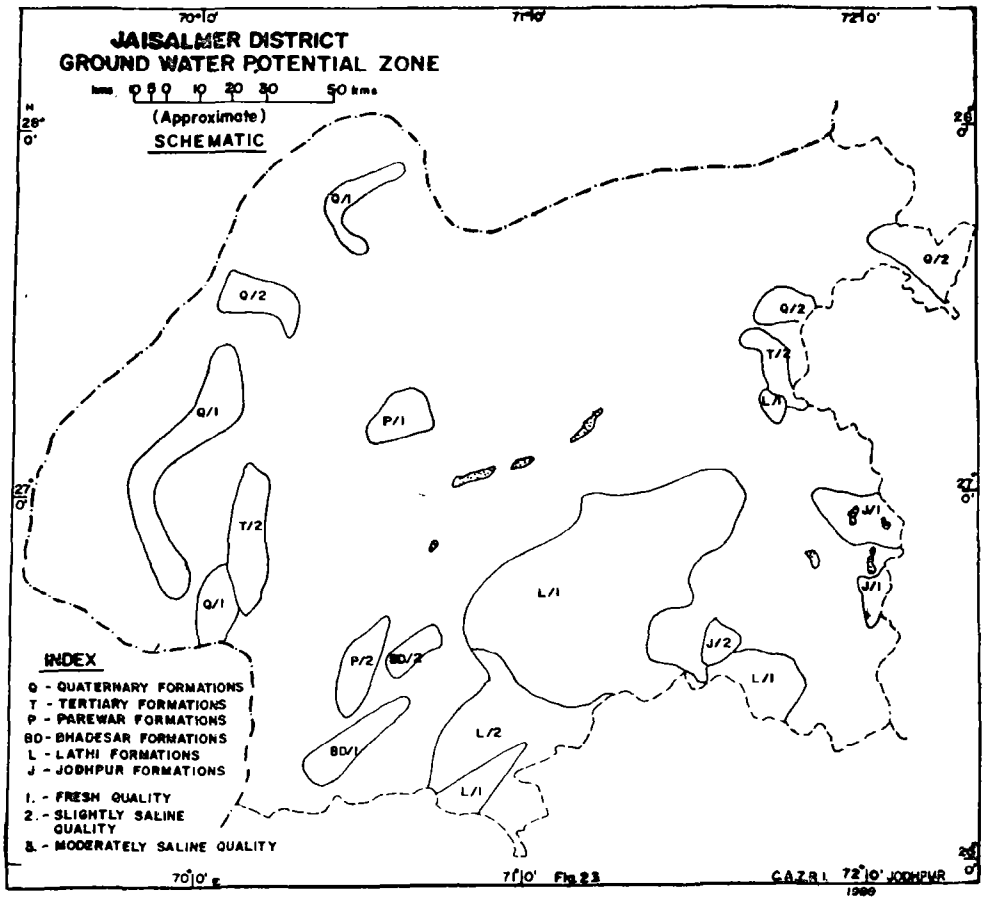

JAISALMER DISTRICT
GROUND WATER POTENTIAL ZONE
(Approximate)
SCHEMATIC
INDEX
Q - QUATERNARY FORMATIONS
T - TERTIARY FORMATIONS
P - PAREWAR FORMATIONS
BD - BHADESAR FORMATIONS
L - LATHI FORMATIONS
J - JODHPUR FORMATIONS
1. - FRESH QUALITY
2. - SLIGHTLY SALINE QUALITY
3. - MODERATELY SALINE QUALITY
Fig 23
CAZRI 1980

Fig. 23.

Table 17. Hydrogeological data of water potential zones in Jaisalmer district

Hydrogeological unit	Zone	Location	Area (sq.km)	Depth to water (m)		Yield of dugwells M^3/Day		Yield of T.W. M^3/Day		Quality EC
				Range	Average	Range	Average	Range	Average	
										μ/mhos
1	2	3	4	5	6	7	8	9	10	11
Alluvium	Q_1	(a) Asutar area	781.25	9.00-59.00	29.00	4.00-24.00	11.25	—	238.00	2000-6000
		(b) Kishangarh area	409.37	26.00-53.00	36.00	8.00-40.00	20.40	—	290.00	2000-4000
	Q_2	(a) Nachna area	159.50	14.00-22.00	—	4.00-16.00	11.60	—	180.00	4000-6000
		(b) Muhar area	243.75	21.00-35.00	28.00	4.5-8.00	6.25	—	—	4000-6000
		(c) Naukh area	455.12	20.00-35.00	27.00	9.00-60.00	34.50	—	540.00	2000-6000
		(d) Longewala area	274.50	41.00-65.00	54.00	4.5-14.00	8.65	—	180.00	4000-6000
Tertiary formations	T_2	(a) Askandra area	200.31	19.00-58.00	37.00	—	—	—	270.00	4000-6000
		(b) Bhuvana area	428.12	32.00-92.00	65.00	4.5-16.00	12.12	—	—	4000-6000
Parewar formation	P_1	(a) Sanu area	367.20	88.00-125.00	105.00	8.00-35.00	14.00	—	281.25	1000-6000
	P_2	(b) Koria area	327.00	87.00-122.00	106.00	8.5-8.7	8.5	—	255.00	4000-6000
Bhadasar formation	Bd_1	(a) Myajlar area	327.00	59.00-99.00	76.40	1.00-30.00	14.25	—	227.83	2000-6000
	Bd_2	(b) Dhaneli area	135.00	43.00-123.00	104.00	2.00-8.00	4.83	—	180 00	4000-6000
Lathi formation	L_1	(a) Ajasar area	61.12	47.00-65.00	56.00	8.00-14.00	10.33	—	180.00	2000-4000
		(b) Rajmathai area	412.50	17.00-76.00	50 00	6.00-9.00	7.4	—	225.00	2000-4000
		(c) Chandan area	3213.25	29.00-130.00	83.00	2.00-24.00	12.37	—	338.50	1000-4000
		(d) Jhinjhini-ali area	376.00	93.00-138.00	109.00	4.5-21.00	10.37	—	225.00	1000-4000
	L_2	(a) Devra area	753.54	78 0-108.00	93.00	—	11.75	—	270.00	2000-6000
Jodhpur formation	J_2	(a) Ratdiya area	139.75	16.00-32.00	23.00	8.00-12.00	9.00	—	90.00	3000-4000
		(b) Ramdevra area	255.31	6.00-30.00	21.00	5 00-10.00	7.16	—	90.00	2000-4000
	J_2	(a) Sangram Sing ki dhani area	116.93	17.00-24.00	20.00	4.00-8.00	5.75	—	90.00	2000-6000

cal limitations stated earlier. The natural *Lasiurus* grasslands of Bahala-Sultana-Ranahu-Asu Tar area is best suited for rangeland development, where it can flourish as a fodder bank of the district and the state. Excessive irrigated agriculture, on the other hand, can permanently damage the land here, through salinity build-up, and replace the *Lasiurus* cover. It is, therefore, suggested that the high density *Lasiurus* belt be improved through supplemental sprinkler irrigation and other range cares, rather than replacement by agriculture with flood irrigation.

ii) The marginal lands in the district are being increasingly encroached upon for cultivation, due to biotic pressure. This, however, leads to more vulnerability of the terrain to wind erosion. This trend needs to be restricted and animal husbandry be given a better incentive through an all-out development strategy.

iii) Tourism has already established itself as a major occupation in and around Jaisalmer. However, opening up of some other spots of tourist attraction between Jaisalmer and Sam and also between Jaisalmer and Pokaran, alongwith all the amenities, will not only increase the tourist trade, but will also provide the local inhabitants with job.

iv) The mining is not yet well developed within the district, although it has a great potentiality in respect of limestone and oil and natural gas. This sector, therefore, needs attention in a planned manner from the beginning to forestall any environmental problem that generally comes up in the mining areas.

v) The *Khadin* system of cultivation is traditionally well suited to the environment of the district. Hence it should be encouraged in areas where it is feasible. The physical factors favourable for their development have already been described.

9. Improvement of animal husbandry and its subsidiary systems

i) Much of the district's area is either sandy, rocky/gravelly or saline wastes. Agriculture is severely restricted due to the harsh climate and soil limitations. Animal husbandry is, on the other hand, most viable in this dry climatic setting and is practicted widely. Considering the potentiality of the land to support gratslands and the crucial role the animal husbandry can play in the development of its rural economy, this sector should be given due importance for development. While the condition of the grasslands could be improved through better range care, as stated earlier, attention need also to be paid towards improving the animal health and breed. The cattle fairs need also to be more numerous and well distributed. The animal products like milk, wool, meat, hide and skin need to be given more attention for efficient procurement, processing and distribution, so that these can further improve the economy of the district.

ii) A number of cottage industries are traditionally dependent on the animal by-products, but are not getting proper incentives, leading to abandonment of the crafts. The milk sector is not so well developed as it should have been because of the *potential* grass cover and the livestock population. An integrated approach involving range development, livestock development and subsidiary small industry development (including dairy and wool) will help in improving the situation. Since water and fodder are crucial for the animals these should be provided adequately along the animal migration routes.

10. Credit and training facilities for artisans

Due to modernization the traditional artisan crafts, being carried out formerly mostly in conjunction with the agricultural activity, has dwindled. The artisans are, therefore, forced to seek other sources of employment or perish. To counter these processes it is suggested to provide balanced employment opportunity. The available artisan skills could be better utilized through the provision of credit and training facilities and through improving the designs of the crafts. The artisan craft has a high potentiality for providing employment to the rural folk. Credit facilities from the cooperative and other banks should be provided in a more rational and uniform basis.

11. Strategies for controlling the damages by rodents

The use of toxic chemicals is the most effective, cheap and humane method of reducing rodent population. A number of toxic chemicals, as well as anticoagulants, are available for baiting the rodent. The most used one is zinc phosphide. For good effects 1.5 to 2 per cent of this should be thoroughly mixed with cracked food-grain like wheat, millet, rice, maize, or sorghum, along with 2 to 3 percent vegetable oil. Poison baiting for the field rodents should be carried out for a day only. If it is continued for more than a day, not only the consumption of the poison bait becomes so low that it is waste of labour and material, but the rodents also develop poison aversion and bait shyness. Prior to poison baiting, prebaiting is essential. The *modus operandi* for poison-baiting sequence should be as follows :

Day 1 Prebaiting (Cracked foodgrain + 2-3% vegetable oil)

Day 3 Prebaiting (Cracked foodgrain + 2-3% vegetable oil)

Day 5 Poison-baiting (Cracked foodgrain + 2-3% of vegetable oil + 1.5-2% zinc phosphide)

Day 8 Fumigation of live burrows only with aluminium phosphide tablets

Day 9 & 10 Harborage removal and sanitation

Repeat the whole sequence after six months, or earlier, if required.

APPENDEX-I

List of villages in Pokaran and Jaisalmer Tehsils, Jaisalmer District, alongwith Major Land Resources Units (MLRU). Code number indicates location in Fig. 2.

(a) POKARAN TEHSIL

S. No.	Code No.	Name of village	Dominant MLRU (in perenthesis)*
1.	33	Ajasar	(5)
2.	13	Akal-ka-Tala	(9, 10)
3.	31	Askandra	(5, 9)
4.	23	Awai	(9, 10)
5.	114	Badhewa	(5)
6.	97	Baiteena	(4, 5)
7.	117	Balar	(5, 9)
8.	92	Baloosingh-ki-Dhani	(5, 9)
9.	90	Barath-ka-Gaon	(8, 9)
10.	40	Bardana	(5, 9)
11.	69	Barli Charanan	(3, 5)
12.	70	Barli Manda	(3, 5)
13.	49	Beeram Deora	(2, 5)
14.	30	Beethe-ka-Gaon	(5, 8)
15.	22	Bhadariya	(9, 10)
16.	37	Bhadariya	(5, 8, 9, 10)
17.	98	Bhaisra	(4, 5)
18.	93	Bhaniyana	(1. 3, 5, 8, 9)
19.	87	Bhankhri	(5, 8)
20.	26	Bharamsar	(9, 10)
21.	3	Bharewala	(9, 10)
22.	118	Bheekorai Jooni	(5, 9, 10)
23.	116	Bheekorai Nai	(5, 9, 10)
24.	71	Biliya	(3, 5)
25.	27	Bodana	(9, 10)
26.	111	Bonada	(4, 5)
27.	62	Chacha	(4, 5, 7)
28.	59	Chanani	(5, 8)
29.	35	Chandsar	(5, 9)
30.	41	Chhayan-I	(5, 9, 10)

* Figures indicate MLRU number, as assigned in the text and mentioned at the end of the village list.

31.	42	Chhayan-II	(5, 9)
32.	24	Chinnoo	(9, 10)
33.	76	Chok	(4, 5)
34.	1	Daduda (Daduronwala)	(8, 9, 10)
35.	107	Dantal	(5, 7, 8, 9)
36.	29	Dhaleri	(5, 8)
37.	55	Dholiya	(5, 8)
38.	67	Dhoorsar	(1, 3, 5, 11)
39.	32	Didoo	(5, 8, 9)
40.	94	Doodhiya	(4, 5)
41.	45	Dudiya	(1, 5)
42.	48	Ekan	(2, 5)
43.	36	Eta	(5, 8, 9, 10)
44.	46	Galar	(5)
45.	19	Ghantiyali	(9, 10)
46.	63	Gomat	(1, 2, 5)
47.	84	Gudi	(1, 3, 5, 11)
48.	18	Hariyar	(9, 10)
49.	95	Jaimalan	(4, 5)
50.	7	Jaloowala	(9, 10)
51.	105	Jhabra	(8, 9, 10)
52.	86	Jhalariya	(5, 6, 8, 11)
53.	108	Jhalora Bhatiyan	(5, 9, 10)
54.	102	Jhalora Pokaran	(4, 5)
55.	120	Kajoi	(7, 8, 9)
56.	52	Kala	(4, 5, 7)
57.	8	Karnewala	(9, 10)
58.	72	Kelawa	(4, 5, 8)
59.	78	Keraliya	(5, 8)
60.	115	Kesoola-Ka-Pana	(5, 9)
61.	12	Khara	(9, 10)
62.	16	Khariya	(9, 10)
63.	100	Khelana	(4, 5)
64.	9	Kheroowala	(9, 10)
65.	54	Khetolai	(4, 5, 7)
66.	82	Khuhra	(4, 5)
67.	81	Lakhasar	(4, 5)
68.	56	Lathi	(5, 8)
69.	65	Lawan	(2, 5, 8, 11)
70.	39	Loharki	(5, 9)
71.	57	Lohra	(5, 8)

72.	101	Loona Kalan	(4, 5)
73.	96	Loona Khurd	(4, 5)
74.	25	Madasar	(9, 10)
75.	80	Madasar	(4, 5)
76.	85	Madwa	(1, 3, 5)
77.	60	Mahesha-ki-Dhani)	(4, 5)
78.	5	Malasar	(9, 10)
79.	53	Malka	(5)
80.	51	Mawa	(5, 7)
81.	89	Medwa (Marwa)	(3, 5)
82.	75	Modardi	(4, 5)
83.	4	Mobaronwala	(9, 10)
84.	14	Nachna	(9, 10)
85.	74	Nananiyai	(5, 7)
86.	38	Nawatala	(5, 9)
87.	79	Neran	(4, 5, 8)
88.	28	Nokh	(8, 9, 10)
89.	113	Ola	(4, 5)
90.	61	Orhaniya	(5, 7)
91.	88	Padroda	(5, 8)
92.	15	Panche-ka-Tala	(9, 10)
93.	10	Panna	(9, 10)
94.	121	Phalsoond	(7, 8, 9, 10)
95.	106	Phoolasar	(7, 8, 9)
96.	64	Pokaran (Rural)	(2, 5, 11)
97.	6	Raichandwala	(9, 10)
98.	112	Rajgarh	(4, 5)
99.	109	Rajmathai	(4, 5, 9)
100.	50	Ramdeora	(5, 7)
101.	110	Rampuriya	(4, 5, 9)
102.	58	Ratan-ki-Bassi	(5, 8)
103.	103	Ratdiya	(5, 7, 8, 9)
104.	44	Rathora	(5)
105.	66	Rayad	(5)
106.	2	Rohironwala	(8, 9, 10)
107.	21	Sakariya	(5, 9)
108.	104	Sakariya	(5, 7, 9)
109.	77	Sanawara	(4, 5, 8)
110.	43	Sanda	(5)
111.	99	Sangramsing-ki-Dhani	(4, 5)
112.	83	Sankra	(4, 5)

113.	47	Sarnayat	(5)
114.	20	Satyaya	(9, 10)
115.	17	Shekhonwala	(9, 10)
116.	119	Swamiji-ki-Dhani	(5, 8, 9)
117.	11	Tawariwala	(9, 10)
118.	73	That	(1, 3, 5, 6, 11)
119.	34	Tota	(5, 9)
120.	91	Uchpadra	(5, 8)
121.	68	Ujla	(1, 3, 5, 8)

b) JAISALMER TEHSIL

S.No.	Code No.	Name of Village	Dominant MLRU* (in perenthesis)
1.	304	Achla	(4, 5)
2.	343	Adbala	(9, 10)
3.	58	Adkiya	(9, 10)
4.	93	Ainta	(2, 5, 8)
5.	295	Akal Jodha	(1, 3, 5)
6.	179	Akanwali	(9, 10)
7.	272	Akralapar	(5, 9, 10)
8.	338	Ala	(9, 10)
9.	220	Amarsagar	(2, 5)
10.	335	Antia	(9, 10)
11.	81	Arjana	(2, 5, 8)
12.	232	Arjanhar	(5, 8, 9)
13.	297	Asayacha	(1, 3, 5)
14.	326	Asloi (Asolai)	(1, 3, 5)
15.	170	Asoda	(9, 10)
16.	157	Asooda	(9, 10)
17.	29	Asoo-ka-Tala	(9, 10)
18.	172	Babuwali	(9, 10)
19.	159	Bachhiya	(9, 10)
20.	41	Bachhiya Chhor	(9, 10)
21.	9	Baba	(2, 5, 8)
22.	221	Bada Bag	(2, 5)
23.	322	Badhan	(1, 3, 5)
24.	147	Badhwa	(9, 10)
25.	299	Badoda Gaon	(1, 3, 5)
26.	165	Bagnau	(9, 10)
27.	84	Bahla	(7, 8, 9, 10)

* Figures indicate MLRU number, as assigned in the Text and mentioned at the end of the village list.

28.	375	Baiya	(9, 10)
29.	87	Balana	(2, 5, 9, 10)
30.	336	Bambhara	(9, 10)
31.	28	Bandha	(2, 3, 5, 8, 9)
32.	56	Bandi	(9, 10)
33.	266	Baran	(3, 5, 9)
34.	166	Basana	(9, 10)
35.	247	Basanpeer (Jooni)	(2, 5, 8)
36.	248	Basanpeer (South)	(2, 5, 8)
37.	374	Basda	(9, 10)
38.	163	Batoi Jeewanwali	(9, 10)
39.	164	Batoi Rahimwali	(9, 10)
40.	347	Beejhota	(3, 5, 9, 10)
41.	388	Beermani	(1, 3, 5)
42.	178	Beeryali	(9, 10)
43.	281	Bersiyali	(9, 10)
44.	115	Bhadasar	(1, 2, 3, 5)
45.	241	Bhagoo-ka-Gaon	(5, 8)
46.	238	Bhairwa	(1, 3, 5, 8, 9)
47.	317	Bhakarani	(5, 6)
48.	113	Bharamsar with Vaisakhi	(2, 3, 5, 6, 11)
49.	116	Bhatiya Khadeen	(1, 3, 5)
50.	356	Bhelani	(3, 5, 9)
51.	186	Bhiloi	(9, 10)
52.	57	Bhinda Deslonwala (Bhinda Desla)	(9, 10)
53.	142	Bhinda Khara	(9, 10)
54.	37	Bhinda Mangaliyawala	(9, 10)
55.	253	Bhiyan	(2, 3, 5)
56.	366	Bhiyasar	(3, 5, 9)
57.	243	Bhojasar	(2, 3, 5, 8)
58.	240	Bhojka	(4, 5)
59.	291	Bhoo	(1, 2, 3, 5)
60.	197	Bhoon	(9, 10)
61.	310	Bhopa	(4, 5)
62.	321	Bhopa	(2, 5)
63.	8	Bhutonwali	(8, 9, 10)
64.	136	Bhuwana	(9, 10)
65.	183	Bichau	(9, 10)
66.	208	Bida	(5, 8, 9)

67.	54	Birma	(9, 10)
68.	390	Bogniyai	(5)
69.	101	Boha	(2, 3, 5)
70.	312	Bola	(5, 8)
71.	83	Buili	(7, 8, 9)
72.	160	Buranwali	(9, 10)
73.	226	Chahdoo	(1, 2, 5)
74.	55	Chakrau	(9, 10)
75.	228	Chandhana	(5, 8)
76.	50	Chandrau	(9, 10)
77.	344	Chanpa	(9, 10)
78.	110	Chaudhariya	(2, 5, 6, 8)
79.	316	Cheecha	(3, 5, 8)
80.	346	Chelak	(5, 9, 10)
81.	328	Chatogar (Sala)	(9, 10)
82.	124	Chhatrel	(1, 2, 3, 5)
83.	309	Chhodiya	(5, 9)
84.	300	Chhor	(3, 5, 8, 9)
85.	135	Chhuganiyon-ki-Basti	(5, 9, 10)
86.	120	Chundhi	(2, 5)
87.	251	Dabla	(2, 3, 5)
88.	203	Dabri	(5, 8, 9)
89.	213	Damodara	(1, 3, 5, 8)
90.	360	Dangri	(4, 5)
91.	250	Darbariyon-ka-Gaon	(2, 5)
92.	280	Dav	(9, 10)
93.	214	Dedha	(3, 5)
94.	82	Deega	(2, 5, 8)
95.	7	Deetowala	(9, 10)
96.	234	Delasar	(5, 8, 9)
97.	373	Deora	(3, 5, 9, 10)
98.	95	Deunga	(2, 5, 8)
99.	311	Devikot	(3, 5, 6, 8, 9)
100.	103	Dewa	(1, 3, 5, 6)
101.	175	Dhaloowali	(9, 10)
102.	200	Dhanana	(9, 10)
103.	268	Dhaneli	(5, 9, 10)
104.	294	Dhanwa	(1, 3, 5, 8)
105.	257	Dhauwa	(2, 3, 5)
106.	27	Dhawala-ka-Par	(2, 5, 8, 9)
107.	235	Dhaysar	(5, 8, 9)

108.	282	Dhoba	(5, 9, 10)
109.	210	Dhuliya	(5, 8)
110.	47	Dorau	(9, 10)
111.	125	Dujasar	(3, 5)
112.	302	Duwara	(5, 8, 9)
113.	26	Ekal-ka-par	(2, 5, 8, 9)
114.	365	Fatehgarh	(3, 5)
115.	173	Gajau	(9, 10)
116.	378	Gajsingh-ka-Gaon	(9, 10)
117.	21	Gamnewala	(9, 10)
118.	260	Ganeshdas-ki-Dhani	(2, 5)
119.	52	Ganesiya	(9, 10)
120.	32	Ganesiya Kot	(9, 10)
121.	206	Ganga	(5, 8, 9)
122.	60	Geraja	(9, 10)
123.	340	Geraja	(9, 10)
124.	1	Ghotaru	(9, 10)
125.	6	Godhoowala	(9, 10)
126.	105	Gogadeo	(1, 3, 5, 8)
127.	286	Gorera	(3, 5)
128.	377	Guhra	(9, 10)
129.	68	Habur	(2, 3, 5, 8)
130.	16	Hada	(2, 5)
131.	111	Hadda	(1, 2, 3, 5, 11)
132.	35	Hakra	(9, 10)
133.	225	Hameera	(2, 4, 5)
134.	134	Hameeron-ki-Basti	(9, 10)
135.	24	Hansoowala	(9, 10)
136.	256	Hansuwa	(2, 5)
137.	339	Happa (Kalan & Khurd)	(9, 10)
138.	371	Harbha	(5, 9)
139.	188	Harda	(9, 10)
140.	189	Harnau	(9, 10)
141.	269	Hatar	(9, 10)
142.	69	Hema	(2, 3, 5)
143.	23	Hingolawala	(9, 10)
144.	187	Hotiya	(9, 10)
145.	169	Indewali	(9, 10)
146.	254	Jaisalmer (Rural)	(2, 5)
147.	227	Jaisoorana	(2, 3, 5, 8)
148.	215	Jajiya	(3, 5, 9)

149.	152	Jamdau	(9, 10)
150.	209	Jamra	(3, 5)
151.	150	Janiya	(9, 10)
152.	327	Janra	(5, 9, 10)
153.	154	Jasiya	(9, 10)
154.	353	Jaswa	(3, 5, 6)
155.	236	Jawandh Jooni	(1, 3, 5, 8)
156.	237	Jawandh (Nai)	(1, 3, 5)
157.	296	Jerat	(1, 3, 5)
158.	255	Jayan	(2, 5)
159.	229	Jetha	(5, 8)
160.	222	Jethwai	(2, 5)
161.	180	Jhalariya	(9, 10)
162.	190	Jhanda Khara	(9, 10)
163.	36	Jhanda Madhujawol	(9, 10)
164.	191	Jhanda Meetha	(9, 10)
165.	376	Jheenjaniyali	(9, 10)
166.	258	Jiyai	(2, 5)
167.	182	Jiyau Khara	(9, 10)
168.	337	Jodha	(9, 10)
169.	71	Joga	(1, 2, 5)
170.	293	Joga	(2, 5)
171.	381	Jagidas-ka-Gaon	(3, 5, 9, 10)
172.	218	Kahala	(3, 5)
173.	12	Kakab	(5, 8)
174.	185	Kalau	(9, 10)
175.	22	Kalibhar	(9, 10)
176.	224	Kalyanghat	(1, 2, 5)
177.	106	Kandiyala	(1, 3, 5)
178.	168	Kangoor	(9, 10)
179.	96	Kaọd Beerma	(1, 2, 5, 8, 11)
180.	97	Kanod Rawlotan	(1, 2, 5, 8, 11)
181.	131	Kanoi	(1, 3, 5, 8, 9)
182.	368	Kapuriya	(5, 9, 10)
183.	199	Karamwala (Karmawali)	(9, 10)
184.	275	Karda	(9, 10)
185.	306	Karda	(4, 5)
186.	155	Karta	(9, 10)
187.	330	Katha	(9, 10)
188.	349	Kathoda	(3, 5, 8)
189.	109	Kathodi	(1, 3, 5)
190.	278	Kerla	(9, 10)

191.	89	Keroo	(5, 8, 9, 10)
192.	127	Keshvon-ki-Basti	(3, 5, 9)
193.	193	Khabdela	(9, 10)
194.	212	Khabha	(5, 8, 9, 10)
195.	123	Khanderon-ki-Dhani	(3, 5)
196.	92	Khara Narayatan	(9, 10)
197.	94	Khardi	(5, 6, 9, 11)
198.	46	Khariya	(9, 10)
199.	329	Khariya (Jethwai)	(9. 10)
200.	146	Khariya (Maikhan)	(9, 10)
201.	76	Kheeya	(2, 5)
202.	75	Kheeya Raharki	(2, 5)
203.	153	Khui Fetu Janwali (Khadoojanwali)	(9, 10)
204.	66	Khuiyala	(2, 3, 5, 8, 9)
205.	282	Khuri	(5, 8, 9, 10)
206.	351	Khyala	(9, 10)
207.	292	Kinta	(1, 3, 5)
208.	181	Kiradwali	(9, 10)
209.	5	Kishangarh	(9, 10)
210.	223	Kishanghat	(2, 5)
211.	354	Koda	(5, 9)
212.	359	Kodiyasar	(3, 5)
213.	382	Kohra (Kohara)	(1, 3, 5, 9)
214.	15	Kolootala	(5, 8, 9, 10)
215.	270	Koriya	(5, 8, 9, 10)
216.	323	Koruwa	(1, 3, 8)
217.	372	Kotha	(5, 9)
218.	285	Kotri	(1, 3, 5, 8)
219.	67	Kuchhri	(3, 5, 8)
220.	141	Kulatala	(9, 10)
221.	262	Kuldhar	(1, 2, 5, 8)
222.	265	Kumhar Kotha	(3, 5)
223.	383	Kunda	(9, 10)
224.	161	Kundhau	(9, 10)
225.	171	Kuntara	(9, 10)
226.	102	Lakha	(2, 5, 8)
227.	386	Lakha	(5, 9, 10)
228.	358	Lakhmana	(5, 9)
229.	129	Lakhmanon-ki-Basti	(5, 8, 9, 10)
230.	307	Lala	(4, 5)

231.	162	Lalewall	(9, 10)
232.	273	Lambapar	(9, 10)
233.	114	Lanela	(1, 3, 5)
234.	33	Langtala	(9, 10)
235.	45	Laloi	(9, 10)
236.	121	Liderwa with Deori-ki-Dhani	(2, 5)
237.	156	Lohar	(9, 10)
238.	2	Longhwala	(9, 10)
239.	130	Loona-ki-Basti	(1, 3, 5, 8, 9)
240.	274	Loonar	(9, 10)
241.	167	Maghla	(9, 10)
242.	176	Maghalwali	(9, 10)
243.	39	Mahwa	(9, 10)
244.	230	Maligara	(3, 5, 8)
245.	63	Malingda	(9, 10)
246.	42	Mamdau	(9, 10)
247.	325	Manda	(1, 3, 5)
248.	394	Mandai	(3, 5)
249.	79	Mandha	(2, 3, 5, 8, 9)
250.	98	Mandhau	(5, 8, 9)
251.	385	Mandli with Mehron-ki-Dhani	(5, 9, 10)
252.	217	Manpiya	(3, 5)
253.	205	Matwon-ki-Basti	(5, 8, 9)
254.	62	Meerwala	(9, 10)
255.	48	Meethatala (Mithatar)	(9, 10)
256.	51	Meethdau Sachetan	(9, 10)
257.	348	Megha	(1, 5, 9, 10)
258.	216	Meghwalon-ki-Dhani	(3, 5)
259.	204	Mehboob-ka-Par	(5, 8, 9)
260.	149	Mehna	(9, 10)
261.	140	Mehnau	(9, 10)
262.	305	Mehrajodh	(4, 5)
263.	144	Mehrana	(9, 10)
264.	361	Mehreri	(4, 5)
265.	91	Mengi (Menki)	(9, 10)
266.	177	Mithi Khui	(9, 10)
267.	277	Mithrau Kharewa	(9, 10)
268.	49	Mochiyonwala	(9, 10)
269.	389	Modha	(5, 8)
270.	313	Modha Ganesbpura	(3, 5, 6)

271.	85	Mohangarh	(9, 10)
272.	73	Mokla	(1, 2, 5)
273.	246	Moklayat	(2, 3, 5)
274.	301	Moolana	(1, 3, 5)
275.	219	Moolsagar	(2, 5)
276.	259	Moondari	(2, 5)
277.	107	Motikilon-ki-Dhani	(1, 3, 5)
278.	61	Muhar	(9, 10)
279.	31	Mukna-ka-Tala	(9, 10)
280.	341	Muliya	(9, 10)
281.	194	Mungal	(9, 10)
282.	148	Muradenwala	(9, 10)
283.	198	Murar	(9, 10)
284.	279	Myajlar	(9, 10)
285.	369	Nada	(5, 9)
286.	11	Naga (Nagga)	(2, 4, 5)
287.	13	Naga-ki-Dhani	(5, 8)
288.	345	Nagraja	(9, 10)
289.	320	Nasingh-ki-Dhani	(1, 3, 5, 8)
290.	59	Nayatala	(9, 10)
291.	287	Nediya	(1, 3, 5, 8)
292.	207	Neemba	(3, 5)
293.	384	Neembli	(9, 10)
294.	78	Nehdai	(2, 5)
295.	20	Netsi	(8, 9, 10)
296.	196	Nichoowali	(9, 10)
297.	145	Nijau	(9, 10)
298.	392	Nimba	(5, 9)
299.	211	Nimbiya	(3, 5, 9)
300.	362	Pabnasar	(3, 5)
301.	370	Pancha	(5)
302.	74	Parewar	(2, 3, 5)
303.	174	Patanwali	(9, 10)
304.	34	Peerau	(9, 10)
305.	263	Peethala	(1, 3, 5, 8)
306.	288	Peethalai	(2, 5)
307.	271	Phaledi	(3, 5, 8, 9)
308.	331	Phuliya	(9, 10)
309.	289	Piparla	(2, 5)
310.	276	Pochina	(9, 10)
311.	112	Pohar-Doyan	(2, 3, 5, 6, 11)

312.	290	Polji-ki-Dhani	(2, 3, 5)
313.	357	Punsar	(5, 9)
314.	138	Rabhalu Fakironwala	(9, 10)
315.	139	Rabhlau Rajronwala	(9, 10)
316.	18	Raghwa	(2, 5, 8, 9, 10)
317.	201	Rahoo-ka-Par	(5, 8, 9, 10)
318.	15	Raimala	(2, 5)
319.	350	Rama	(1, 3, 5, 9)
320.	19	Ramgarh	(2, 5, 8, 9, 10)
321.	119	Ram Kunda	(2, 5)
322.	387	Randha	(1, 3, 5, 8, 9)
323.	303	Rasla	(4, 5, 8)
324.	43	Ratdau	(9, 10)
325.	77	Ratta	(2, 5)
326.	44	Ratwa	(9, 10)
327.	86	Rehrund	(9, 10)
328.	192	Relna	(9, 10)
329.	367	Rewari	(3, 5, 9)
330.	244	Righwa	(5, 8)
331.	118	Roopsi	(2, 5, 8, 11)
332.	14	Sadhna	(5, 8)
333.	3	Sadhowala	(9, 10)
334.	364	Sadhnwa (Sadhwa)	(3, 5)
335.	249	Sadiaor Dadiya	(2, 5)
336.	99	Sadrau (Pohar)	(2. 5, 8, 9)
337.	239	Sagra	(3, 5, 8)
338.	133	Sagron-ki-Basti	(2, 5, 8, 9)
339.	393	Sajeet	(3, 5, 9)
340.	126	Salkhan	(1, 2, 3, 5)
341.	132	Sam	(2, 3, 5, 8, 9)
342.	202	Samejan-ka-Par	(9, 10)
343.	308	Samwata	(4, 5)
344.	324	Sanda	(1, 3, 5, 9)
345.	298	Sangana	(3, 5)
346.	355	Sangar	(3, 5, 8, 9)
347.	53	Sanger	(9, 10)
348.	100	Sankhla	(2, 3, 5, 8, 9)
349.	332	Satto	(9, 10)
350.	242	Sanwala	(5, 8)
351.	264	Sapla	(3, 5, 8, 9)
352.	261	Sata	(2, 3, 5)
353.	334	Sehdar	(9, 10)

354.	108	Selat	(1, 2, 3, 5)
355.	284	Senag	(3, 5, 9)
356.	252	Seron-ki-Dhani	(2, 5)
357.	70	Serwa	(2, 3, 5)
358.	17	Seuwa	(2, 5, 8, 9)
359.	30	Shahgarh	(9, 10)
360.	143	Shahra	(9, 10)
361.	151	Shekhar	(9, 10)
362.	315	Sirwa	(3, 5, 8)
363.	318	Sitodai (Seetlai)	(3, 5, 8)
364.	128	Siyalon-ki-Basti	(1, 3, 5, 9)
365.	65	Siyambar	(1, 2, 3, 5, 8, 9)
366.	342	Sobh	(1, 3, 5, 9)
367.	363	Soda	(3, 5)
368.	379	Sodat	(9, 10)
369.	233	Sodha Kanwar (Sodha Kor)	(3, 5, 8, 9)
370.	38	Sodrau	(9, 10)
371.	195	Soma	(9, 10)
372.	352	Somliyai	(3, 5, 6)
373.	72	Sonoo (Sanu)	(1, 2, 3, 5)
374.	231	Sujiya	(5, 8, 9)
375.	80	Sultana	(2, 5, 8, 9)
376.	184	Sumrau	(9. 10)
377.	104	Suthron-ki-Dhani	(3, 5)
378.	137	Suwar	(9, 10)
379.	88	Tadana	(9, 10)
380.	4	Tanot (Tarnot)	(9, 10)
381.	122	Tawariya	(2, 5)
382.	90	Tawarki	(5, 9, 10)
383.	117	Tejawa	(1, 2, 3, 5)
384.	380	Tejmalta	(3, 5, 9)
385.	10	Tejpala	(5, 8, 9)
386.	333	Tejrawa	(9, 10)
387.	267	Tejsi	(5, 8, 9)
388.	245	Thaiyat	(1, 2, 5)
389.	158	Tharai	(9, 10)
390.	40	Thoohar	(9, 10)
391.	391	Toga	(3, 5)
392.	64	Turkon-ki-Basti	(3, 5, 9, 10)
393.	391	Ugawa (Ugma)	(1, 3, 5, 8)
394.	314	Unda	(3, 5, 8, 9)

MAJOR LAND RESOURCES UNITS (MLRU)

(1) Hills
(2) High level rocky structural plains
(3) Rocky/gravelly pediments
(4) Gravelly pavements
(5) Flat colluvial plains
(6) Saline flat colluvial plains
(7) Flat older alluvial plains
(8) Sandy undulating plains
(9) Sand dunes
(10) Interdunal plains
(11) Saline depressions

The spellings of village names in this list is as per the Jaisalmer District Census Handbook (1981) and may differ from the spellings in Survey of India topographical sheets, that has been followed elsewhere in this book.

APPENDIX–II

List of villages facing scarcity of drinking water in Jaisalmer district

Pokaran Tehsil	*Jaisalmer Tehsil*
1. Narawton ki dhani	1. Pithala
2. Mawa	2. Kotri
3. Chanani	3. Phulia
4. Keraliya	4. Sobh
5. Dhursar	5. Modha
6. Bhaniyana	6. Sirwa
7. Hajiron ki dhani	7. Sanwata
8. Didania	8. Chatrel
9. Anesa	9. Kata
10. Biramdeora	10. Kharia
11. Khairuwala	11. Kanod
12. Panna	12. Deunga
13. Bosana	13. Arjana
14. Dhaleri	14. Tadana
15. Bithe ka Gaon	15. Bharamsar
16. Sirnayath	16. Pohar
17. Jhalora	17. Kathori
18. Devewali Talai	18. Kandiyala
19. Tariali	19. Gogade
20. Lundet	20. Gopal Ki Talai
21. Tavriwala	21. Mokal
22. Sanawla	22. Dhoba ki Gol
23. Bahala	23. Hamiran
24. Khewai	24. Lunar
25. Machhera	25. Hamiron ki Basti
26. Bharewala	26. Khara ka Par
27. Lakheri	27. Ganga Baiyawala

APPENDIX-III

New sites for development of Khadins in Jaisalmer district
(Average rainfall at 60% probability = 118.5 mm)

S. No.	Name of site	Water-shed No. in Fig. 13 and 14	Survey of India sheet No.	Catch-ment condi-tion	Catch-ment area (ha)	Expe-cted run off $3^3 \times 10^3$	Proposed area under bed culti-vation (ha)
1.	East of Khuiyala	1	40 I/8	Good	1687	599.72	31.56
2.	Hingola	2	40 I/8	Good	2687	955.23	50.27
3.	Joga	3	40 I/11	Good	2500	888.75	46.77
4.	Randha	8	40 J/16	Good	1625	577.69	30.40
5.	Kohra	9	40 J/16	Cood	1250	444.38	23.39
6.	Dabhala	14	40 N/1	Good	3750	1333.12	70.16
7.	North of Rel Khadin	15	40 I/16	Good	2500	888.75	46.77
8.	Akol	16	40 N/1	Good	2250	799.87	42.09
9.	West of Asayach	17	40 N/1	Good	1562	555.29	29.22
10.	Lulai	25	40 J/6	Average	307	72.76	3.83
11.	Harbha	26	40 N/3	Average	175	41.48	2.18
12.	Rivri	27	40 N/3	Average	287	68.00	3.58
13.	Bhiyasar	28	40 N/3	Average	75	17.78	0.94
14.	Chatrel	29	40 J/9	Good	405	143.98	7.58
15.	Polji ki dehri	30	40 J/13	Good	112	39.82	2.09
16.	Nar Singh ji ki dhani	31	40 J/14	Good	277	98.47	5.18
17.	Korwan	32	40 J/14	Good	360	127.98	6.74
18.	Neran	33	40 N/5	Cood	172	61.14	3.22
19.	Javandh	34	40 N/5	Good	45	16.00	0.84
20.	Basanpir	35	40 N/1	Average	232	54.98	2.89
21.	Bhagu ka gaon	36	40 N/1	Average	190	45.03	2.37
22.	Mogini Khadin near Arjana	Needs repair	—	—	—	—	—
				Total	244.48 sq.km	7.83 mcm	412.07 ha or 4.1207 sq. km

APPENDIX-IV

Sites for construction of earthen check dams, anicuts and gully control structures in Jaisalmer district

S. No.	Name of site	Watershed number in Fig. 13 and 14	Survey of India sheet No	Catchment condition	Catchment area (ha)	Expected run-off (mcm)	Proposed development
1.	Pohar	4	40 I/16	Good	3125	2.73	Earthen
2.	East of Pohar	6	40 I/16	Good	250	0.22	Gully control structures
3.	Janra	10	40 J/14	Good	625	0.55	Earthen check dam
4.	Ugawa	11	40 J/14	Good	875	0.77	—do—
5.	Kotri	12	40 J/14	Good	1187	1.04	—do—
6.	Bhopa	13	40 J/14	Good	1000	0.88	—do—
7.	Hameera	18	40 M/4	Good	2812	2.46	—do—
8.	North of Neran	21	40 N/5	Average	5062	4.43	Anicut
9.	Bhairwa	22	40 N/5	Average	6500	5.69	—do—
10.	Dhaisar	23	40 N/5	Average	4125	3.61	—do—
11.	Bhaniyana	24	40 N/14	Average	2000	1.75	Diversion of saline channel
12.	Khaderan ki dhani	7	40 J/9	Average	937	0.82	Gully control
13.	North of Hameera	19	40 M/4	Average	625	0.55	structures
14.	West of Jaldhari	20	40 M/4	Average	187	0.16	Contour furrows
			Total		29310 ha or 293.1 sq. km	25.66 mcm	

* Considering an annual average rainfall of 292 mm, once in 10 years.

APPENEDIX-V

NATURAL RESOURCES OF SAM PANCHAYÀT SAMITI

INTRODUCTION

Located in the extreme western part of Jaisalmer district Sam Panchayat Samiti is the largest Samiti (Development Block) within the district. It covers 2, 111, 128 ha land and has a population of 65, 513 (1981 census). The climate is extremely arid. The average annual rainfall varies from 175 mm in the southeast to less than 100 mm in the northwest. The mean maximum temperature (May) varies from 41.5°C to more than 42°C, while the mean minimum temperature (January) varies from less than 4°C to 9°C. The mean annual potential evapotranspiration varies from 2000 mm to 2200 mm and more. The expected date of onset of the monsoon is the 15th July in the southeast, while in rest of the area the expected date is the 20th July. The monsoon generally withdraws by 1st September. The dominant wind is during the hot March to September when it blows from SSW or SW. In the rest of the year a weak NE wind blows.

There are 276 villages within the Samiti. The settlement pattern is generally scattered and the villages are mostly located in the interdune areas. The eastern part of the Samiti is dominantly rocky/gravelly.

The resource patterns within the Samiti and the suggestions for their improvement are as follows.

GEOMORPHOLOGY

Nature of the terrain

Located in the less than 150 mm annual rainfall zone Sam Panchayat Samiti is dominated by aeolian processes and sandy terrain. The rocky/gravelly terrain, along with shallow, colluvium-covered plains, occupy the eastern margin of the Samiti. While the sandy terrain occupies 15533.5 sq. km area (73.59% of the total Samiti area), the rocky/gravelly terrain occupies only 5577.8 sq. km area (26.41% of the total).

There are two notable ephemeral channels in the Samiti: (a) the Ramgarh Nala, which originates in the rocky terrain near Ramgrah, flows northward and dies out before Ranahu in the sandy terrain, and (b) the Vikharan Nadi, which originates in the rocky terrain of Khuiyala, flows intermittently past Bandah northwestward and dies out before Ghotaru.

Nine landform units have been identified in the Samiti (Table 18, Fig. 24). The maximum area of 12986.2 sq.km (61.51% of the total) covered with sand dunes of different types. Among these the megabarchanoid fields to the south of Shahgarh and the

Table 18. Landform units in Sam Panchayat Samiti

S. No.	Landform unit	Area (sq. km)	Percent of Samiti area
1.	Hills	200.9	0.95
2.	High level rocky structural plains	311.2	1.47
3.	Rocky/gravelly pediments	690.0	3.27
4.	Gravelly pavements	63.3	0.30
5.	Flat buried pediments/pavements/structural plains		
	a) Non-saline	4290.5	20.32
	b) Saline	21.4	0.10
6.	Sandy undulating buried pediments	595.6	2.82
7.	Sandy undulating older alluvial plains	19.7	0.10
8.	Sand dunes	12986.2	61.51
9.	Interdunal plains		
	a) Flat sandy interdunes	1551.2	7.35
	b) Rocky interdunes	50.2	0.24
	c) Sandy undulating interdunes	330 6	1.57
	Total	21,111.3	100.00

low barchans and barchanoids are completely devoid of any vegetation, while others have open grass and shrub covers, especially away from the settlements and in areas not frequented by the livestock. The mappable interdunes (flat, sandy undulating and rocky) cover 1932. 0 sq. km area (9. 16%). Generally the flat interdunes within the transverse dunefield in the northwest have finer near-surface sediments (mean: 2.70 to 2.90ϕ) than those in the south and southwest where the mean size is between 2.30 and 2.50ϕ. The sediment depth in the west (beyond Ranahu-Ghotaru-Shahgarh line) is however, much more than in the southeast, and is composed of aeolian sand mixed with or underlain by alluvium. The interdunes in the southeast become progressively coarse textured (mean : 1.90 to 2.20ϕ) as rock beds appear nearer to surface. The sandy undulating buried pediments (595. 6 sq. km; 2. 82%) and the sandy undulating older alluvial plains (19.7 sq.km; 0.10%) occur mainly along the margin of the rocky terrain and consist of barchans and other mobile sand streaks.

A significant part of the Samiti is covered with shallow to moderately deep colluvial debris of flat buried pediments, pavements and structural plains (4311. 9 sq. km; 20. 42%), especially in the east. In some areas of centripetal drainage and along the ephemeral channels the depth of sediments locally increases upto 90 cm or more and generally contain increased percentage of finer sediments. Such areas, especially near Sadhan, Sanu, Kapuria, Khuri, Damodara and north of Ramgrah, contain comparatively better cultivated lands, including *Khadins*.

The hills, high level rocky structural plains (hamadas), rocky/gravelly pediments and gravelly pavements cover 1265.9 sq. km area (5.99%) and are completely barren.

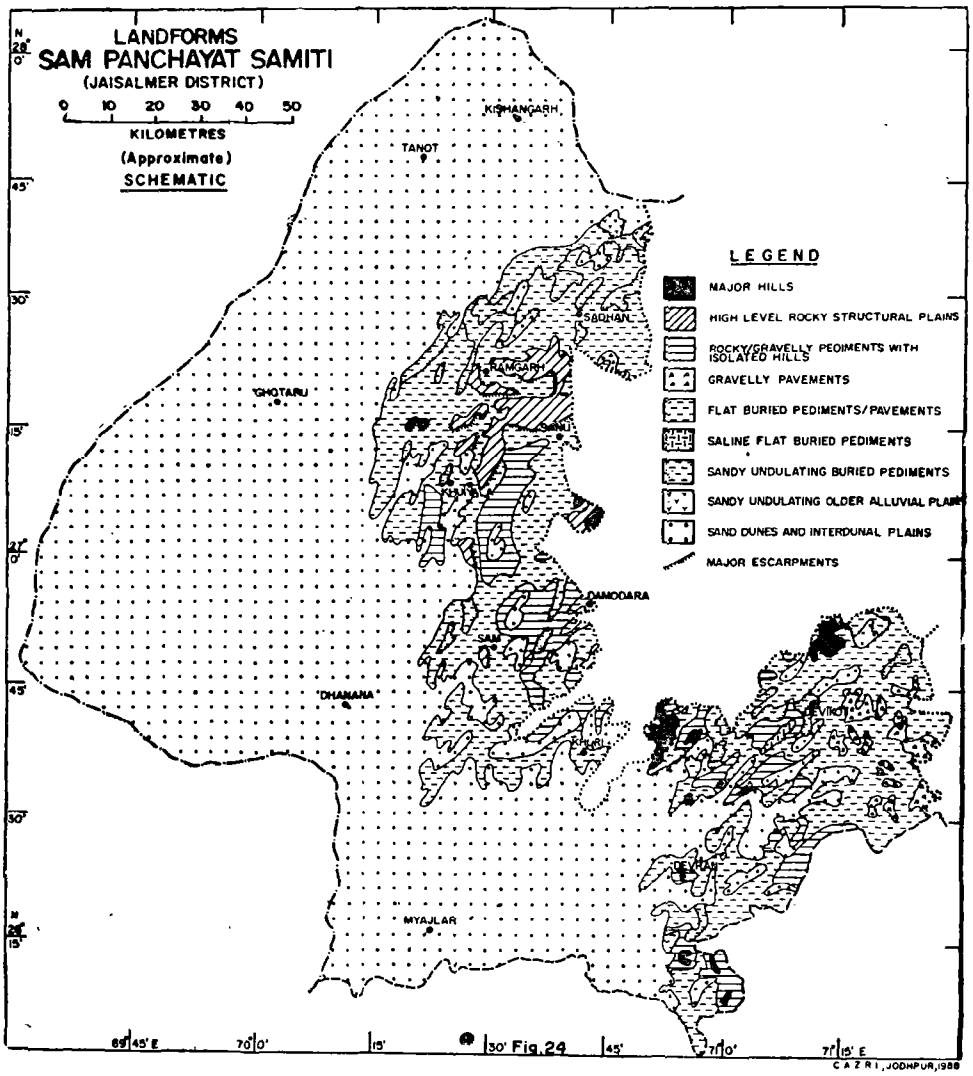

LANDFORMS
SAM PANCHAYAT SAMITI
(JAISALMER DISTRICT)
0 10 20 30 40 50
KILOMETRES
(Approximate)
SCHEMATIC
KISHANGARH
TANOT
SADHAN
RAMGARH
GHOTARU
DAMODARA
DHANANA
MYAJLAR
DEVIKA
LEGEND
MAJOR HILLS
HIGH LEVEL ROCKY STRUCTURAL PLAINS
ROCKY/GRAVELLY PEDIMENTS WITH ISOLATED HILLS
GRAVELLY PAVEMENTS
FLAT BURIED PEDIMENTS/PAVEMENTS
SALINE FLAT BURIED PEDIMENTS
SANDY UNDULATING BURIED PEDIMENTS
SANDY UNDULATING OLDER ALLUVIAL PLAIN
SAND DUNES AND INTERDUNAL PLAINS
MAJOR ESCARPMENTS
69°45' E
70°0'
30' Fig. 24
71°0'
71°15' E
CAZRI, JODHPUR, 1988

Fig. 24

The characteristics of all these landforms are given in chapter IV.

Assessment of processes

Because of extreme aridity, efficient aeolian processes and dominance of sandy terrain, the Samiti is affected mainly by aeolian hazards of different intensities (15533.5 sq. km; 73.59% of the total area). The rest 5577.8 sq. km area (26.41%) is either free from hazards or is affected by negligible fluvial erosion, especially in the southeast.

SOILS AND LAND USE CAPABILITY

There is appreciable variability in the soils of Sam Panchayat Samiti. Nearly 70% of its area is covered by very deep, loose, single grained, droughty aeolian sands with uniform soil profile of dunes and interdunal plains. These soils occur mainly in the extreme northern, western and southern parts.

In the north-eastern and south-eastern parts of the Samiti there is large variation in the soils due to various lithological formations at shallow depth. On the basis of morphological characteristics like soil depth, colour, texture, structure, parent material and physiographic setting, fourteen soil series have been mapped, besides the shallow, miscellaneous soils and hills. These soil series have been further grouped under (A) coarse textured soils, (B) medium textured soils, (C) moderately fine textured soils, (D) shallow miscellaneous soils, and (E) rocks and hills (Fig. 25).

Characteristics of major soil groups

(a) Coarse textured soils

Seven soil series, namely, Duny complex, Madasar, Sam, Myajlar, Dabla, Ghotaru and Sodakor, are included in this group. These soils usually have coarser sand at surface and fine sand to loamy fine sand in the subsoil, followed down the profile by either deep aeolian sand, or weak to well developed lime concretion or weathered rock.

Limitations : Major limitations are (i) hummocky sandy relief; (ii) loose sandy soil, prone to wind erosion; (iii) very low water retention capacity; and (iv) very poor fertility status and root zone limitation in soils like Sam, Ghotaru and Sodakor series.

Potentials : Lasiurus sindicus and *Eleusine compressa* grasses grow well on these soils. Pasture lands are also well established on these soils.

(b) Medium textured soils

This group includes four soil series, namely Bida, Ajasar, Lakha and Nedai. These soils have sand to loamy sand texture at surface and sandy loam to loam in

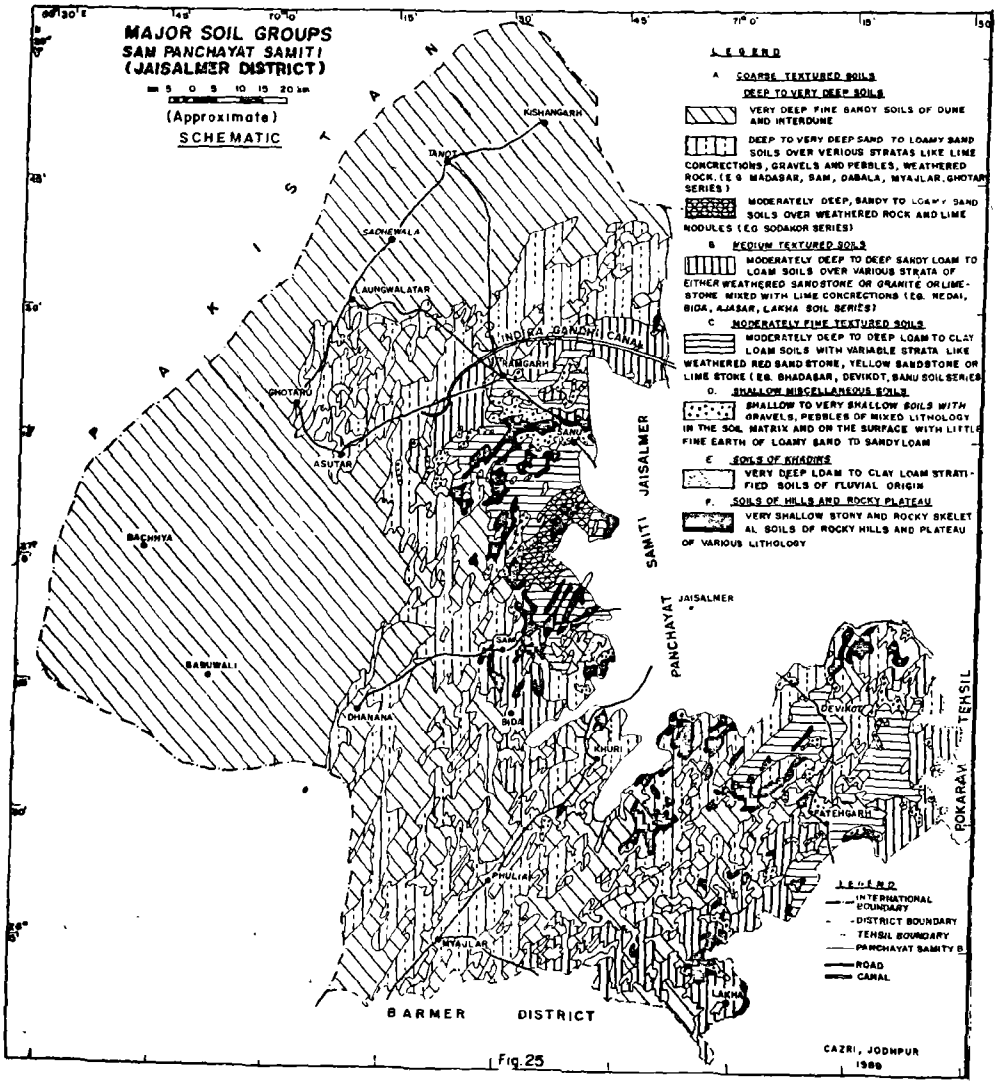

MAJOR SOIL GROUPS
SAM PANCHAYAT SAMITI
(JAISALMER DISTRICT)
(Approximate)
SCHEMATIC
LEGEND
A COARSE TEXTURED SOILS
DEEP TO VERY DEEP SOILS
VERY DEEP FINE SANDY SOILS OF DUNE AND INTERDUNE
DEEP TO VERY DEEP SAND TO LOAMY SAND SOILS OVER VERIOUS STRATAS LIKE LIME CONCRECTIONS, GRAVELS AND PEBBLES, WEATHERED ROCK. (E G MADASAR, SAM, DABALA, MYAJLAR, GHOTARU SERIES)
MODERATELY DEEP, SANDY TO LOAMY SAND SOILS OVER WEATHERED ROCK AND LIME NODULES (EG SODAKOR SERIES)
B MEDIUM TEXTURED SOILS
MODERATELY DEEP TO DEEP SANDY LOAM TO LOAM SOILS OVER VARIOUS STRATA OF EITHER WEATHERED SANDSTONE OR GRANITE OR LIME-STONE MIXED WITH LIME CONCRECTIONS (EG. NEDAI, BIDA, AJASAR, LAKHA SOIL SERIES)
C MODERATELY FINE TEXTURED SOILS
MODERATELY DEEP TO DEEP LOAM TO CLAY LOAM SOILS WITH VARIABLE STRATA LIKE WEATHERED RED SAND STONE, YELLOW SANDSTONE OR LIME STONE (EG. BHADASAR, DEVIKOT, BANU SOIL SERIES)
D. SHALLOW NIGGELLANEOUS SOILS
SHALLOW TO VERY SHALLOW SOILS WITH GRAVELS, PEBBLES OF MIXED LITHOLOGY IN THE SOIL MATRIX AND ON THE SURFACE WITH LITTLE FINE EARTH OF LOAMY SAND TO SANDY LOAM
E SOILS OF KHADINS
VERY DEEP LOAM TO CLAY LOAM STRATIFIED SOILS OF FLUVIAL ORIGIN
F. SOILS OF HILLS AND ROCKY PLATEAU
VERY SHALLOW STONY AND ROCKY SKELETAL SOILS OF ROCKY HILLS AND PLATEAU OF VARIOUS LITHOLOGY
KISHANGARH
TANOT
SACHEWALA
LAUNGWALATAR
INDIRA GANDHI CANAL
GHOTARU
ASUTAR
BACHHYA
BANUWALI
DHANANA
BIDA
KHURI
SAM
JAISALMER
JAISALMER SAMITI
PANCHAYAT
DEVIKOT
KATEHGARH
ROKARAN TEHSIL
PHULIA
MYAJLAR
LAKHA
BARMER DISTRICT
Legend
INTERNATIONAL BOUNDARY
DISTRICT BOUNDARY
TEHSIL BOUNDARY
PANCHAYAT SAMITY B.
ROAD
CANAL
CAZRI, JODHPUR
1989
Fig.25

Fig. 25

subsoils, underlain by limestone, sandstone or granite formations, or by gravels and pebbles coated or uncoated with lime over the weathered rock. Bida and Nedai are moderate to strongly calcareous, whereas Ajasar and Lakha are non to slightly calcareous. Generally these are associated with plain land surface and gravelly areas. There are a number of shallow, gravelly patches on these soils. The soils also have sand sheeting problem throughout the area. The soils can retain 40-80 mm water per metre depth and have low to medium fertility status. Nedai and Bida series soils have hard strata and high content of calcium carbonate. Yet, these soils have better agricultural value than the coarse textured soils. If sufficient moisture is available then these soils can produce 4-6 q/ha of pearl millet.

Potentials : The soil have sandy loam to loamy texture and can hold moisture for long. Therefore, some crops could be grown on these soils. Some of the areas of Nedai soils can be used for water harvesting.

(c) Moderately fine textured soils

This group includes three soil series, namely Bhadasar, Devikot and Sanu and occurs mainly in the northern and southern parts of the Samiti. The soils are brown to dark brown (5 YR) and brown (2.5 YR), loamy sand to sandy loam, non-calcareous at surface and loam to clay loam and silty clay loam at the subsurface, light to moderately calcareous, underlain by weathered sandstone, limestone, etc., at 40-90 cm depth. The substrata of Devikot and Sanu series is porous, but Bhadasar substrata is impervious and hard. This substrata is also saline and will cause salinity problem under irrigated conditions. The soils can hold 70-140 mm water per meter depth.

Limitations : (i) The soils have sand sheeting problem from the adjoining dune-covered areas. (ii) These soils are also affected by water erosion, because of their valley situations. (iii) These soils do not have uniform relief due to rock outcrops and gravels. (iv) Bhadasar series substrata is saline and has contributed to surface salinity at many places. (v) The surface of these soils become hard during droughts.

Potentials : These are fine textured soils and can hold good moisture. The low lying sites on these soils work as sites for *Khadins* and produce winter crops. The fertility status of the soils is better than in many soils. *Khadins* can be developed at many sites.

(d) Shallow miscellaneous soils

These soils do not have uniform profile characteristics. Hence, these soils are not classified under any series. The soil texture varies from sand to fine sand, loamy fine sand and sandy loam with gravels and pebbles and also have a varied substrata like lime concretions, gravels, pebbles and weathered or unweathered rocks at 5-20 cm depth. These soils also have sloping relief and have numerous channels. They do

not have any agricultural value, but are suitable for grazing, pasture and forestry development.

Limitations : (i) Soil texture is highly variable and have sloping eroded surfaces. (ii) The solum depth is very thin and any crop root can be damaged. (iii) The fertility status is very low. (iv) At places thick sand accumulation causes problems, while at others salinity problem is dominant.

Potentials : These lands are potential for harvesting runoff only. These could also be developed as pasture lands.

(e) Rocks and hills

These are completely barren and occur scatteredly in the eastern part of the area. Their values are mainly for mining of industrial, building and road construction materials. The runoff generated from the hills could be used for agriculture.

Land use capability

Because of extreme aridity and scarcity of water, the soils of Sam Panchayat Samiti are not suitable for regular cropping, except in the *Khadin* areas which are assigned class III category (Table 19; Fig. 26). The medium and fine textured soils are under class IV category, or the marginal lands, where cultivation is not possible every year due to severe climatic limitations, even though the soils have high moisture holding capacity. Coarse textured soils are classified as class VI lands with c, s, ea and sh sub-classes. These lands are not totally suitable for crop production, but could be put under permanent pasture or forestry plantation, because of severe climatic, soil, wind erosion and root zone limitations. Shallow, gravelly miscellaneous soils have very severe root zone limitations and are completely droughty. These are not fit for cultivation and could be best utilized as permanent grazing lands Rocks and hills in the Panchayat Samiti area are put under class VIII R lands. These could be utilized as quarries (Fig. 26; Table 19).

VEGETATION

Inventory of vegetation resources

Sam Panchayat Samiti supports five major grass cover types (Table 20; Fig. 27). *Lasiurus sindicus—Panicum turgidum* type occurs predominantly on sand dunes, interdunes and sandy undulating plains and covers the maximum area (70% of the total area). This is followed by *L. sindicus—Eleusine compressa* type on sandy plains, interdunal and alluvial plains (21.62% area); *Dactyloctenium sindicum - Eleusine compressa* on buried pediments (5.07% area) and *Aristida - Oropetium thomaeum* on rocky - stony habitat (3.18% area). While *Lasiurus sindicus* is the natural climax plant of

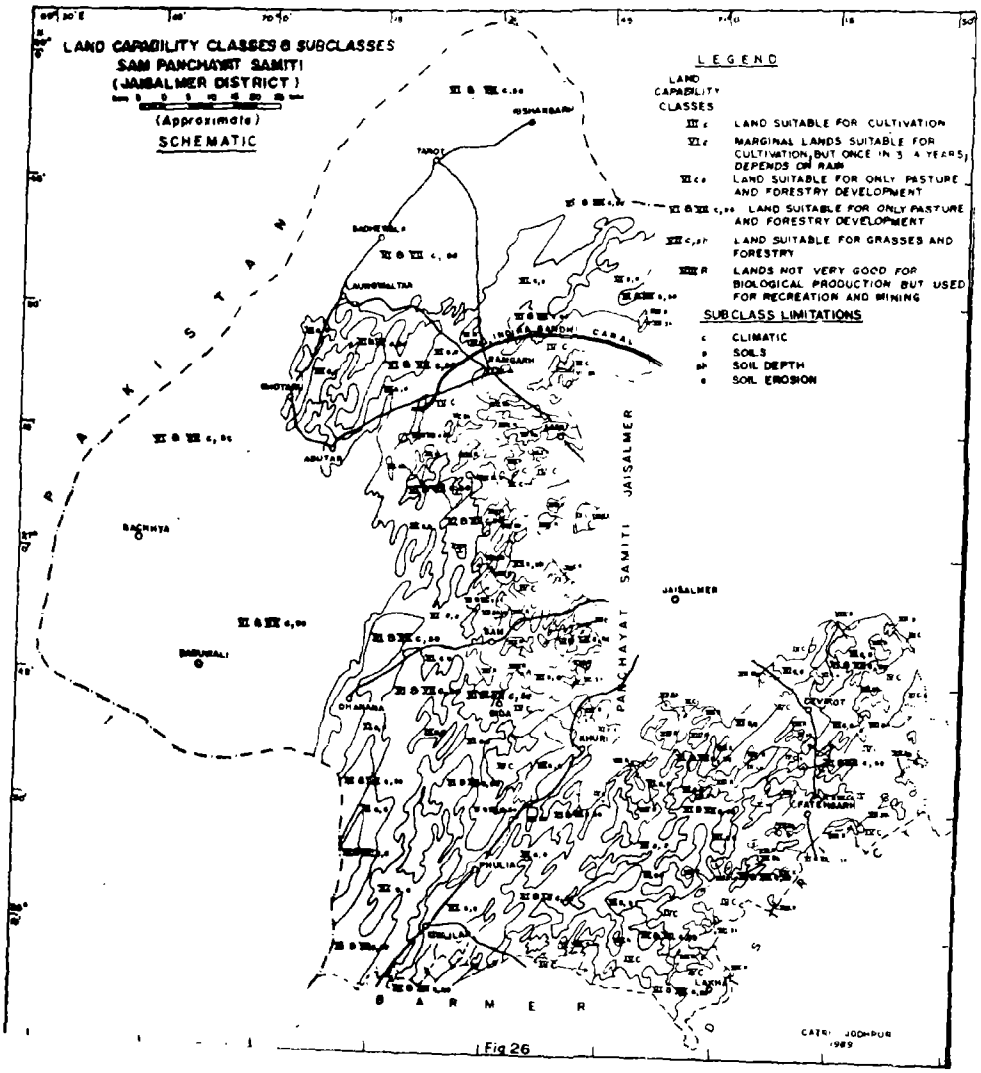

LAND CAPABILITY CLASSES & SUBCLASSES
SAM PANCHAYAT SAMITI
(JAISALMER DISTRICT)
(Approximate)
SCHEMATIC
LEGEND
LAND CAPABILITY CLASSES
III c LAND SUITABLE FOR CULTIVATION
VI c MARGINAL LANDS SUITABLE FOR CULTIVATION, BUT ONCE IN 3 - 4 YEARS, DEPENDS ON RAIN
VI c s LAND SUITABLE FOR ONLY PASTURE AND FORESTRY DEVELOPMENT
VI & VII c, es LAND SUITABLE FOR ONLY PASTURE AND FORESTRY DEVELOPMENT
VII c, es LAND SUITABLE FOR GRASSES AND FORESTRY
VIII e LANDS NOT VERY GOOD FOR BIOLOGICAL PRODUCTION BUT USED FOR RECREATION AND MINING
SUBCLASS LIMITATIONS
c CLIMATIC
s SOILS
sd SOIL DEPTH
e SOIL EROSION
INDIRA GANDHI CANAL
JAISALMER
PANCHAYAT SAMITI JAISALMER
BARMER
Fig 26
CATRI JODHPUR 1989

Fig. 26

Table 19. Characteristics and limitations of the land use capability classes in Sam Panchayat Samiti and recommendations

S. No.	Land capability class	Sub classes	Soils and their characteristics (including soil series)	Limitations and problems	Recommendations
1	III	c (Climate)	Very deep, medium to fine textured soils of valley floor, receiving high runoff from the surroundings.	Uneven land surface affecting distribution of water; Uncertain rainfall and runoff.	Frequent levelling of land is needed after every two to three years. Sometimes flooding brings coarse sediment over good soils; needs to be scrapped. Catchment area needs proper development with good grass cover; controlled grazing to improve runoff potential. Proper maintenance of Khadin bunds which are often eroded.
2	IV	c; e (Water erosion)	Soil series : Devikot, Bhadasar, Sanu, Ajasar, Lakha and Bida. These are medium to moderately fine textured, deep to very deep soils with weathered strata below	Uncertain rainfall; Often sudden cloud burst cause severe sheet and rill erosion; At places aeolian sand deposition	Due to severe climatic limitations these lands cannot be put under crop every year, but once in 3 to 5 years, depending upon rainfall. To cheeck water erosion, land use planning on watershed basis is needed through the use of soil/water conservation measures. Under favourable situations Khadins could be developed.
3	VI	c; sh (Shallow soils)	Soil series : Nedai and Sodakor. Nedai has loamy sand to sandy loam, followed by hard petrocalcic layer, whereas Sodakor has sand to loamy sand texture underlain by thick zone of lime concrelions. These are dominantly moderately deep or deep.	Very thin solum, hence limited moisture for plant growth; Often sand sheeting on surface; Water erosion mainly on Nedai series. Severe climatic limitation	Ideally suitable for permanent pasture; not for agriculture under present conditions. Seeding of good grass and controlled grazing will raise productivity and conserve soil moisture. Plantation of suitable tree species could be taken up.

(Contd.)

4	VI	c; ea (Wind erosion)	Soil series : Sam, Dabla, Madasar, Myajlar, Ghotaru. These are coarse textured sand to loamy sand, deep to very deep with hummocky surfaces or thick sand deposition.	Severe climatic limitations; Low water retention; Hummocky sand surfaces; Severe wind erosion deposition.	Ideally suited for pasture development with trees and shrubs of topfeed value. To control wind erosion, grasses and vegetation cover should be maintained on these lands. Therefore, controlled grazing is needed.
	VI & VII	c ; ea (Soil)	Soils of stabilized sand dunes of various types in class-VI; barchan dunes under class VII. These are very deep aeolian coarse, single grained soils of uniform profile.	Severe climatic limitation; Undulating, sandy surfaces; Very low moisture retention; High wind erosion/ deposition.	Suitable for permanent pasture and forest trees; should not be cultivated. Reseeding of improved grasses and controlled grazing will improve soil condition. Micro-wind barriers are necessary to control sand movement prior to grass/plant establishment. Break method of planting trees developed by CAZRI is useful.
5	VII	sh (Shallow to very shallow)	Shallow to very shallow miscellaneous gravelly/ pebbly soils on gentle to highly undulating surfaces	Severe root zone limitation; Very low moisture retention; Occasional sheet erosion; ravels/pebbles on surface; Undulating topography.	These lands have potentials for development as good pasture lands. Contour furrowing and staggered trenching are necessary to conserve moisture. Moderate grazing could be admissible.
	V	R (Rocky)	Barren hills and other rocky areas	Adverse soil and topographic conditions with harsh climate.	These lands could be used for mining of stones and as run-off catchments for water harvesting.

Table 20. Grass cover in Sam Panchayat Samiti

S. No.	Grass cover	Area in sq. km	Percentage of total grass cover
1.	*Lasiurus sindicus—P. turgidum*	14799.00	70.10
2.	*L. sindicus—Eleusine compressa*	4564.90	21.62
3.	*Dactyloctenium sindicum—E. compressa*	1070.21	5.07
4.	*Aristida* sp.—*Oropetium thomaeum*	670.83	3.18
5.	Khadins	6.24	0.03
		21111.18	100.00

this region, *Dactyloctenium sindicum* on such habitat indicates degraded condition. The remaining two types are also degradational stages. Amongst the trees and shrubs, *Prosopis cineraria* with *Ziziphus nummularia - Capparis decidua* are predominant on sandy plains and buried pediments. *Haloxylon salicornicum - Calligonum polygonoides - Aerva pseudotomentosa*, with sprinkling of *Prosopis cineraria*, occur mainly in the northwestern sandy terrain, while *Haloxylon salicornicum - Capparis decidua - Aerva pseudotomentosa* predominate in the southeastern sandy areas.

Evaluation of vegetation resources

Trees and shrub vegetation are, by and large, cut, browsed and degraded. Range condition analysis was carried out at 28 selected sites. It was found that 78% of the sites belonged to poor to very poor condition class, while the remaining 22% were of fair or good condition (Table 21). The sites under poor condition classes, though having *Lasiurus sindicus - Eleusine compressa* type, were extremely degraded due to grazing, resulting in a loss of cover to less than 3-4%. The vegetation cover on the good condition class grazing lands was over 4%. This is further proved by the fact that good condition class grazinglands had 1. 5 to 2 times more dry forage yield than that of poor grazing lands.

HYDROGEOLOGY

There are eight potential zones in the Samiti. These are Quaternary (Q_1, Q_2), Tertiary (T_2), Parewar (P_1 , P_2), Bhadasar (Bd_1, Bd_2) and Lathi (L_1, L_2), covering a total area of about 5791. 03 sq. km (Fig. 28). Ground water surplus and ground water storages in these zones have been computed (Table 22). Tube wells can be constructed in Q_1 and Q_2 potential zones, having a depth of about 110 m to 170 m. Their yield capacity ranges between 80 cubic metres/day to 225 cubic metres/day. The quality of ground water is fresh to slightly saline. Tubewell can be constructed in remaining potential zones having a depth range of 150 m to 250 m. The yield capacity ranges between 176 cubic metres/day and 285 cubic metres/day. The total groundwater reserve in the Samiti is estimated to be 15706. 5266 mcm (Table 23).

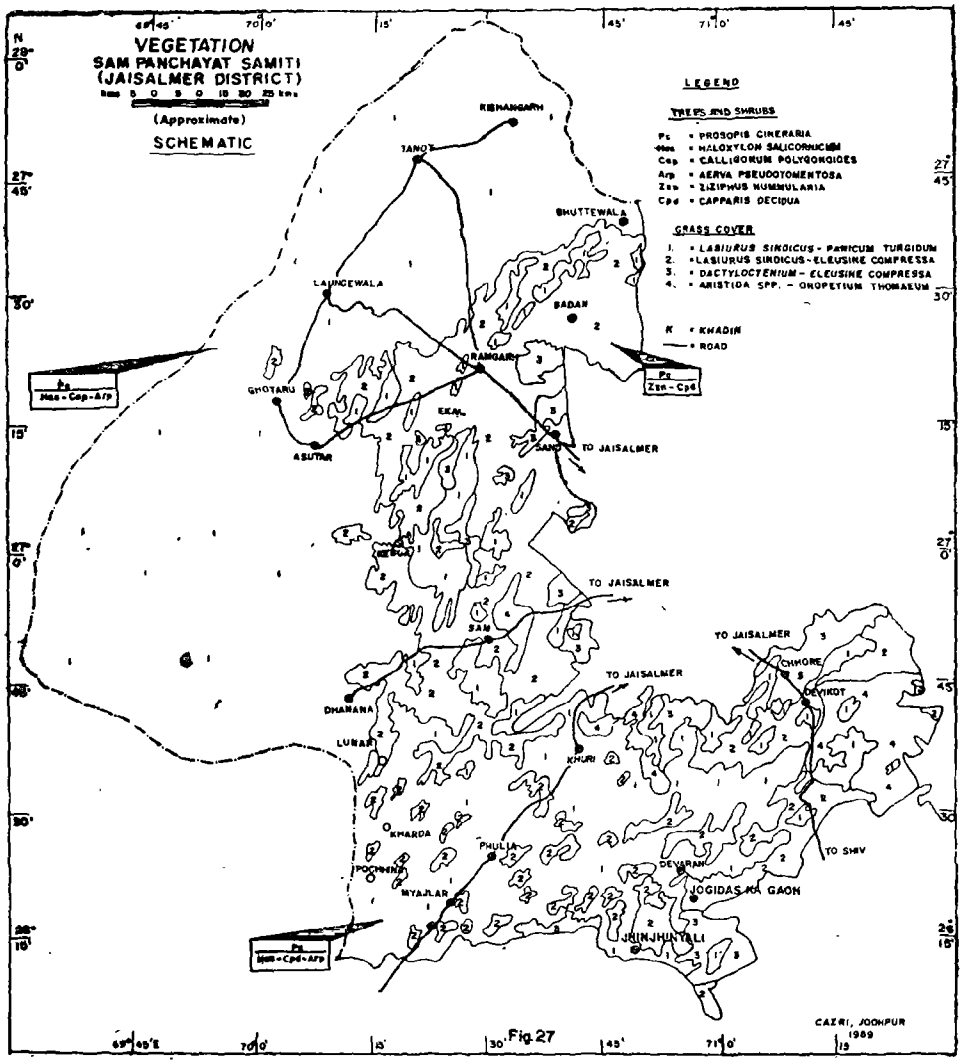

VEGETATION
SAM PANCHAYAT SAMITI
(JAISALMER DISTRICT)
(Approximate)
SCHEMATIC
LEGEND
TREES AND SHRUBS
Pc = PROSOPIS CINERARIA
Hsm = HALOXYLON SALICORNICUM
Cap = CALLIGONUM POLYGONOIDES
Arp = AERVA PSEUDOTOMENTOSA
Zsn = ZIZIPHUS NUMMULARIA
Cpd = CAPPARIS DECIDUA
GRASS COVER
1. = LABIURUS SINDICUS - PANICUM TURGIDUM
2. = LASIURUS SINDICUS - ELEUSINE COMPRESSA
3. = DACTYLOCTENIUM - ELEUSINE COMPRESSA
4. = ARISTIDA SPP. - ORGPETIUM THOMAEUM
K = KHADIN
= ROAD
RENANGARH
TANOT
SHUTTEWALA
LAUNGEWALA
BADAN
RAMGARH
GHOTARU
EKAL
ASUTAR
SANO
TO JAISALMER
SAM
DHANANA
LUNAR
KHURI
CHIMORE
DEVIKOT
KHARDA
PHULIA
POCHHINA
MYAJLAR
DEVARAN
JOGIDAS KA GAON
JHINJHNIYALI
TO SHIV
CAZRI, JODHPUR
1989
Fig. 27

Fig. 27

Table 21. Range condition classes and dry forage (oven—dry wt., q/ha) from grass covers at selected sites in Sam Panchayat Samiti

S. No.	Habitat and sampling sites	Gradings	Grass cover*	Vegetation cover (%)	Productivity (q/h)
Buried pediments					
1.	Baroragaon	Very poor	Ec-Pt	0.58	—
2.	Sanwata	Very poor	Ls-Ec	14.32	—
3.	Raymal	Very poor	Ec	0,31	—
4.	Sultana	Very poor	Ec	0.64	1.23
5.	Naga	Poor	Ec	2.82	2.12
6.	Devikot	Very poor	Ds-Ec	0.78	1.08
7.	Ekal	Poor	Ec	0.95	1.67
8.	Sanu (unprotected)	Very poor	Ec-Ds	0.55	—
9.	Sanu (protected)	Good	Ls-Ec	3.32	29.12
10.	Jawandh	Very poor	Ec-Ds	2.79	—
Interdunal plains					
11.	Ramgarh	Poor	Ec	0.22	0.64
12.	Kishangarh	Very poor	Ec	0.21	—
13.	Pithewala	Good	Ls	7.14	28.32
14.	Asutar	Good	Ls	9·10	—
15.	Ditta ka toba	Good	Ls-Ec	9.88	86.97
Sandy undulating plains					
16.	Chhore	Poor	Pt-Ec	2.95	—
17.	Nagaraja ka tibba	Fair	Ls	3.60	—
Dune-Interdune areas					
18.	Tanot	Very poor	—	1.96	—
19.	Kishangarh	Very poor	Ec	0.11	—
20.	Binjewala (1)	Poor	Pt-Ec	1.79	60.26
21.	Binjewala (2)	Poor	Ls-Ds	3.95	64.26
22.	Binjewala (3)	Good	Ls-Ds	3.95	73.63
23.	Ranahu (1)	Good	Ls	10.00	130.92
24.	Ranahu (2)	Poor	Ls	1.62	—
25.	Ranahu (3)	Very poor	—	1.15	—
26.	Gamnewala	Poor	—	0.11	67.97
27.	Longewala (1)	Very poor	Ls	2.12	—
28.	Longewala (2)	Very poor	—	1.90	—

* Ec—*Eleusine compressa;* Pt—*Panicum turgidum;* Ls—*Lasiurus sindicus;* Ds—*Dactyloctenium sindicum.*

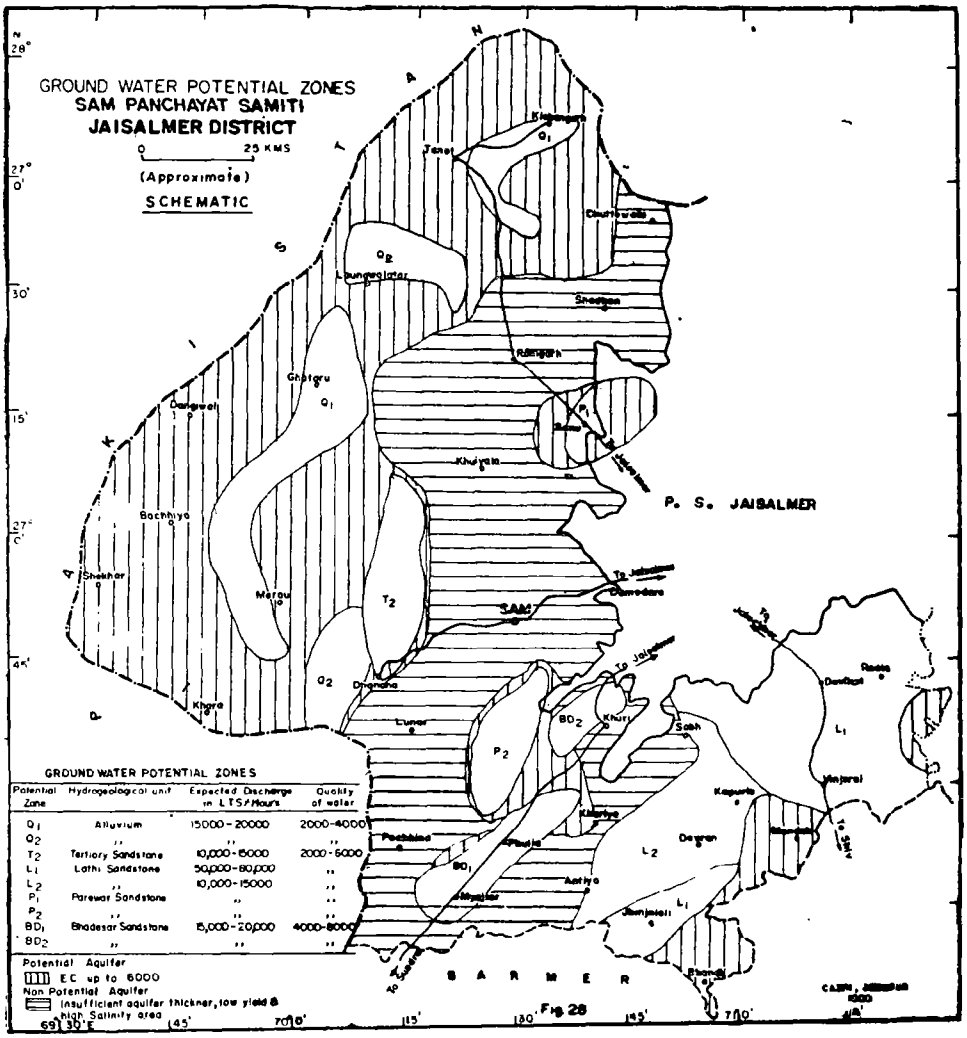

GROUND WATER POTENTIAL ZONES
SAM PANCHAYAT SAMITI
JAISALMER DISTRICT
0 25 KMS
(Approximate)
SCHEMATIC
P. S. JAISALMER
SAM
BARMER
GROUND WATER POTENTIAL ZONES
Potential Zone | Hydrogeological unit | Expected Discharge in LTS/Hours | Quality of water
Q1 | Alluvium | 15000 - 20000 | 2000-4000
Q2 | " | " | "
T2 | Tertiary Sandstone | 10,000 - 15000 | 2000 - 6000
L1 | Lathi Sandstone | 50,000 - 80,000 | "
L2 | " | 10,000 - 15000 | "
P1 | Parewar Sandstone | " | "
P2 | " | " | "
BD1 | Bhadesar Sandstone | 15,000 - 20,000 | 4000-8000
BD2 | " | " | "
Potential Aquifer
EC up to 6000
Non Potential Aquifer
Insufficient aquifer thickner, low yield & high Salinity area
Fig 28

Fig. 28

Table 22. Ground water recharge, draft and surplus in Sam Panchayat Samiti

Potential zone	Locality	Recharge (mcm)	Draft (mcm)	Surplus (mcm)
Q_1	Asutar	32.0243	0.1438	31.8805
	Kishangarh	7.7159	0.0644	7.6615
Q_2	Longewala	11.2520	0.0311	11.2209
	Murar	9.9915	—	9.9915
T_2	Bhuwana	11.9915	—	11.9915
P_1	Sanu	1.1136	0.2004	0.9132
P_2	Koria	6.6097	0.0972	6.5125
Bd_1	Miajlar	1.5396	0.1619	1.3777
Bd_2	Dhaneli	1.0221	0.1552	0.8669
L_1	Chandan	33 5777	0.4382	33.1395
	Jhinjhiniyali	9.2475	0.0324	9.2151
L_2	Dewra	18.5329	0.0466	18.4863
		144.6183	1.3612	143.2571

Table 23. Ground water reserves in Sam Panchayat Samiti

Potential zone	Locality	Area (sq.km)	Specific yield (%)	Aquifer thickness (mcm)	Reserve (mcm)
Q_1	Asutar	781.25	0.08	46.00	2875.0000
	Kishangarh	409.37	0.08	57.00	1866.7272
Q_2	Longewala	274.50	0.08	29.00	636.8400
	Murar	243.75	0.08	22.00	429 0000
T_2	Bhuwana	428.12	0.03	62.00	796.3032
P_1	Sanu	62.50	0.03	96.00	180.0000
P_2	Koria	268.75	0.03	108.00	870.7500
Bd_1	Miajlar	327.00	0.03	70.50	691.6050
Bd_2	Dhaneli	135.00	0.03	41.50	168.0750
L_1	Chandan	1731.25	0.03	91.50	4752.2812
	Jhinjhiniyali	376.00	0.03	66.00	744.4800
L_2	Dewara	753.54	0.03	75.00	1695.4650
					Total 15706.5266

PRESENT LAND USE

The irrigated area (A_{11}) in the Samiti is very negligible (only 3 ha). The total cultivated area constitutes 51217 ha of land, out of which A_1 unit covers 49957 ha (2. 4%) and A_2 unit covers 1260 ha (0.06%) of land (Table 24; Fig. 29). Most of the cultivated lands are located in the Khadin areas or in depressional and interdunal areas which retain moisture for longer period of time. Most of the cultivated areas are concentrated in the south - eastern part, around Devikot, Rasla, Achla, Khuri, Phulia, Chhorm Koda, Sirva, Seetolai, Sabh, Sandu, Khaba, Kanoi and Satta villages. Most of the Khadins of Jaisalmer tehsil are also within this Samiti. In the years of favourable rain these Khadins are cultivated during *rabi* season. Bhuj is the largest Khadin. It covers about 1600 ha land and is highly productive in respect of gram and wheat.

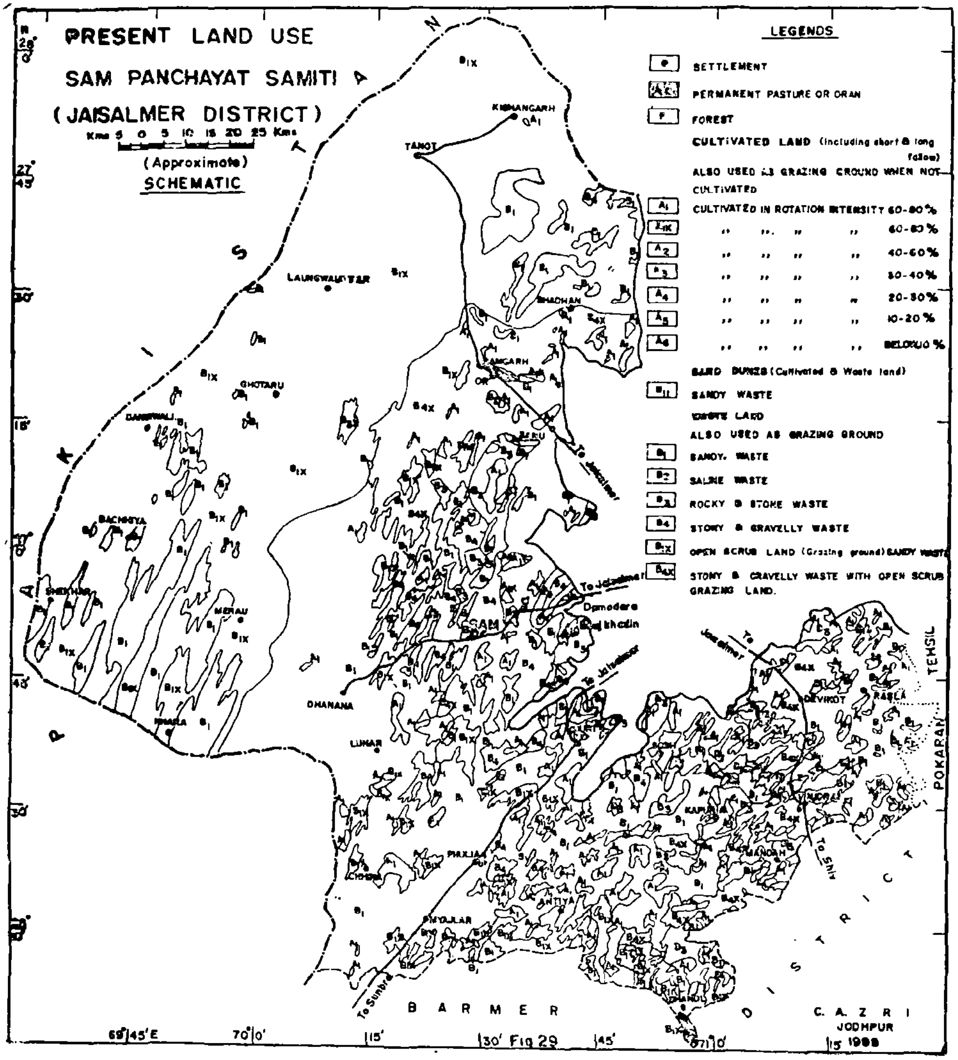

PRESENT LAND USE
SAM PANCHAYAT SAMITI
(JAISALMER DISTRICT)
(Approximate)
SCHEMATIC
LEGENDS
SETTLEMENT
PERMANENT PASTURE OR ORAN
FOREST
CULTIVATED LAND (including short & long fallow)
ALSO USED AS GRAZING GROUND WHEN NOT CULTIVATED
CULTIVATED IN ROTATION INTENSITY 60-80%
40-60%
30-40%
20-30%
10-20%
SANDY WASTE
ALSO USED AS GRAZING GROUND
ROCKY & STONE WASTE
STONY & GRAVELLY WASTE
STONY & GRAVELLY WASTE WITH OPEN SCRUB GRAZING LAND.
TANOT
KISHANGARH
LAUNGWALA
GHOTARU
BACHHIYA
MERAU
DHANANA
LUNAR
SAM
DEVIKOT
BARMER
POKARAN TEHSIL
C. A. Z. R. I
JODHPUR
69°45'E
70°0'
15'
30'
45'
71°0'

Fig. 29

Among the wastelands the sandy wastes (B_1) cover the largest area of 1823638 ha (86 4%). Out of it 46.5% area lies under BIX (sandy waste with open scrub) which has a good grass cover of *Lasiurus sindicus*. The area to the west of Bhuttewala, Bada, Kishangarh, Tanot, Longewala, Dhanana, Lunar and Myajlar is covered with bare sand dunes (B_1) or sand dunes with open scrub. The area from Sultana to Lunar has a good cover of *Lasiurus sindicus* and is considered as a highly fodder productive area. If properly developed it can provide fodder not only for the livestock of Jaisalmer district but also to the livestock of surrounding districts.

The rocky and stony wastes (B_3) cover about 28,736 ha (1.4%) area of the Samiti and are scatteredly distributed. These are mostly located around Ramgarh, to the east of Bhuj and south of Bhuj. Gravelly wastes (B_4) cover 6.8% area around Bhuj Khadin, to the west of Sanu and Lanela and near Devikot, Randha, east of Phulia and Pithal villages. Gravelly wastes with scrub and grass cover (B_4 X) occur around Ramgarh, and in some scattered pockets, covering about 38342 ha (1.3%) of land. It is utilized for grazing purposes for the livestock. The "forest" covers an area of 1840 ha (0.09%) and lies in National Desert Park, but is in a degraded condition.

Area not available for cultivation includes the area under settlements, roads, water features and some tourist places, covering about 1.6% area of the Samiti.

Table 24. Present land use in Sam Panchayat Samiti

Land use categories	Area in ha	Percentage of total area
1. Double cropped area (A_{11})	3	—
2. Single cropped (A_1) (intensity of cultivation 80-100%)	49957	2.4
3. Single cropped (A_2) (intensity of cultivation 60-80%)	1260	0.1
4. Sandy waste (B_1)	842332	39.8
5. Sandy waste with open scrub (B_1x)	981306	46.4
6. Rocky and stony waste (B_3)	28736	1.4
7. Gravelly waste (B_4)	142578	6.8
8. Gravelly waste with open scrub (B_4x)	28342	1.3
9. Forest	1840	0.1
10. Area not available for cultivation	34774	1.6
Total	2111128	100.0

RECOMMENDATIONS

Based on the resource characteristics and their assessment the following broad recommendations could be framed.

i) Highly efficient aeolian processes and extreme vulnerability of the sandy terrain in the Samiti indicate that disturbances caused to the naturally stabilized sand dunes can lead to faster reactivation of the dunes and engulfing of more areas with mobile dunes. Such phenomena are now noticed in the vicinity of villages where

devegetation of dunes and interdunes is loosening the structure of dune sand and increasing the sand mobility. Hence, the present activities related to canal construction should also take into account quick restoration of the ecology of the dunes and sandy plains in the areas of earth-work.

ii) In parts of the Samiti new dunes are forming spontaneously through a series of mobile bedforms. The initial identifiable bedform is a linear arrangement of isolated barchans, moving from SSW or SW to NNE or NE. Although the barchans temporarily obstruct roads and other structures they move away faster unless obstructed at their lee. Any obstruction to these crescent - shaped dunes may lead to attraction of more sand and engulfing of the structure. Hence, rather than checking the isolated barchans these may be allowed to pass. In case of coalescing barchanoids the corridors between the ridges could be used temporarily. Avoidance of such area is economical than trying to counter their advance. The megabarchanoid *fields* in the southwest (Fig. 16), although containing highly mobile dunes, do not advance menacingly. However, over - exploitation of the resources of the stable dunes in the region is leading to the creation of new fields of mobile barchanoids (e.g. to the west of Sam). Such trends could only be checked through much restricted use of the vegetation resources of the dunes.

iii) The natural vegetation of the dunes and sandy plains, especially the Sewan grass (*Lasiurus sindicus*) and the bushes of *Calligonum polygonoides* are good sand binders. Even a 30% cover of the vegetation can substantially reduce the mobility of sand. Hence, efforts should be made to protect and utilize these and other plants through scientific range care. The present practice of unmanaged utilization and destruction must be discouraged, atleast for the sake of sand stabilization.

iv) The suitable plant species for sand dune stabilization in the canal command area (where water is available) and outside the command areas are as mentioned in chapter XV. Local grasses and shrubs should be given preference to trees in the non-command and command areas.

v) The areas with coarse textured soils should be put under permanent pasture. Agricultural activity may be discouraged.

vi) In the medium textured soils land levelling is to be carried out for crop production. The soils need to be protected from the coarser blown sand from the sand dunes in their surroundings. Proper field bunding is to be done to conserve rain water and water from the gravelly areas are to be guided to the fields. Addition of FYM to the soils can improve the porosity.

vii) The fine textured soils can be used for new khadin development. Field bunding and levelling of fields should be done so that rain water can be spread uniformly. Sand sheeting on these lands should be checked. If irrigation is practised, heavy watering should be avoided. The Bhadasar series soils are unfit for irrigation, because of their saline substrata.

viii) The shallow, gravelly lands should be brought under permanent pasture to check further degradation. Apart from run-off harvesting these lands should be brought under silvipastoral programme.

ix) The existing production potential of good condition class grass covers can be increased two - fold by following proper range care methods and reboisement programmes. Such programmes, with their estimated cost and return, are enumerated in Tables 25 to 35. Thus, it is possible to improve the range condition, its productivity, browse resources and general environment, besides providing remunerative livestock production. Plants of economic importance such as Tumba (*Citrullus colocynthis*), can be gainfully exploited.

x) The ephemeral present streams, with coarse bedload, do not have enough surface and subsurface water potentials, especially because of the rainfall constraint. However, beneath the unconsolidated riverine deposits the consolidated riverine conglomerate and/or parent formation creates a subsurface barrier for water percolation and, hence, wherever the granular overburden is thick enough a perched water body develops after the rains. This water, although brackish, is tapped at many places by the villagers through open, shallow dug-wells (*berries*), but need to be maintained properly and periodically treated to check contamination.

xi) In the western part of the Samiti the acute problem of drinking water could also be partially solved through construction of tankas. Some of the villages, selected for tanka construction and communicated to PHED, Government of Rajasthan, are Meerwala, Navtala, Rabhlau Fakironwala, Muhar, Chhaganiyo ki Basti, Khariya, Dorau, Geraja, Suwar, Kulatala, Mehboob ka Par and Bhutonwali. All these villages have high sand dunes, interspersed with elongated interdune plains. The run-off generated from the plains and collected from the slopes of the dunes, could be stored in tankas constructed in the natural low-lying areas within the interdunes, especially in the central part of the interdunes. It is to be noted that, because of the elongated shape of the interdunes, the time of concentration of water in them is more. The construction details of the tankas are given in Chapter XV.

xii) The buried former course of the Saraswati along the westernmost part of the Samiti (Fig. 8), roughly through Kishangarh, Ghantialji ka Mandir, west of Ghotaru, west of Shahgarh and Babuwali, could be explored for ground water. A few wells along it have proved successful. Futher drilling and pump testing may provide enough information on its potentiality and recharge condition. In general, the zones Q_1 and Q_2 are the most potential areas, having yield capacity of 80 to 225 cubic metres/day. The average depth to water ranges from 110 m to 170 m.

xiii) In the other potential zones (Table 22, Fig. 28) the yield ranges from 176 cubic metres to 285 cubic metres and the tube wells can tap water at 150 m to 250 m depth.

Table 25. Development of *L. sindicus—P. turgidum—E. compressa* grasslands : Cost estimates for 100 ha plots (based on 1986 rates)

S. No.	Particulars of work	Unit	Rate (Rs.)	Quantity	Amount (Rs.)
1	2	3	4	5	6
1.	Survey and layout	ha	6.00	100	600.00
2.	Barbed wire angle iron fencing 1-2 m high, 4 strands for external boundary	Rm	10.00	4000	40,000.00
3.	Barbed wire angle iron fencing 1-2 m high, 4 strands for internal fencing to make 4 blocks	Rm	10.00	2000	20,000.00
4.	Field laboratory (20'x12') cum office (10'x10')	Sq. ft	125.00	340	42,500.00
5.	Construction of water reservoir, 'Tanka'	—	—	—	20,000.00
6.	Construction of cattle shed	Sq. ft	15.00	1000	15,000.00
7.	Procurement of animals (Tharparkar breed cow)	Animal	2500	30	75,000.00
8.	Medical facilities for animals	—	—	—	5,000.00
9.	*Raising of browse shrubs and trees (for entire project duration)	Plant	—	185000	133,056.00
10.	**Reseeding of pasture and related cultural activities (for entire project duration)	—	—	—	43,000.00
11.	Seed collection	ha	20	100	2,000.00
12.	Miscellaneous	ha	20	100	2,000.00
					399,155.00
Follow up : 1st year					
1.	Maintenance of fencing	Rm	0.15	6000	900.00
2.	Medical facilities for animals				5,000.00
3.	Seed collection				2,000.00
4.	Miscellaneous				2,000.00
					9,900.00
Follow up : 2nd, 3rd, 4th and 5th year					
1.	Same as in 1st year	4x9,90			39,600.00
				Grand total	4,47,656.00

* Table 26

** Table 27

Table 26. Development of *L. sindicus—P. turgidum—E. eompressa* grasslands : Cost estimates for tree/shrub plantation in interdunal areas (based on 1986 rates)

S. No.	Particuiar of work	Unit	Rate (Rs.)	Quantity	Amount (Rs.)
1	2	3	4	5	6
1.	Survey and layout	ha	8	100	800.00
2.	Digging of pits (50 cm^2)	Pit	1.50	185x100	27,750 00
3.	Cost of raising plants in the nurseries	Plant	0.60	185x100	11,100.00
4.	Transportation of plants from nursery to the site of plantation	Plant	0.15	185x100	2,775.00
5.	Making of crescent shape ridge around the plant	Plant	0.18	185x100	3,330.00
6.	Planting of seedling	Plant	0.40	185x100	7,400.00
7.	Purchase and collection of seeds	ha	20.00	100	2,000.00
8.	Two weeding and hoeing	Plant	0.22	185x100	4,070.00
9.	Pay of one guard	Day	11.00	365	4,015.00
10.	Miscellaneous expenditure	ha	31.00	100	3,100.00
11.	Two watering per plant	Plant	0.60	185x100	11,100.00
				Total	77,440.00
Follow up : 1st year					
1.	Casualty replacement	20% of item 2, 3, 4, 5, 6			10,471.00
2.	Two waterings per plant				11,100.00
3.	One weeding and hoeing @ 22 paise/plant for 1,85,000 plants				4,070.00
4.	Pay of one forest guard				4,015.00
5.	Misc. expenditure				300
					29,956.00
Follow up : 2nd year					
1.	Pay of one guard				4,015.00
2.	Other miscellaneous				2,400.00
					6,415.00
Follow up : 3rd 4th and 5th year					
	Same as in 2nd year	6415.00x3			19,245.00
				Grand Total	1,33,056.00

Table 27. Development of *L. sindicus—P. turgidum—E. compressa* grasslands : Cost estimates for reseeding of pasture lands (Based on 1986 rates)

S.No.	Particulars of work	Unit	Rate (Rs.)	Quantity	Amount (Rs.)
1.	Cost of ploughing/furrowing	ha	100.00	100	10,000.00
2.	Purchase of grass and legumes seeds	ha	50.00	100	5,000.00
3.	Cost of sowing grasses and legumes including cost of making grass pellets	ha	100.00	100	10,000.00
4.	Miscellaneous works	ha	14.00	100	1,400.00
					26,400.00
Follow up : 1st year					
1.	Resowing and ploughing 50% of item 1 & 2	ha	14.00	100	7,500.00
2.	Miscellaneous expenditures	ha	14.00	100	1,400.00
					8,900.00
Follow up : 2nd year					
1.	Resowing and reploughing	ha	35.00	100	3,500.00
2.	Miscellaneous expenditure	ha	14.00	100	1,400.00
					4,900.00
Follow up : 3rd and 4th years					
1.	Miscellaneous expenditure				2,800.00
					43,000.00

Table 28. Development of *L. sindicus—P turgidum—E compressa* grasslands : Return estimates for 100 ha plots (Based on 1986 rates)

S No.	Particulars of work	Unit	Rate (Rs.)	Quantity	Amount (Rs)
1st year					
1.	Seed collection from 25 ha	kg	10.00	250	2,500.00
2.	Milk yield of 30 cows at the rate of 4 lits/cow/day for 365 days	Lit	2.50	43,800	1,09,500.00
3.	Farm yard manure	cft		1.09	500.00
					1,12,500.00
2nd year					
1.	Seed collection from 25 ha	kg	10.00	250	2,500.00
2.	Milk yield of cows at the rate of 4 lits/cow/day for 365 days	Lit	2.50	43,800	1,09,500.00
3.	Farm yard manure	cft			500.00
					1,12,500.00
	Follow up in the 3rd and 4th year (same as in 2nd year)				2,25 500.00
				Total	4,50,000.00
	Follow up II				
1.	Same as in 2nd year				1,12,500.00
2.	Sale of mature calves, 3 years old	Animal	1500	15	22,500.00
	or alternately if calves are not sold				
				Total	5,85,000.00
1.	Same as in 2nd year				1,12,500.00
2.	Milk yield, 4 lits/cow/day for 365 days	Lit	2.50	22900	57,250.00
					1,69,750.00
				Total	6,19,750.00
Project cost in five years					4,47,655.00
Project return in five years					5,85,000.00
Result : Project profit begins from the 5th year					

Table 29. Development of *Dactyloctenium sindicum—Eleusine compressa* grasslands : Cost estimate for 100 ha plots (Based on 1986 rates)

S No.	Particulars of work	Unit	Rate (Rs)	Quantity	Amount (Rs)
1.	Survey and layout	ha	6.00	100	600.00
2.	Barbed wire angle iron fencing 1.2 m high, 4 strands for external boundary	Rm	10.00	4000	40000.0
3.	Barbed wire angle iron fencing 1.2 m high, 4 strands for internal fencing to make 4 blocks	Rm	10.00	2000	20,000.00
4.	Field laboratory (20'x12') cum office 10'x10'	Sq ft	125.00	340	42,500.00
5.	Construction of water reservoir (Tanka)				20,000.00
6.	Construction of cattle shed	Sq. ft	15.00	1000	15,000.00
7.	Procurement of animals (sheep one year old)	Sheep	100.00	300	30,000.00
8.	Medical facilities for animals				5,000.00
9.	*Raising of browse shrubs, top feed trees (for entire project duration)				70,106.00
10.	**Reseeding of pastures and related cultural activities (for entire project duration)				43,000.00
11.	Seed collection	ha	20	100	2,000.00
12.	Miscellaneous	ha	20	100	2,000.00
				Total	2,90,206.00
	Follow up : 1st year				
1.	Maintenance of fencing	Rm	0.15	6000	900.00
2.	Medical facilities for animals				5,000.00
3.	Seed collection				2,000.00
4.	Miscellaneous				2,000.00
	Follow up 2nd, 3rd, 4th and 5th years		9900x4		9,900.00
					39,600.00
				Grand Total	3,89,706.00

* Detailed plan in Table 30.

** Detailed plan in Table 27.

Table 30. Cost estimates for tree-shrub plantation on buried pediments and stream banks (Based on 1986 rates)

S.No.	Particulars of work	Unit	Rate (Rs)	Quantity	Amount (Rs)
1.	Survey and layout	ha	8.00	100	800.00
2.	Digging of pits (50 cm^3)	Pit	1 50	60x100	9,000.00
3.	Cost of raising plants in the nurseries	Plant	0.60	,,	3,600.00
4.	Transportation of plants from nursery to the site of plantation	Plant	0.15	,,	900.00
5.	Making of crescent shaped ridge around the plants	Plant	0.18	,,	1,080.00
6.	Planting of seedlings	Plant	0.40	,,	2,400.00
7.	Purchase and collection of seeds		20.00	100	2,000.00
8.	Two weedings and hoeing	Plant	0.22	60x100	1,320.00
9.	Pay of one guard	day	11.00	365	4,015.00
10.	Miscellaneous expenditure	ha	31.00	100	3,100.00
11.	Two waterings	Plant	0.60	60x100	3,600.00
				Total	31,815.00
Follow : up 1st year					
1.	Casualty replacement 20% of items 2, 3, 4, 5 & 6				3,396.00
2.	One weeding and hoeing @ 22 paise/plant for 6000 plants				1,320.00
3.	Pay of one guard				4,015.00
4.	Miscellaneous expenditure				300.00
5.	Two waterings				3,600.00
				Total	12,631.00
Follow up ; 2nd year					
1.	Pay of one guard				4,015.00
2.	Other miscellaneous operations				2,400.00
				Total	6,415.00
	Follow up 3rd, 4th and 5th year Same as in 2nd year		(6415x3)		19,245.00
				Grand Total	70,106.00

Table 31. Development of *L. sindicus—E. compressa* : Return estimate for 100 ha plots (Based on 1986 rates)

S. No.	Particulars of work	Unit	Rate (Rs.)	Quantity	Amount (Rs.)
1.	Shearing of wool at the rate of 400 g/ sheep a year from 100 sheep	Kg	30.00	80	2,400.00
2.	Ramlambs from sheeps, one ramlamb twice a year from 75% of sheep	Sheep	200.00	150	30,000.00
3.	Farm yard manure	Cft			500.00
				Total	32,900.00
	Follow up 2nd, 3rd, 4th, 5th and 6th year		Same as in 1st year		1,64,500.00
	Follow up 7th year				
	Ramlambs to be kept for restocking; remaining is same as is 2nd year				2,900.00
	Follow up 8th year		Same as in 1st year		32,200.00
					2,33,200.00
	Project expenditure upto 8th year (Rs. 3,39,706.00+29,700.00)				3,69,406.00
	Project return upto 8th year				3,91,206.00
	Result : Project profit begins from the 9th year onwards @ Rs. 32,000 per year.				

Table 32. Development of *Oropetium—Aristida* grass cover type : Cost estimates for 100 ha plots (Based on 1986 rates)

S.No.	Particulars of work	Unit	Rate (Rs.)	Quantity	Amount (Rs.)
1.	Internal fencing by 4-Line barbad wire on angle iron post	Rm	10.00	2	20.000.00
2.	Field laboratory (20'x12') cum office (10'x10')	Sq. ft	125.00	340	42,500.00
3.	Construction of bunded reservoir				20,000.00
4.	Procurment of animals: Goats one year old	Animal	50.00	3000	15,000 00
5.	Construction of cattle shed	Sq. ft	15.00	1000	15,000.00
6.	Medical facilities for animals				5.000.00
7.	*Raising of browse shrubs/tree (for entire duration of project)				2,73,218.00
8.	**Reseeding of pasture				39,250.00
9.	Seed collection	ha	20.00	100	2,000.00
10.	Miscellaneous	ha	20.00	100	2,000.00
				Total	4,32,968.00
	Follow up 1st year				
	Maintenance of fencing	Rm	0.15	6000	900.00
	Medical expenditure				5.000.00
	Seed collection				2,000.00
	Miscellaneous				2,000.00
				Total	9,900.00
	Follow up 2nd, 3rd, 4th and 5th year		4x9,900		39,600.00
				Grand Total	4,83,468.00

* Detailed plan in table 33
** Detailed plan in table 34

Table 33. Tree plantation on hills and piedmonts (Based on 1986 rates)

S. No.	Particulars of work	Unit	Rate (Rs)	Quantity	Amount (Rs)
1.	Survey and layout	ha	8.00	100	800.00
2.	Stone wall fencing (1.2 m height, 0.8 m base, 0.65 m at top)	Rm	12.00	4000	48,000.00
3.	Construction of soil conservation structures	ha	220.00	100	22,000.00
4.	Digging of 250 staggered contour trenches (0.45 x 0.45 x 1 m)	Trench	1.40	100x250	35,000.00
5.	Sowing of seeds on trenches	,,	0.50	,,	12,500.00
6.	Cost of raising plants in nurseries	Plant	0.60	230x100	13,800.00
7.	Digging of pits 50 cm^3	Pit	1.50	,,	34,500.00
8.	Transportation of plants from nursery to the site	Plant	0.15	,,	3,450.00
9.	Crescent shape ridge around the plant	Plant	0.18	,,	4,140.00
10.	Planting of seedling	Plant	0.40	,,	9,200.00
11.	Two waterings	,,	0.60	,,	13,800.00
12.	Purchase and collection of seeds	,,	20.00	100	2,000.00
13.	Two weedings and hoeing	,,	0.22	230x100	5,060.00
14.	Pay for one labour	1	11.00	365	4,015.00
15.	Miscellaneous expenditure	—	31.00	100	3,100.00
				Total	2,11,365.00
	Follow up 1st year				
1.	Casualty replacement 20% of item 6, 7, 8, 9, 10				13,018.00
2.	One weeding and hoeing	Plant	0.22	230x100	5,060.00
3.	Two waterings	,,	0.60	,,	13,800.00
4.	Pay of one labourer	1	11.00	365	4,015.00
5.	Miscellaneous expenditure		3.00x100		.00.00
				Total	36,193.00
	Follow up 2nd year				
1.	Pay of one labourer				4,015.00
2.	Other operations		24x100		2,400.00
					6,415.00
	Follow up 3rd, 4th and 5th year same as in 2nd year			6415x3	19,245.77
				Grand Total	2,73,218.00

Table 34. Reseeding of pasture land on hill slopes and buried pediments (Based on 1986 rates)

S. No.	Particulars of work	Unit	Rate (Rs)	Quantity	Amount (Rs)
1.	Purchase of grass, legume seeds	ha	50	100	5,000.00
2.	Miscellaneous work (Cost of contour digging and sowing seeds included in main schedule in Table 33)	ha	14	100	1,400.00
				Total	6,400.00
	Follow up 1st year				
1.	Resowing and ploughing 50% of item 4, 5				23,750 00
2.	Miscellaneous operations				1,400.00
				Total	25,150.00
	Follow up 2nd year				
1.	Resowing and reploughing	ha	35	100	3,500.00
2.	Miscellaneous exper diture	ha	14	100	1,400.00
				Total	4,900.00
	Follow up 3rd and 4th year				
1.	Miscellaneous expenditure				2,800.00
				Grand total	39,250.00

Table 35. Development of *Oropetium-Aristida* grasslands : Return estimates for 100 ha plots (Based on 1986 rates)

S. No.	Particulars of work	Unit	Rate (Rs)	Quantity	Amount (Rs)
1.	Milk yield @ lit/day/goat of 50 goats for 365 days.	lit	2.00	18,250	36,500.00
2.	Farm yard manure				5,500.00
					37,000.00
	Follow up 2nd year				
1.	Same as in 1st year				37,000.00
2.	Sale of kids (One kid a year from each goat is sold when lad is 1 year old)	Goat	200.00	50	10,000.00
					47,000.00
	Follow up 3rd to 12th year : same as in 2nd year				4,70.000.00
				Total	5,54,000.00
	Project expenditure upto 12th year				5,22,628.00
	Project returns upto 12th year				5,54,000.00
	Result : Project profit begins from 13th year onwards @ Rs. 47,000/- per year.				

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No. 3	Solar energy utilization research (Mimeo.), pp. 1-48 (1975)	by H.P. Garg
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