BASIC AND HUMAN RESOURCES OF JODHPUR DISTRICT (RAJASTHAN)

CENTRAL ARID ZONE RESEARCH INSTITUTE

JODHPUR

Cyclostyled in December 1978

Printed in October 1982

Printed by Automobile Press, JODHPUR

PREFACE

Over the years there has been a favourable trend from the department-wise, compartmental development schemes to programmes of integrated rural development. Though as pointed out by Dr. M.S. Swaminathan and Dr. I E. Soares in their key note address at the workshop on 'Integrated Rural Development with Social Justice" (Bangalore, Sept. 1977), the term integrated rural development means different things to different people, the concept has gained a strong foothold in our thinking and application. In formulation of efficient programmes the key need is a good assessment of the natural resources and socio-economic attributes of the area concerned. Integrated resource survey programme in operation at the Central Arid Zone Research Institute, since 1960-61, precisely aims at this. The present report on Jodhpur district is an outcome of this effort. Earlier reports in this series were on some of the Community Development Blocks and the latest pretained to Bikaner District (Aug. 1974).

The style of presentation and interpretation is essentially the same as adopted for report on Bikaner District although large complexities in landscape of Jodhpur District did pose many special problems.

Individual Major Land Resource Unit descriptions have been made as comprehensive as possible, however as has been stated elsewhere in the report the best results particularly in respect of resource assessment and suggested treatments are achieved though inter-action of scientists, technologists and development specialists. We always look forward to this interaction with aim of making these reports more and more meaningful and pragmatic.

It is hoped that material contained in the report will prove useful to development and plannings agencie in generating fruitful programmes of social and economic development.

JODHPUR

H.S. MANN
Director

CONTRIBUTORS

Resource assessment, suggested treatments and report writing	R.P. Dhir
Integration of survey data and establishment of biophysical units	K.A. Shankarnarayan R.P. Dhir, S. Singh, S.K. Saxena, A.K. Sen and A.S. Kolarkar.
Basic resource survey	
Geomorphology	S. Singh, B. Ghose, P.C. Vats and D.S. Kaith.
Soil and land use capability	R.P. Dhir, N. Singh
Geohydrology	M.L. Sharma
Surface water hydrology	K.N.K. Murthy, D.N. Bohra and V.C. Issac
Plant ecology	S.K. Saxena
Landuse and cartography	A.K. Sen, Gheesa Lal, N.S. Vangani and C.T. Abraham
Socio-economic survey	S.P. Malhotra, L.P. Bharara, M.L.A. Sen, C.S.K. Johary and M.L. Purohit
Agroclimatology	A. Krishnan, B.M. Vyas, A.S.R.A.S. Sastri and Y.S. Rama Krishna
Wild-life resource and rodent pests	I. Prakash
Silvi-pasture and pasture establishment and management	K.A. Shankarnarayan

TABLE OF CONTENTS

		Pages
1.	Preface	i–ii
2.	Introduction	1–2
3.	Major Land Resource Units at a glance	3–8
4.	Jodhpur district and its biophysical and socio-economic attributes–a brief description.	9–16
5.	Description of Major Land Resource Units	17–75
	MLRU–Ju. 1 – Duny complex	17–23
	MLRU–Ju. 2 – Hummocky aggraded plains with light textured soils in association with dunes.	24–29
	MLRU–Ju. 3 – Flat ageraded plains with light textured soils and occasional dunes.	30–35
	MLRU–Ju. 4 – Flat aggraded plains with hard pan soils.	36–38
	MLRU–Ju. 5 – Gravelly aggraded plains with shallow soils.	39–42
	MLRU–Ju. 6 – Flat aggraded plains with medium textured soils.	43–46
	MLRU–Ju. 7 – Flat aggraded plains with fine textured soils.	47–49
	MLRU–Ju. 8 – Flat buried pediments with light to medium textured soils.	50–54

Table of contents (continued)

		Pages
	MLRU-Ju 9 - Hummocky buried pediments with light textured soils.	55-57
	MLRU-Ju. 10 - Rocky pediments and plateaux	58-61
	MLRU-Ju. 11 - Flat aggraded plains with saline-alkali soils	62-64
	MLRU-Ju. 12 - Younger alluvial plains	65-69
	MLRU-Ju. 13 - Saline depressions	70-72
	MLRU-Ju. 14 - Hills	73-75
6.	Socio-economic survey	76-92
7.	Agro-climatology	93-111
8.	Wild-life resource and rodent pests	112-115
9.	Silvi-pasture and pasture establishment and management.	116-119
10.	Technology	120-130
	Appendix I	131-141
	Appendix II	142-146
	Maps and Diagrams.	

INTRODUCTION

Jodhpur is a centrally located district in the western Rajasthan. With its 22860 sq km area it supports a human population of 1.152 million (1971 census) and a livestock population of 1.89 million which constitute respectively 11.2 per cent and 13.2 per cent of that pre cent in whole of the arid Rajasthan. Mean annual rainfall ranges from 425 mm in the south-east to about 200 mm in the north-west. Unlike many districts, Jodhpur has an immense variety of landscape ranging from thickly populated irrigated pockets, good quality dry farming lands, dune chains to rugged hills and nearly desolate gravelly plains. It will be no exaggeration to say that by far a majority of landscape units occurring in arid zone are represented in this district.

This inherent variability in various landscape attributes affect the behaviour and potentiality of land and much of it is already manifest in the present land use and management. Nevertheless, there is considerable scope of developmental effort aimed at improving productivity of land and checking deterioration of natural resources. For deployment of right type of effort, fixing priorities and maximum response it is essential that this variability of land is recognised. Individual attributes surveys say for soil, ground water potentiality and others are important but since any piece of natural resource development is dependent on many others, therefore a multidisciplinary pproacn in the answer. The present attempt has been made on these lines and this approach is essentially the same as developed for the report on Basic Resources of Bikaner District (C.A.Z.R.I., Aug. 1974). Unlike Bikaner, integration of data for Jodhpur district did pose many special problems. First overlay of individual land attribute data generated nearly 67 biophysical units. However, realising that treatment of such a large number of units will adversely affect the operational efficiency and consequent use by development and planning agencies, repeated reviews were made to bring down this number. While this has been done, the exercise has brought in some generalisation and heterogeniety in character of individual units. In order to ensure that information collected in course of field work is not lost this spatial variation within the unit has been incorporated in description of the unit.

Field surveys were carried on SOI topo-sheets at 1:125,000 to 1:50,000 together with aerial-photo analysis and interpretation. However, final MLRU map has been produced at 1:250,000. The

process has led to the disappearance of smaller geographic entities. However, these details are available as sectional records for use by interested development agencies.

Treatment of major land resource units comprises description of geomorphic features, soils, surface and ground water, natural vegetation and present land use. These land attributes together with climate have been interpreted for their behaviour, productivity and potential. Principal reasons for present low productivity scope of improved technologies have been stated. Land use consistent with capability of the land is highlighted. However, best resource assessment is possible only through an interaction of resource survey scientists with actual users of land and development agencies. Many of the suggested treatments call for a coordinated efforts. For example development of pastures requires a simultaneous programme of livestock improvement. Likewise development of irrigation facilities requires an emphasis also on provision of fertilizer inputs, improved varieties and plant protection.

In preparation of this report we have been guided by the "Interim Report on Desert Development" of National Commission on Agriculture. Besides, other useful material is also available namely, the Report on Drought Proofing of Jodhpur District by the Special Schemes Organisation, Government of Rajasthan and the Survey and Investigation Report of the State Ground water Department. These, particularly those on ground water have been made use of. Liberal help of Shri S.K. Das, Director, now Chief Engineer and Shri D. C. Sharma, Superintending Hydrogeologist of the State Ground water Department is gratefully acknowledged. Framework for integration of natural resources data was originally suggested by Mr. J.R. Mc Alpine of the Division of Land Use Research of the C.S.I.R.O. of Australia during this visit to CAZRI during December 1973, and the same is duly acknowledged. Thanks are due to Dr. H. S. Mann, Director, for his valuable suggestion in drafting of this report, to Dr. C.T. Abichandani, former Head of the Basic Resources Studies Division, for his guidance and co-ordination of field work, and to Dr. K. A. Shankarnarayan, Head of the Division of Basic Resources Studies, Dr. A. N. Lahiri, Head of the Division of Soil water Plant Relationship, Dr. R.P. Singh, Chief Scientist, Dry Land Farming, Dr. S.D. Singh, Sr. Agronomist and Shri R.B. Das, Agrostologist, for their help in developing resource assessment and suggested treatments. Help of Shri A.K. Sen, Scientist-2 (Geography) in printing and editing of the report and of Shri B.L. Tak, T-5 (Photography) for providing some of the photographs is acknowledged. The assistance rendered by R. K. Abichandani in printing of this report is also acknowledged.

MAJOR LAND RESOURCE UNITS AT A GLANCE

Given in the following table is a brief account of most salient features of the bio-physical attributes and resource assessment together with respective area and extent of the various major land resources units established in the Jodhpur District. Maps 1 and 2 show the geographical distribution of the proposed land management treatments in the district. The present section aims at providing a quick reference to the resource units and it is a no substitute for the detailed treatment of the individual land resource units contained in the main body of the report.

MLRU No.	Area and extent	Unit name and resource assessment	Salient recommendations
1	2	3	4
1.	3536 km² ; 15.5%	Duny complex comprising dominantly coalesced parabolic dunes and irregular interdunes with loose, structureless soils highly susceptible to wind erosion and deposition. Present productivity is low both under the dominant fallow farming and open grazing systems. Besides, the present use and management are leading to accelerated movement of loose sand.	Arable farming be restricted to interdunes only with intensive wind erosion control as for MLRU 2. Dunes proper should be brought under improved silvipastoral system. Limited ground water potential be exploited for irrigated forage crops to support good dairy cattle.
2.	4316 km² ; 18.9%	Hummocky aggraded plains with light textured soils in association with dunes. Climatic conditions permit good to average crop in 50-70 per cent of the years. But yields are low because of poor plant population and low level of management. Severe wind	Area below 230 mm rainfall as well as high hummocks and dunes be brought under silvi-pastoral system. Cultivation can continue in the rest but with conservation practices like stubble mulching, wind break and field bunding.

1	2	3	4
		erosion problem is besides. Sufficient ground water potential exists to command 750 ha for grain crops or 250 ha of forage crops.	Improved dry farming technology as given for MLRU 3. Increased exploitation of ground water in suggested area for forage crops.
3.	3629 km ^{2}; 15.9%	Flat aggraded plains with light textured soils and occasional dunes In major part lands are fairly well suited to arable farming with some soil conservation practices. Presently crop yields average only 2.5-3.5 q/ha of *bajra* or 1.5-5.0 q/ha of pulses. Main reasons are low plant population, inadequate weeding, less efficient varieties and absence of fertilizer and plant protection inputs.	Sowing with seed-drill to ensure good germination and to enable mechanical weeding; improved varieties, strategic use of nitrogenous fertilizer and plant protection inputs in above 300 mm rainfall zone; growing pulses and *bajra* in rotation. More enterprising farmers can take up inter row and infield water harvesting system and *ber* orchards in combination with water harvesting.
4.	1634 km ^{2}; 7.2%	Flat aggraded plains and with hard pan soils. Low rainfall (around 250 mm) besides limited soil depth permit 50-75 per cent crop yield compared to that on adjoining deeper soils. Presently, on an average, 30 per cent area cropped in a fallow farming system. Fallow lands provide 200 to 450 kg/ha of forage on air dry basis. Ground water potential sufficient to bring 300-500 ha under irrigated forage crops.	Lands well suited for permanent pastures but only moderately so for arable farming. Reseeding to ensure a good stand of *'sewan' 'dhaman'* and *Zizyphus nummularia*, coupled will controlled grazing can raise forage production 2-3 times.

1	2	3	4
5.	1968 km ^{2} ; 7.4%	Gravelly aggraded plains with shallow soils. Soil depth mostly 30-50 cm. Besides. 20-50 per cent area under exposed bouldary strata. On an average 7 20 per cent area under crops in a long fallow farming system. Crop yields are poor. Fallow lands provide 150-650 kg/ha of forage. On exposed strata it is 50-120 kg only. Because of soil and climatic conditions (220-240 mm) lands are poorly suited to cropping except under *khadin* system.	Except for the area under *khadins,* rest be brought under permanent pastures with reseeding, controlled grazing. Scope exists for considerable extension of *khadin* system.
6.	970 km ^{2} ; 4.2%	Flat aggraded plains with medium textured soils. From climate and soil characteristics, lands are well suited to arable farming. Present productivity though higher than that of other units is still below the potential. Causes are same as for MLRU 3. This unit is also amenable to significant run-off losses. Ground water potential exists but because of salinity, these can be used only for-wheat under a cyclic management.	Field and contour bunding coupled with good farming technology as listed for MLRU 3. Response to fertilizer application can be expected in most years. Enterprising farmer can adopt (i) transplanting of *bajra* in years when monsoon is delayed, (ii) inter row and in-field water harvesting.
7,	256 km ^{2} ; 1.1%	Flat aggraded plains with fine textured soils. In years with good rai ifall late in the season such as happens once in 3 years, *rabi* crops can be grown on conserved moisture. Some damage occurs to standing *Kharif* crops because of water	Scope exists for water conservation through bunding with surplussing to divert excess water to low lying areas for *rabi* cropping. Increased exploitation of ground water. This could best used to provide supplementary

1	2	3	4
		stagnation. Good quality water occurs at 35-55 m depth.	irrigation to *kharif* and *rabi* crops with sprinkler system.
8.	2280 km ^{2} ; 10.0%	Flat buried pediment with light to medium textured soils. Soil and climate are favourable for arable farming. In sizeable area ground water availablity is good and much of it is already exploited. Productivity both under irrigated and dryland farming is sub-optimum in the former because of lack of plant protection, inadequate fertilizer input and in the latter because of low plant population, inadequate weeding and less efficient varieties.	Increased exploitation of ground water; improved management, i.e. lining of water courses, furrow system of irrigation use of plant protection and higher level of fertilizer inputs. Improved dry farming technology as for MLRU 6.
9.	1774 km ^{2} ; 7.7%	Hummocky buried pediments with light textured soils. Presently the area is dry farmed but with severe problem of wind erosion. Besides, productivity is low for reasons as mentioned for MLRU 2. However, this area has good ground water availability and an additional 2000 ha can be brought under irrigation.	Increased exploitation of ground water coupled with improved water management technology like land levelling, lining of water courses, introduction of deep rooted economic plants to utilize otherwise unproductive deep percolation losses. Sprinkler system of irrigations is ideal for this situations. For dry farming recommendations are the same as that of MLRU 2.
10.	1459 km ^{2} ; 6.4%	Rocky pediments and plateaues with dominantly shallow, gravelly soils. Presently these are mostly open grazing lands dominated by low yielding plants or unpalatables. Forage production is around 50 to 200 kg/ha. However,	Reseeding with contour furrowing, trenching and bunding followed by control grazing.

1	2	3	4
		under good management these can give 550 to 800 kg/ha or even more. The unit has good surface water potential and the catchments that can be developed for the purpose are listed in Appendix II.	
11.	161 km^2 ; 0.7%	Flat aggraded plains with saline alkali soils. Cropping is done here with water from available saline ground water under a cyclic management, About 25 per cent of the area is highly saline with scanty cover of salt tolerant vegetation of low value. Problem of salinity is due to inadequate drainage	Permanent solution to the problem lies in improvement of drainage to lower the water table in this and much larger area in adjoining Pali district. Till such time efforts need to be made towards (a) increased use of ground water under cyclic management, (b) proper use of canal water under check basin system as against wild flooding in vogue. Use of canal water for irrigation at sowing and mixing of saline and canal water are worth considering.
12.	554 km^2 ; 2.5%	Younger alluvial plain with light to medium textured, well drained soil. Presently, about 6000 ha are under irrigation from ground water mostly around Bilara and Pipar. A variety of cash and field crops are grown but productivity is below optimum because of low level of input and abeence of plant protection. Ground water exploitation has reached and at places	Adoption of integrated technology based on plant protection, improved varieties and fertilizer for irrigaten areas. Digging of more wells to realise unexploited potential is Gunai Mata and Sukli alluvium.

1	2	3	4
		even exceeded the safe limit of exploitation except along Sukli. Potentiality and problem of dry lands are similar to those in the adjoining area.	
13.	156 km^2 ; 0 7%	These are too highly saline to permit any cropping except on margins where some sand sheeting has occurred. During rainy season some salt resistant grasses and unpalatables do come to provide 50 to 150 kg/ha of dry forage.	Introduction of ridge-furrow system can help in raising productivity.
14.	428 km^2 ; 1.3%	Hills. Because of its rugged and mostly bare nature the unit has highly limited potential. Presently most of these are devoid of cover except few *Acacia senegal*. *Euphorbia* and some annual grasses. These do yield considerable run-off. In addition many of them are important source of building stone material.	Under protection with direct seeding or transplanting, even the hills can support a thin stand of tree to yield some useful minor forest produce Potential catchments within this and other units are shown in Appendix II.

JODHPUR DISTRICT AND ITS BIOPHYSICAL AND SOCIO-ECONOMIC ATTRIBUTES - A BRIEF DESCRIPTION

4. 1. *Location*

The Jodhpur district of Western Rajasthan extends between 27°29' N to 25°99' N latitude and 71°59' E 73°46' E longitude and has an area of 22'860 sq km which accounts for 11.6 per cent of arid zone of Rajasthan or 6 7 per cent of the total area of the total area of the State.

It is a centrally located district and well connected by road and rail with neighbouring districts.

4. 2. *Physiography*

Dominant land-form of the district is an old alluvial plain further transformed in its major part by wind action of the late Quaternary. This picture is frequently interrupted by the outcrops of Upper Vindhyan sandstone and limestone, Pre-Cambrian granite and rhyolite and Aravallis slates and quartzite. These outcrops occur in forms of small hills or plateaux, often 25 to 100 metres above ground level. The hills are surrounded by short piedmont and pediment plains.

The old alluvial plains have very general slope. The highest level (275-325 m above msl) is in central part starting from Asop in the east (325 m) through Bhikamkor-Lohawat (310 m) to Phalodi-Dechu in the west (300-275 m). From here the plains slope northward towards Bikaner and Jaisalmer with a a gradient of 0.25 to 0.4 per cent and south - westwards towards Luni River with a gradient of 0.05 to 0.2 per cent This general slope of course is partially broken by hills and plateaux.

Integrated natural drainage comprising Luni River and its tributaries is present only in the South-eastern corner of this district. Northward it is disorganised and further north and westwards it is almost absent.

4. 3. *Administrative units*

The district comprises five *tehsils* or revenue administrative units namely : Jodhpur (3,520 sq km), Bilara (3,400 sq km), Shergarh (3,815 km), Osian (4,162 sq km) and Phalodi (7,738 sq km). For purposes of development, the district is divided into nine blocks or *Panchayat Samitis*. It has in all 707 villages and 4 towns. Size of villages in the south-eastern part is small but in rest of the district villages range mostly between 1000 to 3500 ha. However, the settlement here is not compact. Total urban area is only 456 sq km.

4. 4. *Climate*

Climate in the district is arid with a mean annual rainfall of 366 mm and a range from 425 mm in the south-east to about 200 mm in the north - west. Bulk of rainfall is received during monsoon season from June to September with a maximum in July and August. Mean annual number of rainy days range from 14 to 21. Year to year variability in rainfall is high with a standard deviation of 123 to 226 mm and a coefficient of variation 49 to 55. Analysis of past data shows that years receiving 81 to 150 per cent of mean annual reainfull account for only 41 to 52 per cent at different stations within the district. Years with deficit rainfall (below 80 per cent of normal) account for 31 to 22 per cent.

During April to June mean maximum temperatures are 38 to 41.6°C whereas mean minimum for December and January are 6 to 10°C. There are a few cold waves and the probability of frost occurrence is once in three years. Average wind speed during March to June is 18.3 kmph at Phalodi and 13.4 kmph at Jodhpur. Individual daily means exceeding 20-30 kmph are common during this period.

4. 5. *Land forms*

In Jodhpur district 16 landforms units have been identified namely the hills, piedmont plains, rocky gravelly pediments, flat buried pediments, sanday undulating buried pediments, flat sandstone plateau, flat buried sandstone plateau, flat aggraded older alluvial plains, sandy undulating aggraded older alluvial plains, flat gravelly aggraded older alluvial plains, younger alluvial plains, graded river beds, sand dunes, flat inter-dune plains, sandy undulating interdune plains and saline depressions.

Flat aggraded older alluvial and interdune plains occupy the largest area, i e. 37 89 per cent of the district. The slope of these plains is almost level, less than 1 per cent and the darinage channels except some scar marks of the old channels, are absent. The depth of the sediments varies from 7 to 200 cm and they are underlain by *kankar pan.* The diameter of the sediment particles form 0.06 to 1.19 mm. About 5 per cent area of these units are affected by sheet and salinity hazards The alluvial deposits along the buried courses of the prior drainage channels are the potential aquifers and the water occurs at 10 to m depth.

Sandy undulating, aggraded, older alluvial and interdune plains and interdune plains and sandy undulating buried pediments constitute 25.06 per cent of the total area of the district. The slope of these units is irregular and varies from 1° to 2° and 2° to 3°. The aeolian activities have created undulations in the form of sand mounds, fence line hummocks and low dunes of 45 to 90 cm, 1 to 2 m and 2 to 4 m heights respectively and also the deflation hollows of different size and shape. These units are thus affected by wind ercosional and depositional hazards. The thickness of the sediments varies from 40 to 400 cm and the sand

grains are of 0.06 to 0.59 mm diameter. The ground water potentials along the buried courses of the prior drainage channels are good at places.

Flat buried pediments, flat buried sandstone plateaues and younger alluvial plains constitute 11.35 per cent of the total district area. The slope is almost level-less than 1° and these units are dissected by short, narrow and shallow drainage channels. The depth of the sediments in the first two units varies from 7 to 30 cm underlain by hard rocky strata and in the third units the sediments are 8 to 12 m deep and the kankar pan is absent. Hills, piedmont plains, rocky/ gravelly pediments, sandstone plateaues, flat gravelly aggraded older allavial plains, saline depressions and graded river beds constitute 12.59 per cent area of the district. The slopes of the hills and the piedmont plains are 24° to 26° and 4° to 6° respectively with severe water erosion.

Sand dunes are spread over 13.11 per cent of the total area. The sands are loose and compact and the sand grains are of 0.06 to 0.25 mm size which are finer than the sands of the other units.

4. 6. *Soils*

Deep to very deep, light textured soils (Chirai series-normal phase) with a moisture retention capacity of 65 to 90 mm per metre depth constitutes 13.2 per cent of the district. Similar soils but with a thick over burden of loose sand, of ten in form of tence-line and in field hummocks of varying density constitute another 25.5 per cent Dunes together with inter-dunes constitute 17.7 per cent. Barring Bilara and part of Jodhpnr *tehsil*, these dunes occur in varying association with light textured soils as described above. Another 6 per cent is formed of soils with a loamy fine sand surface and slightly heavier sub-soil (Pal series.). The soils are therefore less erodible compared to the above. Soils with slight to negligible problem of wind erosion occur in eastern and south-eastern part of the district. These are Pipar series (5.7 per cent), Bhopalgarh series with some shallow patches (1.1 per cent), Saila series (1.7 per cent). These soils also have higher moisture retention capacity (70–130 mm). However, the finest textured soils in the area are Gajasinghpura (1.2 per cent) and Asop (0.2 per cent) which can retain 180 to 350 mm of moisture in soil profile. Because of low infiltration rate crops in the latter groups of soils are adversely affected by water stagnation but their high retention capacity does permit *rabi* cropping on conserved moisture.

Soils with a compact / indurated *kankar* pan at shallow depth constitute 7.6 per cent and similar soils with a bouldry strata at surface or at 40-60 cm depth another 6.2 per cent of the total area. Miscellaneous shallow soils of gravelly and rocky pediments occupy 7.2 per cent. Soils with salinity alkali problem occur in an area of 178 sq km or O. 8 percent of the district. Younger alluvial plain, natural saline depressions and plateau-hills are the other units.

Light textured soils test very low in

organic carbon, low, to medium in phosphorus and medium, to low, in potash as per all India standards. Under environment where climate is a severe restraint on quantum of biomass production under dry farming conditions somewhat economic response can be obtained to application of in nitrogen and that too in over 300 mm rainfall zone.

4. 7. *Land use capability*

As is true for other parts of arid zone inadequacy of water is the dominant limiting factor. However, whithin this all prevailing influence the vast range of soils come across in the region do play a very important role in deciding upon the type of land use and the management needs for a sustained productivity. For example the dune soils because of highly erodable nature are best adapted for a silvi-pastroal system (Class VI ec). Deep, light textured soils with a hummocky relief (plains 25.5 per cent and inter-dunes 4.6 per cent) need strict wind erosion control measures for arable farming (Class IV ec). Class III lands with moderate to severe wind erosion form another 20.9 per cent. Soil with no erosion problem and with good moisture retention capacity constitute about 10 per cent. Soil with hard pan (VI sh) or in addition with exposed rocky strata (VI & VII sh) and shallow gravelly soils (VII sh) constitute respectively 6.6, 4.8 and 7.2 per cent These are best suited for pasture lands with due control on graxing Rocky surfaces (VIII) of course, have still limited potential, from this angle but are good catchments for water harvesting.

4. 8. *Vegetation*

Mixed xeromorphic woodland type covers few major land resource units like flat older alluvial plains with shallow to deep sandy loam soils and interdunal plains with deep soils. Here the spiny species are mixed with non thorny and ever green species. Common plant, communities under this vegetation type comprise of *Prosopis cineraria-Capparis decidua-Zizyphus uummularia.* At some places only *Prosopis cineraria* alone dominates. Flat plains with heaviers soils are dominated by *Salvadara oleoides-P. cineraria - Acacia nilotica* community. Plants of above plant communities provide valuable top feed for the livestock. The common associate to these plant communities in the flat interdunal plains are *Tecomella undulata* and *Balaniies aegyptiaca.*

The protected hills of sandstone and limestones with skeletal soil have Mixed Xeromorphic Thorn forest type of vegetation. *Acacia senegal-Grewia tenax* community is the most prevalent here. But similar sites without protection are represented by *Euphorbia caducifolia* community. Some well protected and semi-protected stabilized sand dunes also occupy similar vegetation type. The plant Communities are (i) *Acacia senegal–Maytenus emarginatus,* (ii) *Prosopis cineraria–Calligonum Polygonides* and (iii) *Maytenus emarginatus-Salvadora oleoides.*

Arong the river Luni and its tri-

butaries the water table is comparatively at shallower depth than the flat alluvial plains and available water is more. The natural vegetation supported by this major land resource unit is mixed Xeromorphic Riverine forest. The chief plant community is *Prosopis cineraria-Acacia nilotica-Salvadora oleoides.* Here the tree density and their growth is more than the adjoining resource units.

The lithophytic scrub desert type of vegetation is distributed on major land resource units like eroded rocky surfaces, gravelly plains, exposed pediments and piedmonts which are scattered throughout the district and are more concentrated in the eastern and northern part of the district. The most prevalent plant community on these units is *Capparis decidua* or *C. decidua-Zizyphus nummnlaria.*

Sandy undulating plains, sand dunes, interdunal plains and buried pediments support Psammophytic Scrub vegetation. The unprotected sand dunes are dominated by *Calligonum polygonoides-Panicum turgidum* or *C. polygonoides-Acacia jacquemontii* or *C. polygonoidas-Clerodendrum phlomoides* community. Sandy undulating plains invariably have a community of *C. polygonoides-Leptadenia pyrotechnica - Aerva psendotomentosa.* Saline depressions in the district have halophytic scrub type of vegetation. The plants are quite distinct and adapted on saline soils. *Suaeda fruticosa - Salsola baryosma* or *Haloxylon salicornicum-Sporobolus marginatus* commuuity are recorded on this unit,

The grass communities of the district covering sand dunes, sandy undulating plains, flat and undulating sandy plains are *Lasiurus sindicus-Cymbopogon jwarancusa* and *Panicum turgidum - Cenchrus biflorus.* Flat plains with sandy loam soils are dominated by *Eleusine compressa* and with heavier soil by *Sporobolus marginatus* grasslands. Cultivated sandy tract support *Cenchrus biflorus Eragrostis* sp. Hilly regions are invariably dominated by *Aristida funiculata* grasslands. *Oropetium thomaeum - Dactyloctenium sindicum* grassland are spread over rocky and gravelly surfaces, exposed pediment and piedmont plains.

4. 9. *Water resources*

The district has a reasonable surface water resource. In the south east the runoff finds its way into an integrated drainage system of the Luni River but in rest, major part of the district, the run off goes to ephemeral, short distance streams and gets absorbed in the aggraded alluvial plains. Much of this runoff is already under utilization by way of storage in reservoirs and *nadis* (village ponds). There are 10 reservoirs with a total storage capacity of 121.91 million cubic metres (mcm) and 292 medium and large nadis with a total capacity of 20.66 mcm.

Eisting surface water storage of Jodhpur Distt.

S. No.	*Tehsil*	Major and medium *reservoirs*		Medium and big *nadis*		Water need for human and live stock
		No.	Capacity MCM	No.	Capacity MCM	MCM
1.	Jodhpur	5	48.99	93	7.91	9.31
2.	Bilara	3	54 20	66	4.40	5.50
3.	Phalodi	1	8.76	42	2.54	4.23
4.	Shergarh	–	—	42	2.27	3.50
5.	Osian	1	9.96	49	3.54	4.73
	Total	10	121.91	292	20.66	27.27

Nearly forty per cent of the water stored in the '*nadis*' is amenable to evaporation and seepage losses. Therefore even when the '*nadis*' are full to capacity, these are table to meet only about 45 per cent of domestic needs being to the tune of 50 per cent in the south-eastern part and about 30 per cent in the rest major part of the district. Renovation not only for maintenance but also for increase of existing capacity can improve the situation to some extent. However, seepage and evaporation losses of stored water and inadequate catchment area of the nadis are the major limiting factors to be reckoned with.

There is considerable scope of harnessing the runoff which presently goes to recharge ill-defined aquifers. For this purpose 24 such catchments have been identified for construction of small earthen dams with the purpose of providing recharge to well defined aquifers and for bed cultivation. Details of these potential catchments are given.

Hydrogeological investigations reveal that potable ground water occurs in the coarse grained V ndhyan sandstone, limestone having solution cavities and Jalor granite having well developed angular joint planes specially when underlying alluvium. It is inferred that younger alluvium is by far the water potential formation followed by Jalore granite. older alluvium, Vindhyan limestone and sandstone. Where as the water potential of Malani volcanics, sandstone and the Aravalli slates is very poor. The south eastern part of the district comprising the river Luni and the Mitri basin has saline water. In about 2000 sq km area in central and northern parts, i.e. villages Dasania, Chandsama, Bora and Kapuria the Vindhyan sandstone forms the potential aquifer Vindhyan limestone covering an area of 500 sq. km in Borunda, Rangisaon, Chadi and Phalodi is cavernous at several places and associated with faults.

The depth to water ranges from 10 to 30 m in the south comprising of valley fill deposits to 60 to 110 m in the Vindhy-

yan sandstone and limestone. Depth to water is 5 to 10 m in southern and south eastern portions which is due to the presence of River Luni and Mithri.

Major portion of the district, i. e. about 9250 sq km falls under moderately saline zone having total soluble salts content ranging from 2.9 to 8.2 mmhos EC (2000 to 6000 ppm) whereas 7759 and 5455 sq km area falls under low, i. e. upto 2 9 and high, i. e. above 8.2 mmhos EC salinity zones respectively. Vindhyan sandstone and limestone are by far the best formations so far as irrigation is concerned. Water with low salinity has been recorded in isolated zones in the younger and older alluvium which are generally secondary water bodies overlying saline water areas.

The discharge observed from the dug wells, dug-cumbore wells and the tube-wells specially from the friable sandstone ranges from 23 to 45 cum/hour. But at places like Teori, Rampura and Birai discharge has been recorded upto 62. 92 and 25 cum/hour respectively. In limestone aquifer particularly at Borunda and Rangisaon the discharge ranges from 3,00 to 7,00 cum/hour and can stand regular draft for 18 to 20 hrs without any drawdown. In Phalodi and Shetgarh the discharge from friable sandstone varies from 12 to 13 cum/hour whereas in compact/consolidated sandstone discharge is from 1.5 to 2 cum/hour only In granites, rhyolites and aravallis the discharge is from 3 to 4.5 cum / hour whereas in younger and older alluvium specially near Pal - Doli Jhanwar area discharge varies from 0 8 to 10 cum/hour.

4. 10. *Land Use*

Considering the land records and revenue data for the years 1971 to 1975, an average of 50.9 per cent of the total area of the district is cropped. In addition 17.7 per cent and 13.1 per cent constitute short and long fallows respectively. Thus total area under cultivation comes to 81.7 per cent As against this permanent pastures plus the grazing lands and forest area form respectively 4.7 and 0.07 per cent only. Rest is made up of barren and unculturable land (6.43 per cent and lands not available for cultivation being under habitation, public utilities etc. (4.4 per cent). These data clearly show the dominant position that arable farming occupies in the land use. Culturable warte land, which infact is also open to severe limitation, occupies only 3.7 per cent. Therefore the situation is that almost the entire culturable land nas been brought under plough, though in a system of fallow farming. This picture has infact come into being over a decade ago, the trend since has been a reduction in area under long and short fallow with a corresponding increase in the cropped area.

Irrigated area in the district as per last available data (1974-75) is 0.84 per cent of the district. Therefore dry land farming is the rule. Land use survey showed that in the southern half of the district intensity of cropping is 60-80 per cent with lands close to village settlement being as high as 100 per cent. In the northern half including Shergarh the picture is variable. The duny complex

in Shergarh has cropping intensity of 50 to 75 per cent whereas further north in Ghantiali and Champasar in Phalodi, the intensity is 20 to 35 per cent and still less in far west in Baru. From Dechu through Kolu upto Phalodi proper in hard-pan soils, cropping intensity is 20 to 35 per cent only, the rest being mostly short and long fallows. In the western and northern part of Phalodi tehsil on gravelly plains cropped area ranges mostly between 7 to 20 per cent whereas 40 to 70 per cent is under long and short fallows put together.

4. 11. *Population characteristics*

As per last Census (1971) Jodhpur district has a population of 11,52,712 with 68 per cent being rural. Decennial growth rate has been over 30 per cent for the period 1951-61 onwards which is appreciably higher than that for the Rajasthan (28.4 per cent) or the country (24.7 per cent) as a whole. Amongst the workers 72 per cent are engaged in cultivation and 6.8 per cent are agricultural labourers. Trade, transport, manufacturing / household industry and other services account for respectively 5.3,4.1, 6.8 and 11.7 per cent.

4. 12. *Agriculture*

Agrieulture is by far the principal occupation which is essentially a mixed farming enterprise since most farming households maintain small size herds. Data for the year 1970-71 shows that 73.0, 21.1, 21.8 and 20.1 per cent of the holdings are less than 5, 5 to 10, 10 to 20 and over 20 hectares respectively. In this respect Jodhpur district is close to the pattern applicable for arid region as a whole. Amongst the crops *bajra* accounts for over 65 per cent of the area sown and *kharif* pulses nearly 20 per cent sesamum, *jowar* and wheat each occupy 2 to 6 per cent of the area. Yields of *bajra* in most years ranges between 1 to 4 q/ha and that of pulses from 0.6 to 1.5 q/ha. Prime cause of this is low level of management.

4. 13. *Livestock*

As per 1971 Census, livestock population (18,93,00) in the district exceeds the human population (11, 52, 712). Quinnenial growth rate for the period 1951 to 1956, 1956 to 1961, 1961 to 1965 and 1966 to 1971 has been 17.1, -0.06, 22.0 and 7.9 per cent respectively. Over the period there has been a considerable change in the composition of livestock. Whereas in the year 1951 cattle and sheep accounted for 32.1 and 45.0 per cent of the total livestock, in the year 1971 their proportion was 22.5 and 36.1 per cent thereby showing a distinct decline. During the same period proportion of goat increased from 16.6 per cent to 35.6 per cent.

MAJOR LAND RESOURCE UNITS (M.L.R.U.) OF JODHPUR DISTRICT

Major land resource unit, as defined in the report on Bikaner district, is an area of land with certain homogeneity of land form, soil, vegetation, land use and other features such as climate, water potential, biotic influence etc. which could respond to certain specified management practices for the purposes of development to upgrade production. Land attribute data collected in course of survey by the different subject matter specialists and interpreation of the same in terms of management needs and potentialiaties form the basis for establishment of the fourteen major land resource units in the district. Each MLRU has been described in respect of its land attribute, behavioural aspects, present productivity and major causes for present low level of production. Scope of improvement and suggested treatments are also given.

MLRU-Ju. 1. *DUNY COMPLEX*

1. *Extent and Locatton*

The unit occupies an area of 3536 sq km or 15.5 per cent of the district. It encompasses areas where dunes proper as a recurring feature cover 40 per cent or more of the surface with a narrow and irregular hummocky, sometime flat, interdunal space in between. Such of the dune bodies as lie isolated or separated by much larger interdunal space are not included in this. The latter are taken as part of the respective unit in which these occur though their location to the extent permitted by scale of mapping is shown on the final MLRU map. Major area of duny complex is in the Phalodi and Shergarh *tehsils*. In Phalodi, it lies to the east and north-east of Jambo right upto the border with Bikaner and then again in the western most part of *tehsil*. In Shergarh it occupies a large area from the southern most part upto Dechu and Pilwa. Another area lies to south west of Osian *tehsil* in Barla and Jelu.

2. *Villages covered* (See Appendix I)

3. *Geomorphic features*

The unit is composed of large, contiguous area of dunes and interdunes. Amongst the dunes parabolic type dominate though longitudinal, transverse, obstacle and barchan types are also found. The parabolic type of dunes are mainly coalesced, i. e. a number of longitudinal ridges parallel to wind direction are joined

together towards the leeward side by a crest transverse to the wind direction. The number of sandy ridges that have coalesced varies widely but in Shergarh it is mostly between 10 to 30 with coalesced crest being often 4 to 8 km long. There are few chains over 15 km long to the south-west of Chaba, west of Shergarh proper, north-west of Tena, and around Suwalia (all in Shergarh *tehsil*), around Chimana, south of Chàku, north of Kelansar and around Champasar (all in Phalodi *tehsil*). The height of transverse ridge over ground level on leeward side is often 15 to 40 metres though individual bodies as high as 60-80 metres are also come across as in Rihina, Bungri and Chadi villages. The slope of the crest is steep being 30-40 per cent. The leeward flank has slopes of 17 to 22 per cent whereas windward flank of sandy ridges is 5-8 per cent in the upper part and 2-3 per cent further down. Though dune body proper is stable, the dune flanks are varyingly covered with loose, wind sorted sand from surface reactivation which is a resultant of excessive biotic pressure. The thickness of these fresh sediments is 0.5 to 1 m, at limes in form of barchans. Leeward flank is almost entirely made of these loose sediments. The interdunes, the space between the bodies of coalesced dunes, are irregular in shape, often 2–3 km wide and of variable length. These are highly hummocky, undulating with longitudinal and transverse ridges and shrub coppice dunes of 2 to 5 metres height.

The longitudinal dunes, i.e. those parallel to prevailing south - westerly wind direction occupy sizeable area in the northern part of the district in Phalodi *tehsil* in villages Ghantiali, Jambo, Kelansar, Rupa - ki - Dhani and Mistri – ki – Dhani. These are also seen in Shergarh around Bhungari, Jethaniya and Pugalia where they occur mostly in interdunes between chains of coalesced parabolic dunes. These dunes are 0.5 to 5 km long and often 5 to 25 metres high with slopes of 20-40, 15-20 and 3-6 per cent for the crest flanks and windward sides respectively. The transverse dunes occur scattered to the west of Agolai in villages Dhandhaniya and Dudabera. The dunes are 10-40 metres high, 0.5 to 1km apart with hummocky interdunes in between. The slopes of the crest, leeward and wind ward flanks are 40, 24 and 8 per cent respectively. The *obstacle dunes* are found in the fore-ground as well as on the leeward side of isolated hills. The windward obstacle dunes in the form of longitudinal and semi-conical sand shields are piled immediately against the hills. At many sites the dune proper has been separated from the hill by gullies of 10-25 metres depth and 40-60 metres width. By far the major occurrence of these dunes is around outcrops in Balesar area. Isolated occurrence are seen also outside this mapping unit.

Shifting sand dunas of crescent shape, unlike the above, are contemporary formations resulting from localised, accelerated biotic interference. These do not occupy a sufficiently large area to be shown on 1:253,440 scale. There are seen as small chains or isolated bodies in the

immediate vicinity of village settlement. More prominent occurrences are seen in villages Raneri and Dholasar in Phalodi *tehsil*; in Kolau, Tena, Bhandu, Jeti, Dhandhaniya, Shergarh proper, Balesar and Belwa in Shergarh *tehsil*. The dunes are mostly 3 to 7 m high at the crest and the flanks have 8 to 14 per cent slope. These dunes are higher, being 3-14 metres near Phalodi proper.

The shrub-coppice dunes of varying height in form of low, longitudinal, transverse dunes or fence-line hummocks occur scattered in aggraded, old alluvial plains with light textured soils (MLRU 2) and these will be discussed in detail there.

4. Soils and land use capability

The soils belong to Dunes and Shergarh series. Both the soils are light yellowish brown, uniformly sandy, very deep and without any calcium carbonate concretionary zone. The soils contain 2.5 to 5 per cent clay, 1.5 to 3 per cent silt, 70 to 80 per cent fine sand and rest is coarse sand. Free alkaline earth carbonate ranges between 0.2 to 10.6 per cent but is mostly 0.5 to 2 per cent. Leeward side of dunes is almost entirely made up of loose sand and even the windward flanks as well as interdunes have masses of loose sand in form of hummocks and the area occupied by these is 40 to 70 per cent. The soils can retain 40 to 50 mm of moisture per metre depth. Fertility data shows that soils have between 0.04 to 0.15 per cent organic carbon, 8 to 15 kg of P_2O_5 / ha and 70 to 150 kg K_2O / ha. Lower values in the range are associated with fresh sand depositions. Dunes belong to capability class VI ec whereas interdunes to IV ec.

5. Natural vegetation

Under moderate biotic interference sand dunes proper have "Mixed xeromorphic thorn forest". However, such dunes are very few. By far the common picture is one of "psammophytic scrub desert" because of severe biotic pressure. Most frequent plant communities encountered on these dunes are :

Acacia senegal-Calligonum polygonoides : This community is invariably recorded on high to medium size coalesced parabolic dunes in Shergarh area. *Acacia senegal* has a high density (15-20 plants/ ha) on leeward side while *Calligonum polygonoides* dominates on the crest and flanks.

Calligonum polygonoides – Cleroden-drum phlomoides : This community is prevalent on stabilized parabolic and transverse dunes 10-15 m high in Osian and northern part of the district, i. e. in Jambo, Ghantiali and Champasar area. The low dunes (5-10 m) however, are covered with *Calligonum polygonoides-Panicum turgidum* community.

Beside these, other communities found in the district are :

Prosopis cineraria - C. polygonoides community on well stabilized longitudinal and transverse low dunes.

Maytenus emarginatus - Salvadora oleoides on medium high stabilized longitudinal and parabolic dunes. *M. emarginatus* occupies higher slopes of the flanks and windward side while *S. oleoides* grow on

middle slopes. Here the natural vegetation is quite disturbed due to cultivation.

Acacia jacquemontii - A. senegal community recorded on the obstacle dune, formed near the hillocks. They are well stabilized with *kankar* nodules lying on their top. *A. Jacquemontii* is more prevalent on the slopes while *A. senegal* on the crest.

Crotalaria burhia - Sericostemma Pauciflorum - Leptadenia pyrotechnica community is also recorded on the dissected hill side dunes.

Common associates on different aspects of the dunes are .

(a) Dune crest - *Panicum turgidum, Cymbopogon jwarancusa, Panicum antidotale, Aerva pseudotomentosa, Citrullus colocynthis, Cyperus arenarius, Farsetia hamiltoni, Crotalaria burhia,* (b) Dune slopes - *Clerodendrum phlomoides, Acacia jacquemontii, Calotropis procera, Maytenus emarginatus, Lasiurus sindicus, Salvadora oleoides, P. cineraria, Crotolaria burhia, Cenchrus biflorus, Aristida funiculata, Cyperus arenarius* and *Citrullus colocynthis,* (c) Dune base- *P. cineraria, T. undulata, Leptadenia pyrotechntca, Aerva persica, Indigofera cordifolia, I. trigonelloides, Aristida funiculata, Cenchurs biflorus, Farsetia hamiltonii, Gisekia Pharnacoides, Polycarpea corynmbosa & Molluga* species.

Barchan dunes are devoid of any vegetation. However, in some cases countable plants of *Cyperus arenarius, Aerva persica, Citrullus colocynthis* and *Tribulus terrestris* are present. Interdunal flat are dominated by *Prosopis cineraria-Salvadora oleoides* community to the east of Jambo and to north of Shergarh. In the rest *Prosopis cineraia - Tecomlla undulata* community is common. The shrubby associates of these two communities are *Mimosa hamata, Lycium barbarum, Leptadenia pyrotechnica, Calotropis procera, Clerodendrum phlomoides* and *Acacia jacquemontii.* The plants of ground vegetation are *Aerva pseudotomentosa, A. persica, Lasiurus sindicus, Cymbopogon jwarancusa, Indigofera cordifolia, I. linifolia* and *Aristida mutabilis.*

The space between the dunes proper has a somewhat different spectrum. Here a community of *Calligonum polygonoides-Zizyphus nummularia, Calotropis procera* is quite common. Few scattered associated trees (1–5/ha) of *P. cineraria* are also encountered. The ground flora is sufficiently rich during monsoon which includes grasses and weeds like *Eragrostis ciliaris, E. tenella, E. tremula, E. poaoides, Eleusine compressa, Latipes senegalensis, Cenchrus biflorus, C. prieurii, C. ciliaris, Aristida juniculata, A. mutabilis, A. adscensionis, Lasiurus sindicus, Cymbopogon jwarancusa, Tribulus terrestris, Gisekia pharnaecoides, Polygala erioptera, P. chinensis, Pulicaria wightiana, Convolvulus microphyllus, Indigofera linifolia, I. cordifolia, Citrullus colocynthis, Euphorbia granulata, Tephrosia purpurea* and *Cyperus rotundus.* There is clustering of few under shrubs in this habitat i e. *Aerva pseudotomentosa, Leptadenia pyrotechnica* and *Mimosa hamata.* These species make small colonies and being nonpalatable, show good gorwth.

Shrubs and grasses provide 140 to 1300 kg/ha of forage (air dry basis) but the dominant range in an average rainfall

year is 300 to 450 kg/ha. Tree species provide in addition 25 to 40 kg/ha.

6 Present landuse

Seventy to 95 per cent of the area is under cultivation though in a system of fallow farming. On an average 50 to 75 per cent area in Shergarh and 20 to 35 per cent in Pariyal Ghantiali-Champasar in Phalodi is cropped. Normal practice is that interdunes and lower part of the flanks are cultivated fairly regularly where as dunes proper are cultivated for 2-3 years and then left fallow for 3 to 5 years, Interdunes are cropped with *bajra* alone or in mixture with moong and moth. Some area is also under til in a similar mixture. Dune flanks are generally cropped with a mixture of bajra and moth.

7. water resources

(a) *Surface water* : Hydrological characteristics of the unit are very poor from point of surface water resources. The run-off is very small, and it is only once in 3 to 4 years when run-off of some significance occurs. But even this is soon lost because of high deep percolation losses. Only way of bulilding up surface is through paved catchments.

(b) *Ground water* : The unit is composed of wind-worked sediments overlying older alluvium and Vindhyan sand-stone. There is considerable variability in the depth of occurence as well as quality of water. In Shergarh, to the south of Sukhiatala in villages Raisar, Garha, Bhongra, Khariana, Tena, Timri, Sai and Shergarh, ground water occurs at 30 to 45 metres and is brackish (mostly 2 to 3 mmho EC, 16-18 SAR). Dug-wells have meagre to low discharge, but tube wells yield, 15 to 40 cum/hour. In southern most part water is somewhat saline (3 to 6 mmhos EC) wheras in the west in Dhasania, Suwalia and Chaba though water table is closer, (25-35 m), salinity is very high (15 to 25 mmho). Further north in Khiasaria, Asarlai, east of Burkia and west of Dechu, water table fluctuates between 40 m in the east to 20 in the west. Water here is only brackish (mostly 1.5 to 3.5 mmhos) and discharge of tube-wells is also good (40-70 cum/hour)

In northern area of its occurrence, i. e. Phalodi *tehsil*, static water level is deep (60 to 90 m) and quality variable. In Jambo and Motai and Ghantiali it is saline (5 to 8 mmho EC) but in Chaku, Chmana, Kelansar and Jeslau, it is sweet to brackish (0.7 to 2.0 mmho EC).

8. Resource assessment

The unit lies mostly in the 250-300 mm rainfall belt and therefore is not so favourably placed in comparison to the district as a whole. It has a hummocky to duny relief and highly wind erosion susceptible, loose, structureless soils. Under the present fallow-farming usage the lands give an average 1.5–2 q/ha of *bajra* or 1 q/ha of pulses or moderate grazing amounting to 15 to 30 per cent of what is possible under optimally managed pastures. What is more the land use is leading to an acceleration of wind erosion problem.

Strict soil conservation considerations require that whole of this unit be

brought under a scientifically utilized permanent vegetative cover. However, looking to the bias of the people and strong arable farming based economy, implementation of such a programme will have many problems Therefore what is suggested is a compromise where only the high hummocks and dunes proper, i. e. the more vulnerable areas, are brought under permanent vegetative cover. Cultivation can go on in the interdunal area, and perhaps on regular basis with improved agronomic and soil conservation technology. Happily this will not involve any large change in the actual cropped area. For example in Shergarh this change will mean a reduction in actual cropped area of 10 to 18 per cent only from the present level of 50 to 75 per cent. The interdunes where cultivation can go on constitute here 40 to 60 per cent. The suggestion therefore is for a spatial differentiation of land use, i.e. concentration of cultivation in less vulnerable interdunal area and permanent vegetation cover with utilization on dunes and high hummocks.

The lands can support good pastures but looking to soil andclimatic conditions ideal combination would be grasses, shrubs and fodder trees or a silvi-pastoral system. Shrub and trees will provide the green supplement and the grasses the major subsistance. This should permit upgrading the forage production from the present level of 200-450 kg/ha to 750 to 1200 kg/ha in the rainfall belt of 200 to 300 mm from the third year of establishment. This production under rational utilization should enable maintenance of 20 to 35 adult cattle units per 100 ha. In Shergarh the eastern part of this unit has considerable undergrcund water potential. This should allow digging of about 20 tube-wells of 15 to 40 cum/hour discharge. Instead of raising conventional field crops, the resource should be utilized in raising fodder crops to meet the need of improved dairy cattle. With the above potential about 80 ha can be so commanded

Arable farming productivity as stated above is low. Main reasons are low plant population, less efficient varieties and rather low fertility of the lands. Present practice of mixed cropping, though having some advantages, does not lend itself to use of improved technology.

9. *Suggested treatments*

(i) Re-structuring of present landuse to bring high hummocks and dunes under silvi-pastoral management and restricting arable farming to interdunes only.

(ii) Establishment of silvi - pastoral management should require fencing of the area into paddocks for rotational controlled grazing, reseeding at the rate of 5 - 7 kg/ha with a mixture of *Cenchrus ciliaris, Lasiurus sindicus* and *Cenchrus setigerus.* Associated with this should be a phased programme of top-feed tree plantation comprising *P. cineraria, A. senegal, A. tortilis* to give an over all stand of 40-60 trees/ha. Besides these, shrubs like *Z. nummularia, A. jacquemontii* and *C. polygonoides* be given a prominent place to the extent of

10-15 per cent of the total cover. Grazing should be controlled to about 70 per cent utilization to permit continued good productivity from lands. Further in order to maintain good dairy cattle, patches of irrigated forage be developed. There is scope for digging about 20 tubewells of 15 - 40 cum/hour discharge. After meeting domestic requirement, these should allow 80 ha to be brought under irrigation. A scheme for having green forage all the year round is given in the section on technology.

(iii) Arable farming in the interdunal space should be accompanied by intense soil conservation measures namely :

(a) Wind strip cropping i.e. crops and grasses be grown in alternative strips running from south-east to north-west i e., across the prevailing wind direction. Recommended parttern is 5 m of *L. sindicus* + *C. ciliaris* strip and 25-30 m of crop strip.

(b) Field bunding reinforced with *arni (Clerodendrum phlomoides)*, murali *(Lycium barbarum)* and *ak (Calotropis procera)*.

(c) Stubble mulching : At time of crop harvest *bajra* stubble of about 45 cm height be left standing on the ground.

Besides these improved dry farming practices like legume-cereal rotation, row planting, interculture, use of improved varieties and increased use of organic manures be followed.

MLRU-Ju. 2 HUMMOCKY AGGRADED PLAINS WITH LIGHT TEXTURED SOILS IN ASSOCIATION WITH DUNES

1. *Extent and Locotion*

This resource unit occupies an area of 4316 km^2 or 18.9 per cent of the district. It occurs scattered all over but is most extensive in Phalodi tehsil and lies on either side of the duny complex in the western half along the border with Jaisalmer. It is dominant also in the western half of Osian, northern part of Shergarh, eastern part of Jodhpur and central part of Bilara tehsils.

2. *Villages covered* (See Appendix I)

3. *Geomorphic features*

This plain had initially been created by fluvial action but later on the surface got overburdened by fine sands in form of dunes,hummocks and sand sheeting. Freqency and relative area occupied by dunes within the unit varies. In Dechu, Pilwa, Nathrau, Samrau, Bher, Bhikamkhor, Khetasar and Gheura the dunes proper (as can be seen from accompanying MLRU map where position of major dunes and dune chains is shown) occupy 25 to 35 per cent of the area whereas north of Chirai and chamu they occupy 15-20 per cent These dunes are coalesced, parabolic type, 20 - 40 metres high and occur as chains of 2 to 10 km length interspaced by hummocky plains. Elsewhere within the mapping unit occurrence of such high dunes is a rarity. Instead found are longitudinal and transverse dunes and fence-line hummocks. In Janadesar and Chincharli (Jodhpur tehsil) the dunes are 10-20 metres high and closely spaced But in rest of the area these are 6-10 metres high and 0.5 to 4 km long. In Palina, Motai, Bheeyasar, Kelansar, Champasar (Palodi tehsil) dunes are few but high hummocks (2-5 m high) are very common. Similar is the situation also in Kuri, Kheri Salwo and Salwo Khurd, Devatra (Bilara) and Lord - Jaliali (Jodhpur tehsil).

General slope is negligible but in-field slopes due to hummocks and dunes are dominantly 3-5 per cent with relatively flat areas in between.

4. *Soils and land use capability*

This mapping unit is made up of very deep, light textured soils belonging to Chirai series hummocky phase in association with dunes The soils have a light brown wind sorted sandy surface, mostly 20 to 70 cm thick underlain by a pale brown to yellowish brown, moderately calcareous (1.5-7 percent CaCO3), weakly-aggregated loamy

sand (6 to 10 per cent clay, 4.5 to 7 8 per cent silt). This is followed by a weakly developed lime concretionary layer at 90 to 140 cm. This layer is no limiation for penetration of roots and moisture and, therefore, the soils behave as very deep. Only in part of villages Dholasar and Palina (Phalodi) is this layer strongly developed and also gypseous. Land surface is undulating because of in-field and fence-line hummocks Some variation is seen in degree of hummockiness. In Uttambar, Agolai and Nathrau (Shergarh *tehsil*), in Bastua, Champasar, Kelansar, Shajon - ki - Dani, Chimana (in Phalodi *tehsil*), Samrau, Bhikamkor in Osian, south of Burchhan and Artia Kalan/ Khurd, Kheri Salwo, Ramarawas Kalan, east of Rathkuria and north of Sagriya Kalan (all in Bilara *tehsil*) area occupied by hummocks is 25-40 per cent and therefore highly undulating. In rest of the area, it is mostly between 15 to 25 per cent. Associated dunes are entirely sandy-similar to the ones described in MLRU 1,

The Chirai series hummocky phase soils can retain 50–80 mm of moisture per metre depth whereas associated dune soils only 40–50 mm. Fertility status of the soils shows 0.04–0.14 per cent org. C., 12–18 kg av. P_2O_5/ha and 75–150 kg. av. K_2O/ha.

The soils have a very loose, structureless, sandy surface that is highly susceptible to wind erosion. At times even standing crops are adversely affected due to burial of exposure of seedlings. Moisture retention is low. Because of these adverse features and the need for fairly intense wind erosion control measure, the soils are classified as IV ec. Associated dunes, of course belong to Class VI ec.

4. *Natural vegetation*

Two vegetation types viz. "Mixed xeromorphic woodland" and "psammophytic scrub desert" are generally encountered in this unit. Former is confined only to southernly located, 300-350 mm rainfall zone while the later is quite extensive. Woodland community is made of *Prosopis cineraria– Z. nummularia,* whereas within psammophytic scrub the following are recognised :

1. *Zizyphus nummularia – Calligonum polygonoides* community
2. *Acacia jacquemontii – Lycium barbarum – C. polygonoides* community.
3. *Haloxyton salicornicum, Capparis decidua* community, found in the north western part of the district. *Haloxyton* appears in this part and continue in the west, i.e. Jaisalmer district.

Shrub, undershrubs and herbaceous associates of these communities are *Clerodendrum phlomoides, Leptadenia pyrotechnica. Mimosa hamata, Aerva pseudotomentosa, A. persica, Calotropis procera, Tephrosia purpurea, Lasiurus sindicus, L. ecuadatus, Cymbopogon jwarancusa, C. parkerii, Cenchrus biflorus, C. prieurii, Aristida funiculata, A. mutabtlis, Indigofera linifolia, I. cordifolia, I. trigonelloides, Citrullus colocynthis, Tribulus terrestris, Cyperus arenarius, Polygala erioptera* and *Boorharia diffusa.*

Plant density, cover and forage yield

within the unit are highly variable. Top feed species provide between 60 to 150 kg/ha of dry forage (dry weight basis) whereas grasses and shrubs with a basal cover of 2.5 to 4 5 per cent yield on an average 460 to 520 q/ha of air dry forage with large inter annual variation.

6. *Present land use*

There is some variation in the land use due to range of climatic conditions prevailing within the unit. In Salwo, Burkia, Rathkuria, Bhandhana and adjoining villages in Bilara *tehsil* and in Jhanwar, Chincharli, Hingoli, Bambor etc. (Jodhpur *tehsil*) almost entire area is under cultivation though in any particular year only 60 to 70 per cent of the area is actually cropped. In Nathrau, Samrau, Pilwa area and then again in Au, Chadi, Bhogasar area in Phalodi, the cropped area is 30 to 50 per cent. More hummocky lands have a cropping intensity of 40 to 60 per cent whereas the high dunes occurring in the unit have intensities of 25 to 40 per cent in the Pilwa area and 15 to 20 per cent in Au, Chadi area. In Jambo, Chakkoo, Seer Malam Singh (Phalodi) cropping is 20 to 35 per cent only. Here most dunes are generally uncultivated. In Jodhpur *tehsil* *bajra* and *moong* are dominant whereas in the rest these are grown in mixture with *moth* or *guar*.

7. *Water resources*

(a) *Surface water* : Soils in this unit have high infiltration rate and therefore have low surface water potential. It is only with good antecedent moisture condition in soil profile followed by wet spells of over 50 mm that some runoff occurs. Such wet spells of 50 to 100 mm and over 100 mm occur about twice in three years and once in 5 years respectively in Shergarh and Phalodi. Corresponding figures for Jodhpur proper are once a year five times in 7 years respectively During these heavy to very heavy wet spells 2 to 5 per cent and 5 to 10 per cent of rain may go as runoff. However, this run-off does not travel more than 50 to 100 metres and gets soaked in the immediate vicinity. There are 59 medium and big sized nadis and six more nadis can be had. Construction of *tankas* requires treatmants of catchment with murum.

(b) *Ground water :* In northerly occurrences of this unit i.e. in villages Champasar, west of Jelsar, Nakhra-ki-Dhani, Ghantiali, south of Kelansar, Shajon - ki - Dhani and Ranisar groundwater occurs in old alluvium and underlying coarse and friable Vindhyan sandstone and in solution cavities of limestone. Available water is only brackish (2.5 to 3.5 mmho EC, SAR 6-9) though deep (60–100 m). Exception is Bhiansar and Munjasar where it is salide. Further north in Jambo, Luna and Lumbasar also water is saline (5 to 8 mmhos EC). In the extreme west in Bharu, Tekra. west of Dedasri upto Bhurg waters are brackish (2.5 to 5 mmhos EC) but further north in Kanasar, these are saline. Depth to water every where is 50 to 70 m. In the southern part of the *tehsil* is 60 to 90 m and only slightly brackish (1.5 to 2.5 mmhos EC).

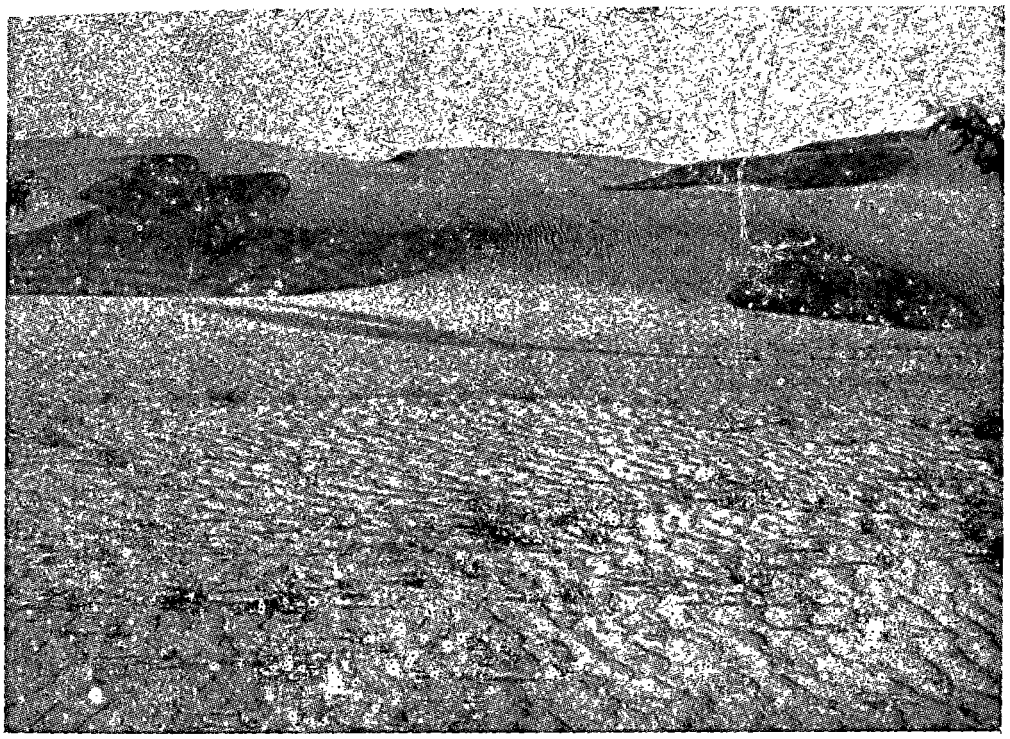


Plate 1. MLRU–Ju. 1. Duny complex. Presently the inter-dunes and a major part of dune body are under cultivation. To minimise the problem of wind erosion and for a sustained productivity, the dunes proper be brought under silvi-pastoral system. Inter-dunes can continue to be cultivated but with intense soil conservation measures.

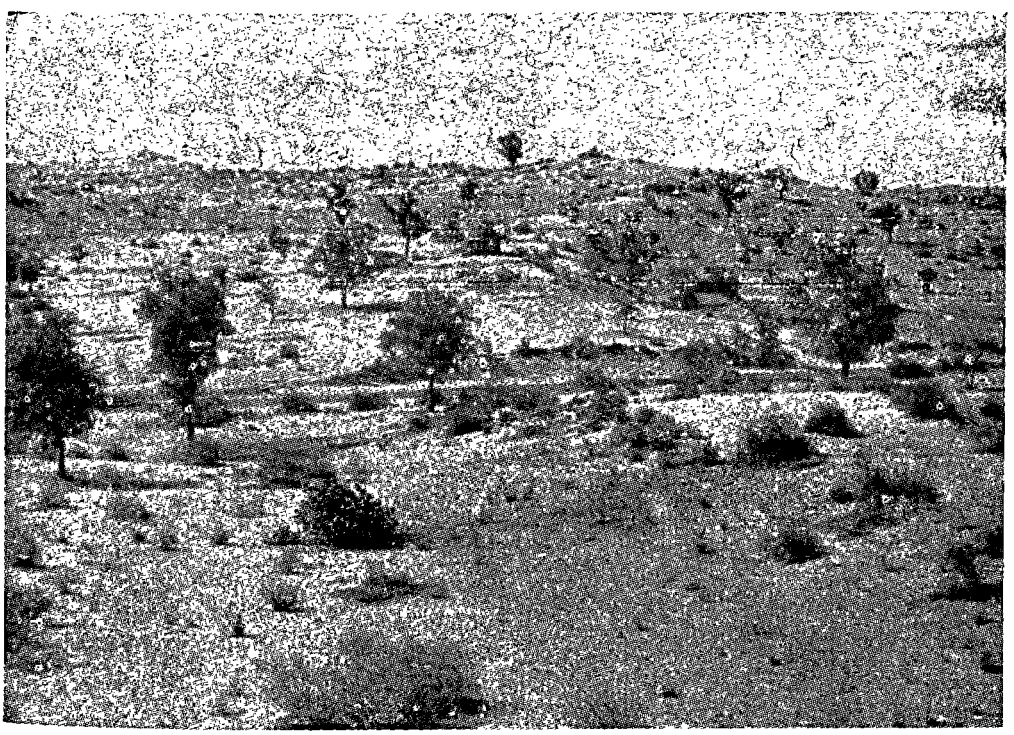


Plate 2. MLRU–Ju 2– Hummocky aggraded plains with light textured soils in association with dunes. Arable farming here requires adoption of intense wind erosion control measures.

In Pilwa, Bhojasar, Binjal, Bher, Dayakor static water level is 40 to 60 m and brackish (2.5–4 mmhos EC, SAR 6–10).

In Shergarh tehsil in Chamu, Diatu, Hapa, Bhalu, Diwaniya, Barnau, Nathrau, Gilankor, Lorta, Kanodia and Lawania groundwater occurs in pinkish white to reddish medium to coarse grained, well bedded Vindhyan sandstone at depths of 30 to 40 m and is brackish (1.5 to 3.8 mmhos EC 3 to 12 SAR). Similar situation prevails further south in Shetrawa, Jethaniya, Samarau, Asarlai, Dechu, Nimbla - ka - Dhora, Burkia, Untwalia and Kalan.

In the area of occurrence of this unit in Jodhpur *tehsil* in Keru and Beru water is at 10 to 15 m but of variable quality i e. in the area of direct recharge, it is 1.5 to 2 mmho EC but in rest 2 to 4 mmhos EC. Further south in Karani, Barli, Moklao and then again in Rohila Kalan, Bhujawar in immediate vicinity of pediments groundwater occurs at 20 m and is only slightly brackish (1 to 2 mmhos EC.) Further down in Jhanwar, Doli, Gangana, part of Pal, Boranada and Narnadi static water level is deeper (35 to 45 m b.g.l) In Bhambhor, Papawas and Puniya-ki-Piao and Jatiad water is highly saline (10 20 mmhos EC.)

In Sagria, Salowo Kalan, Kher Salwo, Rathkuria, Bara Beotian, Ramra was Kalan and Khara ground water is level at 20 to 40 m and somewhat saline (4 to 6 mmhos EC, 15–20 SAR).

8 *Resource assessment*

The unit is made up of deep, poorly aggregated, light textured soils with a loose, structureless, wind sorted sand layer in form of sheet and hummocks of the surface. The soils are susceptible to severe wind erosion hazard under prevailing practice of arable farming without soil conservation practices or open uncontrolled grazing. The lands belong to land use capability class IV ec and associated dunes to class VI ec. Inherent fertilty status of soils is sufficient enough only for a very moderate plant production and is there fore not adequate to take advantage of favourable rainfall years. The unit is spread over a larage range (370–220 mm) of mean annual rainfall. Analysis of past rainfall record shows that in the 300 to 370 mm rainfall, i. e. in the belt from Agolai through Jodhpur proper upto Salwo Kalan climatic conditions perimt good and average crops in about 45 Percent and 25 Percent of the years respecetively. In 30 Percent of years crops are poor or tend to fail. Wheras north and north-west of this in Phalodi, Shergarh and Osian *tensils* good and average crops are possible in 33 and 18 Percent of the years. North of Jambo and in extreme west, corresponding figures are respectively 25 Percent and 15 Percent only. Despite this by far a major area is under cultivation though actual cropping is done on an average in 60-70 per cent of the area in 300-370 mm rainfall belt, in 30-50 per cent in 250-300 mm zone and 15-30 per cent in below 250 mm rainfall belt.

Present productivity from these lands is low and averages 2–3 q/ha of *bajra* or 0.6 to 1,2 q/ha of pulses. Fallow lands provide 460 to 550 kg/ha of air dry

forage. An analysis shows that the prmie reasons for poor farm production are low crop plant population and preponderance of less valuable plants. The latter provide some forage but their competition with crop plants for moisture and nutrients seriously affects grain yields. Other factors are (a) use of less efficient varieites, (b) absence of plant protection and fertilizer inputs, (c) cultivation on marginal lands i.e. high hnmmocks and dunes and in below 250 mm rainfall zone, (d) the present pratice of fallow-farming despite its merits is far from efficient. Therefore considerable improvement in management is required. The suggestions are.

In the area receiving more than 250 mm mean annual rainfall, cultivation in a mixed farming system can continue. However, cultivation should be confined to low hummocky and inter hummocky space only. These may be farmed regularly in place of present fallow farming. High hummocks and dunes should be taken out of cultivation and brought under permanent silvi-pastoral management. In doing so it is necessary that besides dry farming practices like improved varieties, row planting, inter culture, use of fertilizer etc. as mentioned for MLRU 3. Intense soil conservation practices be followed. These include stubble mulching, strip cropping and field bunding. In areas receiving above 300 mm rainfall scope evists even for a strategic use of fertilizer. This would still allow the present incidence of cultivation. The suggestion therefore is to intensify conservation cropping on relatively plain lands and to leave out more vulnerable spots. Improved dry farming technology has scope of easily doubling the present yield level.

Area below 250 mm, i. e. north of jambo and east of Kelansar and Dedasri shoud not be cultivated because climatic condition do not permit satisfactory crops even once in two years. These lands should therefore be brought under silvi-pastoral management. Under improved management such as listed in MLRU 1, these lands can give an average of 5 to 8 q/ha of dry matter. This swould permit maintenance of 25 to 40 adult cattle units per 100 ha.

Ground water potential within the unit is variable. In most situations water quantity and quality are good enough to meet the domestic requirement. Besides, few areas have sufficient surplus to provide some irrigation. These are Jethania, Shetrawa, Asarlai, Kalau, Untwalia, Chamu, Diatu, Samrau, Chirai, Nathrau Lorta (all in Shergarh). Water occurs here at depths of 30-40 m. b. g. l. and fifty to sixty tube wells of 25 to 60 cum/ hour capacity can be dug with the available potential. This could be used for conventional cropping but a better proposition would be to use it for raising forage crops to meet the need of improved dairy cattle. With the potential generated an area af 700 ha can be brought under irrigation for conventional crops or 200-250 ha under forage crops.

9. *Suggested treatments*

(i) Arable farming be practised only in the tract receiving above 250 mm

mean annual rainfall. The rest be brought under permanent silvi-pastoral cover.

(ii) Even in the tract qualifying for the purpose, arable farming be restricted to less hummocky and dunes occurring here also need permanent vegetative cover with silvi-pastoral management.

(iii) In place of present less efficient fallow farming system, regular farming be adopted on lands recommended for the purpose. However, this should be accompanied by adoption of intense soil conservation practices like stubble mulching, strip cropping, field bunding reinforced with vegetation and increased stand of *Khejri* trees as listed for MLRU 1.

(iv)' Mechanisation of sowing and inter-culture operations. Present technology with animal power is unable to cope up with sowing needs during highly restricted favourable period. Besides, the resulting crop stand is poor and dominated by less useful natural vegetation as the situation does not lend itself to mechanical weeding. Tractorisation of the operations is therefore highly desirable.

(v) Use of improved farming practices like legume cereal rotation, short duration efficient varieties as listed in MLRU 3.

(vi) Establishment of silvi-pastoral system on high hummocks and dunes as detailed in MLRU 1.

(vii) Increased exploitation of underground water as indicated in resource assessment. The potential so generated should preferably be harnessed for raising irrigated crops for improved dairy cattle.

(vii) Increased exploitation of under ground water as indicated in resource assessment. The potential so generated should preferably be harnessed for raising irrigated forage crops for improved dairy cattle.

MLRU- Ju. 3 FLAT AGGRADED PLAINS WITH LIGHT TEXTURED SOILS AND OCCASIONAL DUNES

1. *Extent and location*

This resource unit occupies an area of 3629 sq km or 15.9 per cent of the district. Its major areas of occurrence are : (i) East of Phalodi proper, i. e. in villages Moria, Au, Chadi, (ii) North and north west of Osian proper right upto border with Nagaur district, (iii) South of Jodhpur proper upto Luni river. Minor areas occur scattered throughout the district.

2. *Villages covered* (See Appendix I)

3. *Geomorphic features*

The unit comprises flat, old aggraded alluvial plains only moderately modified by wind action. Occasional to few dunes do occur. Prominent bodies of dunes within this unit are shown on the northern and central port of area of occurrence of this unit, notably in villages Hathundi, Tapu, Thob, Bara, Parasla, Matora, Nosar (all in Osian *tehsil*) and Cherwai, Gopalsar and Knudiala (in Shergarh *tehsil*) high dunes cover 10-15 per cent of the area. The dunes are coalesced parabolic type with crest height of 15-35 metres and 0.5 to 4 km length. But for these dunes, the area is plain with only slight to moderate hummockiness. Localised occurrence of relatively hummocky areas are seen in immediate vicinity of dunes, as also in villages Au, Barjasar, Moria (Phalodi *tehsil*) Danwro, east of Hardhani, east of Kharda, Bara Mara, east of Baori and around Melana (all in Osian *tehsil*) and in Bara, Jajiwal Kalan Bhatian (Jodhpur *tehsil*). The area occupied by hummocks here is 15-20 per cent but elsewhere it is mostly 5-10 per cent and limited to fence lines. The height of these hummocks is 0.7 to 1.5 metres.

4. *Soils and land use capability*

This mapping unit is made up of deep to very deep soils belonging to Chirai series normal phase together with few dunes and Pal series. Soils in Chirai series have a light yellowish brown to pale brown, sandy surface followed by a yellowish brown, weakly blocky loamy fine sand sub-soil. Pal series have a reddish brown tinge with a sandy to loamy sand surface and a loamy sand to sandy loam sub-soil. In the two soils clay and silt content in surface layer

range between 5-9 per cent and 2 5-7 per cent, respectively, whereas in sub-soil those are 6 to 12 per cent and 4.5 to 14 per cent, respectively. At depths generally of 80 to 120 cm there is a weakly to moderately developed zone of calcium carbonate connections with or without gravels. At some places together forming 5 to 7 per cent of the area of this unit, this strata is somewhat strongly developed and also closer to surface. Sizeable extent (50-100 ha) of such areas is in villages Chandrok: Gingala, Hathundi, Tapoo, Kapuria, Biloka, Bapani (all in Osian) in Banar, Gujarawas, Khokhariya, Roheecha Kalan (all in Jodhpur *tehsil*). The soil surface invariably has a thin veneer of loose sand. Hummocks and dunes as described elsewhere are sandy and contain 2.5 to 5 per cent clay and 1.5 to 2.8 per cent silt.

Most of the soils have a moisture retention capacity of 75 to 110 mm in metre depth except for dune soils which retain only 40-56 mm. Organic carbon content ranges between 0.08 per cent to 0 35 per cent, available phosphorus between 12 to 24 kg P_2O_5/ha and potassium between 100 to 250 kg K_2O/ha Associated dune soils as described in MLRU 1 have lower fertility status.

The soils have satisfactory moisture retention characteristics and depth to permit good growth of climatically adapted crops. Their fertility status is also fairly good though not sufficient enough to meet crop requirement during favourable rainfall years.[1] The surface layer is only slightly to weakly aggregated and therefore erodible. In fact under prevailing farming practices without conservation measures, there is a significant incidence of erosion. The lands therefore belong to class III ec. Associated dunes are in class IV te.

5. *Natural vegetation*

The most prevalent plant community is *Prosopis cineraria-Zizyphus nummularia-Capparis decidua* with a density mostly of 5-15, 150-250, and 30-70 plants per ha, respectively. Associated shrubs, and trees are *Azadirachta indica, Indigofera tinctoria, Lacium barbarum, Crotolaria burhia, Calotropis procera, Prosopis juliflora, Tamarix articulata, Indigofera oblongifolia* and *Salvadora oleoides*. Grasses and forbs are *Dactyloctenium sindicum, Dactyloctenium aegyptium, Aristida adscensionis, Eleusine compressa, Cenchrus biflorus, Tephrosia purpurea, T. villosa, Indigofera hoschtellori, Pulicaria wightiana, Digera muricata* and *Cyperus rotundus*.

Forage yield within the unit is highly variable and depends on the amount of rainfall, length for which the land has remained fallow and the number of top-feed species. The yield from top feed species ranges between 75 to 450 kg/ha with a mean around 120 kg/ha and that from ground flora with a basal cover of 2.8 to 5.3 per cent from 350 to 800 kg/ha.

6. *Present land use*

By far a major part of this unit, is under regular cultivation. On an average 60 to 80 per cent of the flat plains are cropped. Only in exceptionally poor rainfall years cropping may fall to 40 to 50

per cent. Dunes occurring within the unit are also largely cultivated with a cropping intensity of 30 to 40 per cent. In the Luni Block, *bajra* and *moong* area very common whereas in rest besides these *guar, moth* and *til* also occupy a large acreage. Dunes are cropped mostly with *bajra* and *moth.*

7. *Water resources*

(a) *Surface water* : Like MLRU-2 this unit is also made of light textured soils with high infiltration rate but because of some surface crusting and only a thin veneer of loose sand, run-off is somewhat higher. It is estimated that in area of this unit around Jodhpur proper during wet spells of over 100 mm such as occur on an average little less than once a year, about 10 to 15 per cent of the rainfall is liable for run-off. With spells of 50 to 100 mm run-off is even less. In Osian, Shergarh and Phalodi such wet spells are fewer than Jodhpur. Therefore overall the runoff potential is low. The amount of ruu-off is such that field bunding is able to take care of it. Presently there are 68 big and medium sized *nadis* and six more *nadis* can be constructed.

(b) *Ground water*

There is considerable variation in depth of occurrence as well as water quality. In Moria, Denog, Barjansar, Au, Chadi and Ridmalsar (Phalodi) ground water occurs in solution cavities of limestone, with static water level is at 70 to 80 m b g.l. and is brackish (1.5-3.0 mmhos EC). Near Jalora, west of Lohawat and Chila, ground water is encountered in Vindhyan sandstone. Here the water table is as deep but the water quality is even better (0.8-1.5 mmhos EC).

In Osian reddish Vindhyan sandstone, generally medium to coarse grained, gritty, at places intercalated with shales is the main aquifer. Here in northern part, i. e. in Hathundi, Athob, Gingala, Sili, Chandrok, Godoran-ki-Dhani, static level is 30 to 60 metres b.g.l. whereas further north in Tapu, Ramala, Kapuria, Khabria, Barsalu, Palasla, Karwa, Bapini, Jakhan, Norsar, Pali, and Someta and Motera it is deeper (60-120 m). But water in both the areas is sweet to somewhat brackish (0.8 to 2 2 mmhos EC; 4-12 SAR) only. In Panchla, Grigali Chandalia, Chirwai, static water level is still shallower (20 to 30 metres). In parts of Bhawad, Auwana, Danwro and Khudiala static water level is only 15-20 metres b.g.l. with EC of 2 0 to 3.5 mmhos and SAR of 6 to 12.

In Jodhpur *tehsil* in Thabukara, Godarni, Asarnada, Jajiwal, Banar, Jaleli, Nandra, Pithwas older alluvium is the potential aquifer. Static water level ranges between 5 to 15 metres b.g.l. but water is saline to highly saline (8 to 15 mmhos EC, SAR 16 to 34 with residual carbonate mostly less than 5 me/l). In villages Bawarlo, east of Digari, Nandri, west of Dewalio and eastern side of Jojri waters are less saline (2 to 5 mmhos EC). Then again in Surpura, Gujarwas, Khokharia, Nandria water is of comparable quality (2-5 mmhos EC) but deep seated (20 to 40 metres b g.l.). In the western half of *tehsil* in Kalijaran, Roheecha Kalan Roheecha Khurd, Peeparli and Kagnada

water table is only 15 to 20 metres but saline. In Jhanwrar, Doli, Gangana, Bujawar, west of Boranada and Narandi ground water occurs in old alluvium and is brackish (1.5 to 2 mmhos) but deep (30 to 45 metres b.g.l.). In Basni, Pal, Tanwara, Nandwana, Bhakrasni, Basni Bagela and Jhalamand water occur at 45 to 35 metres b.g.l. but is somewhat saline (4 to 6 mmhos EC). In Sar, Sarecha, Shikarpura, Kankani, Fithkasani, Bidasni, Kakelao and Pithawas water is only 10 to 15 metres deep but mostly highly saline (8 to 12.6 mmhos EC). In Jandesar, Rabria, Khatawas and Khadala water level is deeper (20 to 35 m b g l.) and is saline.

In Shergarh in Agolai, Dhandhania, Dugai water is highly saline and also with high residual carbonate. In villages of Burkiya, Nandia and Godawas (Bilara *tehsil*) water is at 25 metres b.g.l. and only brackish (255 to 3.0 mmho EC and some residual carbonate).

8. *Resource assessment*

The unit is made mostly of deep to very deep, light textured soils with a moisture retention capacity of 75-120 mm. This is satisfactory enough for adapted crops. Inherent fertility is good though additional inputs are necessary for optimum productivity. Mean annual rainfall within the unit ranges from 380 to 250 mm which permit successfull crop of *bajra* once in two years and of pulses in 60 per cent of years. The lands in this unit belong to land capability III ec and are therefore well suited to arable farming and in fact almost the entire area is being so used. However, the level of production with average yields of 2.5-3.5 q/ha of *bajra* or 1.5 q/ha of pulses is low. Besides, the lands carry a wind erosion hazard. Therefore a number of improvements are possible as well as desirable.

Presently, fallowing is a common practice on the cultivated lands. It occupies 15-20 per cent in Luni Block, 30 to 50 per cent in Osian and over 50 per cent in Phalodi area. Current scientific thinking is that fallowing as practised is not an efficient system of building up fertility or moisture. Therefore unless necessitated by livestock maintenance the fallow land should be put under short duration pulses. Further, presently crops are often grown in a mixture. Though the practice has certain advantages, it does not lend itself to adoption of improved technology. Mixed cropping as followed presently permits weeding only by hand and therefore limits the area that can be so covered. Preponderance of less useful natural vegetation and low crop plant population is by far the dominant picture and therefore one of the main reasons of its low productivity. Taking these crops in pure stands at the recommended uniform or paired row system of planting is a better technology. The crops could be grown in a rotational system to the extent permitted by weather conditions. Use of fertilizers in over 300 mm rainfall belt is advantageous. 20 kg of N/ha as basal and 20 kg at 3-4 week stage depending on rainfall conditions is recommended. These practices together with improved varieties, weeding and some pest control can raise the yield

level nearly three times. Stubble mulching including field bunding and ploughing back the piled up sand are suggested for soil conservation. Present stand of *Khejri* is only 5-15 plants/ha. There is a scope for raising this to 25-50 plants/ha.

More enterprising farmers could take up water harvesting as an insurance against extended drought or sub-normal rainfall years which happen once in about 2 years. Transplanting of *bajra* is another useful technique to cope up with delayed onset of monsoon or early drought such as happens once in 3 years. Raising of ber orchards and summer vegetables with water harvesting are other new practices.

In major part of the area ground water is either very deep or very saline. However, potential does exist at places. In villages Panchla, Grigali, Chandalia, Chirwai, Paori, Netran, Anwana, Danwro and part of Bhawad (all in Osian) 40 to 50 tubewells of 40 to 50 cum/hour capacity can be dug and an additional area of 700 ha brought under irrigation. Similarly, potential exists also in Bawarlo, east of Digari, Nandri, west of Diwalio along eastern bank of Jojri, Basni, Pal, Tanwara, Nadwan, Bhakrasni, Basni Bagele (all in Jodhpur *tehsil*) for digging more tube-wells. Doli-Jhanwar area is reserved largely to meet drinking water requirements. Good quality water is available in Moria, Denog, Chadi, Ridmalsar Lohawat and Chila in Phalodi and in Hathundi, Athob, Sili, Kapuria, Khabora, but static water level is deep (60-100 b.g.l.) and therefore not economical enough for irrigation and the same therefore could be used to meet domestic requirement. In rest of the area, i. e in Luni and Mandore Panchayat Samitis water is saline to highly saline but usable for wheat under rainy season fallow. About 500 dug wells of 5 to 10 cum/hour discharge in Mandore block (from Thabukara to Jaleli) and 120 to 175 bore wells/tubewells in south west of Luni block can be had but with the limitation as pointed out above.

9. *Suggested treatments.*

(i) The lands within this unit are fairly well suited to arable farming though simple conservation practices like increased stand of *Khejri* trees, stubble mulching and field bunding are necessary. Isolated dunes within the unit, of course, need to be brought under silvi-pastoral system.

(ii) Land fallowing, being less efficient, should be limited to the minimum required for maintenance of cattle. Rest of the area be brought under regular farming. This would require mechanisation of sowing operation since this is one of the main limitations in fuller exploitation of land resources. This could be achieved by tractor driven seed - cum - fertilizer drill. Experience has shown that this leads to a far superior crop stand. Line sown crop is amenable also to mechanical weeding. Low plant population and preponderance of weeds are the major factors for present low productivity.

(iii) Adoption of pulse-millet rotation and improved varieties. Present practice of mixed cropping has its own

advantages but the practice does not lend itself to adoption of improved technology. Therefore more resourceful farmers be induced for this change.

(iv) Full use should be made of organic manures. However, augmentation of this with fertilizer is necessary for optimum yield particularly in above 300 mm rainfall belt. Recommendation for *bajra* is 20 kg of N/ha at sowing and another 20 kg at knee height stage depending upon weather conditions. Use of pesticides is becoming increasingly important. Details of measures needed for the purpose are given in the section on technology.

(v) More enterprising farmers could adopt in addition:

(a) water harvesting for conventional crops using inter-row water harvesting or infield run-off-run- on system with a catchment to cropped area ratio of 1:2. Details are given elsewhere.

(b) localised bentonites sub-surface moisture barrier system coupled with runoff concentration for vegetable crops.

(c) *ber* orchards under waterh arvesting system. Details of these technologies are given elsewhere in this report.

(vi) increased use of ground water for irrigation as brought out in resource assessment.

MLRU- Ju. 4 FLAT AGGRADED PLAIN WITH HARD - PAN SOILS

1. *Extent and location*

The unit covers an area of 1634 sq km or 7 2 per cent of the district. principal area of occurrence of this unit is in Phalodi *tehsil* where it lies to the east of Phalodi proper in Kheechan, Banasar and Moria and then again in the south western part in Khara, Mokheri, Kolu, Dadu and Sanwrij. A small area lies also in extreme north west of Shergarh in Kalan and Chandsama and in Jodhpur *tehsil* around Nawa, Manai, Melba and Dhawa.

2. *Villages covered* (See Appendix I).

3. *Geomorphic features*

These are flat old aggraded alluvial plains with light, sometimes medium textured sediments. The area is free of dunes, though few hummocks are present. Near Sanwrij and Kolu a few sandstone exposures are also seen.

4. *Soils and land use capability*

The soils belong to Kolu series and are characterised by brown light textured soils with a hard, compact, mostly indurated strata at depths of 40-60 cm. The surface has a thin veneer of sand but sub-soil is loamy sand with 7.8 to 10 per cent clay and 4.4 to 6.3 per cent silt. Underlying strata is made up of lime concretions also gravels further cemented by free Calcium carbonate At few places as in Sanwrij south of Phalodi proper, Kheechan and Amla the underlying strata is compact sandstone. Though dominant range of depth is 40 to 60 cm, in patches it is shallower with exposures of indurated strata. These patches are of 0 4 to 3 ha and are located mostly between Khara and Mokheri, south of Phalodi, Kheechan and Amla. Soil above indurated strata can retain 25 to 50 mm of water. It has 0.13 to 0.22 per cent org. C, 8-18 kg av. P_2O_5/ha and 130 to 180 kg av. K_2O_5/ha.

The soils have a severe depth limitation. The underlying strata at 40-60 cm is slowly pervious to water and difficultly penetrable by roots. Growth of useful trees like *P. cineraria* is very stunted. It is only very hardy plants like *Z. nummularia* and *C. decidua* that are able to put up growth. Because of this limitation these soils are put in Class VI sh.

Plate 3. MLRU-Ju. 3. Flat aggraded plains with light textured soils and occasional dunes. Low plant population, preponderance of weeds, and lack of fertilizer and plant protection inputs are the major reasons for present low crop productivity.

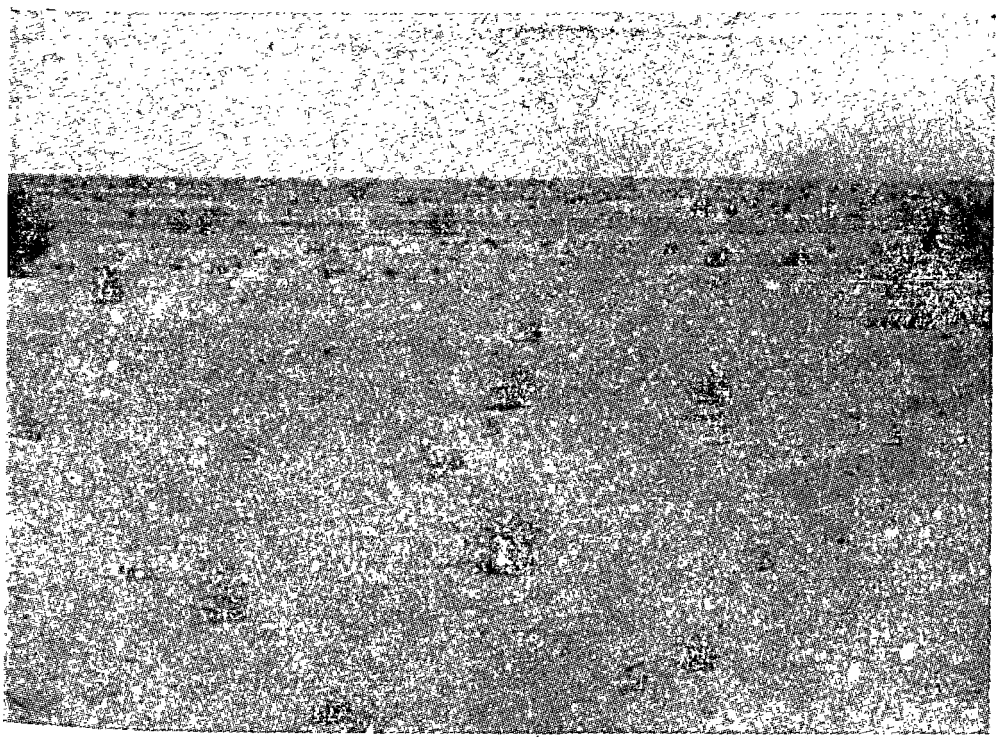


Plate 4. MLRU-Ju. 4. Flat aggraded plains with hardpan soils. At present dominantly cultivated in a long-fallow farming system. Excellent pastures can be developed with treatment and controlled grazing.

5. *Natural vegetation*

Prosopis cineraria trees are highly stunted and widely scattered, with 0.5-1 plant/ha. The most prevalent shrub community of the unit is *Capparis decidua-Zizyphus nummularia.* Associated species of the ground flora are *Indigofera cordifolia, Cenchrus biflorus, C. prieurii, Aristida mutabilis, Tribulus terrestris, Dactyloctenium arigumum and Digitaria adscendens.*

Forage contribution from these lands averages 200 to 450 kg/ha depending upon length of fallow and basal cover. Out of this 30 to 50 kg is from *Zizyphus nummularia.*

6. *Present land use*

Though bulk of the area is cultivated, cropping on average is practised in 20 to 35 per cent of the area only. Rest of the area lies fallow. Besides there is sizeable area under permanent pasture patches of which are seen around Kolu and then again to the south west of Jalore. Cultivated area is often interupted by pockets of gravelly waste, which together constitute 10 per cent. *Bajra, mooth* and *guar* are the common crops.

7. *Water resources*

(a) *Surface water* : The surface soil of this unit also has a high infiltration rate but the concretionary layer at shallow depth is moderately permeable. Therefore during heavy spells after saturation of the solum, some ponding water occurs in response to micro- relief variation. Field bunding is able to take care of this runoff.

(b) *Ground water :* Water bearing strata is older alluvium and weathered sandstone. In villages Dedia, Bara Mandla, Dadu, Bamnu, Mokheri, Phalodi, Kheechan and Amla of Phalodi *tehsil* and Chandsama of Shergarh water occurs at 40 to 60 m and of variable salinity within potable limits (1.5 to 4 mmhos EC, 6 to 10 SAR). In Sanwrij and Kolu it is highly brackish (4.5 to 5 mmhos EC) whereas in Khara it is highly saline (12 to 16 mmhos). In Melba and Dhawa (Jodhpur *tehsil)* also water in this unit is highly saline though closer to surface.

8. *Resource assessment*

The mapping unit is largely made of flat plains with a hard pan mostly at 40-60 cm depth. Mean annual rainfall is around 250 mm. Climate is only marginally suited for dry farming. Further successful cropping is curtailed by root zone limitation. This is reflected in the low incidence of cropping which is only 20 to 35 per cent as compared to 40 to 55 per cent in neighbouring area of deeper soils in Pilwa-Kushlawa. The prevailing practice is cropping with long fallows in between. Satisfactory yields are obtained in years with well distributed rainfall only. Average yields are only 1.5 to 2 q/ha, which are 50 to 75 per cent of those obtained on deeper soils.

These lands even under fallow farming are not able to give yields that are average for the areas as a whole. Besides, arable farming is quite hazardous because any further loss of limited soil depth will do irreparable damage to its long range productivity. The lands in fact are ideally

suited for development into good pasture lands. Grubbing of less productive species, reseeding with *L. sindicus* and *C. cilaris,* followed by controlled grazing can yield on an average 800 to 1200 kg/ha of dry forage as compared to only 200 to 450 kg/ha on present day fallow lands. Under improved management the land should be in a position to sustain 30 to 45 adult cattle units per 100 ha on year long basis. However, a wholesale change over to the exclusion of any farming may have difficulties in adoption. Therefore the suggestion is continuation of cropping under improved dry farming technology at present level of cropped land (20-35 per cent) on a regular basis and bring the rest of the area under well managed pasture lands. The system should permit more efficient utilization of its natural resources.

The ground water in the area occurs at 40-60 m depth and is mostly brackish. It is good enough for irrigation and stock drinking. Existing potential should allow digging of 50 to 60 tubewells of 25-60 cum/hour discharge to irrigate an area of 1,000 ha under conventional crops or 300-500 ha under irrigated pasture. This could be used for raising forage crops to meet the need of improved dairy cattle.

9. *Suggested treatments*

(i) The lands are well suited for permanent pastures and only moderately so for crops. Therefore the present system of arable farming with long fallows needs to be replaced by well managed pasture lands. This wholesale change may have resistance to adoption. Therefore to start with effort should be to regularly farm at the present level of 20 to 35 per cent but regularly instead of fallow farming and bring the rest under permanent pastures in a phased manner.

(ii) In order to establish pastures the lands need to be reseeded with *L. sindicus, C. ciliaris* and *C. setigerus* @ 5-8 kg/ha. Even normally, the lands have a very good stand of *Z. nummularia.* With little care, their cover can be raised to desired level of 15-20 per cent. To maintain the productivity, the lands should be grazed at 60-70 per cent utilization. Bunding and furrowing is useful also for conservation of moisture.

(iii) As indicated in resource assessment there is scope of digging 50-60 new tubewells sufficient to bring 300 to 500 ha under irrigated forage crops. This should be sufficient to meet specific requirement of livestock in this and adjoining land resource units.

MLRU-Ju. 5 GRAVELLY AGGRADED PLAINS WITH SHALLOW SOILS

1. *Extent and location*

The unit occupies 1698 sq km or 7.4 per cent of the area of the district. It lies in the north-western and northern part of the Phalodi *tehsil* starting from Jodhsingh-ki-Seer though Bap upto Noore-ki-Burj, and southward in Shekhasar, Raneri, Sihar, Bengti and Kundal.

2. *Villages covered* : (See Appendix I)

3. *Geomorphic features*

These plains are made up of unsorted, alluvial deposits with appreciable proportion of sub-angular to rounded gravel and cabbles of sandstone, limestone and granite. The plains are gently slopping to undulating. Because of past wind erosion surface has concentration of gravels and stones to form desert pavament. These occur as varying sized patches. Accumulation of sand is generally absent.

4. *Soils and land use capability*

This unit comprises Bap series, i. e. the area with a compact, often indurated, gravelly-bouldry strata either exposed or at some depth below the soil. The exposures of bouldry strata are not continuous and occur as irregular patches of 5 to 100 ha which together form 20 to 50 per cent of the total area of this unit. Elsewhere it occurs at varying depths, often at 40 to 60 cm. Dominant soil has a sandy to loamy sand surface and a loamy sand to sandy loam sub-soil (clay 7 4 to 11.7 per cent, silt 4.6 to 10.3 per cent). Moisture equivalent values range between 8.3 to 14.6 per cent giving a profile moisture retention capacity of 30 to 60 mm. The soil contain 0.1 to 0.2 per cent org. C, 8-16 kg P_2O_5/ha and 150 to 300 kg K_2O/ha. The underlying strata is a heterogenous mixture of rounded and sub-rounded rock fragments of varying sizes, with calcareous concretion and cementation and appreciable quantities of silt and clay. Around Shekhasar and in a 4-6 km wide north-south running strip starting 6 km to the north-west of Phalodi proper upto Manchitia the soil is fine sandy loam to clay loam of 30 to 70 cm depth with 10 to 30 per cent exposed bouldry strata. These soils have 150 to 250 mm moisture retention capacity.

Soils with 40-60 cm depth and an indurated layer underneath are too

shallow to permit satisfactory crop growth but are well suited for permanent pastures. These therefore belong to class VI sh. Soils with thick desert pavement or very shallow depth is far from ideal even for grasslands and because of this these belong to Class VII. *Khadin* lands within the unit are better placed into Class III.

5. *Natural vegetation*

Prosopis cineraria and other tree species so common in Jodhpur are scarce and also stunted. The most predominant community is of *Capparis decidua, Zizyphus nummnlaria* with each component having a density of 40-60 and 50-250 plants/ha, respectively. This is a quite open community and a limited associate is *Calotropis procera.* The plants of ground storey are also very few but in patches with some soil, a colony of *Indigofera cordifolia* or *Tephrosia purpurea* develops and exert dominance in this layer. Other grasses and weeds are *Cenchrus biflorus, Eleusine compressa, Aristida funiculata, Aristida funiculata, Aristida mutabilis, Dactyloctenium sindicum, Corchorus depressus, boerhavia diffusa; Aerva persica, Cleome brachy corpa, C. papillosa. Lepidagathis trinervis, Blepharis sindica, Cyperus rotundus* and *Indigofera hoschetteri. C. decidua* offers limited nibbling but *Z nummularia* provides an average 5 to 25 kg/ha of nutritious *pala.* Production from ground flora in an average year is 50 to 120 kg/ha an exposed boulders and 150 to 650 kg/ha on shallow soi s depending upon degree of grazing stress Dominant range is 200 to 300 kg/ha.

6. *Present land use*

Cropped area range mostly between 7 to 20 per cent, whereas 40 to 70 per cent lies fallow. Rest is made up of gravelly waste. There is no irrigation though wheat is grown under *Khadi* system to small extent. *bajra, moth* and *guar* are the main crops.

7. *Water resources*

(a) *Surface water* : Though the unit is located in low rainfall zone (220-240 mm), undulations of topography together with somewhat compacted or slow absorbing soil surface induce good runoff. During wet spells of 100 mm or more and of 50 to 100 mm which occur with a mean frequency of 0.25 and 0.8 per year, runoff of the order of 40 and 25 per cent of the rainfall received is anticipated Part of this runoff is under utilization through an indigenous water harvesting system. About 1600 ha are being cropped under this system. However, a sizeable surplus of an estimated 100 million cum is there which could be used to develop about 8,000 ha of crop land under water harvesting system.

(b) *Ground water*: Bap boulders, older alluvium and at places weathered sandstone form the aquifer. Static water level is very deep being 50 to 80 m b g.l. at most places. Only in the extreme north-east around Sird it is 25 to 30 m. South of Bhuraj in Raura, Sihar, Mandli, Akhadkana, Bengti, Hangoli Shekhasar and in Sird area water is mostly 2.5 to 5 mmhos salinity but northward in

Plate 5. Highly overgrazed **Oran** (Permanent pasture) in MLRU-Ju. 4

Pate 6. MLRU-Ju 5. Gravelly aggraded plains with shallow soils. Under the present dominantly open grazing system, the lands carry highly degraded pastures. Reseeding with high yielding perennials followed by controlled grazing can dramatically increase productivity.

Manchitia, Newaton - ki - Dhani, Bap, Khriwa it is saline (5 to 10 mmhos). In vicinity of Malhar water is highly saline (over 15 mmhos EC).

8. *Resource assessment*

This unit has severer limitations than even MLRU 4. The soils have a highly indurated cobbly strata under neath at 30-50 cm. At many places this strata lies exposed in form of large blocks of 5 to 100 ha. Only in small pockets which together do not exceed 12-15 per cent of the area, are the soils deep enough. Therefore by far a majority of the area is affected by severe to very severe soil depth limitation for cropping. Mean rainfal is 240-220 mm. Hence, from both the soil and climate considerations the area is poorly suited for cropping (except under *Khadin* system to be discus ed later). Presently, 60 to 80 per cent of the area is under cultivation though in a system of fallow farming. Therefore in any particular year, actual cropped area does not exceed 10 to 30 per cent. Rest is under 2 to 5 year fallow. Present yield of crops average 0.8 to 1.5 q/ha of *bajra* and 0.5 q/ha of pulses, which is very low. Pasture production from fallow lands is around 250-350 kg/ha. Under *Khadin* system such as occur in Shekhasar, and in 3-4 km vide strip from Phalodi to Manchitia, production under *Khadin* system in most years is 5-6 q/ha of *bajra* or 6-8 q/ha of wheat.

Though the *Khadin* system developed through native skill is a great improvement for rest of the area full potential of natural resource in not being realised. The fallow lands are dominated by low yielding annuals because of irrigational grazing practices. Under good management comprising contour furrowing, reseeding and controlled grazing the lands can give an average production of 600-1,000 kg/ha. The suggestion, therefore, is that except for the area presently under *Khadin* system or the area that can be so developed, the rest be brought under improved permanent pastures. The productivity under the system should permit maintenance of 25-35 heads of cattle per 100 ha.

Surface water assessment shows that only a small fraction of run-off is being utilised presently. There is sufficient suplus to bring an additional 8,000 ha under *Khadin* system. At present area under *Khadin* is only about 1,600 ha. The area has not been sufficiently explored from view point of ground water. A tubewell at Manji-ki-Sird is quite successful and gives a discharge of 30 cum/hour. Indications are that the area as a whole has got enough potential to permit irrigated forage crops.

9. *Suggested treatment*

(i) Cultivation be limited to *Khadin* system only which means to about 8 per cent of the area. The rest bulk of the area be brought under permanent pastures. Therefore, arable farmed be curtailed by nearly half from the present level of 7-20 per cent.

(ii) Establishment of good pasture lands requires the same treatment

as those listed in MLRU 4. However, unlike the previous unit, the lands are required to be contour trenched and furrowed. Experience in similar terrain conditions has shown that production gets doubled by adoption of these water conservation measures.

(iii) There is scope for bringing more land under *Khadin* system.

MLRU-Ju. 6 FLAT AGGRADED PLAINS WITH MEDIUM TEXTURED SOILS

1. *Extent and location*

The resource unit occupies an area of 970 sq km or 4.2 per cent of the district. The unit forms a continuos area but for a narrow strip of Mitri alluvium in between. It lies mostly in Bilara *tehsil* to the east of Khangta, Sathin and Kur villages and extends up to Khejarla and Bhavi in the east. Southwest wards it extends upto the confluence of Mitri and Luni rivers. A small pocket occurs south of it in Bhetanda.

2. *Villages covered* (See Appendix I)

3. *Geomorphic features*

These are moderately deep to deep, flat old aggraded alluvial plains overyling mostly weathered granite. These are level to gently slopping and free of erosion except for sheet and gully erosion in immediate vicinity of streams.

4. *Soils and land use capability*

Mapping unit comprises largely of Pipar series i. e. soil with a greyish brown, fine sandy loam (sometimes loamy fine sand), surface layer, and a still denser, loam, well aggregated sub-soil followed mostly at depths of 40 to 60 cm by a calcium carbonate concretionary strata mixed with coarse alluvium or weathered zone of granite. In pockets around villages Silari, Tilwasni, Ghanamagra, south of Jaspli, Khejarla, Madlia and Raona (all in Bilara). the soils are somewhat lighter, whereas in pockets in Binawas, southeast of Chandelao, north of Chaukri Bari and in Dangiawas, soils are shallower, i. e. concretionary strata is at 15 to 30 cm. Dominant soils in the surface layer have 10 to 16 per cent clay and 6 to 11 per cent silt whereas sub-soil has 14 to 21 per cent and 9.4 to 15 per cent respectively. Moisture equivalent values are 9 to 13 per cent in surface and 11 to 16 per cent in sub-soil giving moisture retention up to concretionary layer of 70 to 120 cm. Org. C is 0.25 to 0.45 per cent available phosphorus 12 to 25 by P_2O_5/ha and potassium 140 to 220 kg K_2O/ha. The soils have a well aggregated surface that forms good clods when ploughed. It is therefore able to resist wind erosion. The sub-strata of the soils is pervious and therefore 40–60 cm soil depth is not a significant limitation. Moisture retention is good and soil fertility adequate though

handsome response to application of fertilizer is obtained. Major limitation is climate only. Soil characteristics are good and hence lands, therefore, belong to class IIIc.

5. *Natural vegetation*

Prosopis cineraria-Capparis decidua-Zizyphus nummularia is the dominant community. However, stand (5-10 plants/ha) and growth of *P. cineraria* is rather poor. Associated species are *Lycium barbarum* and *Calotropis procera.* There is a good assemblage of flora comprising *Cenchrus biflorus, Aristida funiculata, Eragrostis tremula, E. ciliaris, Dactyloctenium sindicum, Indigofera cordifolia, I. hoschetteri, Tephrosia purpurea, Crotalaria burhia, Boerhavia diffusa, Polycarpea corymbosa, Corchorus tridens, Pulicaria wightiana, Tribulus terrestris, Digera muricata* and *Convolvulus microphyllus.* Forage yield from top-feed species mainly *Z. nummularia* with a basal cover of 1.5 to 4.3 per cent averages 80 to 125 kg/ha and that from lower level flora 300-700 kg/ha with large inter annual and inter-field variations.

6. *Present land use*

Almost the entire area of this unit is cultivated with exception of few *orans* and pocket of shallow soils or rock exposure. Cropping intensity is 70 per cent to 80 per cent. In other words the area is regularly cultivated. *Bajra, til, moong, guar* and *jowar* for fodder are the common crops.

7. *Water resources*

(a) *Surface Water* : Lands urface in this unit has gradual slope mostly between 0.5 to 2 per cent. But because of medium infiltration rate and torrential character of rainfall, appreciable runoff does take place from this land-unit. It is estimated that during wet spells of over 100 mm (such as occur on average 0 8 times a year) and of 50 to 100 mm (which occur 1.3 times a year) 20 to 30 per cent and 10 to 15 per cent of the rainfall received during the spell respectively is liable to runoff. Overall the estimated annual run-off averages around 10 per cent of the mean annual rainfall. It rises to about 25-30 per cent once in 3 years. In order to conserve runoff, lands with 1-2 per cent slope need to be contour bunded but in rest of the area field bunding will be enough. Some farmers already practice field bunding but majority of fields are in need of this development activity. This unit has 28 medium and big sized *nadis.*

(b) *Ground Water* : Medium to coarse grained, well jointed, fractured Jalore granite and its weathered zone form the aquifer. Water occurs mostly at 10 to 20 m b g.l. and is generally saline (5 to 10 mmhos EC, SAR 13 to 26). In Madlia, Kharia, Sownia, Raona, Anawas, Runkia, Khejarla, Tilwasni, Ghanamagra, Binawas (all in Bilara) water is brackish to saline (2.5 to 7 mmhos EC, SAR 11 to 32) but with variable residual carbonate (0.4 to 9.5 me/l). In Jaspali, Buchkala and in pockets in Silari, Khejarla relatively less saline water (2 to 3.5 mmhos) is found. Similarly, areas under the influence of

Mitri, i.e. Kosana and south eastern part of Sathin also have comparable water quality. In Bhetanda, Singhasni, Mortuka, Birdawas, Khari, Khurd and Palani, water level is only 3 to 10 m but water highly saline (7 to 15 mmhos EC). Yield from dug wells is low to meagre (0.3 to 1.5 cum/hour).

8. *Resource assessment*

MLRU 6 is one of the best agricultural lands. The soils are well aggregated with slight wind erosion hazard. These have good inherent fertility and sufficient moisture retention capacity to enable crops withstand extended droughts Mean annual rainfall averages 370 to 430 mm and its annual distribution permits successful cropping in 60 per cent of the years. Once in five years short duration *rabi* crops are possible on conserved moisture. Present productivity though better than what is obtained on other units, however is still only 4-5 q/ha of *bajra*, 2-3 q/ha of *mung* or 1 to 1.5 q/ha of *til*. The main reason is inadequate water conservation and low level of dry farming technology. Majority of land are unbunded and on an average 7-10 per cent of rainfall goes as run-off from individual fields. Whereas once in 3 years the loss may be as much as 25-30 per cent. With a depth of 40 - 60 cm and a retention capacity of 70 to 120 mm that majority of lands have, there is a good scope of contour and field bunding. The practice is expected to increase average productivity by 15-25 per cent.

Other factors responsible for low productivity are low plant population, less efficient varieties and lack of alacrity to scope up with aberrant weather by mid season corrections. Sowing in rows that permit weeding with bullock or tractor drawn implements and improved varieties alone can raise the yield by 50 to 75 per cent. Use of cash inputs like fertilizer and pest control can raise it to an equal extent. In case of delayed monsoon, transplantation of *bajra* should be taken up to the extent possible by man power availability. Good quality wells along the Mitri river could be used for raising *bajra* nursery. Enterprising farmers could put a limited area also under inter-field water harvesting with a catchment to cultivated area of 1:2 as an insurance against drought years. Once in 4 years heavy rainfall is received in the end of August or in September. Presently, some farmers do take advantage of it for growing *raya* or *tara-mira* on conserved moisture. But yields are only 0.5 q/ha. These are low because of low plant population and lack of insect pest control, particularly against aphids. Russian thistle (ver. *Unth Katala, Echinaps echinatus*) has become a serious weed and is menacing a large area of this and adjoining units. Hand weeding is not proving very effective. However it can be successfully controlled by a preemergence soil application of Simiazine or by a spray of 2,4-D at young stage.

Ground water storage is reasonable though quality puts a restraint on its potential. In the eastern part starting from Madlia - Kharia in the north through Khejarla upto Ghanamara, potential exists of increasing the

irrigated area from the present 3 to 10 per cent to 10 - 15 per cent by having more dug wells. On about 40 Percent wells mostly in Madlia, Rawanya, Anawas and Runkia in fact doule cropping, i e. irrigated wheat and rainfed *bajra* can be grown. In another 40 Percent only wheat is possible. Whereas in 20 Percent mostly in southern part Khejarla-Ghanamagra water is generally bad because of high rsidual carbonate (above 7.5 me/l). In Kaparda-Boyal and then agian in Bhetanda, Mortuka also water is highly saline but can be used for wheat in a cyclic management reqniring 2 rainy season fallow.

9. *Suggested treatments*

(i) In order to minimise runoff losses which are quite sigificant, contour bunding or failing that field bunding should be followed.

(ii) In order to overcome the present low crop plant population and overcrowding with weeds, sowing be attempted with seed-cum-fertilizer drill in paired or uniform row system with proper spacing. This should permit weeding by mechanical means. Control of Russian thistle using weedicide 2, 4-D need be taken up.

(iii) The lands occur in favourable climatic zone (370-430 mm). This should be taken advantage of through use of inputs at optimum rate and combination. These are fertilizers (30 kg N at the sowing time and 20-30 kg at knee height for b*ajra*). This of course should be over and above other good practices like legume cereal rotation, use of organic manures, plant protection and efficient varieties as listed in the section on technology.

(iv) Enterprising farmers can take up in addition.

(a) raising *bajra* nursery on wells along Jojri and resorting to its transplanting in case of delayed onset of monsoon.

(b) inter-row and in-field run-off run-on system.

(v) Digging of more wells in potential areas. However, before use the water from wells should be analysed to decide upon type of managements needed.

MLRU-Ju. 7 FLAT AGGRADED PLAIN WITH FINE TEXTURED SOILS

1. *Extent and location*

This unit occupies 256 sqkm or 1.1 per cent of the district. Its area of occurrence is north-western part of Bilara *tehsil*, i.e. villages Gajsinghpura, Rarod, Asop, Kakardo, Darmi, Girasni and also other adjoining village.

2. *Villages covered* : (See Appendix I)

3 *Geomorphic features*

These flat, aggraded alluvial plains are made up of fine sediments. They are level to gently sloping with few dolomitic limestone exposures in between.

4. *Soils and land use capability*

The unit comprises heavy textured soils belonging to Gajsinghpura and Asop series. Of these the former dominates whereas Asop. series occurs only in pocket of 50 to 400 ha in villages Asop, Rarod, Kukardo and Basni Harisingh. Gajsinghpura soils have greyish brown, fine sandy loam to loam, well aggregated surface and clay loam, well aggregated sub-soil followed at depths of 70 to 110 cm by a zone of calcium carbonate mixed with soil. The surface has 16.3 to 22.7 per cent clay and 11.3 to 17.4 per cent silt and sub soil 21.8 to 28.9per cent of clay and 11.3 to 17.4 per cent of silt. Moisture equivalent value is 14.6 to 18.1 per cent giving a total moisture retention capacity of 180 to 230 mm for the profile. Asop series are similar to above but are even heavier in texture i. e. silty clay loam to clay with 33 2 to 40.4 per cent clay and 18 to 20 per cent silt. Moisture equivalent values are 16.3 to 20 per cent in surface and 24 to 30 per cent in sub-soil giving a profile storage of 260 to 350 mm. Both the soils have between 0.25 to 0.50 (mean 0.37) org. C, 12 to 24 kg av. P_2O_5/ha and 160 to 350 (mean 266) kg K_2O/ha.

The soils have a very well aggregated surface, no erosion problem and a high moisture retention capacity- Their fertility status is good too. However, the permeability of the soils is low to very low. Therefore during wet spells the soil remain saturated with water for long time and standing crops are adversely affected, even destroyed. Because of this soils are grouped in capability class as III c w

5. *Natural vegetation*

It is dominated by a plant community

of *P. cineraria-A. nilotica* ssp *indica*. Associates are *Salvadora oleoides, Tamarix articulata* and *Indigofera oblongifolia*. Ground flora includes *Dichanthium annulatum, Dactyloctenium aegyptium, Aristida adscensionis, Tephrosia purpurea, T. villosa, Tribulus terrestris, Pulicaria wightiana, Cyperus rotundus, Oropetium thomeaum, Cleome viscosa, C.gynandra, Fagonia cretica. Boerhavia diffusa* and *Heliotropium sobulatum*. Forage yield from top feed species averages 40 to 70 kg/ha and that from ground flora 250 to 600 kg/ha. Some long fallows yield as much as 2500 kg/ha.

6. *Present land use*

Almost the entire area is under cultivation and regularly cropped *Bajra* and *til* are common crops in *Kharif*. Sizeable area is put under barley, wheat, *raya* on conserved moisture.

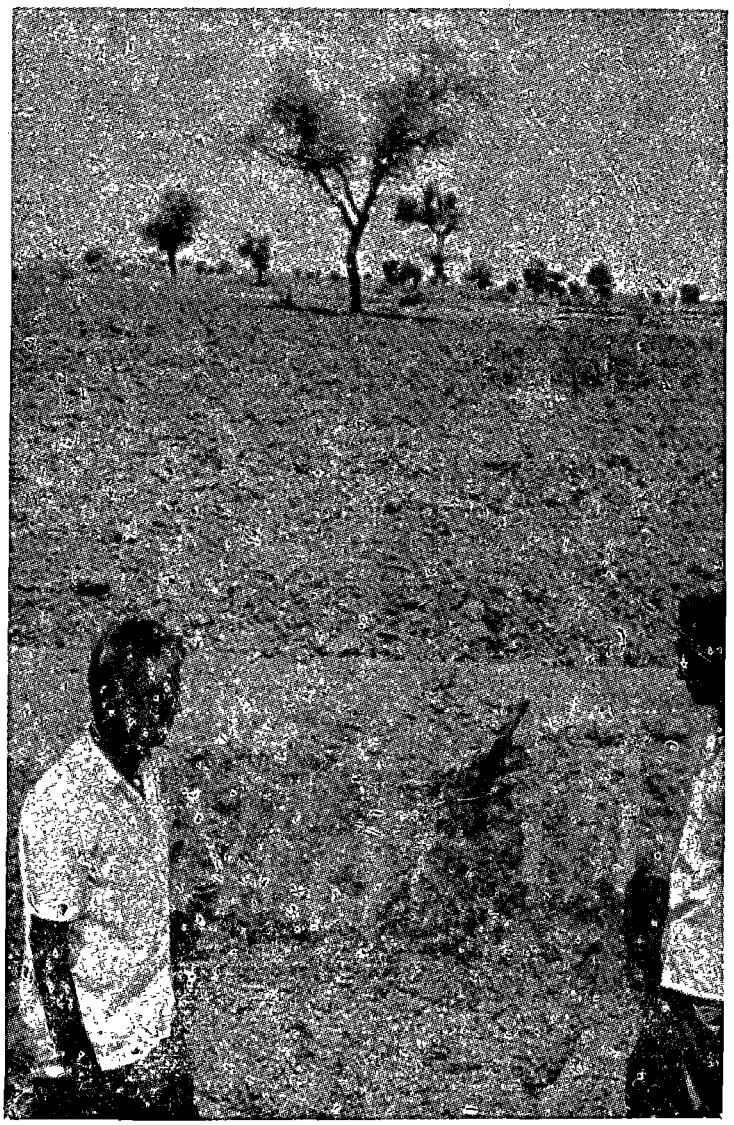
7. *Water resources*

(a) *Surface water* : Soils in this unit are fine textured and so have a low infiltration rate. Though slopes are gradual, yet large runoff does take place during wet spells. It is estimated that during rain spells of over 100 mm such as occur with a mean frequency of 0 8 times/ year, 30 to 40 per cent of rainfall is liable to runoff. With wet spells of 50 to 100 mm, runoff is around 20 per cent. There are reports that at times standing crops are adversely affected by stagnation of water. Therefore, bunding alone is is not the solution. The fields should have outlets whereby surplus runoff waters can be transported to farm ponds/ low lying depressions. The unit has six medium and big sized *nadis*.

(b) *Ground water* : Water occurs in cavities and fractures of underlying Bilara limestone. Static water level is to 55 to 35m and it is of good quality (0.5 to 2 mmhos EC, SAR 5-9, residual carbonate is 1 to 4 me/1).

8. *Resource assesssment*

This unit is made of fine textured soil with a high moisture retention capacity, slow internal drainage and a well aggregated surface layer. Inherent fertility is fairly good, Mean annual rainfall averages 360 mm. Therefore, the lands are well suited to arable farming though with some special behavioural features. Because of slow internal drainage, water stagnation occurs during wet spells of over 75-100 mm. It has been estimated that in 35 per cent of otherwise good rainfall years, significant damage occurs to standing crops because of this factor. Good rainfall years occur once in two years. However, this property of soil coupled with high moisture retention capacity is also an advantage in a way. In years when such heavy wet spells occur after 15th August a good moissure build up occurs. This enables taking up *rabi* cropping on conserved moisture. It has been estimated that such conditions permitting average to good crop occur roughly once in three years. Mean run off has been estimated as 15-17 per cent whereas in individual wet spells it may reach 30-40 per cent. From this it would be seen that there is appreciable scope for run off management. To some extent it is being realised through



Plath 7. MLRU-Jnc. 7. Flat aggraded plains with medium textured soils. These have a large scope for use of improved farm technology coupled with water conservation measures.

local ingenuity. Scope exists for improvement. This could be achieved by diverting surplus waters from high lying area north of Asop to southern half. This would permit a reduced damage to *kharif* crops and *rabi* in the inundated areas.

Present yield of crops averages 3-4 q/ha of *bajra* and *jowar* or 3-4 q/ha of wheat. Improvement in planting technique with uniform or paired row that permits mechanical weeding and inter-culture is highly desirable for *kharif* crops In many years crops are adversely affected because of inadequate moisture at crop maturity. Therefore, supplementary irrigation at this stage will greatly improve and stabilise production. Fortunately, a major part of the area has good quality water at 35 to 55 m depth. This could be exploited for the purpose. Sprinkler could be a satisfactory system. This would also permit use of more inputs for still higher returns.

It has been estimated that over an area of 152 sq km the annual recharge is about 6 million cum. Assuming that 50 per cent of recharge is exploitable. This should allow digging of about 60 tubewells of 20-40 cum/hour discharge, this should permit supplementary irrigation to the entire area of this unit.

Bunding of fields to conserve moisture is in vogue to some extent. But much of the area to the south and east of Asop has received inadequate attention. There is a large scope of field and contour bunding as part of above suggested run-off management technology.

9. *Suggested treatments*

(i) Development of a large scale inter-field run-off run-on system. Therefore good scope exists for a bunding system with surplussing arrangement. The surplus of above normal years could be carried over to low lying area south of Asop for use of *rabi* farming in above normal years. The proposed system whereas permitting rainfed farming in the entire area in normal or just sub-normal years, would ward off large scale failure as it occurs during wet years. The redistribution of run-off would save *kharif* crops in high lying area and ensure *rabi* cropping in the low lying area.

(ii) Use of improved dry farming technology as listed for MLRU 7.

(iii) This unit as shown in resource assessment has fairly good potential of ground water. Most effective use of it would be supplementary irrigation for rainfed *kharif* and for *rabi* on conserved moisture. This could feasibly be achieved with sprinkler system with dramatic results.

MLRU-Ju. 8 FLAT BURIED PEDIMENTS WITH LIGHT TO MEDIUM TEXTURED SOILS

1. *Extent and location*

This unit occupies an area of 2,280 sq km or 10 per cent of the district. Principal areas occur in Bilara and Osian *tehsils*. In Bilara it runs from Borunda and then again around Bhopalgarh, Kummara, Ustaran, Palri and Dandora. In Osian *tehsil* it is found in Mathania, Tinwri and around Soila. A small area lies to the north-west of Phalodi.

2. *Villages covered* (See Appendix I)

3. *Geomorphic features*

These pediments, unlike the rocky type, are covered with colluvial and alluvial sediments to varying depths, mostly between 40 to 250 cm. The sediments are partly developed *in-situ* and partly transported and deposited by streams and runnels. The drainage density and stream frequency is quite high and much better than in any other unit. Drainage pattern is dendritic and parallel to sub-parallel. Considerable sub-terraneous water flow takes place along the courses of existing and buried streams which goes to recharge the underground water storage. The plains are nearly level to gently sloping and free from erosion except along the channels where moderate water erosion is seen.

4 *Soils and land use capability*

These soils belong to Bhopalgarh and Soila series. Occasionally, Pal series also comes across. Dominant soils are 40 to 60 cm deep and sandy loam but considerable variation both in depth and texture of soil, does exist. In Hingali, Kumara, Surpura north of Gaderi and in Bhopalgarh (all in Bilara *tehsil*) soils are brown, sandy loam to loam (15.3 to 24 per cent clay; 7.2 to 9.2 per cent silt in sub-soil) 60 to 90 cm deep with partially weathered sand stone underneath. 10 to 25 per cent of the area in pockets is make up of shallow soils. Dominant soils have a retention capacity of 80 to 130 mm, 0 22 to 0 32 per cent Org. C, 15 to 24 kg av. P_2O_5/ha and 230 to 350 kg av. K_2O/ha. A strip one kilometre long and 200 metres wide along drainage line south of Bhopalgarh proper and in Basni has deeper and heavier textured soils. In Tambariya Kalan, Hiradesar, Birani, Rudiya, Ustara, Sopda (all in Bilara *tehsil*) soil depth is only 40-60 cm with pockets of shallow soils constituting 15 to 30 per cent of this area. Soila soils are reddish

brown, with a sandy loam, sometime loamy sand (10.3-16.4 per cent clay; 5.9-7.4 per cent silt). These are found in Rampura, Mathaniya, Binjwaria, Jug, Gudiya, Rajasani, eastern part of Tinwri, Dhanaria Kalan, Soyla Kajnau, Mornawara, (all in Osian) and in Todiana (Bilara). Here also rock exposures of 1 to 5 ha size are common and these together form 20 to 40 per cent of the area. The soils can retain 50 to 80 mm of moisture in profile. These have 0 20 to 0.28 per cent Org. C, 8 to 16 kg av. P_2O_5/ha and 100 to 160 kg av. K_2O. Irrigated plots have 0.30 to 0.45 per cent Org C. in Jodhpur and around in villages Barli, Narwa, Manai, Daijar and Manaklao and then again in Borunda, Hariadhana, Ransigaon, Khejarla, Bangara (all in Bilara) the soils are lighter, i. e. loamy sand (8-12 per cent clay; 5-8 per cent silt) with a moderately to strongly developed zone of calcium carbonate or rocky strata. These soils can retain 50 to 90 mm of moisture.

The soils have a somewhat aggregated surface and therefore problem of wind erosion is moderate. Their depth, moisture retention and inherent fertility status is good enough for adapted crops. Climate is the only limitation and therefore soils belong to class III ec. As brought out later, sizeable part of the area is under irrigation with good quality water and these lands fall in class II c. Associated pockets of shallow soils are in classes VI and VIII.

5. *Natural vegetation*

Density of *Prosopis cineraria* and other tree species is highly variable. The most predominant community is *Capparis decidua-Zizyphus nummularia* with each component having a density of 40-60 and 50-250 plants/ha, respectively. This is a quite open community and a limited associate is *Calotropis procera*. The plants of ground storey are also very few but in patches with some soil, a colony of *Indigofera cordifolia, or Tephrosia purpurea* develops and exert dominance in this layer. Other grasses and weeds are *Cenchrus biflorus, Eleusine compressa, Aristida funiculata, Aristida mutabilis, Dactyloctenium sindicum, Corchorus depressus, Boerhavia diffusa, Aerva persica, Cleome brachyaerpa, C. papillose, Lepidagathis trinervis, Blepharis sindica, Cyperus rotundus* and *Indigofera hoschetetteri*.

C. decidua offers limited nibbling but *Z. nummularia* provides an average 5 to 25 kg/ha of nutritious *Pala*. Production from ground flora ranges in an average year from 50 to 120 kg/ha on exposed boulders to 150 to 1150 kg/ha on soils depending upon degree of grazing stress. Dominant range is 220 to 350 kg/ha.

6. *Present land use*

Cultivated area is 60 to 80 per cent out of which about 15 per cent is under irrigation except in Mathaniya, Rampura, Binjbariya, Rajasni and Balkha in Osian and Bilara, Khariya Mithapur, Hariadhana, Ransigaon and Borunda in Bilara *tehsil* where irrigated area is 35 to 65 per cent. Intensity of cropping is 50 to 80 per cent under rainfed farming and 110 to 200 per cent under irrigation. Common crops under irrigation are chillies,

corrinder, cumin, vegetables, lucerne, wheat and *bajra*. Under rainfed farming crops grown are *bajra*, *moong*, *til* and *guar*.

7. *Water recources*

(a) *Surface water* : Local slopes within this unit are frequent and therefore considerable runoff does take place in response to torrential character of rainfall. During rainfall spells of over 100 mm, which occur with a mean frequency of 0.7 per year, runoff of 20-30 per cent can occur. There are 11 *nadis* and two more *nadis* are proposed. Contour bunding in 32 sq km area is also suggested.

(b) *Ground water* : Sub-strata of this unit is generally a good host of ground water accumulation and much of it is already under exploitation. In Osian *tehsil* pinkish - white to reddish sandstone, often well bedded and weathered, medium grained Vindhyan sandstone is the aquifer. Here in Danwro, Anwana, Jud, Mewasa, Neora, Sunaria, part of Baori, Balarwa, Gagari and Jelu static water level is 10 to 20 metres b. g. l. Electrical conductivity ranges between 0.6 to 3.5 mmhos, SAR 3 to 9 with negligible or no-residual carbonate.

Umednagar, Mathania, Binjwaria, Balarwa, Gheura, Tinwri, an area of 620 sq km has also very good quality waters with a water level of 10-20 metres b. g. l. Discharge from dug-well with pump set is about 15 to 40 cum/hour whereas that from tubewells it is 30 to 200 cum per hour. This is already an over drafted area.

In Dhandhar, part of Palri, Andio, Surpura, Hingoli, Bhopalgarh, Narsar, Rajlani, Hiradesar, Ustran, Rundia, Birai and Tambria Kalan of Bilara *tehsil* static water level is mostly 20-30 metres b. g. l. E. C. values are between 0.55 to 2.8 mmhos, SAR 2 to 6 with high residual carbonate in 20 per cent of samples. Yield of wells is 10 to 50 cum/hour, averaging around 35 cum/hour. RGWB survey of 1973 showed an average rise in water table of 0.76 m giving annual recharge of 23 mcm. In Todiana and Dodiar water level is 30 to 45 metres and water saline.

Borunda, Hariadhana, Ransigaon, Sambria, Murkasni, Bhijasni, Jhak, Rampuria (309 sq km) has static water level of 10-55 metres and the water has 2.5 to 3.0 mmhos EC and an SAR of 6 to 12. Yield from wells is very high (40 to 200 cum per hour). South of this in Udliawas, Kaloona Kooprawas, Khariya Mithapur, Bilara, Barna and Jetiwas, an area of 170 sq km has water table at 5 to 15 m b. g. l. EC varies mostly between 1.5 to 4.0 mmhos with residual carbonate of 0.5 to 5.0 me/l. Presently this region is well exploited but it still has some surplus potential.

In Jodhpur *tehsil* village of Narwa, Manai and Manaklao (100 sq km) water of excellent quality occurs at depths of 10 to 20 m. Present exploitation is 1.3 mcm and area is showing an annual water level decrease of 0.3 m and therefore is over drafted. Daijar, Karwar, Desoria, Chainpura (68 sq km; on rhyolite) have water level at 25-30 metres. E.C. ranges 2.0 to 5.0 mmhos; SAR 6 to 16 with variable R.S.C. Present draft is 0.42 mcm and a surplus exploitable potential is estimated at 1.08 mcm.

8. *Resource assessment*

This unit is made of moderately deep to deep, high to medium textured soil on flat aggraded plains. Climatologically the unit is better placed as the entire unit lies within 280 to 430 mm rainfall belt. Problem of wind erosion is moderate and therefore, overall, the lands are well suited to arable farming though present level of production is rather low. The area is favourably placed with regard to avilability of good quality ground water. Though, the same is being exploited to an appreciable extent, a considerable surplus potential still exists. Therefore, scope for increased productivity lies both in improvement of dry farming and in development of ground water.

Desired improvement in dry land-farming technology are similar to those described under MLRU 6 and these will give about the same degree of response.

Based on available data, assessment of ground water is as follows:

To the north of Bilara from Rampuria-Kaloona up to Borunda, in an area of 391 sq km a surplus potential of 12 mcm is available. Accordingly another 150 tubewells giving discharge of 40 to 60 cum/hour can be installed This would permit irrigation an area of 1200 ha under double cropping.

In Bhopalgarh area starting from Tambria-Raika Dhani in the south upto Palri-Andia in the north an area of about 600 sq km has an annual recharge of 23 mcm. Present exploitation is about 9 mcm giving a surplus of 14 mcm Accordingly, over 200 tubewells with a discharge of 25 to 40 cum/hour or 500 dug-cum-bore wells could be dug to bring an additional area of 1400 ha under double cropping. This could raise the present irrigated area from the present level of about 6 per cent of cropped area to about 10 per cent.

In Jodhpur *tehsil*, a potential of about 1 mcm exists in villages Daijar, Karwar, Deronia and Chainpura permitting an additional 100 ha to be brought under double cropping. However, some wells are likely to turn out with high salinity or residual carbonote.

In Osian *tehsil* the area in Umednagar, Mathania Rampura, Birjwaria, Balarwa, Gheura and Tirwri, with present pumpage of 25 mcm per year, the water table is already declining and hence the area is overdrafted. Unexploited potential is available in Kharda Mewasa, Neora and Jelu and then again in Soila, east of Dhanari Khurd, Kajau Khurd, Chotiala and north of Kherapa. In the latter presence of shales of some places limits productivity from wells. Hence detailed studies are necessary.

Considerable improvement in water and crop management technology is reguired. This includes lining of water courses, furrow system of irrigation for vegetable crops, and increased use of inputs. Present level inputs is low and inadequate. This is considerably due to the risk factor resulting from absence of plant protection. In many situations cash crops are greatly damaged by white grub, nematodes and virus in case of chillies, brinjals and tomatoes, and mildew in cumin Hence there is a need for an integrated technology.

9. *Suggested treatments*

(i) Digging of more wells and tube-wells in presently under exploited zones as indicated above.

(ii) Use of intergrated technology including plant protection, use of fertilizer inputs and water management as detailed in the section on technology.

(iii) Improved dry farming practices as suggested in MLRU 6.

MLRU-Ju. 9 HUMMOCKY BURIED PEDIMENTS WITH LIGHT TEXTURED SOILS

1. *Extent and location*

This resource unit occupies 1774 sq km or 7.7 per cent of the district. Major areas are (1) north eastern part of Bilara *tehsil*, i. e. part of Khariya-Khangar, Chhapla, Rajlani and Bhopalgarh villages; (2) eastern part of Osian, i. e. Melana, Jaintra, Anwana, Danwra and Kasti, (3) Balesar, Shekhala in Shergarh *tehsil* (4) east of Lohawat in Osian, (5) northwest of Phalodi proper.

2. *Villages covered* : (See Appendix I)

3. *Geomorphic features*

These pediments are initially made of fluvial and *in situ* sediments that have since been covered with aeolian sand in form of dunes, hummocks and sheets. South of Panchla in Osian; Chirwai, Khudiyala, Chanchalwa, Birai in Shergarh *tehsil*; Manaklao, Palri Khichian in Jodhpur *tehsil* the buried pediments are relatively flat and only have a thick sand sheeting and scattered dunes. In rest of the area in Shergarh of this unit, the buried pediments have thicker sand sheeting (50 to 400 cm deep) with frequent hummocks, maximum being ni Balesar area and then again in Khariya Khangar and Rathkuria area in Bilara *tehsil*. In Kherapa, Lawera, Nandian Kalan and Danwro such highly hummocky areas occur in pockets. Outside the area is only moderately hummocky. General slope is 1 to 3 per cent with high local relief. Drainage lines issuing from adjoining hills have moderately dissected the land forms with gullies of varying depth and width. In the upper part of pediment these are 120 to 200 metres apart whereas lower down 500 to 2000 metres apart.

4. *Soils and land use capability*

In the relatively flat plains described above, the dominant soil is Chirai series normal phase, i. e. light soil with a light brown sandy surface a loamy sand sub-soil and a zone of calcium carbonate concretions. The soils can retain 65 to 90 mm of water. The soils have 0.08 to 0.20 per cent Org.C, 12 to 20 kg av. P_2O_5/ha and 100 to 220 kg/ha. In the undulating buried plains in Danwra, Anwana, Nanadia Kalan, Lavera and Kherapa, the soils are less deep because of presence of a concretionary/gravelly or rocky strata

at 50 to 80 cm depth. In Balesar area, the soils are very deep, sandy throughout or in major part of the profile. These soils retain 40 to 70 mm of water in major part of the profile. These soils retain 40 to 70 mm of water in profile and have 0.04 to 0.15 per cent Org. C, 8 to 15 kg av. P_2O_5/ha and 70 to 150 kg av. K_2O/ha.

Dominant soils have a thick cover of structureless loose sand and hence are highly droughty. Their moisture retention capacity is low too. Hence these lands belong to capability class IV ec. Only in less extensive flat plains as pointed above, the soils are in class III ec.

5. *Natural vegetation*

Acacia senegal-Calotropis procera-Calligonum polygonoides community is common on such sites. The associated species and forage resources are almost similar to those in MLRU 2.

Under open grazing conditions, production from this unit ranges between 250 to 400 kg/ha. Howeve, uuder some protection 750 to 1000 kg/ha forage yields have been obtained.

6. *Present land use*

Cultivated area is 60 to 80 per cent with a cropping intensity of 50 to 70 per cent Only exception is villages Bari and Chhoti Bengti in Phalodi *tehsil* and villages Pali and Unawara in Osian *tehsil* where intensity is 30 to 50 per cent only. Irrigated area is 1 to 3 per cent in Balesar (Satan and Durgawatan) and Belwa. In rest of the area farming is only rainfed. Wheat, chillies, Osian, sunflower, *raya* are the main crops under irrigation.

7. *Water resources*

(a) *Surface water* Hydrological characteristics of this unit are similar to that of MLRU-2 and accordingly runoff potential is poor. However, this unit is traversed by quite a few drainage lines which carry storm waters from the adjoining rocky catchments. Use potentiality of this is given in Appendix II. There are four *nadis* in this unit.

(b) *Ground water* In Phalodi *tehsil* static water level in buried pediments over sandstone is 80 to 100 m b. g. l. though perched water is found at 30 to 40 m b. g l. In Lohawat-Dhelana water level is 60 to 90 m b. g. l. Water is brackish (1.5 to 3 mmhos EC).

In Osian *tehsil* in Nandia, Bara, Jatias, Hardhani, Kherapa, Lavera, Basni, Melana weathered zone of medium to coarse grained Vindhyan sandstone intercalated with shales is the main host. Water occurs at 25 to 35 m b. g l. and is of good quality (0 8 to 1.5 mmhos EC) and wells with pump sets give a yield of 25 to 30 cum an hour. Again in Pabuji-ki-Basni Kasti, north of Gangani, Melana, Bhawad, Chari, Bolam-ki-Dhani, west of Gharaw water occurs at 15 to 25 m b g l though slightly breckish (1.5 to 2.5 mmhos EC). East of Umednagar, Dudiyan-ki-Dhani, Huddon-ki-Dhani situation is comparable to above but in Jhipasni water is saline (5 to 15 mmhos EC).

In Shergarh *tehsil* pinkish white to reddish, medium grained, well bedded sandstone is the main aquifer. It occurs in Bastua, Derio, Gopalsar, Belwa, Utambar, Berwa, Chahlawas, Ajbar, Jiabera. Mithabera, Durgawatsar, Shekhala, Bhohu Rajabar and Ketu Bara bas and Balesar. Water level is at 15 to 25 m b. g. l. (except Shekhala 30-35 m) and a fairly good quality (0.6 to 2.8 mmhos EC SAR 2-12). Yield from wells with pump sets is 25 to 30 cum per hour.

In Bilara the unit occurs in Chhapla with water level at 20-30 m b. g. l. Though water is only brackish (2 to 3.0 mmhos E.C.) but it has 7 to 9 me/l residual carbonate.

8. *Resource assessment*

Like MLRU 8, this unit also distinguishes itself by its good ground water potential. In Shegarh *tehsil* an annual surplus potential of nearly 16 mcm of good quality water exists in area mostly located in villages Bastua, Derio, Gopalsar, Utambar, Berwa, Chachlawas, Ajbar, Jiabera, Mithabera, Shekhala, Bholu Rajabar and Ketu. This should permit installation of nearly 250-300 tubewells of 15 to 35 cum/hour capacity or an additional 2000 ha under double cropping. Good potential exists also in Osian *tehsil* in Nandia, Bara, Jaitias, Hardhani, Kherapa, Lawera, Basni, Melana, Danwro, Anwana and Jud. About 150 tubewells or 400 wells can be dug to irrigate an area of 1000 ha. Some potential exists also to the east of Bhopalgarh in Bilara *tehsil* But in Chhapla water quality is not good because of high residual carbonate.

In Balesar are the soils are sandy with low moisture retention capacity and rapid infiltration. Therefore deep percolation losses are very high, being 40 to 60 per cent of applied water. For effective utilization, land levelling, lining of water courses and association of deep rooted plants is suggested. Planting of castor or dates in rows so as not to interfere in normal cropping is one way. Sprinkler irrigation is another good solution. The high initial cost could be offset by increased area that could be brought under command.

For dry farming, resource assessment is similar to that for MLRU 2.

9. *Suggested treatment*

(i) Increased exploitation of underground water as indicated in resource assessment.

(ii) Improved water management through land-levelling and lining of water courses with mud-plaster or *Janta* emulsion. Permanent channels be lined with stone masonary. To utilize in-field deep percolation losses deep rooted horticultural plants like sour lime, date palm, *gunda*, pomegranate be planted along field boundary. Alternately, use could be made of sprinkler system.

(iii) Improved crop husbandry practices as listed in the section on technology.

(iv) Improved dry farming practices as listed for MLRU 2.

MLRU-Ju. 10 ROCKY PEDIMENTS AND PLATEAUX

1. *Extent and location*

This mapping unit occupies 1459 sq km or 6.4 per cent of the district. Its area lies scattered throughout the district but principal occurrences are : (1) a narrow strip in eastern part of Bilara *tehsil* from Pichyak to Borunda; (2) northern part of Bilara *tehsil* in Bhopalgarh, Ustaran, Asop, Darmi; (3) eastern part of Osian *tehsil*, i. e. Kherapa, Lavera, Mewasa, Methania; (4) Kailana-Mandor, Daijar, Keru, Lordi in Jodhpur; (5) Shekhalaketu, Khirjan. Agolai, Balesar in Shergarh; (6) Dedia - Ugras Mandla Dhelana etc. in Phalodi.

2. *Villages covered* : (See Appendix I)

3. *Geomorphic features*

Unlike the buried type, rocky pediments are almost entirely devoid of sediments save for stones and gravels resulting from weathering of exposed rocky surface. Besides, there are vertical joints along which a number of channels of 2-5 m width and 0 5-2.5 m depth have formed. The channels form dendridic, sub-parallel to parallel drainage pattern. Dominant slopes are 1-3 per cent.

The plateaux have been sculptured by erosional-denudational activities of the horizotally and sub-horizontally bedded Vindhyan sandstone. Both rocky and buried types are seen. Rocky type occurs in Kailana-Mandor and in west of Dedia and Ugras Nandla in Phalodi. The surface has 0-1 per cent slope but at margins there are steep scarps (40-60 per cent slope) of 20-40 m height. Along the joints and fissures flow numerous channels that are 120-250 m apart in upper reaches and 500 to 1000 m apart further down. The buried type occurs around Dedia Rann, north of Dedia (Phalodi), south of Narwa and Bhirkali and in Keru and Barli (Jodhpur). The plateau in Phalodi is flat whereas in Jodhpur it is covered with 40-50 cm of sand and dissected by water in to gullies 1-2 m deep, 2-4 m wide.

4. *Soils and land use capability*

The unit is made up of shallow miscellaneous soils with rock exposures. The surface of pediments in the eastern most part of the district, i. e. north of Pichyak upto Borunda (with exception of Kumharaon-ki-Dhani), Marasia, Chaukri Kalan and Madpuria, Basni, Norsar, Asop, Gajsinghpura and Lawri (all in Bilara *tehsil*) is made up of gravel and stones mixed with loamy fine sand to fine sandy

loam soil of 15 to 20 cm depth. In Bhopalgarh, Ustara and Kumaro-ki-Dhani it is mostly gravelly loamy sand with occasional hummock. Elsewere namely in Lavera, Hardani, Melana Bandero, Umednagar, Osian, and particularly in Shergarh-Balesar and Degana-Suap in Phalodi, hummocks and thin sand sheeting are seen in pockets overlying fractured rock surface. These pockets of irregular shape and small size constitute mostly 15 to 25 per cent of the area.

Bare hard rock areas belong to class VIII whereas those with some soil cover belong to class VII.

5. *Natural vegetation*

In the Kailana and Agolai plateaux a community of *Euphorbia caducifolia-Acacia senegal* is quite common. Here 2 to 16 sq m clumps of *Euphorbia caducifolia* with 60 per cent relative dominance (20-40 pts/ha) and fairly good growth make the area a moderately open shrub land. Some of the common associates are *Lycium barbarum, Maytenus emarginatus* and *Zizyphus nummularia.* The plants of ground flora are *Tephrosia purpurea, T. petrosa, Oropetium thomeaum, Cenchrus biflorus, D. sindicum, Indigofera cordifolia,* and *Boerhavia diffusa.*

In some rocky pediments *A. senegal Maytenus emarginatus* community is recorded.

The associated trees, shrubs and climbers of the above communities are *Maytenus emarginatus, Anogeissus pendula, Cordia gharaf, Capparis decidua, Lycium barbarum, Solanum albucaule, Cocculus pendulus, Tinospora cordifolia. Asparagus recemosus* and *Ephedra foliata.* The composition of the ground flora is fairly rich under protected conditions. It includes *Tephrosia pursurea,* a non-palatable under shrub, as dominant. Other herbs and grasses are *Cleome papillosa, Lepidagathis trinervis, Blepharis sindica, Boerhavia diffusa, Peristrephe bicalyculata, Digera muricata, Achyranthas aspera, Sida species, Indigofera cordifolia, Cenchrus biflorus, Aristida funiculata, Dactylectenium sindicum, Eleusine compressa, Melanoceuchrus jacquemontii, Enneapogon brachystachys, Cenchrus ciliaris* and *Cenchrus setigerus.* All these species either do not exist in in unprotected conditions or they are very poorly represented.

Under open grazing conditions, production from pediments with shallow soils ranges between 50 to 100 kg/ha. However, under protection 550 to 800 kg/ha of forage yields have been obtained. In a recent exclosure on rocky and gravelly pediment (Salawas) 1210 kg/ of herbage production has been obtained.

There are very few trees on this habitat. Mostly these areas are clothed with various types of shrubs providing fuel wood of low value. The standing tree biomass ranges from 4.5 q/ha to 20 q/ha.

6. *Present land use*

It is dominantly an open grazing land with 5 to 10 per cent of the area under cultivation.

7. *Water resources*

(1) *Surface water* This unit has a high potential. Studies made in small catchments in Kailana area in this unit revealed that on an average, 40 per cent of mean annual rainfall goes as runoff. Under high rainfall conditions of 50 mm/ hour as high as 70 per cent as runoff has been recorded. Similar is the situation also in Bhopalgarh pediments. However, runoff from Asop and Borunda and Ransigaon pediments, though still good, is less than this. Potential catchments together with their catchment characteristics and runoff potential are given in Appendix II. There are six big and medium sized *nadis* within this unit.

(b) *Ground water* This unit has generally a thin cover of sediments and it is therefore a very poor host of groundwater.

8. *Resource assessment*

By far the major land usage is as open grazing lands and for quarrying stone. These also serve as catchments for a number of streams and ponds.

Present day forage production from these lands is nominal being 50 to 100 kg/ha. The grazing lands have a herbage cover of 0.2 to 0 7 per cent only. What is more it is composed mostly of undesirable or less desirable species like *Tephrosia purpurea, Oropetium thomeaum, Capparis decidua* and *Euphorba caducifolia.* Stand of trees like *Acacia senegal* and *Propopis Juliflora* is highly variable but is mostly from nil to 15 plants/ha. In the absence of soil and water conservation measures, much of water along with sediments goes as run-off. Therefore, considerable scope exists for upgrading production. In areas with shallow soils such as in Asop, Bhopalgarh, Ustara area and then again in the narrow strip from Pichyak up to Borunda, furrowing and staggered trenching have good scope in soil and water conservation. This pratice coupled with reseeding of *Dicanthium annulatum, Cenchrus ciliaris,* can raise pasture production to 600 to 900 kg/ha. Elsewhere also, soil depth permitting, similar technology can be applied. However, in areas dominated by bare rock a combination of adapted trees like *Acacia senegal, Zizyphus nummularia, Anogeisus pendula* and short grasses are ideal. With the protection and controlled grazing, these lands can support 60 to 100 trees/ha of *Acacia senegal* for pods and gum. A tree can yield about 100 gm of gum. A pasture production of 300 to 500 kg is besides.

The unit also has considerable surface water potential. Details of catchments falling in this and other units is given in Appendix II.

9. *Suggested treatments*

(i) Furrowing and staggered trenching followed by reseeding with *Dicanthium annulatum, Cenchrus ciliaris* and *Cenchrus setigerus* in the *magras* in Bhopalgarh, Asop and Bilara-Borunda areas. It should be followed by controlled grazing

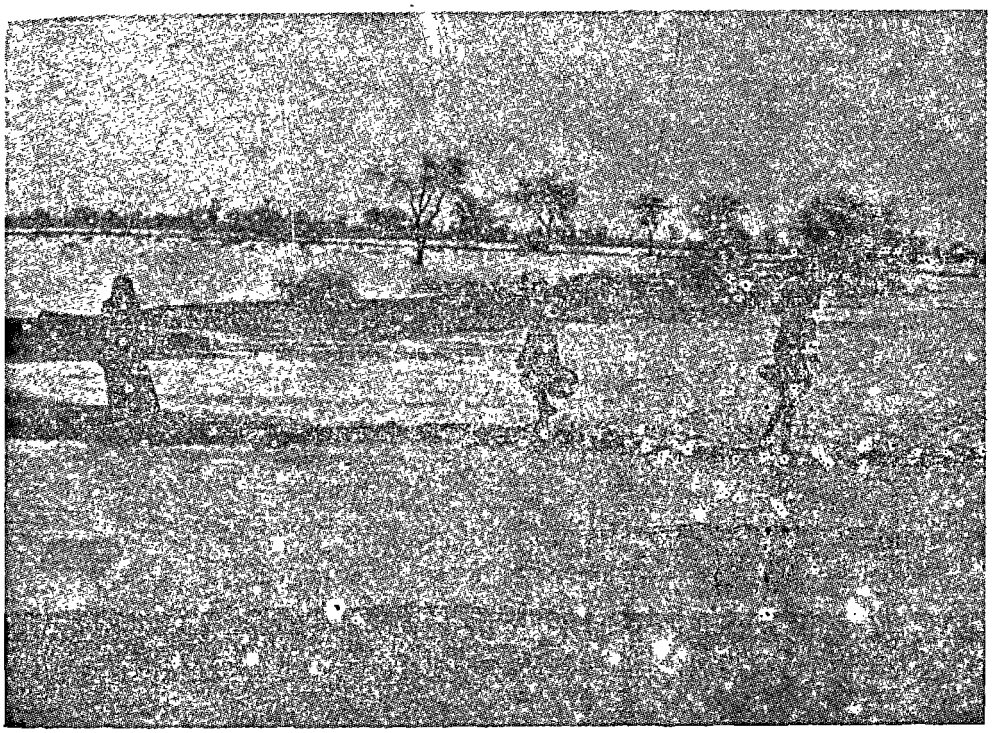


Plate 8. MLRU-Ju. 7. Flat aggraded plains with fine textured soils. Besides good farming technology, scope exists for intra and inter-field run-off management. Limited ground water can be used through sprinkler system to provide supplementary irrigation.

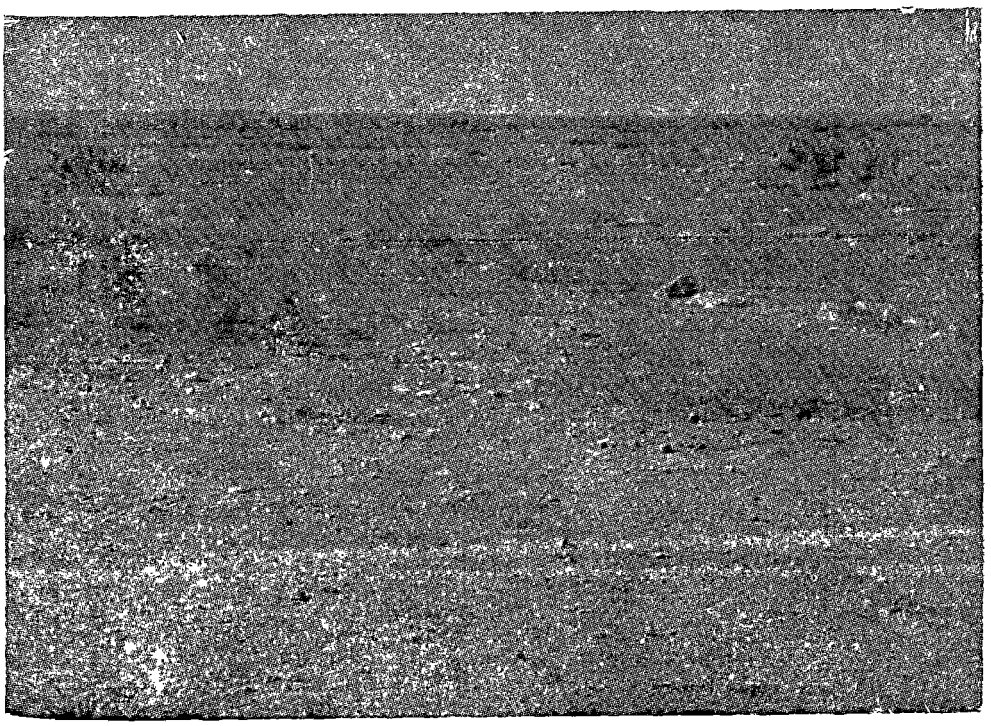


Plate 9. MLRU-Ju. 10. Rocky pediments. Presently dominated by unpalatables or low-yielding annuals.

Plate 10. Through reseednig and controlled grazing, good grass-lands can be developed o the rocky pediments.

Plate 11 Sand-stone rocky plateau is intensively quarried as a building material.

MLRU-Ju. 11 FLAT AGGRADED PLAINS WITH SALINE ALKALI SOILS

1. *Extent and location*

This unit occupies an area of around 161 sq km or 0.7 per cent of the district. It lies as a continuous strip in the southern part of Bilara *tehsil* in villages Bijasani, Malkosni, Gujarawas, Parasla and Hariyada.

2. *Vtllages covered* : (See Appendix I)

3. *Geomorphic features*

These are medium textured, nearly level plains with salinity problem. This plain is associated with the courses and interfluves of the prior streams and salinity-alkali problem has developed in it due to excessive irrigation and impeded drainage conditions.

4. *Soils and land use aapability*

This unit comprises saline-alkali soils associated with occurrence of highly saline sodic waters close to surface. The soils are saline-alkali throughout or in the sub-soil with a alkali surface. These are dominantly medium textured though variations from loamy sand to clay loam are seen. The soils in their dry state are very hard with a platy crust and a columnar blocky structure below. In wet state, these are in puddled, dispersed condition. The pH values are between 8 3 to 9.6 with EC 1:2 values in surface layer of 0.4 to 3.5 mmhos and in sub-soil of 1.5 to 6.3 mmhos. Organic carbon ranges from 0.20 to 0.25 per cent, available phosphorus from 12 to 24 kg P_2O_5/ha and potassium from 140 to 250 kg K_2O/ ha.

The salinity-alkali regime in soils is too adverse to permit normal growth of common crops of the area. In some high lying pockets *bajra* is tried but with little success. Common use is wheat farming with under ground saline water irrigation. It calls for a specialised management of rainy season fallow. Because of these limitations the lands are classed as V sa.

5. *Natural vegetation*

The unit is dominated by *Salvadora oleoides-Capparis decidua* community. Associates are *Salvadora persica, Prosopis juliflora, Zizyphus nummularia, Indigofera oblongifolia.* Density of vegetation is highly variable. Whereas regularly farmed lands have 10-20 trees of *Salvadora* and 15 to 40 trees of *P. Juliflora* long fallows

and *orans* have a density as high as 120 and 60-200 trees per hectare respectively of each of these species. Ground flora comprises *Eleusine compressa, Sporobolus marginatus, Dicanthium, annulatum, Panicum turgidum, Dactylocenium aegypticum, Chloris virgata, Bracharia ramosa,* and *Cyperus rotundus.* Forage yield and quality is low. In average rainfall years, the produotion ranges from 200 to 350 kg/ha. But in years of above normal rainfall as much 500 kg/ha is realised.

6. *Present land use*

Cropped area is only 50 to 60 per cent. Out of this irrigated area is 30 to 60 per cent farming both under rainfed and under irrigation has monocropping as the main practice. Rest of the area is fallow and saline waste.

7. *Water resources*

(a) *Surface water* : Low water intake rate of the lands induces considerable runoff. Presently. much of this runoff goes into Chopra canal and then into the Nayagaon tank in the Pali district. However, the run-off waters are brackish in character. There are five *nadis* in this unit.

(b) *Ground water* : Old alluvium is the main aquifer and static water level ranges between 10 m b. g. l in the east to 4 m b. g. l. in the south west. But water is highly saline (8 to 16 mmhos EC, SAR 24 to 35) Under the influence of fresh rechage cushions of brackish water form such as are found in Kunhiya, Haria, South of Padasla Khurd and Hungaon Kalan. However, the main aquifer underneath continues to be highly saline. Yield from dug wells is good (5 to 20 cum/hour).

8. *Resource assessment*

This unit, though lying in a favourable rainfall zone (400-430 mm) has a limitation on account of soil salinity. The problem is due to high water table arising from the absence of good drainage. This problem got accentuated by introduction of Pichyak irrigation system (Parasla canal). Presently, water table is at 4-10 metres during dry part of the year. But, it rises to within 2 metres of surface during rainy season. The underground water is highly saline. Present position is that 25 per cent of the area in form a one km strip from Bari Kalan upto Parasla Khand is so saline that no cropping is possible. The area provides nominal grazing and some fuel wood. Rest 80 per cent is also saline but within range where salt tolerant wheat could be grown with ground and in fact 20 to 40 per cent of the area is being so used. Occasionally irrigation water is available from Pichyak canal also. Crop yields are 6-7 q/ha.

The principal cause of salinization is lack of adequate drainage. Presently, there is no convenient way of providing such a drainage system unless the much larger area lying further south is also so treated. Only after this, other soil reclamation measures can be successful. Till such time, some helpful suggestions are: (a) increased use of ground water to help reduce water level, (b) improved water management of canal water. Presently, wild flooding is practised.

Ground water storage is very good but quality is highly saline. This water should still permit a yield level of 10 q/ha by increasing seed rate to 2 q/ha, proper varieties, i. e. Kalyan Sona upto 8-10 mmhos water and Kharchia with more saline waters, use of nitrogenous fertilizers where water salinity is less than 10 mmhos. In areas where feasible, mixing of canal and underground water in 1:1 ratio will be very helpful.

9. *Suggested treatments*

The area is in need of detailed studies. The work till now suggests that major requirement is lowering of water table for which an integrated drainage system has to be developed for the area as a whole, which includes a much larger part further south in Pali district. This can then be followed by other measures like gypsum application and green manuring. Till such time emphasis should be on increased use of ground water in mixture, wherever feasible, with canal water.

With waters upto 10 mmhos salinity, preference should be for Kalyan Sona with a basal dose of 40 kg N and 30 kg P_2O_5/ha. At higher salinity, Kharchia 65 would perform better. However, because of its high susceptibility to brown rust, control measures are necessary. In area where canal water is available, successful crop of *raya* can be had with 2-3 irrigations. Protection against aphids is a pre-requisite.

Plate 12. MLRU–Ju. 11. Flat aggraded plains with saline–alkali soils. Permanent solution lies in improvement of drainge followed by use of soil amendment.

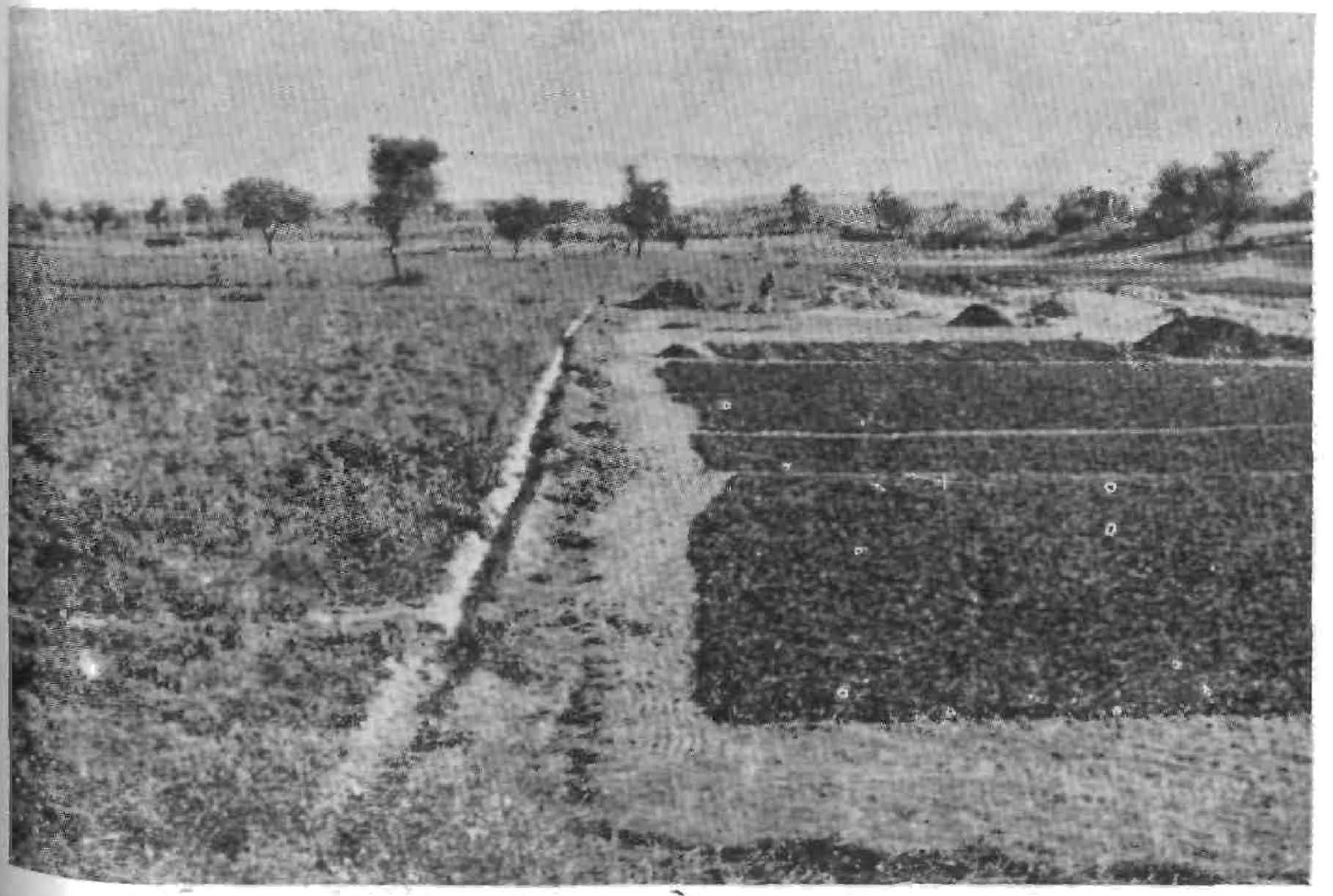


Plate 13. MLRU–Ju. 12. Younger alluvial plains. On lands irrigated with good quality water, there is an acute need of an integrated technology based on plant protection, improved varieties, higher fertillizer input and better water management. Photo shows the produce of chilles being dried.

MLRU-Ju. 12 YOUNGER ALLUVIAL PLAINS

Extent and location

The unit occupies an area of 564 sq km or 2.5 per cent of the district. It occurs as a narrow strip along the natural drainage lines. By far the major area is that lying on either side of river Luni as a 5-6 km wide strip. Its width along other streams namely, Mitri, Gunaimata, Sukli, Reria, and Jojri is much smaller and ranges between 2 km to less than 250 m. Along other streams like Golasni, Ghat, Gotabar, etc. it is too small to be shown on the map.

2. *Villages covered* : (See Appendix I)

3. *Geomorphic features*

These plains have formed as a result of over flow or meandering. The top 40 to 80 cm thickness is made almost entirely of waterborne, coarse sands occasionally with bands of grits. The diameter varies from 0.06 to 1.19 mcm (mean of 0.39 mm. The plains are nearly level with less than 1 per cent slope. Area near Dunara, Jhak and Karniali are degraded by aeolian activity which has created hummocks of 0.6 to 1.5 m height and longitudinal dunes of 3 to 6 m height. The flood plain of Luni river between Pichyak and Udlia is affected by salinity due to impeded drainage caused by construction of Pichyak dam. Flood plains of some of the minor streams, particularly Khari, Ghati, Gotabar and Bandi are not only very narrow but also highly degraded. Parabolic and longitudinal dunes of 3 to 10 m height and sand ridges and hummocks of 0 9 to 2 m height are very common.

4. *Soils and land use capability*

Soils are very light greyish brown, generally calcareous, light textured with 6.4 to 11.3 per cent clay and 3.7 to 9.3 per cent silt in sub-soil. Surface is lighter and at places, as in Hungaon Kalan and Parasla, it is also highly hummocky. These are mostly very deep. Exception is alluvium in Khoaspura, Jaspali and in Gangana where old concretionary strata is present at 60 to 80 cm. The pH is mostly 8.4 to 8.7 but with no salinity except where irrigated with saline water or where inundation occurs. The soils can retain 60 to 80 mm of moisture/metre depth. These have between 0.20 to 0.32 per cent Org. C, 10-22 kg/ha available phosphorus and 150 to 280 kg/ha available potassium.

The soils have a moderate to moderately severe problem of wind erosion. Their moisture retention capacity and soil

depth are sufficient for adapted crops. Fertility status is also sufficient though handsome response is obtained to application of fertilizers. Majority of the soils belong to class III ec. Those with availability of good quality water within easily exploitable limits belong to class II c.

5. *Natural vegetation*

Alluvial plains of Luni proper is dominated by a community of *Prosopis cineraria-Acacia nilotica* Spp *indica-Salvadora oleoides*. Plant density varies from field to field depending upon the maintenance of these trees by the cultivators. In the upper reaches, i. e. in Bhawi, Lamba and Olwi, *P. cineraria* has a very good stand and vigour (20-40 trees/ha; 50 to 120 cm B. H. G.). Some of the low lying areas near the river course are dominated by *Salvadora oleoides* (95 per cent relative dominance). *Salvadora* is associated with *Capparis decidua*, which at Sikarpur gains 73 per cent proportion while *Salvadora* gets reducted to 15 per cent only for the major area, generally *Salvadora oleoides, Prosopis cineraria* combine to form a community with 75 and 15 per cent relative dominance. *Salvadora* trees are quite big (50-140 cm BHG). Other associated species are *Calotropis procera, Balanites aegyptiaca, Indigofera tinctoria, Indigofera oblongifolia* and *Prosopis juliflora*. In larger part of this unit *Tephrosia purpurea* is prominent too. The *kharif* weeds common with these communities are *Corchorus tridens, Cleome viscosa, Cleome gynandra, Fagonia cretica Boerhavia diffusa, Eleusine compressa, Cenchrus biflorus, Aristida funiculata A. adscensionis* and several species of *Eragrostis*.

At certain places, along the river course, there is the formation of sandy hummocks due to large sand supply from river bed. Vegetation comprises psammophytic plants like *Calligonum polygonoides, Calotropis procera, Leptadenia pyrotechnica, Aerva pseudotomentosa* and *Crotalaria burhia*.

Mitri alluvium with a sizeable area under irrigation has a community of *Prosopis cineraria - Acacia nilotica* Spp *indica*. The associated species of trees and shrubs are *Prosopis juliflora, Azadirachta indica, Albizzia lebbek, Zizyphus mauritiana, Capparis decidua, Poincia elata*

Natural ground flora during *Kharif* season includes *Dactyloctenium sindicum, Digitaria adscendens, Cenchrus setigerus, Pulicaria wightiana, Viscoa indica, Aerva persica, Boerhavia diffusa, Tephrosia purpurea, Cyperus rotundus, Cynodon dactylon* and *Xanthium strumarium*. Some of the common winter weeds of *rabi* crops are *Anagalis arvensis, Asphodelus tenuifolius, Chenopodium album, C. murale, Solanum nigrum, S. surattense, Meliobotus alba* and *Carthomus oxyacantha*

In the river bed proper the hummocks have almost a pure stand of *Tamarix erecoides*. Depending on deposition, few shrubby associates are encountered, i. e. *Acacia jacquemontii, Alhagi pseudolhag, Desmostachya bipinnata, prosopis juliflora* and *Leptadenia pyrotechnica*. Other associates are *Xanthium strumarium, Salvia aegyptiaca, Tephrosia purpurea, Sporobolus coromandelianus* and *Boerhavia*

diffusa. Along the course of river Luni, the river bed terraces possess different picture of the vegetation. Some portions are dominated by *Prosopis juliflora* with 90 per cent dominance but large courses all along the river Luni are occupied by *Salvadora persica* and *Tamarix dioica* community. Their relative dominance vary from one place to the other. But, on an average, it is of the order of 50 and 40 per cent, respectively. These species are mostly found in bushy form because of continuous cutting and browsing.

The unit makes good contribution to forage resources of the region. Fallow lands with basal cover of 3.5 to 6.5 per cent provide on an average 950 to 1140 kg/ha of dry matter. Top feeds in addition give 350 so 600 kg/ha of nutrition dry matter.

6. *Present land use*

Cropped area is 80 to 90 per cent. Out of this 50-70 per cent is in Bilara, on Luni river and from Khoaspura to Benan on Mitri and in villages Birain, Kasti and Gangana are under irrigation and mostly double cropped. In the rest irrigated area is only 10-20 per cent and mostly single cropped.

7. *Water resources*

(a) *Surface water* : Surface and sub-surface flow in the streams along which the area of this unit is located, is a major hydrological feature. For efficacious utilization of flow in Luni river proper, a major storage structure with irrigation facility exists. Similary, on the other tributaries namely Mitri and Gunaimata structures have been built with the dual purpose of bed cultivation and groundwater recharge. Though the surplus surface water potential and its management is a subject of detailed study, the present analysis suggests that there is a good surplus flow once in about three years for which utilization need to be planned. The underlying principle should be construction of sub-surface semipermeable barriers along with infiltration galleries to ensure local recharge and sufficient flow down stream for recharge of wells there. This treatment could be done at a number of places particularly along Mitri river so that no flow even of above normal years goes waste and is evenly distributed for recharge of groundwater. There are six *nadis* within this unit.

(b) *Ground water* : Depending upon the amount and duration of flow, ground water in the unit is amenable to inter-annual, seasonal as well as spatial variations. Results of observations of 1971 and 1972 show the following :

Luni : In the eastern most point of entry of river Luni, i. e. in Khariya, Meethapur and Koopdewas water is at 10 m. b. g. l. and only slightly brackish (1 to 1.5 mmhos EC). Downstream in Bilara, Pichyak and part of Bhawi the water level is at 10 to 15 m b. g. l. and water highly brackish (3 to 5 mmhos EC, 6-12 SAR and 2 to 5 me/l residual carbonate). Further down in west part of Bhawi and part of Rawar, Olvi, Lamba, Holpur Bala, (Bilara *tehsil*), Pesawas, Mortuka, Golio, Goojrawas, Rajpuria,

Nimbla, Dhingana, Shikarpura, Luni, Khera, Karmiali and Lakhar Thumla (all in Jodhpur *tehsil*) static water level is 5 to 10 m and water highly saline (8 to 14 mmhos EC, 18 to 32 SAR) but overlying fresh water cushious are only brackish (3 to 5 mmhos EC). On the northern bank of Luni in Lalasni, Dudia and Dhundara waters are relatively less saline (4 to 8 mmhos EC). In Reria *nadis* (south of Bhetanda) water is also highly saline.

Mitri : In the upper part of the stream namely, in part of Kosana, Siara, Chakkri Chhoti, Khoaspura water occurs at 10 to 20 m and of only slightly brackish (0.5 to 2.6 mmhos EC, 0.5 to 5 SAR and residual carbonate upto 6 me/l). Further down in part of Pipar, Jaspali, Benan, Buchleala, Chodlia, Binawas south of Bisalpur and Rurkali, the water occurs at 12 to 20 m deep and is of variable salinity being brackish (2 to 3 mmhos) in immediate vicinity of river course to highly brackish (3 to 5 mmhos EC) away from it. Further down in Birdawas, Singhasni, Bhagasni the waters are saline (6 to 12 mmhos EC).

Jojri : The strip of alluvium has static water level at 5 to 10 m. b. g. l. south of Banar upto Kharda but further down it is 10 to 15 m. But water is generally saline (5 to 10 mmhos EC, 10 to 18 SAR) except in few pockets as in Salawas, Nandwana and then again in Lunawas Khurd and Jatiawas where water is only highly brackish (2.5 to 4 mmhos EC). A tributary of this namely Golasni has relatively good water (1.5 to 2 mmhos EC) but water level is deep, i. e. 25 to 40 m b. g. l.

Others : Sukli alluvium falling in villages Kori, Artia has water at 10 to 15 m and brackish (0.8 to 3 mmhos EC, 5 to 11 SAR, occasionally residual carbonate present). Gunaimata alluvium in villages Rundia, Ustaran Birani, Birai, Sheoki Kalan Gangani water table is at 15 to 20 m and water is brackish (0.5 to 2 mmhos EC, 3 to 7 SAR and 2 to 7 me/l residual carbonate).

8. *Resource assessment*

This MLRU distinguishes itself by the presence of less mineralised groundwater within easily exploitable limits in sizeable area. It therefore has a large concentration of double cropped area. In Bilara and adjoining area of Luni alone there are about 3000 ha of irrigated area. Similarly, Mitri alluvium in its upper reaches has 1550 ha of such lands. Gunimata has another 970 ha, whereas Sukli *Nadi* has 580 ha under irrigation. With present intensive exploitation little surplus potential exists. Bilara area is already over exploited. In Mitri *nadi* alluvium also, wells run dry in most years. It is only during flood years, that situation is easier. Gunai Mata and Sukli *nadi* have some potential. Though detail studies are necessary, present rough estimates indicate that 140 more dug-cum-bore wells in Gunai Mata and 50 such wells in Sukli can be had with a discharge potential of 20 to 30 cum/hour. An additional area of 1200 ha can be brought under irrigation.

Luni and Sukli and to a sizeable extent Gunai Mata alluvium have light textured soils with high deep percolation losses

The farmers in the area have made big investments in irrigation facility and capitalised on it by commercial cultivation of lucerne, chillies, coriander, cumin and vegetable crops, yet the benefit realised is short of optimum. Presently, yield of chillies is only 15-20 q/ha and that of corriander and cumin respectively 3-4 and 1.5-2 q/ha. The prime reason is white grub and nematode problem in chillies and powdery wildew in cumin. In certain years the yields are close to nothing. Therefore lack of plant protection is a big limiting factor. In case of wheat with common low level of fertilizer inputs yields average 15 q/ha. *Raya*, a very profitable crop, has restricted coverage on account of severe aphid infestation.

9. *Suggested treatments*

(i) Digging of more tube wells in the presently under exploited area namely that along Gunai Mata and Sukli *nadis*.

(ii) Improved management of existing command areas through:

(a) Replacement of existing *desi* or farm wheat with Kalyan Sona and its optimum fertilization, i. e. 70-100 kg N 30-40 kg P_2O_5/ha.

(b) Increase in area under more efficient crops like *raya* with plant protection measures against aphids.

(c) Adoption of control measures in vegetable crops against white grub (thiodemeton or lindane) in chillies against nematodes (dichloropropane-dichloropropine-mixture), in cumin against powdry mildew (corathion or other sulphur containing fungicide).

(d) Linning of water courses.

(iii) Improved dryland farmnig technology as listed for MLRU 3.

MLRU-Ju. 13 SALINE DEPRESSIONS

1. *Extent and location*

This unit is composed of a number of isolated pockets which together occupy an area of 156 sq km or 0.7 per cent of the district. Amongst these the major once are Agar-Ka-Rann (73 sq km) Kaparda (25 sq km) and Dedia (6sq km). Smaller once are located near Bilara, Bhetnada and Netran.

2. *Villages covered* : (See Appendix I)

3. *Geomorphic features*

These flat depressions are the relict of past drainage channels. These are the result of impeded drainage developed due to choking of stream beds by sedimentation. The depressions are constituted of thick, sandy clay loam to clay deposits underlain by thick beds of aeolian sand and /or deeper by weathered rock.

4. *Soils and land use capability*

High salinity is the characteristic feature of these soils. Range of salinity in soil profile in the three principal depressions are given in Table 1.

Table 1. Range of salinity in different saline depressions

Kaparda Rann			Agar-ka-Rann (Phalodi)			Dedia Rann		
Depth	pH	EC 1:2	Depth	pH	FC 1:2	Depth	pH	EC 1:2
0-10	7.8-8.8	0.11-2 45	0-15	8 4-9.1	0.42-1.72	0-5	8.5-8.41	0-42-1.83
10-35	7.8-8.7	0.22-3.65	15-30	8 3-8 8	2.21-3.89	5-20	8 8-8.6	8.41-20.33
35-60	8.1-8.6	1.82-3.78	30-75	8 2-8 6	6.74-12-43	20-45	8.2-8.5	11.41-24.76
60-90	8.2-8.7	2.98-6.43	75-100	8 2-8.4	12.70-19-64	45-80	8.2-1.5	14.76-29.30
90- +	8.2-8.7	3.12-8 32						

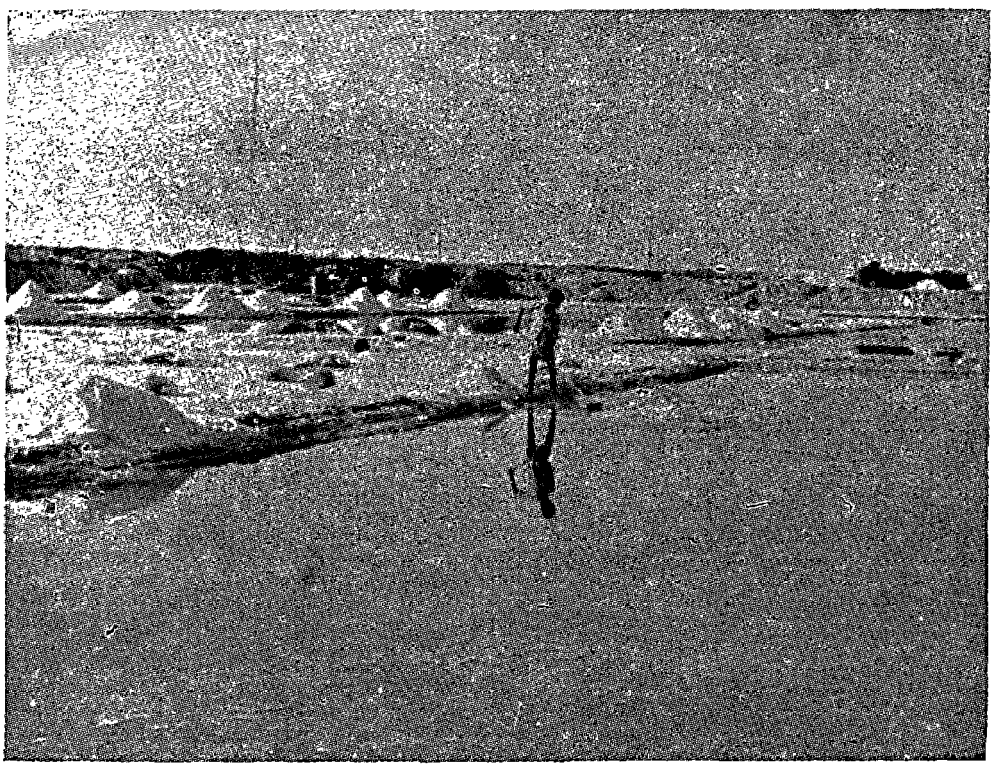


Plate 14. MLRU-Ju. 13. Natural saline depressions. Extracation of common salt from the Malhar (Aghar) Rann.

The salinity figures for Kaparda and Dedia are for winter months, whereas there are for only summer in case of Agar-ka - Rann. During dry summer months there is a great increase in salinity particularly in case of Kaparda-*Rann* and a white crust appears. Texture of soil is variable. Whereas Kaparda Rann is mostly sandy loam to gravelly loam, Dedia Rann is silty clay loam. In case of Agar-ka-Rann, profile shows a high degree of stratification. Surface 30 to 70 cm is silty clay loam but underneath there are stratified bands of clayey silt and fine sand.

High salinity severely limits the agricultural potentiality of these lands during rainy season, when the salinity gets diluted or partially leached, a thin stand of salt resistant grasses come up. Where there is some sand accumulation on surface, farming is practised. Such area with sand overburden is small, and therefore by far the major area falls in land-capability unit VIII.

5. *Natural vegetation*

Mining site is almost free of vegetation except few scattered bushes of *Suaeda fruticosa*. The mining areas are surrounded by some sand accumulated patches where halophytic and few psammophytic species get their foot hold. Over all these saline areas are occupied by 'Succulent halophytic desert." In these saline areas there is a marked difference of plant assemblage which directly reflects the extent of salinity and water logging conditions. The following plant communities are recorded :

1. *Suaeda fruticosa-Salsola baryosma* on high salinity zone.

2. *Haloxylon salicornicum-Sporobolus marginatus* on patches completely covered by sand sheets.

3. *Fimbrystylis / Scirpus - Cyperus species* on water logged patches.

Other halophytic species met within these saline areas are *Halophytic recurvum, Atriplex* sp., *Desmostachya bipinnata, Aleuropus lagopoides, Sporobolus marginatus, Eleusine compressa, Portulaca oleracca, Cressa cretica, Zygophyllum simplex, Sesuvium portulacastrum, Boerhavia elegans, Trianthema pentrandra, T. triquetra. Eragrostis diarrehna, Cenchrus setigerus* and *Aerva persica.*

The fringes of the saline depressions with less salinity are occupied by widely scattered tree species of *Prosopis juliflora, Salvadora oleoides, S. persica, A. nilotica* Spp *indica* and *Capparis decidaa.* These saline areas afford some grazing and with better management practices productivity can be improved.

In these areas of Rann some sand piling occurr on the outer periphery which allow the germination and establishment moderately salt tolerating grasses like *Sporobolus marginatus, Chloris virgata* and *Dicanthium annulatum.* Under protection these grasses form good grassland providing a herbage production of 2632 kg/ha. The production can further be improved upon by adopting contour furrows. Unprotected and heavily grazed grasslands under normal years give a forage production of 400 kg/ha.

6. *Present land use*

A major part of the *ranns* is devoid of a vegetation cover and hence is barren. This vegetation cover in patches provides a very limited grazing. But some of these like Agar-ka-Rann are in use to extract the common salt.

7. *Water resources*

(a) *Surface water* : Being depressions, there is hardly any runoff from this unit. The rainfall received trends to pond on the surface. Part of it goes to recharge the underground storage. Particularly for Agar-ka-Rann (which has a fine textured surface and hence limited intake) steps could be taken to artificially recharge the groundwater in order to increase the yield of brine from the wells.

(b) *Ground water* : It occurs at depths of 2.5 to 4 m b. g. l. in Malhar and Kaparda Ranns but it has no agricultural potentiality because of extremely high salinity (20 to 35 mmhos EC). As regards Dedia Rann no such information is available. Saline depression South-east of Netran also has very bad water because of salinity and residual carbonate.

8. *Resource assessment*

Am ongstthe saline depressions, the one at Malhar is exploited for common salt, with an average production of about 0.1 million tons/year. Kaparda Rann has not proved productive. Agricultural utility and potential of these lands is rather low. On the marginal area of these ranns variable capping of wind blown sand is observed and this permits conventional dryland farming though yields are low, i. e. 1-1.5 q/ha of *bajra.*

Saline depression proper has same specific vegetation cover which remains dormant during low rainfall years. But in good rainfall years, with dilution of soil salinity these put up growth. Much of this green mass is of low palatability. Grazing potential of these lands in such years has been assessed at 50-150 kg/ha. On the periphery wherever sand piling exists productivity is 400 kg/ha.

9. *Suggested treatments*

Forage production from these lands can be improved by giving the lands an undulating micro relief. This treatment would help creating localised area of low salinity on slope and top of the bed.

MLRU-Ju. 14 HILLS

1. *Extent and location*

This unit occupies an area of 428 sq km or 1.8 per cent of the dtstrict. It lies scattseed as irregular exposures of varying hight and extent throughout the district. Major areas are : (1) South-eastern corner of Bilara *tehsil*, (2) Central part and Chhapla, Bhopalgarh, Ustaran also in Bilara (3) North of Jodhpur proper; (4) Kharda Mewasa and Osian proper in *tehsil* Osian; (5) Shergarh-Balesar; (6) around Osian.

2. *Villages covered* : (See Appendix I)

3. *Geomorphic features*

This unit is made up of hills and associated piedmonts. The hills are made up of Upper Vindhyan sandstone and limestone, Pre-Cambrian granite and rhyolite and Aravalli slate and quartzite. Of these, sand stone hills occupy the the largest area followed by rhyolite and granite. Sandstone hills occur as isolated features and chains and are scattered throughout the district. Hill chains in Osian *tehsil* are seen in Kharda Mewasa Begriya-ki-Dhani, Lavera, Kalan area. In Shergarh these chains are seen in Bastua, Deriya, Meriya upto Ratton-ka-Bas and then again in Belwa Rajwas, Ketu Madan and Balesar area. Chains of sand stone hills in Jodhpur *tehsil* are in Kailana-Mandore area where these occur as scarps of 5-25 metres thickness uncomfortably overlying Malani rhyolites. Small chains are also seen in Parli Bari, Magalian and Sursagar villages. In Bilara *tehsil* there are three distinct chains. One starting from Banderao to Gaderi passing through Sopda, Ustra and Hiradesar village. The last chain lies in Bhopalgurh village. The hills are mostly 50 to 150 metres above ground level. Isolated hills of sandstone of 20-80 metre height occur in Amla, Bhadaura, Himal-ka-Gol, Kundal and Lohawat in Phalodi *tehsil*; in Nerwa and Kelawa Kalan, Indroka and Sunariya in Osian; in Khirjasoria in Shergarh; in Keru, Meglasiya of Jophpur and in Todiyana, Mandoli in Bilara.

Limestone out-crops occur in Bithri and Kundal villages in Phalodi. In Bilara a north-south a continuous ridge of sub-dune height of 8-30 metres runs through Borunda Hariyadhana and Ransigaon. Another chain of hills upto 100 metres high is seen to south of above, in villages Jeti; Barna and Ajbar.

Rhyolite hills of 60-150 m height occur in Santora in Osian. Khirjan, Qui Indo, Bhalu, Agolai and Dugar in

Shergarh and in Sar, Kankani, Mogra, Barli and Daijar villages in Jodhpur. Granite hills of 24 to 108 metres height occur in Salawas, Jhalamand, Nandwan, Ritleasni, and Rasido villages of Jodhpur and Bhetanda, Pipar, and Madaliya villages of Bilara *tehsil*.

Aravalli out crops occur in Bilara *tehsil* only. Of these exposures of slates occur near Chandelao, Merasia, Pichyak and Sonia villages. The quartzites are found in Olwi and Rawaniyana villages.

Unlike most hills with precipitious slope, some in Jodhpur *tehsil* have gentlar slopes due to deposition of colluvial and aeolian sediments as piedmonts. The upper part of these have 5-10 per cent slope, and 3-5 per cent further down. The thickness of sediments is highly variable but down slope it is as much as 10 to 25 metres. At most places the sediments have been dissected by water to create gullies of various dimensions. Principal locations are in Bujawar, Rohila Kalan, Sar Nandwan, Fifkasni all in Jodhpur *tehsil* and in Olwi in Bilara.

4. *Soils*

Soil cover is practically non-existent. In an area 5-10 per cent in form of small pockets a cover of loose sediments of 1 to 5 cm thickness is present. In 1 to 2 per cent of the area in depression, course colluvial deposites mixed with sand are present. Piedmonts are made of coarse scree with sand cover at places. Lands belong mostly to capability class VIII.

5. *Natural vegetation*

Sand stone hills are dominated by *Capparis decidua* and *Maytenus emarginatus*. However, the stand is extremely poor but their growth is quite stunted, The rhyolite sandstone hills in Kailana-Mandore area have *Acacia senegal*, *Grewia tenax* and *Euphorbia caducifolia* community. Also come across a e *Euphorbia caducifolia-Acacia senegal* community a seral community on moderately exploited rocky places. *Euphorbia caducifolia* community, a mixed degraded seral community on severely affected hillocks and parts of the plateau. The limestone hillocks common in Bilara *tehsil* have few scattered bushes of *Capparis decidua* or *Lycium barbarum*. Here the ground flora includes *Cenchrus setigerus*, *Tephrosia purpurea*, *Crotalaria burhia*, *C. biflorus*, *Tragus biflorus*, *Dropetium thomeaum*, *Eragrostis* sp., *Indigofera cordifolia*. Here again ground flora is dominated by *T. purpurea*.

On piedmonts around hills, the following are recognised ;

(i) *Cappraris decidua* community on the lower piedmont plains of sand stone and rhyolite hills (Nagtalao, Agolai, Bhoja-ka-Bas).

(ii) *Zizyphus nummularia* community on rhyolite piedmont plains (Balarwa, Teori, Bhaduria, Balesar).

(iii) *Prosopis cineraria* — *Acacia senegal* community on granite piedmont plains.

Few associated trees and shrubs are *Maytenus emarginatus*, *Salvadora oleoides*, *Grewia tenax*, *Lycium barbarum* and *Leptadenia pyrotechnia*. The ground flora is almost negligible. Due to grazing, it is *Tephrosia purpurea* which dominates this habitat. Few *Cenchrus ciliaris* clumps escape grazing as they grow in various

shrub speeies. Other species include *Cenchrus prieurii, C. biflorus, Eleusine compressa, Aristida funiculata, Oropetium thomeaum, Dactyloctenium sindicum, Indigofera cordifolia, Crotalaria burhia, Boerhavia diffusa, Corchorus depressus, Fagonia cretica* and *Tephrosia purpurea.*

Forage production (under natural conditions) of hilly areas ranges from 70 kg/ha whereas on piedmont plains with good sand deposition it was between 1200 to 1500 kg/ha. However, in many situations grazing lands are degraded.

The hilly region of Kailana (Jodhpur) with twenty years old exclosures provide 47.5 q/ha of firewood from *Acacia senegal* alone with an average tree density of 120 plants/ha whereas similar degraded situations give 5-15 q/ha firewood with 20-60 plants/ha. This value still goes down under extremely degraded conditions.

6. *Present landuse*

The area is used mostly as open grazing land. In vicinity of Jodhdur proper, a large area of this unit is a protected forest. It is also extensively exploited for building stone material

7. *water resources*

(a) *Surface water* : Like MLRU 10, this unit also is very good runoff producer. The runoff through a large number of drainage lines goes to recharge the groundwater in ill-defined aquifers with comparatively small utilisation. Therefore obstructing this flow to recharge small aquifers is considered a favourable proposition. A number of sites therefore have been proposed in Appendix II.

(b) *Ground water* : The area has hardly any ground water except in valley fills. wells in these valley fills supports shallow dry well with discharge.

8. *Resource assessment*

The unit has severe limitation, because of ruggedenss of the terrain. However, considerable experience on such sites has shown that through protection and management the present barren hills can be converted into a thin forest. These could provide some grazing together with secondary produce like gum and seeds. Much of the piedmont area is covered with degraged pastures.

The area has surface water potential and a number of catchments have been identified.

9. *Suggested treatments*

(i) Wherever some soil depth is present as in crevices, fractures and depressions, planting of presprouted stumps of *Prosopis juliflora* and direct seeding of *Acacia senegal* be carried out. In pockets with soil depth of 30 to 50 cm, even *Acacia tortilis* can do well. Both transplanting and direct seeding are successful. Reseeding of degraded piedmonts with *Cenchrus setigerus.*

(ii) Development of catchments as given in Appendix II.

SOCIO ECONOMIC SURVEY OF JODHPUR DISTRICT

A spatial integration of bio-physical and socieconomic data was attempted for Jodhpur district. Fortyeight villages were selected for study from amongst the Major Land Resourcc Units comprising of (I) Dominantly dunes with dew sandy undulating interdunes (about 13 percent -4 villages), (Ia) Flat Interdunal plain in the Chirai series (2 villages), (II) Sandy undulating aggraded older alluvial plain with dunes Chirai series hummocky phase (about 14 percent-5 villages), (III) Flat aggraded older alluvial plain with Chirai and Pal series (about 12 percent 5 villages), (IV) Flat aggraded plain with Kolu series (9 percent–3 villages), (V) Flat gravelly aggraded plain with Bap series (6 percent-3 viliages), (VI) Flat aggraded older alluvial plain with Pipar series (6 percent-4 villages), (VII) Flat aggraded older alluvial plain with Gajsinghpura and Asop series (1 percent -3 villages), (VIII) Flat buried pediment with Bhopalgarh and Soila series (3 percent-4 villages), (IX) Pediments with scattered dunes and Chirai series pediments dotted with scattered dunes (7 percent -2 villages), (Ixa) Sandy undulating buried pediments with Chirai series hummocky phase (7 percent -5 villages, (X) Rocky pediments and sand stone plateau (6 percent 3 villages), (XI) Flat aggraded plain with Malkosni series (1 percent - 2 villages) (XII) Younger alluvium with coarse textured soils appreciable area under irrigation (I) -3 villages

Data pertaining to demographic aspects including density of population, size of household, sex ratio, literacy level, earnings and dependents, caste composition etc. were collected and analysed. Land utilization statistics in defferent land form units, crops grown and livestock census were also recorded. Schedule was applied to sample respondents of different land form units and data collected were analysed and compared.

Population characteristics

Jodpur district has a population of 11,52,712 during 1971 out of which 68 05 per cent lived in rurala reas whereas 31.95 per cent in urban areas and had an average denity of 50 persons per square kilometre as against 46 in arid zone and 75 in the whole of Rajasthan.

The growth rate of population in Jodhpur districts between 1901 to 1971 (Table 2) has been of the order of 171.35 per cent as compared to 158 in arid zone and 150 per cent increase for the state of Rajasthan as a whole and 132 per cent increase in the country.

Table 2. Growth of population in Jodhpur district (1901-1971)

Census Year	Population			Variation	
	Persons	Male	Female	Absolute	Percentage
1901	4,24,805	2,25,021	1,98,784	.....	.....
1911	4,35,306	2,30,161	2,05,145	−10,501	+ 2.47
1921	3,82,855	2,04,790	1,78,065	−52,451	−12.05
1931	4,44,013	2,35,572	2,08,417	+61,158	+15.07
1941	5,58,841	2,96,424	2,62,417	+114,828	+25.06
1951	6,72,653	3,54,015	3,18,638	+113,312	+20.37
1961	8 85,663	4,69,147	4,16,516	+213,010	+31.67
1971	11,52,712	6,06,802	5,45,910	+267,049	+30.15
1901—1971	171.35	169.66	173.25	+727.907	171.35

Table 2 reveals that the growth during the 1951 to 1971 is double of the growth during the first 50 years. The annual growth rate in exponential form of Jodhpur districts comes out to be 1.48.

The age and sex composition of population inhabiting the Jodhpur district in 1971 exhibits a broad based population pyramid indicating a high concentration of population in lower age groups. The percentage distribution of children (0-14 years), young (15-34 years), middle aged (35-54 years) and old (55 years and above) came to 44.05, 24.89, 24.12 and 6.94 per cent as against 43.56, 31 62, 12.44 and 7.38 per cent in arid zone. This exhibited high potentialities of the future growth rate of population and also quite a high percentage of dependent population (50.99 per cent children and old people).

The number of women in reproductive period (15-44 years) and their marital status further exhibited the expansive potentialities of future growth rate of population (Table 3.) Over fourtenths of the total female population is in reproductive period, which is quite high. Further over 88 per cent of women in reproductive period were marrird. The sex ratio was 888 in 1971 as against 928 in arid zone and 911 in Rajasthan. Thus the demographic features reveal that apart from the higher growth rate in the past, the future potentialities of growth of population in Jodhpur district are quite high. Coupled with this are the social values pre-disposed for having more and more children. The positive sanctions in the society out number the negative ones. Early marriage and begetting of chiidren

are integral parts of the social ethos of these people.

Table 3. Women in the reproductive period (15-44 years)

Marital status	Number	Percentage
Unmarried	17,165	7.54
Married	2,00,892	88 19
Widowed	9,493	4.17
Divorced	125	0.05
Others	125	0.05
Total	2,27,790	100.00

The percentage of literacy and its level is rather low and the people by and large are orthodox and traditionalists and the feelings of factionalism are acute. Caste is still the pivotal social institution and has restricted social and occupational mobility and fostered values concerning cultivation and animal husbandry some of which are definitely economically untenable. If the birth rate does not fall, the gap between births and deaths will further widen and the region will face rapidly increasing multitude of population explosion.

People belonging to different religion Hindu, Jain, Sikh, Bodh, Muslim, Christian and others constitute respectively 88.09, 2.14 per cent nil, 9.41 per cent, 0.16 per cent and 0.05 per cent. The proportation of scheduled castes and scheduled tribes in population is 13.44 and 2.11 per cent respectively according to the census 1971.

Major Land Use Resource Units (MLRU) and population characteristics

Different biophysical land form units in Jodhpur district revealed significant variations in socio-economic characteristics namely demographic features, social structure, education, occupational structure, livestock, land use and cropping pattern.

Major land resource unit wise poulation variation in Jodhpur district from 1901-71 (Table 4) revealed that the LEU'S III, Ia, IV and VIII had higher increase in population ranging from 193 to 293 perecnt as compred to an overall increase of 171 percent population in the whole of the district. Within the land form units, variation was least (92 percent in MLRU XI inand highest (293) MLRU VIII. The overall increase in population of all the MLRU'S together was 158.59 from 1901-71 and 31.53 percent from 1961-71 The reasons for the highest land and water potential available coupled with age and sex composition, and marital status of the population.

Present position of various population characteristics, viz. density of popuation, percentage of schedule caste/ tribe population, sex ratio, size of household, literacy level, and percentage dependent is revealed in Table 5.

The perception of educational usefulness in case of both boys and girls is perceived by the households having large sizes in almost all the MLRU's. The reasons are that the large size households have enough of family labour and consider more usefulness of

education for their children as compared to the small and medium size households having just sufficient of family labour who can not spare their services. Educational usefulness in relation to occupatinal caste composition revealed an insignificant variation in caste composition revealed an in case of boys. More than nine-tenths of the total households of both the agricultural and non - agricultural caste occupations of all the MLRU's had affirmative responses, For educational usefulness for female children agricultural caste groups had higher perception. Amongest the agriculturists the middle class farmers (40-60 *bigha* land holding) had the highest perception. The reasons of higher perception by the agricultural castes are that these are economically more sound, socially recognized at the social organisation of the village and of dominant nature due to majority in the village and so on,

Table 4. Major Land Resource Unit wise population variation in Jodhpur district (1901-1971) (Based on sampled villages)

M.L R.U.	1901	1911	1921	1931	1941	1951	1961	1971	per cent change 1961–71	per cent change 1901–71
I	967	955	888	1062	1315	1368	1992	1929	−3.00	99.40
I a	730	808	525	711	738	854	1123	1628	+37.00	123.00
II	1108	1127	1016	1194	1394	1619	2392	2801	+17.00	152.70
III	703	680	660	795	1000	1438	1078	2060	+91.00	193.00
IV	658	742	645	587	852	579	1166	1982	+69.00	201.20
V	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	595	805	+35.00	N.A.
VI	723	698	529	707	822	907	1160	1499	+29.00	107.30
VII	490	544	462	565	763	864	1133	1740	+53.00	225.10
VIII	288	267	292	316	429	377	878	1131	+28.00	292.00
IX	638	544	511	501	839	842	1164	1449	+24.00	127.10
IX a	527	589	515	576	742	706	1013	1158	+14.00	119.70
X	200	217	182	225	266	414	354	469	+32.00	134.50
XI	463	529	384	450	551	298	769	889	+15.00	92.00
XII	492	487	375	393	533	634	813	1114	+37.00	126.40
	7987	8187	6984	8082	10242	10900	15690	20654	+31.63	+158.59%

N.A. = Not available.

Table 5. Major land resource unit wise population characteristics in Jodhpur district.

S. No.	Poulation characteristics	Major land resource unit (Codes)
1.	*Density of papulation* (Persons per sq km)	
	Below 10	V
	10-20	I, Ia
	20-30	IV
	30-40	II, IX, XI
	40-50	III, VI, VII IXa
	50-60	VIII, X, XII
2	*Poulation of Scheduled Castes and Scheduled Trtbes* (Percentage of total population)	
	∠ 10	Nil
	10-15	VII, X
	15-20	I, II, III, Ia, V, VI VIII, XII
	20-25	IV, IXa
	25-30	IX, XI
3.	*Sex ratio* (Females per 1000 males)	
	700-800	II,
	800-900	I, III, Ia, IV, V, X
	900-1000	VI, VII, VIII. IX, IXa, XI, XII
4.	*Size of household* (Number of persons)	
	∠ 5	IV
	5 - 7	V, VI, VII, VIII, IX, IXa, X, XII
	7 - 9	IV
	9 & above	Ia
5.	*Literate persons* (Percentage of total population)	
	∠ 5	VII
	5 - 7	III, Ia, IXa.
	7 - 9	I, IV, IX, XII,
	9 - 11	V
	11 - 15	II, VI, VIII, X, XJ

Earning strength

Sex wise composition of working and non-working population in the district is given in Table 6.

About 70 percent of the population constituted non-workers in the district. This large dependency is due mainly to the concentration of child population in the age structure described earlier.

Data collected on the socio-economic characteristics of the workers in some of the MLRU were analysed. Workers in relation to population characteristics, viz. age, sex, size of household, and caste composition revealed that the percentage of workers in the various age groups of the population of MLRU I and MLRU VIII differed significantly. The workers in the younger age group of children in MLRU I constituted about two and half times more than that of the MLRU VIII. Because of too much adverse physical, climatic conditions prevailing in MLRU I, the children were from the very begining motivated to share in supplementing the household economy. In MLRU VIII there is a possible influence of urbanisation also. Workers in relation to caste structure differed significantly. The maximum (about half) percentage of workers belonged to agricultural castes in MLRU VIII as compared to MLRU I where 66 per cent of the workers belonged to live stock rearing castes. The reasons were that the sand dune unit was inhabited chiefly by the Sindhi Muslims traditional livestock breeders while the base buried pediment (MLRU VIII) was dominant by traditional agriculturists.

Occupation distribution in the district

Table. 7 presents the percentage occupation distribution of population in the district during the year 1961 and 1971.

Table 6. Workers and non-workers in Jodhpur district

	1961			1971		
	Workers	Non-workers	Total	Workers	Non-workers	Total
Males	(54.57)	(45.43)	100.00	(50.55)	(49.45)	100 00
	356027	213120	469147	306765	300037	606802
	(68.01)	(41.85)	(52 97)	(87.88)	(37.34)	(52.64)
Females	(28.92)	(71.08)	100.00	(7.74)	(92.26)	100.00
	120434	296082	416516	42274	503636	545910
	(31.99)	(58.15)	(47.03)	(12.12)	(62.62)	(47.36)
Total	(42.51)	(57.49)	100.00	(30.28)	(69.72)	100.00
	376961	509202	885663	349039	803673	1152712

Table 7. Occupation distribution of workers in Jodhpur district

Occupation	1961 (%)			1971 (%)		
	Male	Female	Total	Male	Female	Total
Cultivators	66.32	87.12	72.98	61.41	67.37	62.13
Agricultural labourers	1.81	4.25	2.59	5.46	16.35	6.78
In mining, livestock, fishing, etc.	1.83	0.71	1.47	1.97	1.52	1.91
In household industry	4.12	2.90	3.73	2.67	2.56	2.66
In manufacturing other than household industry	3.28	0.57	2.41	4.58	1.25	4.18
In construction	2.22	0.35	1.62	1.39	0.42	1.27
In trade & commerce	4.90	0 41	3.46	5.88	1.10	5.30
In transport	4.55	0 04	3.11	4.60	0.20	4.07
In other services	10.97	3.64	8.63	12.04	9.22	11.70
Total	100 00	99.99	100.00	100.00	99.99	100.00

The data revealed that the percentage of workers engaged in the occupation of cultivation, agricultural labour and other occupations came respectively to 72.98, 2 59 and 24 43 in 1961. There has thus been huge over-crowding on cultivation during both the census period though the percentage workers engaged in cultivation is relatively lesser but this mainly is due to the general decline of percentage female workers which are engaged in the occupation of cultivation as family workers.

Land use

Land utilization statistics (1951-52 to 1974-75) of Jodhpur district is given in Table 8. A significant change occurred in the area under forests which depleted almost completely within the period of 1951-52 to 1961-62. Whereas the net area sown increased by 48.53 per cent within the period of 1951 to 1971. Growth rate of various land use parameters is given in Table 9.

It is observed that most sizeable magnitudes in land use pattern were revealed in the extent of net area sown, other fallow land, barren and uncultivable land and permanent pastures. The increase in total cropped area can be attributed, to decline in area of fallow lands.

Table 8. Land utilisation statistics of Jodhpur district (in '000 ha) (1951-52 to 1974-75)

Classification	1951-52	1961-62	1971-72	1974-75	1951-61 to 1961-62	1961-62 to 1971-72	Change during 1951-52 to 1971-72	Change during 1951-52 to 1974-75
1	2	3	4	5	6	7	8	9
Reporting area	2332	2253	2265	2256	-79 (-3.39)	12 (0.53)	-67 (-2.97)	-76
Forest	34	2	–	2	-32 (-94.12)	-2 (-100.00)	-34 (-94.12)	-32 (-94.11)
Not available for cultivation								
i) Land put to non-agril. use	74	77	98	99	3 (4.05)	21 (27.27)	24 (32.43)	+25 (33.78)
ii) Barren and unculturable land	176	162	147	143	-14 (-7.95)	-15 (-9.26)	-29 (-16.48)	-33 (-18.75)
Total	250	239	245	242	-11 (-4.40)	6 (2.51)	-5 (-2.00)	-8 (-3.20)
Other uncultivation land excluding fallow land								
i) Permanent pasture and other grazing land	46	107	106	106	61 (132.61)	0 (0.00)	61 (132.61)	60 (130.43)
ii) Land under misc. tree. crops & groves	—	—	—	—	—	—	—	—

Table 8. (Contd.)

1	2	3	4	5	6	7	8	9
(iii) Culturable waste	109	51	99	84	-58 (-53.21)	48 (94.12)	-10 (-9.17)	-25 (-22-93)
Total	155	158	206	190	3 (1.93)	48 (30.38)	51 (32.90)	+35 (22.58)
Fallow land								
i) Fallow land other than current fallow	655	524	383	516	-131 (-20-00)	-141 (-26.91)	-272 (-41.53)	-139 (-21.22)
ii) Current fallow	430	303	227	295	-127 (-29.53)	-76 (-25 08)	-203 (-47.21)	-135 (-31.39)
Total	1085	827	610	811	-258 (-23.78)	-217 (-26 24)	-475 (-43 78)	-274 (-25.25)
Net area sown	808	1027	1202	1011	219 (27.10)	175 (17.04)	394 (48.76)	203 (25.12)
Total cropped area	814	1030	1209	1024	216 (26.54)	179 (17.38)	395 (48 53)	210 (25.79)
Area sown more than once	6	3	7	13	-3 (-50.00)	4 (133.33)	1 (16.67)	7 (116.66)

Table 9 : Growth rate and variability in land use parameters— 1956-57 to 1974-75 (area in '000 ha)

	Report area	Forest	Not available for cultivation		Other unculturable land excluding fallow land		Fallow land		Net area sown	Total cropped area
			land put to non-uncultiagri. use	Barren vable land	permanent pasture Other grazing	Culturable waste land	Other fallow land	Current fallow land		
Mean	2252.61	3.15	93.47	142.84	100.31	52.26	540 36	269.94	1053.63	1059.52
Growth rate	+0.10	−5.91	−0.19	+0.63	+3.40	−2.30	−1.87	−0.22	+1.47	+1.52
Coefficient of variation	0.45%	2.14%	23.5%	14 47	21.28%	53.61%	16.35%	20.41%	10.10%	20.21%

The land use statistics regarding degenerated land Jodhpur district revealed that as a consequence of high growth rate of population marginal and sub-marginal lands have been brought under agriculture. The percentage of area sown increased by 16.77 per cent from 1951 to 1971 and decreased during 1951 to 1961 by (50 per cent) and again increased by 1.33 33 per cent from 1961-71. The permanent pasture land increased by 132.61 per cent from 1951 to 1961 and remained constant from 1961-71 and the change observed during 1951 to 1971 by 132.61 per cent. The total ~~degenerated~~ degenerated land declined by 22.53 per cent from 1951 to 1961 to 1961 and 17.31 per cent during 1961-71 and over all change revealed from 1951 to 1971 was 35.95 per cent. Thus during 1951-71 there had been a substantial shrinkage of grazing lands fallow land and degenerated lands due to extensive cultivation on marginal lands.

Distribution of size of holdings in Jodhpur district (1970-71)

The proportion of various size of holdings are differ from region and within the same region. This type of distribution is the result of area available, quality of land, irrigation facilities, population pressure on land, etc. The total number of holdings distributed in the various class interval is set out in Table 10

Table 10. Distribution of the number of holdings according to size in Rajasthan, Arid zone and Jodhpur district (1970-71).

Classs interval of size of holdings (ha)	Number of holdings		Jodhpur district
	Rajasthan	arid zone	
Less than 5 (very small)	2630640 (70.59%)	614839 (47.33%)	50700 (37.03%)
5 to less than 10 (small)	575024 (15.43%)	286154 (22.03%)	28824 (21.07%)
10 to less than 20 (medium)	331999 (8.91%)	233510 (17.98%)	29897 (21.83%)
20 and above (large)	188881 (5.07%)	164496 (12.66%)	27500 (20.07%)
Total	3726544 (100.00)	1298999 (100.00)	136921 (100.00)

Source : Computed from Report on Agricultural Census (1970-71) Directorate of Economics & Statistics, Jaipur, Rajasthan.

Table 10 reveals that the percentage of number of holdings under various size groups go on decreasing as the size of holdings increase in case of Rajasthan and arid zone. While this type of trend has not been observed in Jodhpur district. This maximum percentage of number of holdings is in class (less than 5 hectares followed by the class of 10 to 20 hectares, 5 to 10 hectare and 20 hectares and above. It is clearly discernible from the Table that the proportion of medium and large size of holdings is much more in Jodhpur as compared to arid zone and Rajasthan.

Crops grown

Area, production, productivity and their growth rate and coefficient of variation for major crops of the district are given in Tab e 11. It is seen that amongst the crops, *bajra* and *kharif* pulses occupied larger proportion of the cultivated area in the district followed by sesamum, *jowar* in *kharif* and wheat, gram and barley in *rabi* season. The maximum instability in area has been observed over a span of nineteen years (1956-57 to 1974-75) in gram followed by *jowar*, barley, sesamum, wheat, *kharif* pulses, and *bajra*. The area under *jowar* and gram have shown negative growth rate while maximum was registered in other *kharif* pulses, followed by *bajra*, wheat, sesamum and barley.

Variations in land form units revealed differential cropping pattern (1973-74) followed in the units. Percentage of the total average grown under *bajra* varied from 51.26 per cent (MLRU XII) to 85.70 per cent (MLRU VIII), *moong-moth* from 1.96 per cent (MLRU-VIII) to 20.01 per cent (MLRU II). Till from 0.35 per cent (MLRU VIII) to 16.03 per cent (MLRU XII) and *guar* 2.17 per cent (MLRU X) to 13.74 per cent (MLRU II). Cotton and vegetables were grown but to a limited extent in MLRU VIII and MLRU X where irrigation facilities were available.

Drought and land disposition

A case study in Shergarh *tehsil* of the district reveals that agricultural lands witness distress activity in land disposition as an impact of drought in the area. Number of households selling land, extent of land disposed and its value decrease during drought year as compared to good year (Table 12).

Per household mean annual area sold decreased from 8.69 ha to 8.60 ha and its value from Rs, 326.55 to 298.55 during drought year. Seasonal variations also influence land disposition activity. During *Kharif* season of the drought year, maximum households (41.83 per cent) sold lands @ Rs 297.70 per ha as compared to minimum households (23.71 per cent selling land at increased rate of Rs. 309/- per ha during good year. Land disposition activity increases in *Kharif* season during drought year and *zaid rabi* season during good year. For bare subsistence needs the peasants sell their lands comparatively cheap in drought years.

Land disposition activity was more prevalent among agriculturists than non-agricultural communities of the house-

Table 11. Area, production and productivity of major crops of Jodhpur district (1956-57 to 1974-75)

Crop	Area (000 ha)				Production (000 m tonnes)				Productivity (kg/ha)			
	Range	Mean	G.R.	C.V.%	Range	Mean	G.R.	C.V.%	Range	Mean	G.R.	C.V.%
Bajra	48-764	583.47	1.79	11.56	7-346	92.47	4.18	91.97	12-528	154.21	0.96	83.10
Jowar	3-82	34.84	−4.75	69.40	0.0-9.0	2.61	−3.49	116.47	1-292	62 26	3.52	86.28
Other *kharif* Pulses	121-240	178.89	1.95	18-50	2.76	34.52	−6.35	69.00	—	—	—	—
Sesamum	30-65	49.84	0.89	24.65	0.1-17.0	6.17	−1.87	83 24	6-328	120 68	−2.37	84.38
Wheat	15-35	23.15	1.41	2.198	11-53	20.73	3.54	43.07	508-1512	888.89	1.57	28.37
Barley	1-2	1.47	0.77	34.69	1-3	1.78	0	39.66	731-1506	1140.1	−.71	17.44
Gram	0.1-9.0	2.96	0.88	89.52	0.1—	1.24	4.93	103.22	51-793	390.63	5.36	48.00

Table 12. Comparative seasonwise land disposition in drought and good year

Crop season	Drought year			Good year		
	Sellers No. (%)	Mean area (ha)	Mean value (Rs.)	Sellers No. (%)	Mean area (ha)	Mean value (Rs.)
Kharif-Rainy (July–October)	64 (41.83)	7.99	297.70	46 (23.71)	12.0	309
Rabi-Winter (Nov.-Feb.)	41 (26.80)	11.27	218.30	53 (27.32)	7.0	364.30
Zaid *rabi*-summer	48 (31.37)	7.25	336.50	95 (48.97)	7.0	317.77
All years average	153 (100.00)	8.00	298.55	194 (100.00)	8.60	326.55

holds selling land, 70.2 per cent belong to agricultural caste group (*Rajput, Jat, Charan, Purohit, Bishnoi*); 9.30 Percent religious caste group (Brahmin, Sadh); 9.4 Percent servicing castes (*Meghwal, Suthar, Nai, Dholi, Darjee*); 1.8 Percent livestock raisers (Raika, Sindhi, Muslim livestock breeder); and 9.3 Percent other castes (*Mahajan, Rao, Khatree*). Agriculturists being completely dependent upon lands are more adversely affected than non-agriculturists who have diversified economic base also. This reveals maximum effect of drought on agriculturists and minimum on livestock raisers who migrate with livestock in order to cope up with the ill effects of drought.

Livestock

Next to agriculture, livestock supplement household economy of the district. The livestock population for period 1951 to 1972 is given in Table 13. Livestock in district increased from 1.22 million in 1951 to 1 89 million in 1971 showing an overall increase of 53.96 Percent The quinquennial growth rate of livestock in Jodhpur district was 17.08 Percent from 1951 to 1956, -0.06 Percent from 1956 to 1961, 21.97 Percent from 1961 to 1966 and 7.88 Percent from 1966 to 1972. In period 1956 to 1961 the growth rate declined by 0.06 Percent due to spreading of some disease in this period and number of fell down heavily (-16.09 Percent) mules (-54.76 Percent) Camels (-29.76 Percent) and pigs by (-44.07 Perecent). The over all change in the various type of livestock population over 20 years, i.e. from 1951 to 1971 was in case of cattle, buffaloes, sheep, goats, horses, mules, donkey, camel and pigs by 7.96 per cent -17.36, 23.39, per cent 229.89, -31.23, -98.15, 10.39, 342.18 and 2286.66 per cent respectively.

The data thus not only reveal the preponderance of goats and sheep in the total livestock population in the Jodhpur district but also the in goat population due to famine years. Table 14 presents the pressure of livestock on grazing land.

Table 14. Pressure on grazing land per 100 hectare.

Livestock	1951		1961		1971	
	No.	A.C.U.	No.	A.C.U.	No.	A.C.U.
Cattle	31	25	54	44	52	43
Buffaloes	5	4	6	5	6	5
Sheep	43	7	49	8	84	14
Goat	16	2	34	4	83	9
Camel	1	1	2	2	7	9
Others	1	1	1	1	1	1
Total	97	40	146	64	235	81

It is observed that livestock pressure both absolute number as in terms of adult cattle units has been substantially increasing all through the twenty years from 1951 to 1971, i e. increased from 97 per 100 hectare to 235 per 100 hectare. The adult cattle units also increased from 40 to 81. Considering the present carrying capacity of the grazing lands the density of livestock on grazing lands is quite high which evidently presents a sad picture of the district.

In Jodhpur district the fodder production was deficit during the last 20 years. In year 1951 it was dificit by 44 per cent, in 1961 by 46 20 per cent and in year 1971 by 55.01 per cent (Table 15).

It shows that the deficiency in fodder production with respect to the requirements has been increasing, rising to a value of 55.01 per cent in year 1971.

The data clearly shows that the animal population in Jodhpur district are seriously underfed. The situation is also causing severe stress on the over utilization already degraded pasture lands.

Table 15. Balance sheet for fodder for Jodhpur district

Years	Total No of A.C.U.	Total fodder requirement (tonnes)	Total fodder production (tonnes)	Deficit/ surplus
1951	1229612	3074030	1721600	—1332430 (-44.20)
1961	1438768	3596920	1935300	—1661620 (-46.20)
1971	1893200	4733000	2128400	—2603600 (-55.01)

AGRO-CLIMATOLOGY OF JODHPUR DISTRICT

The climate of Jodhpur district can be classified as arid to extremely arid. The aridity index for the district varies from 70 to 87 and increases from southeast to northwest.

Distribution of rainfall

In Jodhpur district. rainfall data for a number of years are available for 4 stations, viz Jodhpur, Bilara, Shergarh and Phalodi. The rainfall data for Osian are available from 1957 only.

The distribution of normal rainfall and number of rainy days of these stations based on data for the period 1901-1970 are shown in Table 16.

Table 16 : Normal monthly rainfall (mm) and number of rainy days* in Jodhpur district (period of data used 1901-1970)

Station	Jan.-May	June	July	Aug.	Sep.	Oct.-Dec.	Annual total
			A. *NORMAL RAINFALL*				
Jodhpur	25.7	29.1	111.3	128.6	57.4	11.1	361.2
Bilara	25.7	39.3	132.6	156.4	49.4	10.7	424.1
Shergarh	20.0	23.1	80.5	90.1	36.3	3.8	253.8
Phalodi	25.3	28.6	71.9	85 8	26.9	5.2	243.7
Osian	12.6	17.2	96.5	80.8	41.3	3.4	251.8
			B. *NORMAL NUMBER OF RAINY DAYS*				
Jodhpur	2.6	2.3	5.9	6.2	2.7	0.9	20.6
Bilara	2.6	2.1	6.1	6.2	3.0	0.9	20.9
Shergarh	1.6	1.6	4.3	4.7	1.8	0.5	14.5
Phalodi	2.1	1.5	3.8	4.6	1.8	0 4	14.2
Osian	1.4	1.6	5.0	4.3	2.6	0.4	15.3

*Rainy days are days receiving a rainfall of 2.5 mm or more. Normals of Osian are based on data for the period 1957-1970.

However there is a large year to year variability in the amount of rainfall. The standard deviation and the coefficient of variation of annual rainfall and the extremes of rainfall that occurred during the period 1901–1970 at various stations in the district are shown in Table 17.

Coefficients of variation are very high in respect of Phalodi, Shergarh and Jodhpur with values ranging from 53 to 55. The highest variability is in respect of Phalodi This becomes still more clear from the data presented in Table 18 wherein different years have been categorised into surplus or deficit in relation to the mean annual rainfall.

A high surplus rainfall year (flood year) is defined here as a year receiving a rainfall of 150 per cent or more of the normal annual value, a normal years as the one receiving between 81 to 149 per cent deficit year as the one receiving 15 to 80 per cent and a large deficit rainfall of 50 per cent or less of the normal annual value.

It will be seen from the data that for all the stations excluding Osian the percentage of years receiving normal rainfall is 41 to 52 percent. Years with deficit rainfall account for 22 to 31, whereas large defict and large surplus rainfall years are 10 to 20 per cent.

Further, as can be seen from data below, the deficit years are not uniformly distributed. In some decades as from 1901 to 1910, from 1911 to 1920 and then again from 1961 to 1970, there was a greater frequency of drought years, whereas the decade from 1951 to 1960 had the least.

Table 17 : Mean annual and extreme rainfall in Jodhpur district and its variability.

Station	Normal annual rainfall (mm)	Standard deviation	Coefficient of variation	Extremes of annual rainfall (mm)					
				Highest			Lowest		
				Amount (mm)	Year	Percentage of normal	Amount (mm)	Year	Percentage of normal
Jodhpur	361.2	193.9	53	1176.5	1917	326	37 0	1918	10
Bilara	424.1	225.9	53	1214.8	1908	286	98.2	1918	23
Shergarh	253.8	123.0	49	825.7	1908	325	59.8	1969	24
Phalodi	243.7	135.1	55	631.8	1917	259	31.3	1918	13
Osian*	251.8	87.8	35	383.1	1959	152	98.6	1963	39

*Data for Osian is from 1957 only.

Table 18. Number and percentage of years receiving surplus or deficit rainfall

Tehsil	Large deficit	Deficit	Normal	High surplus
	Number of years			
Jodhpur	11	18	30	11
Bilara	7	17	37	9
Shergarh	7	22	33	8
Phalodi	12	16	28	14
Osian*	1	3	9	1
	Percentage of years			
Jodhpur	15.7	25.7	42.9	15.7
Bilara	10.0	25.3	51.9	12.8
Shergarh	10.0	31.4	47.2	11.4
Phalodi	17.1	22.1	40.8	20.0
Osian	7.0	21.5	64.3	7.1

*Data for the year 1957 to 1970 only.

The decade-wise occurrence of such probabilities are given in Table 19. deficit rainfall as well as their percentage

Table 19. Decade-wise frequency and percentage probability of occurrence of years receiving less than 80 per cent

Tehsil	1901 to 1910	1911 to 1920	1921 to 1930	1931 to 1940	1941 to 1950	1951 to 1960	1961 to 1970	Percentage probability of deficit rainfall
Jodhpur	6	6	4	3	4	1	5	41
Bilara	4	3	3	3	3	3	5	35
Shergarh	4	6	3	4	4	1	7	41
Phalodi	3	5	7	4	4	2	3	40
Osian*	–	–	–	–	–	2	3	29

*Data commenced from 1957. only.

Duration and intensity of rainy spells occurring in Jodhpur district

On the basis of the data for the period from 1901-1970, the highest rainfall intensities in Jodhpur district are as follows :

Station	Highest rainfall intensity in 24 hours (mm)	Date
Jodhpur	189.9	2nd September 1908
Bilara	249.7	17th June 1917
Shergarh	298.5	2nd September 1908
Phalodi	167.5	12th July 1964
Osian*	114.0	4th August 1966

*Data used for Osian are from 1957 to 1970.

The above figures indicate that Jodhpur district is susceptible to very heavy rainfall intensities in occasional years when monsoon depression passes through west Rajasthan and the area concerned falls in the southwest sector of the depression. Though Shergarh's mean annual rainfall is 253.8 mm, it has recorded 298.5 mm on a single day which is the highest value for any station in the district. The intensity values for this district are much higher than those of Bikaner district.

Longest single wet spell

The durations of the longest single wet spell for the period (1901–1970) in respect of various stations are as follows :

Station	*Duration (day) of longest wet spell during 1901–70*	*Amount of rain (mm) and dates*
Jodhpur	14	118.6 (July 1927)
Bilara	13	545.6 (August 1908)
Shergarh	6	145.3 (August 1907) 117.6 (August 1919), 116.6 (August 1931) 217.2 (August 1944),
Phalodi	8	121.2 (Augnst 1908), 61.0 (August 1944)

It is seen that the persistency of wet spell is much greater in the eastern portion of the district than in the west. In case of Bilara the wet spell of longest duration and the heaviest intensity coincide, viz 545.6 mm recorded in 13 days. But in case of Jodhpur, Shergarh and Phalodi, the spells of heaviest intensity were as follows :

Station	*Heaviest intensity spell (mm)*	*Duration (day)*	*Period*
Jodhpur	450.6	9	August 1944
Shergarh	328.9	2	September 1908
Phalodi	233.7	3	September 1916

Thus it is also noticed that in the western half of the district, the durations of spells are much lower. However, extremely heavy intensities are recorded for spells of shorter duration thereby indicating occasional occnrrence of violent rain storms of 1 to 3 days duration.

The frequency distribution of wet spells occurring during each month from May to October at different stations in Jodhpur district with regard to intensity are shown in Table 20 to 28. The information on the expected spells per year as well as intensity per spell with respect to spells of different intensity have also been included in these Tables.

The percentage values of spells having intensity of less than 25 mm (1 inch) are 72,61.69 and 73, respectively at Jodhpur, Bilara, Shargarh and Phalodi. A number of small areas adjacent to hills or on flood plains of the river receives run-off and therefore have more favourable moisture status. They are characterised by longer growing season, better growth of pastures and plants normally considered suitable only for areas with somewhat higher rainfall. As regards duration, it has been seen that the wet spells extending to 2 days or more constitute 45 per cent in case of Jodhpur and Bilara and 33 per cent in case of Shergarh and Phalodi, thereby showing greater persistency of rainfall in the eastern half of Jodhpur district. The expected numbers of spells/year in Jodhpur and Bilara are 14 and 12, respectively, though the normal rainfall of Jodhpur is much less than that of Bilara, It shows that the intensity per spell is much higher in case of Bilara. It is futher seen that the rainfall intensity values at Bilara are higher than those of Jodhpur for spells of different duration by 6 to 14 mm. It is interesting to note that even in case of Shergarh and Phalodi where the number of wet spells per year is mnch lower, viz. 10 per year the intensities per spell are comparable or higher than those of Jodhpur therby indicating that lower

Table 20. Frequency distribution of wet spells with respect to intensity at Jodhpur (1901–1970)

Month	Rainfall (mm)									Total	percentage of the total
	0.1–12.5	12.5–25	25–37.5	37.5–50	50–62.5	62.5–75	75–100	100–125	125 & above		
May	76	7	5	1	1	–	–	–	–	90ϕ	9.2
June	103	27	9	7	7	–	–	–	1	154	15.7
July	140	45	26	21	5	15	9	8	12	281	28 6
August	120	45	25	20	13	13	8	6	16	265	26.9
September	92	17	15	9	4	–	6	4	5	152	15.5
October	29	6	2	1	–	1	–	–	1	40	4.1
Total	560	147	82	59	29	29	23	18	35	982	
Per cent of Total	57.0	14.9	8.4	6.0	2 9	2.9	2.3	1.8	3.6		
Expected spells per year	8.0	2.1	1.2	0.8	0.4	0.4	0.3	0.3	0.5		

Table 21. Frequency distribution of wet spells with respect to intensity at Bilara (1901-1970)

Month	Rainfall (mm)										
	0.1–12.5	12.5–25	25–37.5	37.5–50	50–62.5	62.5–75	75–100	100–125	125 & above	Total	Percentage of the total
May	33	8	2	2	–	–	1	–	–	46	5.5
June	68	21	10	12	7	3	1	2	1	125	15.0
July	101	51	33	24	16	5	14	10	10	264	31.7
August	87	41	32	19	11	11	12	11	18	242	29.1
September	59	23	11	10	8	5	7	3	4	130	15.6
October	14	6	2	2	1	–	1	–	–	26	3.1
Total	362	150	90	69	43	24	36	26	33	833	
Per cent of total	43.5	18.0	10.8	8.3	5.2	2.9	4.3	3.1	4.0		
Expected spells per year	5.2	2.1	1.3	0.9	0.5	0.3	0.5	0.4	0.5		

Table 22. Frequency distribution of wet spells with respect to intensity at Shergarh (1901-1970)

Month	Rainfall (mm)										
	0.1-12.5	12.5-25	25-37.5	37.5-50	50.1-62.5	62.6-75.0	75.1-100.0	100.1-125.0	125.1	Total	percentage of the total
May	37	9	5	1	–	–	–	–	–	52	7.7
June	52	20	8	3	2	2	1	1	–	89	13.2
July	86	51	31	15	9	7	6	6	2	213	31.6
August	88	41	30	17	12	4	11	4	5	212	31.5
September	43	24	11	5	1	5	2	-	3	94	13.9
October	8	5	–	–	–	–	–	–	–	13	1.9
Total	314	150	85	41	24	18	20	11	10	673	
Per cent of total	46.6	22.2	12.6	6.2	3.4	2.8	3.0	1.6	1.5		
Expected spells per year	4.5	2.2	1.2	0.6	0.3	0.3	0.3	0.2	0.1		

Table 23. Frequency distribution of wet spells with respect to intensity at Phalodi (1901-1970)

Month	Rainfall (mm)									Total	Percentage of the total
	0.1-12.5	12.6-25	25-37.5	37.5-50	50-62.5	62.5-75	75-100	100-125	125		
May	44	12	4	–	2	–	–	–	–	62	8.8
June	75	14	7	9	2	–	1	1	1	110	15·6
July	109	41	23	10	11	6	3	4	3	210	29.7
August	92	40	31	20	9	6	9	4	4	215	30.4
September	52	19	10	6	2	1	2	–	1	93	13.2
October	15	1	–	–	–	1	–	–	–	17	2.4
Total	387	127	75	45	26	14	15	9	9	707	
Per cent of total	54.7	17.9	10.6	6.4	3.7	2.0	2.1	1.3	1.3		
Expected spells per year	5.5	1.8	1.1	0.6	0.4	0.2	0.2	0.1	0.1		

normal rainfall at these stations are mainly due to less number of spells per year.

Percentage probabilities of different amounts of weekly rainfall

In view of high variability from year to year, mean values for different weeks would not provide complete information. Accordingly weekly rainfall frequencies for the five stations were prepared. Though the mean weekly rainfall generally exceeds 7 mm in Jodhpur district for the period from mid June to mid September (25th week to 37th week), the period when probability of obtaining measurable rainfall exceeds 50 per cent is much less than this period as is evident from the data in respect of various stations presented below.

Actual mean percentage probabilities of obtaining measurable rainfall during thsse periods are also indicated.

Thus the duration of period when probability of occurrence of measurable rainfall exceeds 50 percent covers only 7 to 11 weeks. Tha mean percentage of the same is 67 for eastern portion of district and 50 to 57 for the western portion.

Station	*Duration when percentage probabtlity of measurable rainfall exceeds 50 percent*	*Mean percentage probdbility of the period*
Jodhpur	26th week to 36th week (11 week) (25th June to 9th September)	67
Bilara	27th week to 35th week (9 weeks) (2nd July to 2nd Septemoer)	67
Shergarh	27th week to 35th week (9 weeks) (2nd July to 2nd September)	56
Phalodi	27th week to 35th week with a break for 2 weeks (7 weeks) (2nd July to 2nd September)	55
Osian*	26th week to 36th week with a week's break (25th June to 9th September) (10 weeks)	57

*Data based on 14 years only.

The median values for each week are much smaller than the mean values showing extreme skewness in their distribution. It is the few spells of large intensities in a few years increase the mean values of the respective weeks. Further for the monsoon weeks the percentage frequency does not diminish for increasing intensities. The number of weeks when percentage of getting mor than 20 mm of rain in a week exceeds 30 percent covers 9 to 10 weeks in Jodhpur and Bilara and 4 to 6 weeks in Shergarh and Phalodi.

The weeks in which the highest probability of measurable rainfall occurs at different stations are as follows. The same occurs in July in eastern portion and in western portion of the district.

Jodhpur	29th week	74 per cent
Bilara	27th week	73 per cent
Shergarh	30th week	60 per cent
Phalodi	34th week	60 per cent
Osian	29th week	79 per cent

From the above stations it is seen that it is the few spells of good rainfall intensities in some weeks which would in crease the soil moistur storage which is later utilised by the vegetation in the subsequent weeks. Thus for clearer undertstanding of the quantum of water available in the soil for vegetation, successive weekly water balanceshave to be worked out and the duration of adequate soil moistur storage periods for crop and pasture growth have to be computed.

Crop growing season

The percentage freqaency of years with crop growing season commencing from different standard waeks as well as their durations were compiled for various stations in Jodhpur district. The maximum percentage frequency corresponds to 27 week (2nd July to 8th July) at all stations except at Bilara where it occurs on 26th week (25th June to Ist July). The percentage frequency of years when growing season occurs after 30th July are as follows in respect of different stations.

Bilara	10
Jodhpur	16
Phalodi	37
Shergarh	36

Thus the stations in the western parts of the district viz., Shergarh and Phalodi are more suitable for growing short duration pulse crops or pasture crops in view of the occurrence of late commencement of growing season once in three years.

The average total duration of growing season is 14.5 weeks at Bilara, 11 weeks at Jodhpur and 7.6 to 7.8 weeks at Phalodi and Sherggrh. The percentage frequency of severe droughts increased in case of Phalodi and Shergarh. There is considerable year to year variation in the duration of the growing season.

The range of variation is as follows :

Bilara	5 to 25 weeks
Jodhpur	1 to 20 weeks
Phalodi	1 to 15 weeks
Shergarh	Nil to 15 weeks

Systems approach for crop planning

In view of high variability in the commencement and duration of crop growing season in Jodhpur district, use of systems approach for crop planning would be useful. Analysis of 70 years rainfall data of the district indicate that there exist the following three main subsystems in the pattern of growing :

Early commencement (4 June to 1 July)	30.9 per cent
Normal commencement (2 July to 29 July)	52.9 per cent
Late commencement (30 July or later)	16.2 per cent

Cumulative actual evapotranspiration (AE) models were compiled for early, normal and late commencement subsystems. Assuming that crops would suffer from water stress if cumulative AE valuee are less than corresponding cumulative PE/2 values, these models were examined from the point of adequacy of crop growing. The main features for different stations are as follows :

(i) *Bilara* : Both in case of early and normal rainfall subsystems no water stress is observed throughout the crop growing season. However, in case of late onset, AE curve falls very much below the PE/2 curve showing significant water stress from the 5th week of crop growing season.

(ii) *Jodhpur* : In case of early rainfall years, AE curve falls slightly below PE/2 curve in the first 9 weeks of the crop growing period. Thereafter AE curve shows slightly higher values than PE/2 curve indicating slight water stress in the earlier part of the crop season and little to no water stress in the later stages of crop growth. However since water requirement of crops in early stages will be comparatively less, this effect will not be very adverse. In the normal and late rainfall subsystems the cumulative AE curve shows that the crop would not encounter any water stress in the first 65 to 70 days of its crop growth.

However, beyond 70 days the crops are likely to face water stress upto the harvesting period as the AE curve falls below PE/2 curve during this phase of the cropping period indicating necessity of having short duration varieties of crops for these subsystems.

(iii) *Shergarh* : AE curve falls below PE/2 curve for all the weeks in the season of the early commencement subsystems thereby showing that the crop will be subjected to moderate stress throughout its growing season. Upto 8th week there will be only slight stress followed by there weeks of moderate stress. The periods of severe water stress was determined by comparing actual weekly AE values and corresponding PE/4 values. Thus in this case, drought is severe in the last three weeks. For the normal and late commencement subsystems AE exceeds PE/2 only in the first two weeks and there is moderate to severe water stress thereafter. The stress becomes severe from 9th week onwards in case of normal commencement and 7th week onwards in case of late commencement.

Table 24. Normal climatological data of Jodhpur (1931–1960)

Month	Air Temperature (°C)					Humidity			Mean wind speed (kmph)
	Mean of		Extremes			Relative		Vapour	
	Daily maximum	Daily minimum	Highest	Date & year	Lowest	Date & year	Humidity (%)	pressure (mb)	
1	2	3	4	5	6	7	8	9	10
Jan. I	24.6	9.5	32.8	31	-2.2	31	50	7.0	8.9
II				1932		1035			
Feb. I	27.9	12.0	38.3	29	-0.6	6	44	7.3	8.8
II				1953		1920			
Mar. I	33.3	17.1	41.8	23	5.0	7	35	8.5	9.8
II				1959		1908			
Apr. I	38.3	22.4	48.0	25	9.4	7	31	10.8	10.2
II				1958		1918			
May I	41.6	27.3	48.9	25	17.2	6	43	18.5	15.0
II				1932		1909	16	12.6	
June I	40.1	28.5	47.8	11	19.4	9	60	25.9	18.5
II				1901		1914	30	20.4	
July I	35.7	26.8	45.6	5	19.4	19	75	29.0	16.6
II				1901		1926	54	26.7	

Table 24. (contd.)

1	2	3	4	5	6	7	8	9	10
Aug. I	33.2	25.2	42.9	5	20.6	4	81	28.6	12.9
II				1957		1927	61	27.4	
Sep. I	34.7	24.1	42.8	11	17.8	28	74	25.5	10.6
II				1915		1908	48	22.9	
Oct. I	35.7	19.6	42.2	9	10.0	31	49	14.5	6.6
II				1920		1949	24	10.6	
Nov. I	31.4	13.9	37.2	2	5.6	29	38	7.7	5.8
II				1957		1938	22	8.5	
Dec. I	26.7	10.7	33.3	24	0.6	23	48	7.3	7.3
II				1953		1945	26	8 3	
Mean I	33.6	19 8	48.9		-2 2	52	15 9	10 9	
Annual II						30	14.1		

Table 25. Normal climatological data of Phalodi (1931–1960)

Month		Air Temperature (°C)					Humidity			Mean wind speed (kmph)
		Mean of		Extremes			Relative		Vapour	
		Daily maximum	Daily minimum	Highest	Date & year	Lowest	Date & year	Humidity (%)	pressure (mb)	
1		2	3	4	5	6	7	8	9	10
Jan.	I	22 7	6.6	31.1	22	-3.3	12	62	7.0	10.0
	II				1946		1942	36	9.8	
Feb.	I	26.3	9.9	37.8	28	0.6	2	54	8 6	8 8
	II				1953		1951	38	11.8	
Mar.	I	32.1	15.9	41.7	28	1.7	5	52	11.5	12 9
	II				1945		1945	32	13.3	
Apr.	I	37.6	21.8	47.0	25	12.2	2	43	14.4	14.1
	II				1958		1953	26	15.3	
May	I	41.6	26.6	47.2	29	19.4	2	52	21.9	20.7
	II				1956		1944	25	17.9	
June	I	40.8	28.0	46.7	1	20.6	1	66	27.7	25.6
	II				1944		1945	34	23.8	
July	I	36.9	27.1	45.6	14	22.2	12	76	29.9	23 6
	II				1947		1950	51	27.9	

Table 25. (contd.)

1	2	3	4	5	6	7	8	9	10
Aug. I	24.5	25.8	43.1	5	21.7	29	81	29.5	19.4
II				1957		1957	60	28.2	
Sept. I	35.5	24 6	41.5	4	20.0	28	77	26.4	16.6
II				1960		1940	50	25.7	
Oct. I	35.2	19.7	42.2	12	8.9	31	57	16.0	11.6
II				1941		1949	34	16.5	
Nov. I	30.3	13.1	36.7	3	5.0	30	53	10.0	11.8
II				1943		1946	37	13.6	
Dec. I	24.7	8.0	32.2	2	0.6	24	59	7.7	8.3
II				1953		1945	26	8.3	
Mean I	33 2	18.9	47.2		-3.3		61	17.6	15.3
Annual II							39	17.8	

(iv) *Phalodi* : The drought free period for cropping is very limited being only 4 weeks under early and late rainfall subsystem and about 7 weeks under-normal rainfall subsystem during which period the AE curve remins above the PE curve. However, under early rainfall subsystem the crops will be subjected to moderate stress from 5th week onwards. The moisture stress would be severe (weekly AE values being less than PE/4 values) from 11th week onwards upto the end of the cropping season. Under normal rainfall subsystem crops would encounter severe water stress generally from the 9th week onwards while in late rainfall years the severe water stress begins from 5th week onward indicating that there are no changes of crop success under late sown conditions in this region.

The above mentioned systems analysis indicates that drought free period for cropping is very limited under all subsystems at Phalodi and Shergarh and bence these regions are suitable only for growing of short duration grain legume crops or forage crops. However, in Bilara region early and normal subsystems indicates better crop growth and yields as the cropping season does not encounter any moisture stress. At Jodhpur only early rainfall subsystem indicates longer duration of crop growing season with slight moisture stress while under normal and late subsystems the growing season is shorter (10 weeks) limiting the choice of short duration crops only.

Other climalological features of Jodhpur district

The standard monthly normals of various climatological elements in respect of Jodhpur and Phalodi are presented in Tables 24 and 25. A general description of weather over the district and the synoptic features is given below.

Winter (December-February) are mild and dry. Due to western disturbances some rain occurs and the amount recorded forms no more than 2 to 4 per cent mean annual. The mean monthly maximum temperature in winter varies from 22.7°C to 26.3°C in Phalodi while the same varies from 24.6°C to 27.9°C in Jodhpur. Similarly the mean monthly minimum temperature varies from 6.6 to 9.9°C in Phalodi, while the same varies only from 9.5 to 12.0°C in Jodhpur. The lowest extreme temperature so far recorded is -3.3°C in Phalodi and -2.2°C in Jodhpur. Both were recorded in January which is the coldest month in the district.

For the 31 years (1945-75) under study it was seen that the number of years in which cold waves occurred during each of the months of November, December, January and February are 18, 21, 22 and 19 respectively, there by showing that the probabilities of occurrence of cold wave spells for these months are 58, 68, 71 and 61 per cent respectieely. Of these cold spells, in November, 16 in December, 14 in January and 15 in February become severe (departure in minimum temperature over 6°C) either partly or wholly during their duration. The rest of the cold waves

were of moderate intensities. Table 26 shows the frequency of cold waves with respect to duration during different months.

Table 26. Frequency of cold waves of different durations

Duration days of cold wave	November	December	January	February	November to February
1	18	24	18	21	81
2	6	10	11	8	35
3	3	4	5	4	16
4	1	2	2	2	7
5	0	2	3	0	5
6	0	0	0	1	1
7	1	2	1	2	6
8	1	0	0	1	2
Total	30	44	40	39	153
Percentage	19 6	28.8	26.1	25.5	

The percentage frequency of cold waves is slightly higher in December than in other months. The less percentage in respect of November may be due to the fact that only data from 12 th November are considered in this study.

Occurrence of frost days

There can be a difference of 2° to 3°C between the ground minimum temperature and the minimum temperature recorded in the Stevenson screen. Accordingly, frost days are taken in the study as days in which a minimum temperature of 3°C or less has been recorded in the Stevenson screen. A list of such frost spells during each winter season lasting from mid November to end of February of the next year in respect of the period 1945-1975 is given below :

Duration of frost spell

1945-46

23 Dec. 1945 to 24 Dec. 1945 (2 days)
26 Dec. 1945 to 27 Dec. 1945 (2 days)
2 Jan. 1946 to 3 Jan. 1946 (2 days)

1948-49	4 Jan.	1949	to 6 Jan.	1949	(3 days)
	10 Feb.	1950	to 12 Feb.	1950	(3 days)
1950-51	2 Feb.	1951	to 3 Feb.	1951	(2 days)
1951-52	3 Jan.	1952			(1 day)
1963-64	18 Jan.	1964			(1 day)
	22 Jan.	1964	to 23 Jan.	1964	(2 days)
	26 Jan.	1964			(1 day)
1964-65	11 Dec.	1964			(1 day)
	13 Dec.	1964			(1 day)
1968-69	27 Dec.	1968			(1 day)
1971-72	13 Feb.	1972			(1 day)
1973-74	29 Dec.	1974			(1 day)
	5 Feb.	1974	to 7 Feb.	1974	(3 days)

Thus the frost has occurred at Jodhpur only in 10 winter seasons out of 30 seasons studied giving a probability of occurrence of once in 3 years. However, the total number of spells were 16. It is interesting to note that nearly seven spells occurred during 1945-1952 and there was complete absence of frost for more than a decade, viz. from 1953 to 1963. The longest durations of frost spell is 3 days only (recorded during the winter seasons of 1948-1949, 1949-1950 and 1973-1974).

Occurrence of heat waves at Jodhpur

Normals of daily maximum temperatures were worked out for the months April to July based on the data for the period 1945-1969. Then in order to eliminate spurious variations, five day normals were worked out for each five days from 1st April to 29th July. The criteria for occurrences of heat waves was criteria, daily maximum temperature lying between 4° to 5.9°C above the normal of the periad concerned. A perusal of data for the period 1945 to 1969 showed that there were on an heat waves of 1 to 4 day duration each.

WILD LIFE RESOURCE AND RODENT PESTS

Jodhpur district is an admixture of undulating dune country in the northwest and plains of medium textured soil-which have been transformed from grasslands to crop lands in the south. These diverse habitats provide hanen to animals of saharian affinities in its typical western parts and animals of oriental distribution in eastern region. For example, in the typical desert occurs the Desert Cat, *Felis libyca ornata* but in eastern parts it is replaced by the Jungle Cat, *Felis chaus prateri*. If the district is properly managed, it has the potential of "ranching, of partridges, sandgrouse, hare and some of the ungulates.

Aves

Pea fowl, *Pavo cristatus*, the National bird, is found in fair abundance in the village environment in the southeastern district as it gets almost total protection from the people. Another common wildlife bird, the Grey Partridge, Francolinus pondicerianus, commonly occurs all over the district whereas Quails, *Coturnix* spp and the common sandgrouse, *Pterocles exustus* are found in smaller numbers. In the gravelly habitat in the western parts, a few Great Indian Bustard, *Choriotes nigriceps* have also been observed. Among the winter visitors, the Imperial sandgrouse, *Pterocles orientalis*; the Lesser Florican, *Sypheotides indica;* the Houbara, *Chlamydotis undulata macqueeni;* and the Crane, *Grus dem moi selle* are the important birds which are found in the southeastern parts of the district in the period September - February. Besides a number of ducks and teal visit the water reservoirs in the winter season.

Mammals

The outstanding feature of the wildlife fauna in the Jodhpur district is the presence of five to ten thousand Black bucks, *Antelope cervicapra rajputanae,* around the villages of Bishnoi community which regard them in veneration. They also aggressively protect them. Dhawa, Gudha Bishnoi and Hingoli are the major localities where very large herds of black buck are still found. These are by far the largest population of this animal found at a place in whole of India Along with them occurs a fair number of the India Gazelle, Gazelle, *Gazella g. bennetti,* Whereas Black buck are found mainly in the southeastern villages, the Chinkara is also found in grasslands in the sand dune dominated northwestern parts of the Jodhpur district. The Nilgai, *Boselaphus*

tragocamelus commonly occurs in the Jodhpur - Sardarsamand - Bhopalgarh region, mostly associated with irrigated crop fieelds. They inflict considerable damage to the crops. The Desert Hare, *Lepus nigricollis dayanus* is well distributed in the region but is more commonly found in the vicinity of gram, wheat and mustard crop fields. The Wolf, *Canis lupus pallipes,* regarded in the past as a vermin, has become rather common in the Salawas–Gudha Bishnoi. Since they are now considered a vanishing species, and that killing is not allowed by Bishnois in this region, it is reported that their numbers have increased in recent years. Besides, a number of other mammalian species are found in the desert region.

However, in the recent past, Panther, *Panthera pardus* and Wild Boar, *Sus scrofa* were fairly common the district but due to deterioration of habitat they have totally vanished from the scene.

In the Jodhpur district, three regions are worthy of receiving attention of Wildlife conservationists with a view to augment the vegetal resources which will in turn improve the multiplicity of primary consumers and they in turn of secondary consumers. These area Pheench-Doli, Gudha Bishnoi and Sardarsamand–Kharda. These regions are dominantly inhabited by the Vishnoi people.

It will be prudent to use the religious sentiments of Bishnoi community for the conservation of Wildlife. At present, however, the grassland in Doli and Gudha area is highly degraded and there is need for enhancing the carrying capacity of the bare patches by re-seeding the grasses. The ungulates mostly thrive by feeding on crops but if the ranges are improved, the crop losses due to them can be reduced. Another important requirement of developing these areas in to good wildlife reserves is to provide drinking water to the black bucks. Unlike gazelles, the antelopes do need at least one drink per day. During summer the nadis dry up and Black buck scatter out of the Bishnoi dominated areas for search of drinking water and are shot by poachers. During summer, for thermo-regulation purposes, the ungalates rest throughout the hot day under shade which is scarce because only *Prosopis ceneraria* trees grow in these habitats. It would be fruitful to plants haddy trees, neem. *Azadirachta indica*; Siris, *Albizzia lebbbek* etc. When the habitat improves, there is a scope of re-introduction of wild boar in all the three areas suggested and panthers in the Sardarsamand–Kharda area. It is quite likely that two other carnivores, which were found in the southesastrn district in the past namely, the Caracal, *Felis caracal* and the Civet, *Viverricula indica* may stage a come back in the Sardarsamand area when conditions improve and a total prohibition on shooting and snaring is imposed effectively.

Rodent pests and their management

Field rodents not only destroy the crops but draw heavily on the grasses and grasses fodder species, thus competing with the livestock. It has been estimated that the annual dietary requirement of a

population of 477 merion gerbils per hectare in a *Cenchrus ciliaris* dominated range would be 1044 kg. The annual production of edible (for sheep) plant species was found to be 865 kg/ha and the total forage production 1100 kg/ha. From this comparison it is evident that rodents maintain a severe pressure on the vegetable production in the desert. In the croplands, the rodents are especially destructive to the irrigated crops. Besides damaging the vegetation, the rodents are potent agents of soil erosion. The heaps of loose soil excavated by them are quickly drifted by the strong desert winds. Their burrow openings as many as 14,000 per hectare, also deter the vegetation growth. The severity of the problem of rodents in deteriorating the fragile ecological balance in the desert environment can thus be easily appreciated.

The rodent pests

About 16 species of rodents occur in the Jodhpur district varying in species composition as well as in order of predominance in different habitats. In the sandy habitat, the Desert Gerbil, *Meriones hurrianae* (30–50 per cent of the total number of rodents collected) is found to be most commonly found. On the sand dunes the Hairy-footed Gerbil, *Gerbillus gleadowi* out-number all other species along with the Little Gerbil, *G. nanus indica*, the Sand - coloured Rat, *Rattus gleadowi* predominates. In crop lands, the Soft-furred Rat, *Rattus meltada pallidior*, the Brown spiny Mouse, *Mus platythrix*, the Indian Field Mouse, *Mus booduga* and the Bush Rat, *Golunda ellioti* gujerati form the rodent fauna. In the *Rocky* habitat, the Cutch Rock-rat, *Rattus cutchicus*, *M. platythrix sadhu* Fawn-coloured spiny Mouse, *Mus cervicolar phillipsi* and the Northern Palm squirrel, *Funambulus pennanti*, the Indian crested Porcupine *Hytrix indica* are found. In the village complex, the House Rat, *Rattus rattus rufescens* and the House Mouse, *Mus musculus bactrianus* inhabit almost every house in abundance.

Rodent control

Crop fields : Rodent control methods have been evolved at the Central Arid Zone Research Institute, Jodhpur after studying their habitat, feeding behaviour, bait shyness, breeding cycles and poulation dynamics through the year. The lowest population of rodents occur in May and June. Acceptability of bait is also maximum duriug these months, because of scarity of other food material Months of May and June are therefore the best for rodent control on large scale. Pre–baiting for 3 days is considered necessary to condition the rodents to accept bait freely. Pre-baiting mixture consist of 97 parts *bajra* flour and 3 parts groundnut oil. The mixture is kneaded with water and made into small round balls and these are pushed near burrow openings. On the fourth day 95 parts *bajra* flour with 3 parts of groundnut oil and 2 parts of zinc phosphide is used as poison bait in the similar manner as the pre-bait mixture.

Yet another effective and cheaper method is to use *ber* (dried berries of *Zizyphus nummuiaria*), which is available

in abundance in the desert and can be used as a carrier of poison. Air dried *bers* are soaked in a solution of compound 1080. 3 mg of compound 1080 per kg of rodent live weight is adequate letal dose. 109 grams of treated *ber* are enough for one hectare of land for control of odents. 300 mg of compound 1080 are dissolved in 300 ml of water and 100 grams of *ber* are allowed to soak in the solution for a period of 24 hours. This impregnates each berry with the lethal dose of poison for the rodents. One lethal berry along with four ordinary berries are then pushed inside the burrow openings. This one-shot baiting technique is highly economical and costs about 50 paise per hectare inclusive of labour charges. The residual population of field rodents should be later on killed by fumigating the the burrows with aluminium phosphide, 1.5 g tablet per burrow. Fumigation of burrows is more successful in rainy season and in irrigated fields.

Residential premises and Godowns : It is not advised to use acute rodenticides in the house as they are hazardous to non-target species also. Instead, warfarin based anti-coagulant poisons, the ratio of of 1:20 crushed bait *(bajra*, wheat) should be used. These multiple dose poisons are slow reaching but are relatively safer. Poison-baiting continuously for 20 days should be ensured. It should also be understood that rodent control is a continuous process and as far as possible should be taken up in large areas to minimise the reinfestation after a short period.

SILVIPASTURE AND PASTURE ESTABLISHMENT AND MANAGEMENT IN JODHPUR DISTRICT

The scope of pure pasture/silvipasture establishment and management is considered extremly relevant in the following land resources units identified in Jodhpur district as a result of integrated natural resources survey namely the Duny complex, Hummocky aggraded plains. Flat aggraded plains with hard pan soils, Gravelly aggraded plains and Rocky pediments, Blateaux and Hills. Adoption of Silvipasture-management systems in the above land resource units would not only be consistent with the land capability class of the land but will also generate higher yields per hectare without further deterioration of the land. Of these, silvipasture system is recommended for dunes and high hummocks. This system could also be applied to a limited extent to other land units but pasture system is better suited.

The first step in a management programme consists in the closure of the area to any biotic interference principally grazing. Although angle iron and five strand barbed wire constitute the ideal type for fencing at an estimated cost of Rs9/- per running metre, it is very expensive. Therefore, live hedge fencing with locally adapted species would seem a cheaper alternative. *Euphorbia caducifolia* as live fencing material has shown good performance in Daijar on dune soils. Shallow trenches 60 cm wide 30 cm deep and as much long as required are dug and cuttiugs of *E. caducifolia* are planted in staggered two rows at 30 cm spacing between plants. Cuttings of *Clerodendron phlomoides* and *Dichrostachys nutans* would appear to be very promising on the dunes as well as in the plains. *Dichrostachys* has the amazing quality to produce numerous root suckers conferring it an aggressive characteristic for survival. The planting of cutting would be similar to that mentioned for *E. caducifolia*. *Agava americana* is another important fence plant already in use in the semi-arid zones. In this case. single row planting at 60 cm between plants would provide an impenetrable barrier. What is more, the outer mature leaves can be cut for conversion to flax fibre.

By simple closure to grazing it was observed that the dry grass yield was 15 q/ha in closed area compared with 0.2 to 0.5 quintal per hectare from a comparable unenclosed area.

Having done the closure of an area with live hedge fencing one year in

advance of any contemplated establishment programme, the next step in the management programme would depend on the nature of land resource units as follows.

Silvipasture establishment

This consists of two phases namely (1) establishment of top-feed tree species and (2) pasture reseeding for maximum efficiency. The two compooents should be spatially integrated so that 60 to 100 trees/hectare are uniformly scattered amongst the grass ground cover. However, viewing from the needs of the people, this system appears too rigid in as much as the area is not open to grazing at least for 3 to 4 years of closure because the growth requirements and protection needs of trees and grasses differ. The needs of people and their participation being more sacrosanct for successful operation, a flexible approach is called for and can be had, if so needed. The area envisaged under such a program can be apportioned separately for tree belts and grass belts. That is to say the trees can be planted in 20 m wide belts running across the prevailing wind direction using technique mentioned earlier alternating with 100 m wide grass belts. The area under tree belts can be closed to grazing for the desired period whereas that under grass belts canbe opened to controlled grazing after flowering stage (November-December) even in the first year itself. The regeneration and growth of grass in the following year will not be affected by this measure and thus will meet the demands of the local people.

Since the main body of the dune is generally stable, mulching for establishment will be necessary for the crest and leeward flank only. Where required the mulching could be done with the locally available brushwoods such as *Crotalaria burhai, Aerva tomentosa, Leptadenia pyrotechnica, Zizypeus nummularia* or *Lycium barbarum*

Establishment af top-feed species

This comprises selection of species, nursery raising and planting. Amongst the species, there is no doubt that *Khejri* (*P. cineraria*) is the finest. Therefore, every effort should be made to give as a high a representation as possible to this species in selecting the tree component. However, its slow growth rate is an important factor to be reckoned with although a few fast growing provenances have recently been inentified as promising at Central Arid Zone Research Institute. Till such time used could be made of other top-feed species.

Acacia tortilis, A. aneura, A. victoriae, A. senagal, Dichrostachys mutans and *Colophospermum mopane* are the most promising species on the dunes.

Technique of seeding raising

The seedlings of above trees are raised in nursery by the 'Brick Receptacle' technique. The bricks are prepared with the help of wooden or steel mould 30 cm high. 10 cm and 15 cm square at the top and bottom respectively. The bricks themselves are made out of a mixture of equal proportion of clay, sand and manure with

the requisite amount of water and moulded and sun dried with a cavity of 2.5 cm diameter and 15 cm deep at the top in order to sow the seed or plant the stump depending on the species used.

After the outbreak of monsoon, these bricks along with 9 to 12 months old seedlings in them are removed from nursery beds and planted deep (60 cm below the dune surface) at the site with the bricks intact.

Pasture establishment

The space available amongst the tree rows is advantageously utilised for intercropping with good quality and high yielding forage grasses. Some of the promising grasses identified at Central Arid Zone Research Institute are as follows.

Cenchrus ciliaris strain No. 357, 358, 214.

C. setigerus strain No. 176, 175.

Lasiurus sindicus strain No. 319, 353, 352.

Adopting a seed rate of 5 kg/ha of unhusked seeds, the above species are line-sown at 1 to 2 cm depth in rows 75 cm apart just immediately after the first soaking shower of heavy rain. This would give a good stand of grass between the tree rows.

Maintenance of the system

The tree component, once established, happly needs relatively less effort for maintenance. Lopping (one-third of the canopy) can start after the *P. cineraria* trees are about 10 years old. In the case of the other trees, it can be even earlier, i.e. 5-6 years. Lopping can be done every year but at least in case of *P. cineraria* better returns can be had by lopping in alternate years.

In case of pasture lands more careful management is required. A grassland has optimum number of desirable perennial grasses and a perennial puts forth now growth with the advent of monsoon. If this new growth is continuously clipped, as it happens under continuous grazing, the desirable perennial grass will not be able to restore food material in its roots which will affect the growth and production of the grass in the following year. If continued over the years the plants lose vigour and will die. The aim of grazing management should be to give early nutritions grazing to animals but allow for periods of rest to enable grasses to recoup vigour. Deferred grazing in a three compartment scheme is one such compromise management technique. In its simplest form, the deferred rotation grazing system consists in dividing the area into three compartments. Generally the point during the grazing season at which seed of the principal forage plant matures determines the number of grazing units. In a three compartment scheme the third compartment is deferred first for two-thirds of the season and the animals are grazed rotationally in first and second compartments until 70 percent utilization is achieved. In the second year, the first compartment is defered and the second and third compartments are rotationally grazed. In the third year the second compartment is deferred and grazing rotationally in first

and third compartments. The grass in defrred compartment is cut and stored as hay for using during lean season. In this way each compartment gets deferred in turn in a three year cycle and self seeding of the compartment is ensured for sustained growth and production of the grassland. Such a grazing management enable to support more cattle grazing days than the traditicnal continuous grazing system. In addittion to above management, water holes and licks be provided at suitable place to avoid spot grazing.

Establishment of pasture system

Flat plains with hard-pan soils, gravelly plains, shallow and rock pediments are recommended for establishment of pasture lands. Scope of trees as top-feed species is limited because of highly restricted growth that these plants put up, However, it would still be desirable to have some shande of trees to provide shade to grazing livestock and for fuel needs of the area. Various steps involved in the establishment of pastures are adoption of water conservation measures, reseeding and controlled grazing.

Soil and water conservation : In gravelly plains and pediments, the sloping nature of terraing requires contour bunding or furrowing at 50-60 cm vertical interval, Alternately staggered contour trench system can also be adopted. Experience has shown that bunds 1.5 m wide at the base 0.15 m as top and 0.6 m high are quite effective for the purpose. Suggested dimensions of contour furrow are 0.60 m wide and 0 20 m deep with exacavated earth put on the down-slope side. In the flat plains simple bunding to form blocks of about 1.00 m x 100 m will be enough to prevent runoff in response to micro-relief variations.

Choice of species : Good pastures can be established by a mixture of *Lasiurus sindicus* (Strain 319). *Cenchrus ciliaris* (strain 357, 358) and *C. setigerus* (strain 176). In case of gravelly plains and pediments *Chrysopogon Rulvus* can be introduced also. Experience has shown that presence of shrubs like *Zizyphus nummularia* add considerably to the value of the pastures. What is more their presence to form upto 15 per cent cover does not adversely affect the bio-mass yield of grasses.

Seeding method as well as maintenance technology are same as described earlier for silvipasture system. However, because of the compactness of land surface, ploughing of land with sub-soiler is necessary before seeding.

As mentioned earlier, plantation of trees could be taked up to a limited extent in the pure pasture systems also to provide shade to grazing livestock and for fuel needs. The species snggested for the purpose are *Acacia tortilis, Acacia senegal, Azadirachta indica, Albizzia lebbek, Holoptelia integrifolia* and *Dichrostachys mutans*. In case of gravelly plains and rocky pediments, the trees need to be planted in staggered contour ridges cum trenches 3 metres in length and 60×60 cm in cross section are made. Planting of 9 to 12 month old seedlings of above species raised in nurseries separately are made in pits 60×60×60 cm half filled the weathered soil and the other half made with 15 cm high crescent shaped ridge across the slope to harvest the runoff water.

SOME IMPROVED FARM TECHNOLOGIES

The object of this section is to provide a quick reference material for user of this report on technologies suggested for efficient utilization of natural resources in description of various Major Land Resource Units. The compilation is based on scientific informations available at Central Arid Zone Research Institue. It does not claim to be exhaustive. Interested users may find it advantageous to consult the original materials on technologies, reference to which is also included.

A. *Package of practices for dryland crops**

Bajra : Prepare the field by cross disc harrowing and planking. Incorporate 20 kg B.H.C. 10 per cent dust and place the fertiliser (20 kg N per ha) 10 cm deep before sowing. Sow Agrosan GN treated seeds of *bajra* NHB 3 or BJ 104 @ 4 kg/ha in rows 45 cm apart or still better in paired rows (30/60 cm). Seed should not be sown more than 5 cm deep. One weeding is necessary 15-20 days after sowing. Thin out plants in the row so as to maintain plant to plant spacing of 10-15 cm. Gap filling may be done by transplanting 20-25 days old seeddling on a drizzling day. Top dress 20 kg N/ha 30-45 days after sowing on the receipt of good rain. In the event of infestation of blister beetle and leaf cutter, dust the crop with B H.C. 5 per cent.

Jowar : Prepare the field well by giving one to two harrowings and plankings. Incorporate 20 kg BHC 10 percent dust per hectare at the time of last ploughing. Place the fertilizer mixture (30 kg N/ha) 10 cm deep at the time of sowing. Drill 12.5 kg seeds per hectare in rows 60 cm apart with the plant to plant distance maintained at 30 cm for getting adequate plant population. The seeds of CSH 1 (recommended for *Kahrif* cultivation in Northern India) should be treated with carbofuron (66 gm per kg seeds for control of shoot fly and borers). For control of loose smut, and grain smut use seeds treated with Agrosan GN and apply Endrin granules 2 per cent in the event of incidence of stem borers. Top dress 30 kg N/ha 4-6 weeks after sowing on the receipt of good rains.

Moong and moth : Field may be prepared with a disc harrowing and planking. Incorporate 20 kg BHC 10 per cent dust and place 10 cm deep fertiliser mixture of 15 kg N and 30 kg P_2O_5/ha

*Source : "Improved Dryland Agriculture for Jodhpur and Nagaur Districts" Dry Farming Research Main Centre, CAZRI, Jodhpur.

before sowing depending on the soil test. 10-12 kg inoculated seeds of recommended varieties of moong (S8, M-8) should be sown in rows 30 cm and plant to plant distance maintained at 5 cm in second or third week of July. Pests like flea beetle, gassids, white fly can be effectively controlled by spraying of 0.03 per cent solution of Thiodan.

Guar : Prepare the field with a discharrowing and planking. Incorporate 20 kg BHC 10 per cent dust and apply 20-30 kg P_2O_5 by placement depending on the soil test values before sowing. Sow 12-15 kg inoculated seeds per hectare of improved varieties of guar (FS227 and Durgapura Saffed) in the second or third week of July in rows 45 cm apart for getting adequate plant population. Thinning may be done 10-15 days after sowing, maintaining plant to plant spacing at 7.5 cm. One weeding after 20-25 days of sowing is essential. Pests like leaf cutters, jassids can be effectively controlled by spraying the crop with 0.05 per cent solution of Thiodan.

Til : Field may be prepared by cross discharrowing and planking. Incorporate 20 kg BHC dust 10 per cent along the preparatory tillage. Place the fertilizer mixture (20 kg N and 10 kg P_2O_5/ha) 10 cm deep before sowing. Sow 3 kg seed/ha of improved varieties (T13) in rows 30 cm apart in the end of June or 1st week of July and the seed should not be sown more than 3 to 4 cm deep. Thinning should be done 15-20 days after sowing, maintaining plant to plant distance at 10 cm. Crop should be weeded 20-25 days after sowing. Top dress 20 kg N/ha 3-4 weeks after sowing on the receipt of good rains. Pests like Antigestra, leaf and pod Cater pillars can be controlled by dusting BHC 5 per cent. Crop should be harvested at the physiological maturity stage to avoid shattering.

Castor : Prepare the field with cross discharrowings ann planking and incorporate 20 kg BHC 10 per cent dust. Apply 30 kg N and 30 kg P_2O_5 per hectare (depending on the soil test values) by placement 10 cm deep before sowing. With the onset of monsoon, sow 2-15 kg eeed/ha of improved castor varieties (Aruna R-63) in rows 60-90 cm apart and plant to plant distance maintained at 30 cm. Oneweeding is essential 20-25 days after sawing, Nipping of axillary beds at 45-50 days after germination should be encouraged to promote good development on primary spike. Castor hairy caterpillar and castor somi-loop are the main pests which canbe effectively controlled by dusting BHC 5 per cent dust or by spraying the crop with 0.03 per cent solution of Endrin.

Sunflower : Two ploughings or discharrowings are sufficient for satisfactory seed bed preparation. Incorporate 20 kg BHC 10 per cent dust with the preparatory tillage. Place 30 kg N/ha 10 cm deep before sowing. With the onset of monsoons, sow, 12-15 kg soaked seeds (24 hours in water) in rows 60 cm apart with a plant to plant distance of 30-40 cm. One weeding is essential 15-20 days after sowing. Top dress 30 kg N/ha at the time of capitulum initiation stage. In the event of Myllocerus infestation, spray the crop with 0.03 per cent Rogor solution or dust the crop with BHC 5 per cent dust.

B. *Improved crop varieties for dryiands of Jodhpur tract**

Crop	Variety	Duration (days)	Yield+ (q/ha)	Salient features
Moong	S8	60-65	10-12	Semi compact profuse bearing.
	M8	60-65	13-15	Semi spreading, profuse bearing.
	RS4	70-75	7-9	Spreading type
Cowpea	FS68	65-70	10-12	Compact plant type, profuse bearing, pods protrude out of leaf canopy, shattering of pods at maturity.
	K-11	70-75	10-11	Compact plant type
	JC-10	80-90	6-8	Spreading type
Guar	KVSI	85-95	18-20*	Branched
	2470 (12)	110-120	8-12	Branched
	FS277	100-105	5-7	Single stemmed
	Durgapura Saffed	105-110	5-7	Branched
Castor	Aruna	130-140	10-12	Dwarf compact type
	Gujarat Hybrid-3	130-140	10-12	Dwarf hybrid
Sunflower	EC68414	75-80	6-7	—
Til	T13	80-85	5-6	Branched, white seeded
	Var 4-2	80-85	6-7	Branched, white seeded
Raya	KYSR	95-100	14-15	Compact plant type, profuse bearing synchrous in maturity, suitable for limited moisture supply conditions in *rabi* season.
	T59	110-115	10-11	Medium early, less vegetative
	RL18	120-125	9-10	Late, excessively vegetative

*Source : "Improved Dryland Agriculture for Western Rajasthan" *Tech. Bull. No. 1*, CAZRI, 1976. Compiled by R.P. Singh.

+Mean of 2 to 3 years yield data

*Based on one year (1976) data only

C. Water harvesting for field crops

(a) *Permanent run-off-run-on system*[a] : In this system field is divided into 3 m and 6 m wide strips in altunating manner. The 3 m wide strip is raised in the middle with earth from the 6 m wide strip to give a 4-5 per cent slope on either side after ramming and rolling In case of light textured soils the surface of this micro-catchment is made imperious to water by giving a thin layer of tank silt and rolling the same after wetting. Sowing is done in the 6 m wide strip

(b) *Inter-row and modified inter-row, water harvesting*[b] : Inter-row water harvesting is to convert inter-row spaces into micro-catchment with a view to concentrate moisture in a smaller area around the seed row. This system comprises opening 20-25 cm deep furrows with ridger at the required spacing and at the same time converting the inter-row space into a convex platform with a suitable attachment to the ridger. This arrangement induces the rain water from the inter-row spaces (converted into micro-catchments to the furrows. In case of *bajra* furrows are 30 cm wide and the distance between the centre of one furrow to the other is 1m The crop is planted on either side of the furrow. In modified inter-row water harvesting, the furrows are 40 cm wide with a distance from centre of one furrow to the other of 90 cm. Further, after every two furrows the 50 cm convex bench is raised very high to give a steep slope of 100 per cent on either side.

D. Water harvesting with moisture barrier for vegetable crops[c]

In this system 75 cm deep and 50 cm dia. pits are dug 2.5 m apart in a checker board design. At the bottom of pit bentonite layer is put @ 2.5 to 3 kg clay/pit. After dusting the sides also with this clay, the pit is filled with the dug soil mixed with organic manure. The intervening space is converted into inverted 'V' shaped micro catchments of 1 m width on either side and with 5 per cent slope toward the pits. The system has worked well on light textured soils for crops like round gourd and tinda and seems to have potentiality for water melon, chillies and ladies finger. Another modification is where instead of pits, long trenches of 45 cm width are dug.

---

[a]Adapted from "Runn-off farming - Making the best available water" S. D. Singh, H. S. Daulay and K. D. Muthana, *Indian Farm*, July 1973.

[b]Adapted from "Improved Dryland Agriculture for Jodhpur and Nagaur Districts" by Dry Farming Research Main Centre, CAZRI, 1976.

[c]Adapted from "Improving the moisture storage in sandy soil by sub-surface barrier" by H. P. Singh. "*Arid Zone Res. & Development*" Feb. 1978, CAZRI, Jodhpur, 242-252.

*E. Insect pests and their control**

Insect pests of *bajra*, sorghum and maize

Pest species (family) according to sequence of incidence	Control measures
Termites (Termitidae) : *Odontotermes obesus* Ramb : *Microtermes anandi Holmg.*	Aldrin or heptachlor (5 %) or BHC (10%) dust @ 25 kg/ha to be incorporated into soil about 15 cm deep.
White grub (Melolanthinae) : *Holotrichia consanguinea* Bl. *H. serrata* Fabr.; *H. insularis* Brenske *Anomala bengalensis* Bl.	Phorate (10 G) or thiodemeton (5 %) or lindane (6%) @ 20 kg/ha mixed with the soil. For controlling beetles, use mechanical-cum-chemical method, vide text).
Sorghum shootfly (Anthomyidae) : *Atherigona variasoccata* Rond; Bajra shootfly, *A. approximata* Malloch.	Seed treatment with carbofuran (50 WP) @ 60-100 g/kg (or a pre-sowing soil application of phorate or thiodemeton granules @ 20 kg/ha 40 kg/ha respectively).
Grasshoppers (Acridiidae) : *Chrotogonus trachypterus* Bl ; *Hieroglyphus nigrorepletus* Bol.; *Oxya ebneri* Will	BHC (5%) dust @ 25 kg/ha
Shoot-borers : *Chilo partellus* (Swinh) (Pyralidae), *Sesamia inferens* (Walk) (Noctuidae).	Endosulfan (4 G) or carbaryl (4 G) or lindane (2 G) three times @ 5.0, 7.5 and 10.0 kg/ha, after 20, 30 and 40 days of germination.
Hairy caterpillars (Arctiidae) *Amsacta moorei* Butler,; *A. albistriga* Walk ; *A. lineola* Fabr.	Endosulfan (4%) or carbaryl (5%) dust @ 15-20 kg/ha.

Armyworm (Noctuidae) : *Mythimna separata* Walk. ; Grey weevil (Curculionidae) : *Myllocerus maculosus* Desb.	BHC (5%) or carbaryl (5%) dust @ 20-25 kg/ha or carbaryl 0.1% or endosulfan 0.075% spray phosphamidon or dimethoate 0,03% or methyl.
Aphid (Aphididae) : *Rhopalosiphum maidis* Fitch.	Demeton 0.025% spray Endosulfan 0.05% or carbaryl 0.1% or lindane.
Sorghum midge (Cecidomyiidae) : *Contarinia sorghicola* Coq ; Ear-thead bug (Miridae) *Calocoris angustatus* Leth.	0.1% or malathion 0 03% spray (or endosulfan 4% or carbaryl 10% dust @ 12 kg/ha after 90 percent earhead emergence; repeat 4-5 days. after the first application.

*Source : "Inset Pests and their Control" by K. S. Kushwaha and S. K. Pal. In *Desertification and its Control*, ICAR Publication, 1977.

Insect pests of pulses (green-gram, moth, gram, cowpea)

Pest species (family) according to sequence of incidence	Control measures
White grub and termite spp.	Vide Table 1.
Cutworms (Noctuidae) *Agrotis ipsilon* Hagnagel, *A. spintifera* Hubner.	Aldrin or heptachlor 5% dust @ 25 kg/ha BHC 5% or carbaryl 5% dust @ 20-25 kg/ha.
Galerucid beetle (Galerucidae), *Madurasia obscurella* Jacoby	
Green Jassid (Jassidae),	Vide Table 3.
Amrasca kem D. Hairy caterpillars (Arctiidae), *Amsacta moorei* Butler; *Diacrisia obliqua* Walk.	Vide Table 1.

Caterpillars (Noctuidae),	BHC 5%, carbaryl 5% dust
Plusia orichalcea Fabr.	@ 20-25 kg/ha.
P. nigrisigna Walk.	
Anticarsia irrorata Fabr.	
Laphygma exigua Hubn.	

Insect pests of oilseed crops

Pest species (Family) according to sequence of incidence	Control measures
Mustard, *Brassica campestris*	Seed treatment with lindane and
Mustard sawfly (Tenthredinida)	phorate @ 2.5 kg and
Athalia proxima Kiung.	1.0 kg/100 kg of seed
Mustard aphid (Aphididae)	Spray malathion 0.05%
Lipaphis erysimi (Kalt.)	
Painted bug (Pentatomidae)	Phosphamidon 0.03%
Bagrada cruciferarum Kirk.	
Leaf-miner (Agromyzidae),	Methyl demeton 0 03%
Phytomyza atricornis Meigen.	Dimethoate 0.08%; Carbaryl 0.2%
Til, Sesamum indicum; *Til,*	Carbaryl 0.1%
caterpillar (Pyralidae).	
Antigastra catalaunalis (Dupon)	
Til hawk *moth* (Sphingidae)	BHC 5% dust.
Acherontia styx Westw.	
Castor, *Ricinus communis*	Carbaryl 0.1%
Castor semi looper (Noctuidae),	
Achaea janata Linn. Hairy	
caterpillar (Lymantridae)	BHC 10% dust.
Euproctis lunata Walk.	
Castor mite (Tetranychidae),	Phosphamidon 0.03%
Tetranychus Linn.	

Castor capsule-borer (Pyralidae) *Dichocroces punctiferalis* Guen.	Malthion 0.1%
Groundnut *(Arachis hypogaea)* Termite. *Odontotermes obesus;* White grub, *Holotrichia consanguinea, Amsacta moorei*	Vide Table 1
Safflower *(Carthamus tintorius)* Safflower aphid.	Methyl demeton 0.03%
(Aphididae) *Uroleucon* (Uromelan) *compositae* Theob.	Dimethoate 0 03%
Sunflower *(Helianthus annus* Aphid) (Aphididae) *Brachycaudus helichrysi* (Kalt). *Aphis gossypii* Glov.	Vide Table 1.
Jassids (Jassidae) *Distantasca terminalis* (Dist).	Phosphamidon 0.03%
Empoasca lybica deG, *E. motti,* Pruthi, *Amrasca* sp. Whitefly (Aleurodidae) *Bemisia tabaci* Gen.	Dimethoate 0.03%

F. *Improved Horticulture**

Under irrigatton with sweet water : The characteristics soil and water situation in Jodhpur and adjoining areas are most favourable for production of certain fruits and after conditions for development of a distinct fruit quality. The suggested fruit trees, productivity and salient features of management are as follows :

Ber : Though a variety of *ber* cultivars can be grown, *Gola* and *Mundia* are found high yields (80-140 kg/tree). This is followed by *Jogia* (60-80 kg/tree) and seb (30-45 kg/tree), Fruit fly is a serious pest and there-fore prevention spray schedule with 0.02 per cent parathion at 3 week interval starting from fruit set is essential, usually 3 sprays are required.

*Adapted from "Arid Horticulture" by O. P. Pareek in "*Desertification and its Control,*" I.C.A.R. Publication, 1977.

Pomegranate : *Mandor, Saharanpuri* and seedless are the common varieties and each is able to give 150 to 300 fruits per tree.

Guava : Although frost susceptible, the tree is very drought hardy. Varieties *Allahabad Safeda* and *Lucknow*-49 have given the best performance.

Sono lime : *Kagzi* variety is very good performer with yields of 100 kg/tree. *Papaya;* Jodhpur and adjoining areas favourable for this fruit tree since viral and fungal diseases which limit its cultivation in other environments are assent. Variety Honey Dew is very successful with a fruit yield of 30 to 50 kg/tree. Washington is another promising variety.

Other fruits common in the area are *gonda,* custard, apple and *phalsa,*

Under rainfed conditions

Raising fruit crops under these conditions is possible only by canpling it with water harvesting technology. Experience gained so far at Jodhpur has shown that grafted ber orchards can be successfully raised using this system. The optimum catchment area has been found to be 54 sq m per tree#. The optimum slope is 5 per cent.

G. *Improved variety forage crops and rotations for year round production**

Through use of improved varieties and proper rotation a large increase in yield as well as duration of supply are possible. The common improved varieties suitable for irrigated conditions in arid zone are given in Table 27.

Table 27. List of improved varieties of fodder crops and grasses.

Crop	Botanical name	Improved varieties
A. *KHARIF FODDERS*		
1. Sorghum	*Sorghum bicolor*	JS20, JS 263, JS 29/1, Pusa-Chari-1, Haryana Chari (JS 73/53), SL-44, CO 11, Vidisha 61-1, Nilva and M.P. Chari (J6, IS 4776, HFS 566 are new strains).
2. Sudan grass	*Sorghum sudanense*	Meethi Sudan (SSG 59-3), (HFS 478 and J 69 are new strains).
3. *Bajra*	*Pennisetum typhoides*	S 530, T 55, A 1/3 and F2 generation of NB 3 and NB 5 hybrids.

*From "Forage Crops-their improvement and management for increased productivity" by R. S. Paroda. In *Arid Zone Research in India Silver Jubilee Souvenir,* 1952-1977, CAZRI, 1978.

4	Maize	*Zea mays*	Ganga-1, Ganga-5, Deccan, Vijay composite and Bassi local.
5.	Teosinte	*Euchlaena mexicana*	Improved teosinte.
6.	Cowpea	*Vigna unguiculata*	HFC 42-1, IGFRI-S-450, IGFRI-S-457, Russian Giant EC 4216, FOS-1, Co 1 and No. 10.
7.	*Guar*	*Cyamopsis tetragonoloba*	No. 2, FS 277, Durgapur Safed, AG 111.
8.	*Moth*	*Phaseolus aconitifolius*	T 3 and Jodhpur local.
9.	Napier x *bajra* hybrid	*(P. purpureum x P. typhoides)*	Pusa Giant Napier, Gujraj and NB 21.
B.	*RABI FODDER CROPS*		
1.	Berseem	*Trifolium alexandrium*	Mescavi, Tetraploid berseem and IGFRI-S-99-1.
2.	Lucerne (Alfalfa)	*Medicago sativa*	Sirsa 9 (T-9), IGL 1, Anand 1, S-244 and IGFRI-S-54.
3.	Oats	*Avena sativa*	Kent, Weston 11, Fulghum, FOS 1/29, Algerian, Haryana Javi (HFO 114) and I GFRI-S-2688.
4.	Senji	*Melilotus* spp	FOS 0
5.	*Methi*	*Trigonella foenum-graecum*	T-8
C.	*PERENNIAL GRASSES AND LEGUMES*		
		GRASSES	
1.		*Cenchrus ciliaris*	IGFRI-S-3108 & CAZRI 358
2.		*Cenchrus setigerus*	CAZRI 1 and CAZRI 76
3.		*Dichanthium annulatum*	IGFRI-S-495
4.		*Lasiurus sindicus*	CAZRI 318 & CAZRI 319
5.		*Sehima nervosum*	Local

	LEGUMES	
1.	*Stylosanthes guyanausis*	IGFRI-S-4214 & IGFRI-S-91-1.
2.	*Stylosanthes humilis*	IGFRI-S-4109 & IGFRI-S-22-48
3.	*Stylosanthes hamata*	A collection from CSIRO, Australia.
4.	*Macroptilium atropurpurium*	Siratro
5.	*Dolichos lablab*	CAZRI 144
6.	*Clitoria ternatea*	CAZRI selection

Under situation where water is plentiful, rotation for maximum productivity are (a) napier × *bajra* hybrid in the cropped with berseem or napier × *bajra* hybrid + lucerne or sweet sudangrass-berseem/lucerne. Their rotations are capable of yielding 150 to 200 tons/ha of forage in regulated manner, even covering the lean period. The napier × *bajra* hybrid should be planted in rows 2 m apart. Under limited moisture conditions rotation like *bajra* + cowpea *guar* + cowpea — cowpea + oat is most suitable and give about 90 to 120 tons/ha. However, this rotation is unable to supply fodder all the year round. Under still scarce water availability conditions *guar*, cowpea and oat can be grown for seasonal supply of fodder. A graphic representation of various possible rotations is given in Plate 15.

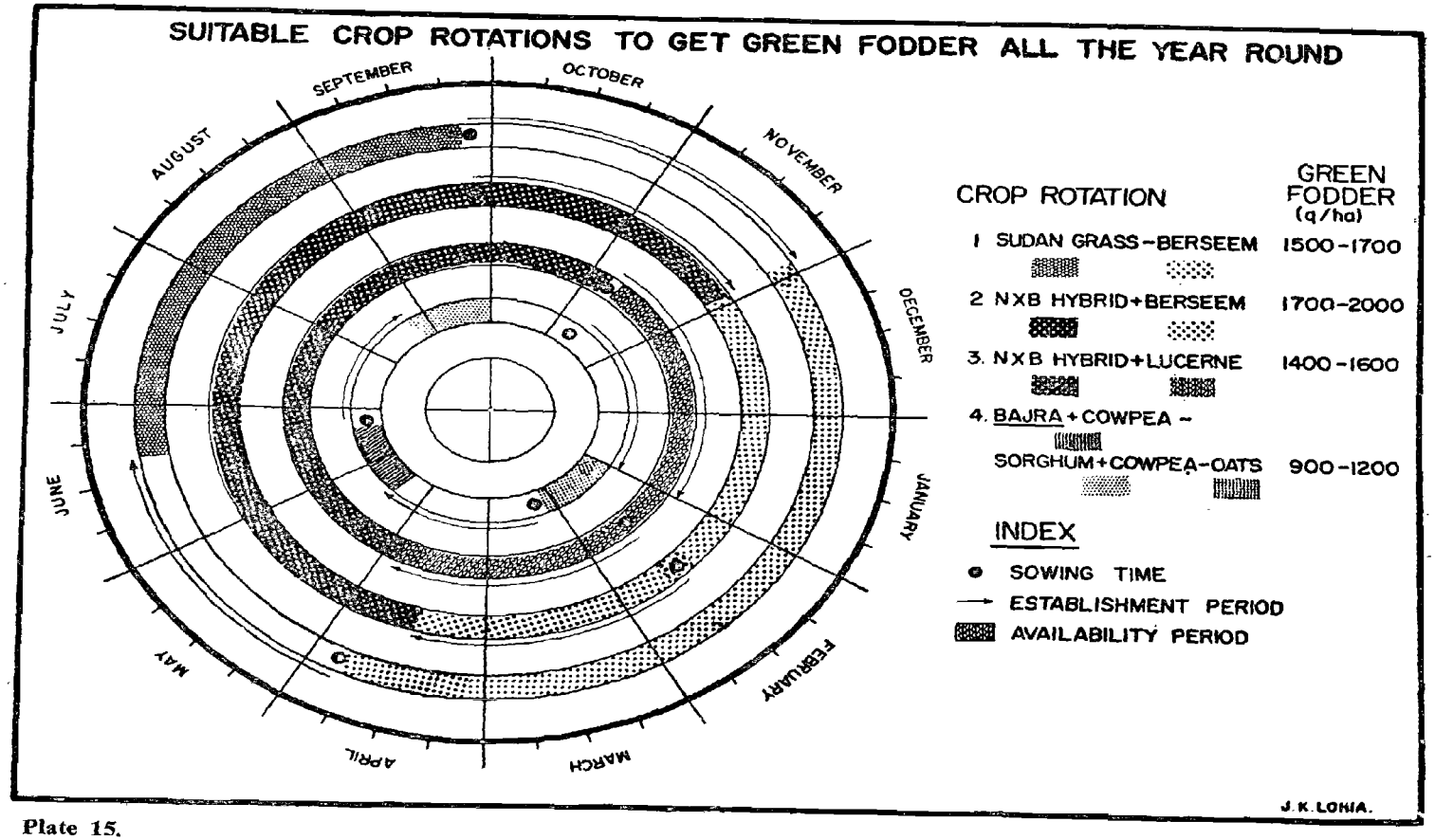

SUITABLE CROP ROTATIONS TO GET GREEN FODDER ALL THE YEAR ROUND
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
CROP ROTATION
GREEN FODDER (q/ha)
1 SUDAN GRASS-BERSEEM 1500-1700
2 NXB HYBRID+BERSEEM 1700-2000
3. NXB HYBRID+LUCERNE 1400-1600
4. BAJRA+COWPEA -
SORGHUM+COWPEA-OATS 900-1200
INDEX
SOWING TIME
ESTABLISHMENT PERIOD
AVAILABILITY PERIOD
J.K.LOHIA.

Plate 15.

APPENDIX - I

Villages and their major land resource units

Code No.	Name of the village and MLRU No.	Total area (acres)	Code No.	Name of the village and MLRU No	Total area (acres)
1	2	3	1	2	3
TEHSIL PHALODI			23	Bap* 1,5,13	51,871
1	Baroo 1,2,5	62,469	24	Baghauda 5	1,697
2	Khetoosar 2,3,5	6,808	25	Bhojon-ki-Bap Chak 5,8	1,254
3	Durjani 1,2,5	20,137	26	Shekhasar 8,10	28,115
4	Dadasari 5	13,562	27	Akhadhna 5,8	11,958
5	Khakhuri 5	6,372	28	Sanguri 5	12,007
6	Noore-ki-Bruj 1,2,5	48 835	29	Raneri 5	29,868
7	Kanasar 1,2,5	59,384	30	Modkiya 5	1,512
8	Madli 2,8	6,485	31	Jodhani 5	3,954
9	Rawra 5	9,769	32	Kanasi Meetha (Kalrawas) 3,4,5	3.912
10	Beeemji-ka-Gaon 5	10,362	33	Chhayan 1,2	19,792
11	Sawaragaon 2,4	5,496	34	Tekara 2,4,5	25,138
12	Lumbani 5	1,754	35	Durgani 3,4,5	1,530
13	Manchitiya 4,5	8,801	36	Jaimgla 5,8	20,147
14	Bari Seer 4,5	26,800	37	Baori 8,10	12,464
15	Jodhsingh-ki-Seer@ 1,2,4,5	68,688	38	Hindalgol 4,5	2,867
16	Udat 1,2.4	1,872	39	Kheerwa 4,5,13	12,620
17	Seer Malamsingh 1,2	26,487	40	Reen 13	6,905
18	Kilyan-singh-ki-Seer 1,5	13,956	41	Degawari 2,13	6,745
19	Gura 1,2,15	2,138	42	Siwandi 4,13	3.762
20	Nayagaon 5	882	43	Jambo 1,2	29.961
21	Gadna 5	6,431	44	Chakhoo 1,2	54,341
22	Baori Barsinga 5	13,198			

@Kansingh-ki-Seer *Temple of Bherunji *Temple of Jambeshwarji

1	2	3	1	2	3
45	Loona 1,2	14,279	82	Bitari 4	6,457
46	Lumbasar 1,2	7,017	83	Mokheri 4	14,239
47	Meethdiya 1,2	6,242	84	Ekabhatiya 4	2,292
48	Mayakor 1	6,804	85	Gajan 4,5	1,573
49	Arandiya 2	2,708	86	Lordiya 4,8	13,766
50	Cheemana 1,2	14,514	87	Dedisara 4,8	2,632
51	Dhadharwala 1,2	5,040	88	Amla 4,8,10	17,669
52	Kelansar 1,2	21 064	89	Banasar @ 3,4,8	10,441
53	Ghantiyali 42	29,071		Shaitansinghnagar	
54	Khariya 1,2	3 072	90	Paleena 2,3,4	26,403
55	Bheeyasar 1,2	28 800	91	Moriya 3	7,958
56	Pariyal 1,2	26,540	92	Ranisar 2,3	7,498
57	Balassar 1	3,800	93	Barjasar 1,3,8	11,260
58	Motai 1,2	18,601	94	Bhojasar 2,3	16,787
59	Cheeri 2	2,452	95	Aau 1,3,8	
60	Naneu 1,2,4	20,996	96	Nokha Patawaton 1,2	2,430
61	Dholasar 1,2,3	10,102	97	Nokha Charna 2	2,514
62	Kanasariya 1	3,274	98	Nokha Bhatiya 2	4,624
63	Kheechan 4	10,988	99	Jaisala*	18,951
64	Godarli 4,5,13	13,449	100	Ajasar 1	6,245
65	Malar 4,13	10,785	101	Rohina 1	18,583
66	Jor 4	3,124	102	Boogdi 1	20,998
67	Mohran 4,5	2,658	103	Champasar 1,2	12,186
68	Jagariya 4,5,9	4,203	104	Maneora 1	3,844
69	Baggan 9	607	105	Ridmalsar 1 2	23,984
70	Bhojko 9	1,805	106	Chadi 1,2	37,115
71	Gopa 9	3,008	107	Ishru 2	19,791
72	Maya Koriya 9,10	3,311	108	Suwap 8	1,673
73	Begti Kalan 4.5,9	20,502	109	Kerla 8,10	3,684
74	Sihra 2 5	18,272	110	Denok 2,3,8 9,10	40,023
75	Rayda 2 4,5	7,443	111	Bhujasar 2,3,4	15,451
76	Khara 4	27,084	112	Lohawat Bishnawas 2,9,10	35 394
77	Begti Khurd 4,9,10	17,921	113	Lohawat-Jetwas 2,3,10	18,904
78	Kundal 9,10	9,021	114	Chheela 1,2,8	6,566
79	Sadawaton 9 10	2,269	115	Jalora 1.3,4	27,196
80	Kalra 4	2,712	116	Kolu Pabooji 3,4	16,169
81	Hopardi 4	8,441	117	Sanwreej 4	25,159

1	2	3	1	2	3
119	Bamnoo 4	9,114	22	Harlaya* 2,3	6 179
120	Dhadhoo 4,5	22,107	23	Bheekamkor 1,2	34,608
121	Ugras 4.5	23.605	24	Khabra khurd 1,3	13.030
122	Dediya 5,10	9,205	25	Dabri** 1,2	6 999
123	Khera Bagoriya 4,5	3,431	26	Berdon-ka-Bas 1,2,3	6,664
124	Gandla 3,4	21.521	27	Cherai 1,2.3	36.810
125	Kolu Rathora 3,4	13,551	28	Bana-ka-Bas 1,3	8,926
126	Kushlawa 1,3	12.438	29	Khabra kalan 3	4,048
127	Dayakor 1,3.8	12,175	30	Beh Charan 1,3	2,353
128	Peelwa 1,2,8	42,081	31	Sirmandi 3	8,920
129	Dhelana 9,10	7,788	32	Khetasar 1	11,136
TEHSIL OSIAN			33	Osian*** 1,10	26,928
			34	Parasla 1,3	12,811
1	Bher 1,8	14,293	35	Bedhwasiya**** 3,8,10	23,796
2	Bhakhri 1,8,9	6,594	36	Thob 1,3,10	13,053
3	Samrau 1,2,3	30,143	37	Khindakor 1,3	7,243
4	Pali 1,8,10	30,620	38	Tapoo 1,3	11,442
5	Jeriya 9 10	3,001	39	Keenjri 1,3	3,759
6	Unawara 9,10	2,014	40	Khabaniya 1,3	1,428
7	Bedoo 1,9,10	10.334	41	Seeli 3	2,718
8	Bhanda 2	6,807	42	Basni Tarda 3	784
9	Meyan 2	1,045	43	Hatundi 1,3	6,118
10	Karwan 1,3	621	44	Geengala 3	5,262
11	Bapini 1,3	19,320	45	Chandrakh 1,3	10,123
12	Poonasar 1,2	25,461	46	Baran Khurd 1,3,9,10	6,167
13	Jakhan 3	23.009	47	Baran Kalan 9,10	3,812
14	Barsaloo Kalan 1,3	3,396	48	Begariya 8,9,10	2,657
15	Barsaloo Khurdi 1,3	628	49	Dhunadiya 9,10	4,746
16	Kapooriya 1,3	025	50	Newra 8,9,10	21,529
17	Raymalwara 1,3	11,773	51	Bigchi 8	1,534
18	Matora 1 3	18,075	52	Gopasariya 8,10	3,695
19	Sanwantan 1,3	4,123	53	Bhalasariya 1,8,10	3,860
20	Nimba-ka-Talab 1,3	9 476	54	Barla Basni 1,8	8,614
21	Naser 1,2,3	31,198	55	Ghewra 1	8,856

*Dharamshala, **Fair of Ramdeoji and Hanumanji annually.

***Cattle Fair annually; Temple of Sacchi Mata & Jain Temple.

****Fair of Ramdeoji annually.

1	2	3	1	2	3
56	Chandaliya 1	4,208	91	Nadiya Jajra 8,10	4.061
57	Panchla Khurd 1,3	8,195	92	Hardani 9,10	5,404
58	Jeloo Gagari 1.8,10	19,390	93	Anwana 9,10	7,533
59	Malunga 2.8 10	8,411	94	Kelawa Khurd 8,10	3,925
60	Santora Khurd 2	3,544	95	Kelawa Kalan 8,9,10	9,511
61	Santora Kalan 2	1,539	96	Jur with Gudiya* 8 9	6,954
62	Basni Bhatiyan 2,12	536	97	Keeramsariya Kalan 8	1,623
63	Narewa Charana 12	1,513	98	Bhainser-Chawandiyali 8	3,597
64	Doli-Nekha 8,10	404	99	Bhainser Kotwali 8,10	4,475
65	Bari**** 10	3,744	100	Bhainser Kootri 8	4,475
66	Bara Kotecha 8,10	7,551	101	Balkha 8,10	11,718
67	Tinwari 8	14,893	102	Beejoariya 8	3,315
68	Mandiyai Khurd 8,10	2 921	103	Rajasani 4,8	2,156
69	Mandiyai Kalan 8,10	2,894	104	Kotra 8	1,044
70	Reeniyan 8	3,307	105	Chopasani Charna 4,8,9	1,180
71	Keeramsariya 8	2,018	106	Mathaniya** 8,9	6,324
72	Khuriyala 8	2,894	107	Rampuriya Bhatiya 9,10	8 788
73	Kharda Mewasa 8,9,10	9,066	108	Ujaliya 9,10	3,224
74	Danwara 9,10	18,717	109	Ummednagar 8,9,10	8,766
75	Raikoriya 9	2,465	110	Bhawad 3,9,10	11,698
76	Jaitiyawas 9	3,527	111	Khari Khurd 3,9	2,947
77	Nandiya Kalan 10	10,106	112	Khari Kalan 3,8	349
78	Umadeshar 1,3	2,819	113	Baori 3,8,9	17,174
79	Nandiya Khurd 1,3	6,231	114	Sanwat Kua Kalan 9	2,602
80	Cheendari 3	3,485	115	Sanwat Kua Khurd 9	1,487
81	Dhanari Kalan 3,8 10	8 195	116	Bhat Koriya 9	507
82	Dhanari Khurd 8	3,422	117	Basni Patan 9	1,280
83	Mornawara 8	2,471	118	Lawera-Khurd 9,10	5,792
84	Chheendiya 8	2,751	119	Mailana 9,10	7,585
85	Kajnau Khurd 10	5,463	120	Jointara 9,10	4,422
86	Soyla 8	6,153	121	Birai*** 9,10	14,344
87	Chataliya 8,10	5,062	122	Kasti 9,10	7,731
88	Kajnau Kalan 8 9	5.439	123	Netra 3,8,10,12	15,426
89	Kheraya 9	3 994	124	Nawa Nagariya 3	551
90	Lawera Kalan 9,10	13 736	125	Gagani 3,12,13	19,250

****Fort of Rao Chundaji *Ancient Temple **Temple of Karni Mata
***Fair on Ram Navmi and Shrine of Ram Sanehi Sadhus

1	2	3	1	2	3
126	Surpura Kalan 2	2,312	25	Kanodiya Mahasingh 2,4	5,753
127	Borvi Kalan 2,3,12	1,271	26	Dasaniya 1	26,416
128	Lunavasiya 3,12	1,293	27	Somesar 1	11,280
129	Sevki Kalan 2,3,12	6,416	28	Pugliya 1,2	6,708
130	Sevki Khurd 2	1,755	29	Setrawa** 1	25,412
131	Bucheti 2,12	6,158	30	Khanori 9,10	1,508
132	Borvi Khurd 2	802	31	Deda Chak II 8,9,10	400
133	Changawara Charna 2	724	32	Deda Chak I 1,3	361
134	Changawara Kalan 2	493	33	Dera 1,3	12,048
135	Changawara Khurd 2	1,391	34	Dewatoo 1,3	13,081
TEHSIL : SHERGARH			35	Bhaloo Kalan 9,10	17,862
			36	Bhaloo Rajwan 8,9,10	5,142
1	Chandsama 1,4,10,13	30,629	37	Ketoo Manawta 1,3,8	1,880
2	Sanwalon-ki-Dhani 4	2,176	38	Ketoo Madan 8,9,10	6,867
3	Kalau 1,2,4	22,183	39	Sekhala 1,3,8 9	20,595
4	Burkiya 2,4	13,838	40	Solankiya Tala 1	33,609
5	Cotwaliya 1,2	10,747	41	Suwaliya 1	3,502
6	Sagran 1	7,621	41	Chaba 1	15,411
7	Dechoo 1,2,9,10	34,574	43	Sai 1	39,068
8	Thakoya 1,9	5,926	44	Shergarh 1	24,610
9	Gilakor 1,2	10,203	45	Bhoogra 1	14,837
10	Sukhmandla 1,2	4,837	46	Raisar 1,3	9,677
11	Nathrau 1,2	21,909	47	Gadha 1,3	7,769
12	Bainau 1 2	8,359	48	Ketoo Kalan 1,3	19,871
13	Panditon-ka-* Bas 1,2	4,269	49	Ketoo Hema 9,10	2,797
14	Chamu 1,2,3	27,260	50	Meriya 9,10	3,804
15	Dewaniya 1,2	4,821	51	Bastwa* 9,10	9,047
16	Lodta Achalwata 1,2,3	13,686	52	Deriya 9,10	6,222
17	Dhedha-Chak III 1	3,059	53	Chirwai 9,10	5,762
18	Lodta Hiradasot 1,3	8 593	54	Khudiyala 9,10	16,269
19	Lawaran 1,3	7,835	55	Gopalsar 9,10	7,822
20	Kanodiya Purohitan 1	9,907	56	Jhinjhaniyala 9,10	4,780
21	Khiyasariya 1	9,565	57	Birai 9,10	7,408
22	Asarlai 1,2	6,658	58	Uthambar 2,9,10	6,310
23	Chordiya 1,3,10	5,668	59	Basni Manna 2	4,378
24	Jethaniya 1,2	11,731	60	Bawarli 1,8,9	13,945

*Temple of Ramdeoji **Cattle fair in September *Temple of Gotamber Devi

1	2	3
61	Chanchalwa 2,9	3,728
62	Nimbo-ka-Gaon	12,499
63	Subera-Sasan 9,10	1,378
64	Belwa 9,10	24,133
65	Judiya** 1,9	9,339
66	Balesar Dugawatan 9,10	6,250
67	Kui Inda 9,10	3,935
68	Kui Jodha 9,10	5,025
69	Khirjan Fatehsingh 9	3,036
70	Khirjan Bhoja 9,10	2,548
71	Khirjan Khas 1,3	7,770
72	Khirjan Asa 9	3,298
73	Khirjad Tibna 9,10	2,519
74	Timri 9,10	569
75	Tena 1,9	21,353
76	Sointara 1	9,548
77	Chakder 1	1,459
78	Siyanda 1,9,10	11,080
79	Bhandoo Charan 1,9,10	9,223
80	Bhandoo Jati 1,9,10	5,581
81	Balesar Satan 9,10	12,735
82	Doodabera 1,9	2,499
83	Dhadhaniya Sasan 1	3,394
84	Dhádhaniya Barda 1	1,077
85	Dhadhaniya Bhaila 1	8,663
86	Agolai** 1,2	17,103
87	Surani***	3 914
88	Dugar**** 2,8,10	9,822
89	Tolesar Purohitan 3,8,10	3,828
90	Tolesar Charnan 8,10	1,872
91	Bhatelai Purohitan 3 8	3,139
92	Bhatelai Charnan 3,8	3,708
TEHSIL JODHPUR		
1	Basni Sepha 2 10	2,192
2	Ghantiyala***** 2,8,10	5,450
3	Sirodi 10,12	510
4	Chawanda****** 2,10,12	4,074
5	Salori 2,8,9,12	6,453
6	Beroo 2,5,10	7,983
7	Indroka 4,10	7,523
8	Khokhari 4	483
9	Manai 4	3,486
10	Narwa 4,8,10	7,463
11	Bheer Kali 8	711
12	Palri Panwaran 8,9	1,061
13	Palri Mangliya 8	2,342
14	Palri Khichiyan 10	3,559
15	Manaklao 9	7,195
16	Basni Karwar 9	1,299
17	Daijar 9,10	5,463
18	Basni Lachhan 8,9,10	1,606
19	Karwar 8,9,10	5,967
20	Jeepasani 9,10	1,703
21	Gharao 3,8,10	2,040
22	Ralawas 3,8,10	1,250
23	Desooriya Khorala 3,8,10	1,293
24	Desooriya Bishnoiya 3,8,10	1,731
25	Lordi Panditji 3	4,024
26	Jajiwal Genlota 2	4,443
27	Jajiwal Bhatinda 2	4,194
28	Thabukra 2,3	5,373
29	Dai Kara 2	9,912
30	Salwan Kalan 1,2	12,814
31	Jaleli Dai Kara 1,2	3,523
32	Kukanda 2	4,209
33	Asaranada 2	1,843
34	Akthali 2	2,017
35	Soorajbasni 2,3,10	798
36	Jajiwal Khichiya 2	3,008

**Tample, ***Temple of Mahadeoji & Thakurji; Jain Temple
****Temple of Thakurji *****Temple of Thakurji and Shrine of Jog Maya
******Tample of Hanumanji

1	2	3	1	2	3
37	Jajiwal Dhadhla 2	2,226	71	Alakhdhara 3	100
38	Jajiwal Kankarala 2	1,090	72	Bhsni Beda 3	1,335
39	Jajiwal Bhandariya******* 2	2,582	73	Phitkasni 3	1,638
40	Jajiwal Kalan 2	5,658	74	Jhalamand 3	6,332
41	Jajiwal Kutri 2	1,568	75	Koori Bhagtasani 3	2,578
42	Borawas 3	2,286	76	Sagariya 3	3,185
43	Jajiwal Biraman 3	1,075	77	Pal 3	7,776
44	Bala Kua 3	894	78	Gangana 3	1,276
45	Soorpura 3	2,253	79	Chokha with	
46	Gujrawas Khurd 3	2,104		Chakand* 3,8,10	5,961
47	Anganwa 3	2,018	80	Golasani 10	669
48	Khokhariya 2,3	1,766	81	Barli** 8,10	5,404
49	Nandri 2,3	1,700	82	Keroo 2,10	17,828
50	Nandra Kalan 1,3	4,506	83	Bhagtasani 2	325
51	Nandra Khurd 1,2,3	3,830	84	Popawas 2,12	2,851
52	Banar 1,2,3	8,942	85	Rajwa*** 2	2,793
53	Deoliya 1,2	1,474	86	Meghasiya 2	743
54	Jaleli 1,3	2,560	87	Lenga-ki-Dhani 2	1,820
55	Jaleli 3	2,090	88	Bamboor Darjiyan 2	4,992
56	Peethawa 3,6	2,538	89	Bamboor Purohitan 2,3	1,262
57	Jatiyawas 6	1,580	90	Joliyali 8,10	6,574
58	Doliya 3,6	1,672	91	Lordi Daijgara 2	5,118
59	Dangiyawas******** 2,3 6	6,172	92	Karani 2	2,655
60	Banwarla 2,3	6,983	93	Lordi Doliyas 2	6,159
61	Khatiyasani 2 6	3,745	94	Moklawas**** 2	6,029
62	Dantiwara 6	5,755	95	Royala Kourd and	
63	Bisalpur 6	15,478		Phalasiya 2,10	3,007
64	Roodkali 6,12	3,749	96	Royala Kalan 2,10	3,203
65	Kakelao 4,6	10,958	97	Boojawar 2,10	4,030
66	Raseeda 3	2,003	98	Doli 3	5,784
67	Kanawas 3	653	99	Basni Silawata 3	798
68	Basni Nikooba 3	787	100	Boranada 3	3,246
69	Uchiyarda 1 3	1,638	101	Tanowara 3	4,005
70	Kharda Randheer 3	1,534	102	Bhakhrasni 3,4	2,200

*******Tample of Chawanda Mata ********Monthly Fair

*Bandh Ummed Sagar **Temple of Bherunji ***A religious place Raja Mandi

****Shrine Arnaji & Fair on Kartik Shukla Poornima.

1	2	3	1	2	3
103	Basni Bagela 3,4	1,102	139	Sarecha 3	5,511
104	Magera Kalan 3,4	5,438	140	Feench***** 1,3	12,132
105	Salawas 3	10,048	141	Kalijal 1,3	5,079
106	Nandwana 3	12,182	142	Roheecha Kalan 3	8,605
107	Kharda Bhandoo 3	807	143	Roheecha Khurd 1,3	5,175
108	Bhandoo Kalan 3	3,220	144	Peeparli 1,3	7,783
109	Katarda 3	5,138	145	Ghughara 3	10,288
110	Katarda 3	980	146	Lakar Thoomb 11	1,876
111	Royla Bhandoo 3	1,056	147	Lolasani 3,12	1,560
112	Jatiyasani 3,4	740	148	Bhacharna 3,12	6,061
113	Khudala 3,4	5,038	149	Bhakhri 11	2,523
114	Loonawas Khara 2,3	7,140	150	Karniyali 11	5,491
115	Jhanwar 1,2	18,776	151	Doodiya 12	3,276
116	Janadesar 1,2	8,418	152	Satlana 3,12	15,635
117	Hingola 1,2	4,962	153	Rendari 13	1,301
118	Robariya 2	5,163	154	Vishawas 3,11	552
119	Cheecharli 1,2	23,012	155	Chanwa 3,12	10,432
120	Modathali 2,3	1,545	156	Dhandhiya 3	6,160
121	Jogiyasani 3,4	727	157	Sikarpura 3,12	5,487
122	Beota 3,4	2,390	158	Doli-ka-Kani 12	795
123	Khatawas 4	3,490	159	Nimbla 3	1,472
124	Loonawas Charana 3,4	2,281	160	Khara Bera Purohitan 3,11	7,950
125	Loonawas Khurd 3,4	2,421	161	Kakani 3,10,12	10,838
126	Gelawas 4	1,766	162	Magera Khurd 3	1,925
127	Dhawa 3,4	23,136	163	Guda Bishnoiyan 3,4,10,12	14,700
128	Chhali 4	10,048	164	Khejarli Kalan 3,6,12	6,177
129	Subdand 3,4	4,596	165	Bidasni 6	1,376
130	Senai 3	3,514	166	Bhagatsni Khalsa 4,6	1,227
131	Uttesar 1,3	4,685	167	Sangasni 6,12	1,326
132	Kagnada 1,3	3,169	168	Charan Basni 6,12	1,232
133	Sinli 4	4,408	169	Birami 12	5,694
134	Loonawas Kalan 3,4	8,141	170	Miyasani 12	2,195
135	Badliya 1,3	3,107	171	Birdawas 6,12	2,576
136	Bhandoo Khurd 1,3	4,169	172	Peethasni 6,12	1,068
137	Basni Jhoothan 1,3	2,796	173	Goliya 12	1,905
138	Sar 3	5,754	174	Palasni****** 6,12	9,200

*****Fair of Tajaji ******Fair of Bulab Nathji on Chaitra Badi 4.

1	2	3
175	Khari Khurd 6,12	2,034
176	Khari Kalan 12	3,678
177	Mortuka 3,6,12	4,467
178	Singasni 3,12	2,050
179	Goojarwas Kalan 3,12	1,990
180	Pesawas 3,11	2,265
181	Baniyanwas 3,11	2,265
182	Khejarli Khurd 3	3,201
183	Dhigana 3	2,825
184	Rajpuriya 3	2,369
185	Khara Bera Patteka-was* 3,11	—
186	Khara Bera Bheemotan 3	6,046
187	Modi-Soothra 3,11	2,432
188	Modi Joshiyan and Manana 3,6,11	2,187
189	Sajara 3,6	1,515
190	Bhetanda 4,6,13	15,430
191	Lalawas 6	2,184
192	Moklasni 4,6	2,374

TEHSIL : BILARA

1	Dodiyal 8	1,276
2	Mageriya 7,10	6,173
3	Dhandhora 7,8	3,506
4	Asanda 7,9,10	3,436
5	Gajsinghpura 7,10,4	10,884
6	Suwana 7,10	2,840
7	Basni Harisingh 7,10	5,619
8	Kukarda** 10	4,109
9	Asop*** 7,10	23,363
10	Radod**** 7,10	9,408
11	Lawari (Khalsa) 8,10	3,193
12	Palri Ranawata***** 8,10	6,980
13	Nagalwas 8,10	2,784
14	Todiyana 8,9,10	4,751
15	Mindoli 9,10	2,447
16	Mandali 8,10	1,159
17	Gaderi 8,9,10	4,961
18	Surpura*** 8,10	7,158
19	Hingoli 8,10	7,708
20	Kumbara 7,8,10	4,033
21	Barni Kalan 8	1,337
22	Rampura 7,8,10	4,089
23	Govindpura 7,8	821
24	Garasni 8,10	5,362
25	Dadmi 8,10	3,376
26	Barni Khurd 8,10	4,842
27	Nadsar******** 9,10	12,454
28	Basni Sadwan********* 8,10	386
29	Bhopalgarh********** 8,9,10	19,324
30	Ustara 8,9,10	11,125
31	Rudiya********** 8,9,10	6,407
32	Beerani 8,10,12	4,226
33	Kalawas@ 10,12	2,631
34	Bandra 8,10	2,641
35	Tambariya Khurd£ 10	1,796
36	Tambariya Kalan 8	2,303

*Information included in village Khara Bera Purohitan at Code No. 160
**Temples ***Cattle Fair in December ****Tample of Thakurji
*****Temple of Thakurji ******Temple & ancient Chhatri *******Temples
********Tamples of Charbhujaji *********Temple of Thakurji
**********Temple of Thakurji and Mahadeoji and Jain Temple
***********Temple @Tample of Raghunathji and Thakurji
£Tample of Thakurji

1	2	3	1	2	3
37	Hiradesar+ 8,10,12	3,194	68	Nandiya Prabhawati 2,6,8	5,021
38	Sopda++ 8,9,10	3,316	69	Budkiyo 2,6	7,613
39	Dhoku++ 8,9,12	3,921	70	Kheri Salwa++ 2	4,762
40	Bagoriya++ 9,10	3,656	71	Ramdawas Kalan******** 2,6	6,295
41	Burchhan++ 1,9,12	3,708	72	Ramdawas Khurd++ 2	2,674
42	Rat Kudiya 1,9,10,2	10,892	73	Kheri Charna& 2	1,256
43	Basni Budha 9,10	1,199	74	Tigra 2	494
44	Chhapla 9	3,371	75	Bada Khurd%% 2	1,038
45	RajlaniX 9,10	12,781	76	Bada Kalan 2,6	4,534
46	Dhadhesari 9	3,823	77	Sawala Khurd*+ 2,6	10,660
47	Khariya Khangar 9,10	9,466	78	Bagarki 6	1,281
48	Basni Khariya 2,9	2,083	79	Jawasiya 6	1,152
49	Palri Siddha 9,10	7,188	80	Nanan 6	4,156
50	Madpuriya 10	1,709	81	Khudechan 6,10,12	1,147
51	Khawaspura% 8,10,12	5,454	82	Jaliwara Kalan 6,10	1,848
52	Chokri Kalan+++ 6,10	5,182	83	Jaliwara Khurd 6,0,12	2,516
53	Mirasiya 10	1,574	84	Malawas 6,8,12	5,695
54	Khangta 6,10	12,090	85	Madliya 6,8	4,439
55	Kosana 6,12	8,618	86	Lawari Jageer 1,8,12	3,600
56	Satheen++++ 2,6	16,752	87	Siyara 6,10	2,517
57	Sargiya Khurd 1,2	1,344	88	Chaukri Khurd 8,10,12	8,567
58	Sargiya Kalan 1,2	2,340	89	Ghodawat 8,10	4,633
59	Kagal 1,22,352	2,352	90	Boroonda 8,10	16,418
60	Bhoondana++++++ 1,2	5,093	91	Gadh Sooriya 8,10	3,577
61	Kuri+* 1,8,10,12	7,946	92	Sowaniya 8,10	3,961
62	Artiya Khurd 1,6,8,12	5,322	93	Hariyadana 8,10	16,627
63	Malar 1,2	7,464	94	Ransigaon*++ 8,10	13,412
64	Artiya Kalan 1,6,8,12	5,322	95	Rawniyana 6,10	5,360
65	Jhala Maliya 1,2,6,12	3,738	96	Khariya Anawas 6	2,516
66	Devatara 2,6	8,953	97	Anawas 6,13	1,906
67	Godawas 2,6,8	874			

+Temple of Thakurji, Gangaji and Bishwajinath ++Temple of Thakurji
XTemple & Baori of Shivnathji %Tample of Devalji +++Fair on Shiv Ratri
++++Temple of Bherunji- +++++Temples of Mahadeoji and Thakurji
+*Temples of Nathji & Charbhujaji ********Temples & Temple Mahadeoji
%%Temple of Thakurji *Temples *++Temple of Shyamji, Kunj Beharjji & Mosque

1	2	3	1	2	3
98	Roonakiya* 6	1,696	130	Birawas££ 6	5,284
99	Cheerdhani* 6,13	8,206	131	Bhawee 6,12	15,866
100	Jalkha 6	2,543	132	Lamba 3,6	7,502
101	Jaspali 6,12	4,856	133	Kanawasiya 3	1,239
102	Rayan 6	8,871	134	Rawar 3,6	7,022
103	Bankaliya 6	2,792	135	OlviXX 3,6,10,13	8,249
104	Buch Kalan 6	4,861	136	Rampuriya BhatiyanXX	
105	Jatiyawas 6	2,958		3,6,10,13	2,495
106	Benan 6,12	4,420	137	Ramasani 3,6,10,13	7,809
107	Chodha 6,12	6,736	138	Hoongaon Khurd 12	1,577
108	Kood* 2,6	4,216	139	Hoongaon Kalan 12	3,408
109	Hingoniya 6,2	1,819	140	Holpur KalanXX 12	3,990
110	Khokhariya 2,6	2,423	141	HariyadaXX* 11	7,097
111	Binawas 6,12	4,656	142	Khoontliya 11	2,248
112	Chandelao 6,10,13	7,443	143	Padasala Khurd 11	1,859
113	Basni Kaparda 6,13	759	144	Holpur KhurdXX 11	1,520
114	Kaparda 6,10,13	14,299	145	Bagawasiya 11,12	493
115	Boyal 6,13	11,434	146	Bala 12	10,314
116	Silari 6	5,796	147	Padasala Kalan** 10,11	3,762
117	Tilwasni£ 6	5,517	148	Goojrawas 11,12	1,828
118	Ghana Magra@ 6	3,618	149	Malkosni 11,12	7,697
119	Khejarla+ 6,10	9,343	150	Beejasani 11	2,351
120	Sambariya++ 6,8,10	3,307	151	Bari Kalan 8,10,11	1,258
121	Murkasni%% 8,10	2,276	152	Bari Khurd 11,12	1,618
122	Jhak%% 10	7,679	153	Jhurli 3	1,153
123	Bhagasni*+ 8,10	1,746	154	Jelwa@@ 8	948
124	Banjara%% 6,8,10	1,867	155	Jetiwas@@@ 8	5,722
125	Rampuriya 8,10	1,380	156	Barna 8	7,875
126	Kalaoona 10	7,241	157	Harsh 8	994
127	Kooprawas 8,12	918	158	Beejwariya 8	2,486
128	UdliyawasX	10,699	159	Khariya Meethapur 8,12	0,376
129	PichiyakXX 6	10,679			

%%Temple of Thakurji *+Temple of Jog Maya XTample of Mataji
XXTemples of Mahadevji, Gajanandji, Mataji & Raghunathji.
£Temples of Thakurji, Charbhujaji, Ramdevji and Mahadevji
@Temples of Thakurji, Hanumanji and Ramdevji +Temples of Jog Maya & Thakurji ++Temple of Shyamji ££Temple of Charbhujaji, Mahadevji & Ramdevji XXTemple of Mahadevji, Gajanandji, Mataji & Raghunathji.
££Temples of Charbhujaji, Mahadevji & Ramdevji XX*Fair of Gogaji in Septemer
**Fair of Mataji on Dushehra @@Temple of Mataji and Mahadevji
@@@Temple of Thakurji, Mahadevji and Mataji. *Temples

APPENDIX II

Potential catchments for harnessing surface water resources

There is considerable scope particularly in Bilara and Jodhpur tehsils for effective utilization of surface water. In all, 24 such catchments i. e. 10 in Bilara, 6 each in Jodhpur and Shergarh and 2 in Osian have been indentified for the purpose. These catchments are generally rocky, some only partly so. The general slope is 0.2 to 2% with pockets of steep to very steep slopes. Nearly half of the catchments have a fan shaped drainage pattern which means a low time of runoff concentration or a short peak time discharge. Besides, the volume will also be high. In case of 'fir' shaped catchments the drainage density is less, the time of concentration longer and accordingly the volume of peak flow lower.

Accompanying map gives the location of these catchments whereas Table 28 gives the slope and catchment condition and Table 29 the mean estimated runoff and yearly runoff for the period 1961 to 1970. Table I also gives the the type and extent of soil and water conservation treatment needs of the individual catchments.

Table 28 : Potential catchments and their hydrologic characteristics in Jodhpur district.

S. No.	Location	*Tehsil*	Catchment area (km^2)	Average slope	Catchment condition	Area recommended for soil & moisture conservation (km^2)	Approximate length of bunding structure (km)
1	2	3	4	5	6	7	8
1.	Jawar	Jodhpur	13.12	0.50	Average	3.26	22.96
2.	Manaklao	,,	28.12	0.50	Average	8.44	59 00
3.	Keru	,,	29.00	0.40	Good	5 80	38 67
4.	Nerwa	,,	39.50	0.30	Good	11.85	59.25
5.	Chavanda	,,	40.00	0.40	Good	8 80	59.05
6.	Bandu Kallan	,,	87.62	0.40	Average	21.90	145.85
7.	Burchha	Bilara	11.50	1.00	Average	2.30	32.20
8.	Ratkuriya	,,	13.75	2.00	Average	3.44	86.00
9.	Kuri ki Jaton ki Dhani	,,	14.75	1.00	Good	4.42	61.95
10.	Gujaro Ki Dhani	,,	20.00	0.40	Good	4.00	26.00
11.	Madpuria	,,	23.25	0.50	Good	5.81	48.22
12.	Rudia	,,	36.00	0.20	Average	9.00	30.00
13.	Artiya	,,	55.00	0.30	Average	11.00	35.00
14.	Khoaspura	,,	70.12	0.20	Good	21.03	70.00

Table 28 (contd.)

1	2	3	4	5	6	7	8
15.	Hiradesar	Bilara	70.00	0.20	Average	21.00	70.00
16.	Kosana	Jodhpur	87.50	0.30	Good	17.50	87.50
17.	Deriya	Shergarh	11.25	0.50	Good	1.60	14.07
18.	Bastua	,,	16.87	0.50	Good	2.53	21.07
19.	Bhojon ka Bas	,,	17.50	0.40	Average	3.50	23.31
20.	Balesar	,,	34.25	0.50	Good	8.56	71.30
21.	Bhandu Jati	,,	36.25	1.00	Average	7.25	103.67
22	Rajwaton ki Dhani	,,	56.25	0.50	Average	16.87	140.57
23.	Mangalio ki Dhani	Osian	10.62	0.40	Bad	1.59	10.59
24.	Hardani	,,	24.50	0.15	Average	4 90	12.25

*Contour bunding structures proposed have top width of 0.15 m, bottom width of 2.3 to 2.9 and a height ranging from 1.06 to 1.37 metres.

Table 29. Estimated surface water yield from potential catchments in Jodhpur district (Figures in tens of thousand cubic metres)

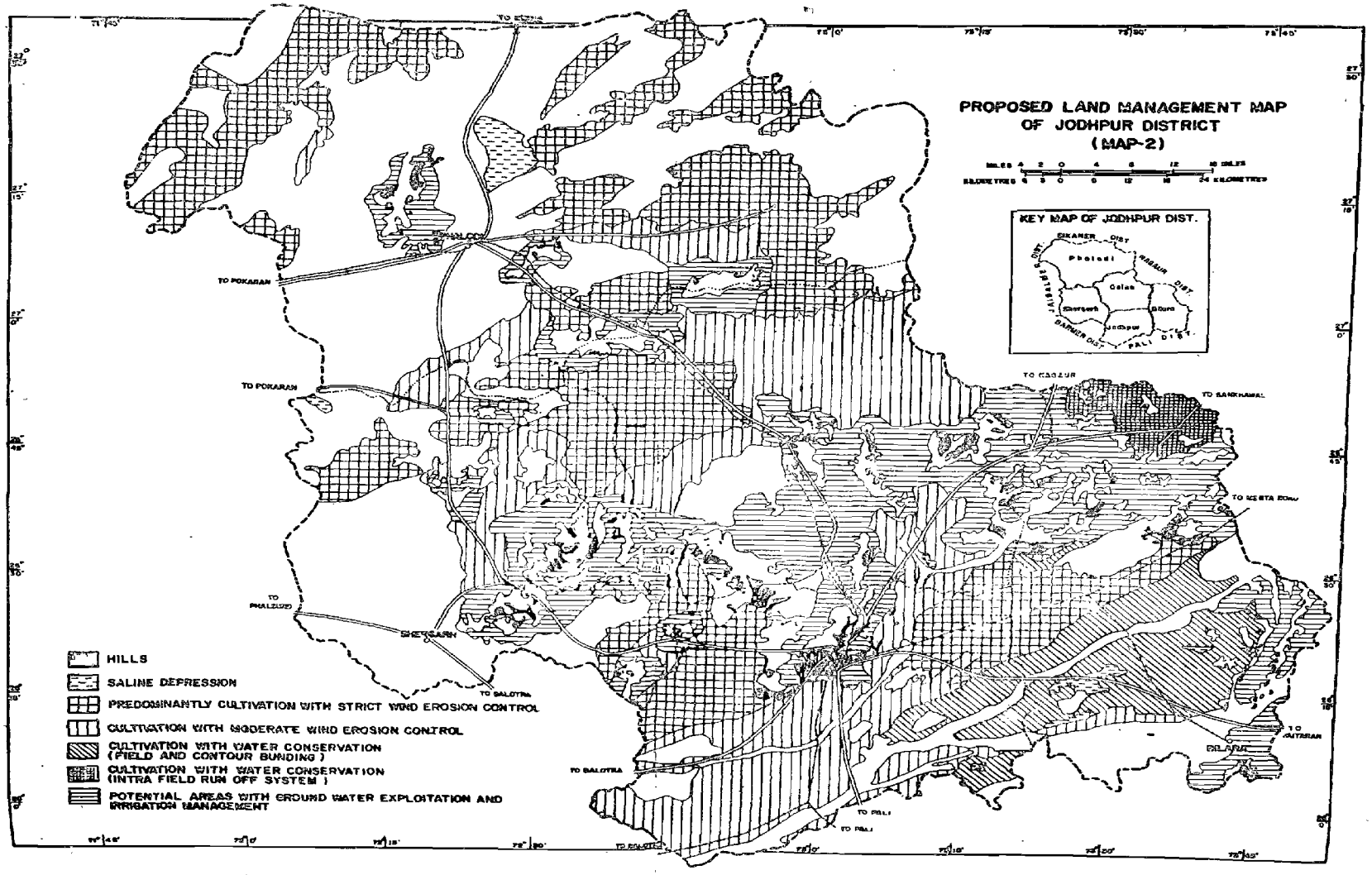
S. No.	Location	1963 (cms) x10⁴	1964 (cms) x10⁴	1965 (cms) x10⁴	1966 (cms) x10⁴	1967 (cms) x10⁴	1968 (cms) x10⁴	1969 (cms) x10⁴	1970 (cms) x10⁴	1971 (cms) x10⁴	1972 (cms) x10⁴	Mean annual (cms) x10⁴
1	2	3	4	5	6	7	8	9	10	11	12	13
						Jodhpur						
1.	Jawar	39.36	78 72	52.48	78.72	78 72	26 24	1.312	183.6	26 24	91.84	05.72
2.	Manaklao	84.36	168.70	112.50	168 70	168.70	56.24	2.812	393 6	56.24	196.80	140.87
3	Keru	108 75	217.50	145.00	217.50	217.50	72.50	3.625	507.5	72.5	253.70	181.61
4.	Nerwa	148 00	296.20	197.50	296.20	296.20	98 73	4.937	691.2	98 75	345.60	247.33
5.	Chavanda	165 00	330.00	220.00	330.00	330.00	110.00	5.500	770 0	110.00	385.00	275.55
6	Bandu Kallan	262.80	525.70	350 500	525.70	525.70	175.20	8 762	1226.0	175.20	631.30	438.83
		808.27	1616.82	1077.98	1616 82	1616.82	538.93	26.95	3771.90	538.93	1886.24	
						Bilara						
7.	Burchha	11 50	138.0	92.0	34.50	103.5	69 0	34.50	195,5	138.0	23.0	83.95
8.	Ratkuria	13.75	165.0	110.0	41.25	123.7	82.5	41 25	233 7	165.0	27.50	100.37
9.	Kuri ki Jaton Ki Dhani	18.43	221.2	147.5	55.31	165.8	110.6	55.31	313.4	221.2	36 9	124.67
10.	Gujaro ki dhani	25.00	300.0	200.0	75 00	225.0	150 0	75.00	425.0	300.0	50.0	182.50
11.	Madpuria	29.06	343.7	232.5	87.19	261.5	173 9	87.19	494.0	348.0	58.12	211.52
12.	Rudia	36 00	432 0	288.0	108 10	324.0	216.0	108.00	612.0	432.0	72 0	262.80
13.	Artiya	55.00	660.0	440.0	165 00	495.0	330.0	165.00	935 0	660.0	110 0	401 50
14.	Khoaspura	87.65	1051.7	701.1	262.80	789 0	525.9	262.90	1490 0	1051.8	175 2	639 80
15.	Hiradesar	70.00	840.0	560.0	210.00	630.0	420.0	210 00	1190.0	840.0	140.0	511.00
16.	Kosana	109.40	1312 0	875.0	328 10	984.5	656.2	328.10	1859 0	1312 0	219.0	798.33
		455.79	5454.60	3646.00	1367.15	4102 00	2734.10	1367.25	7747.60	5468.0	911.72	

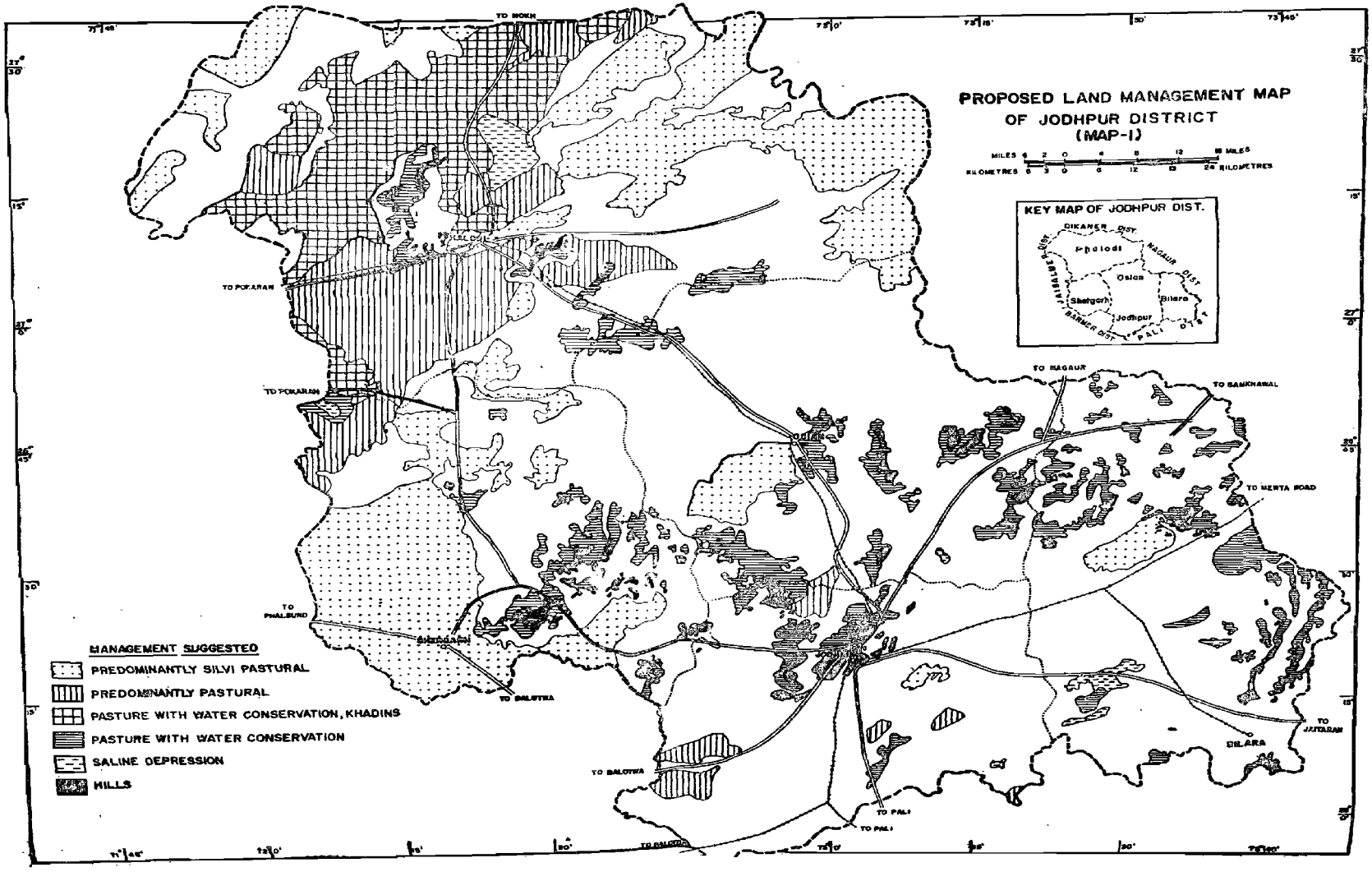
Table 29. (contd.)

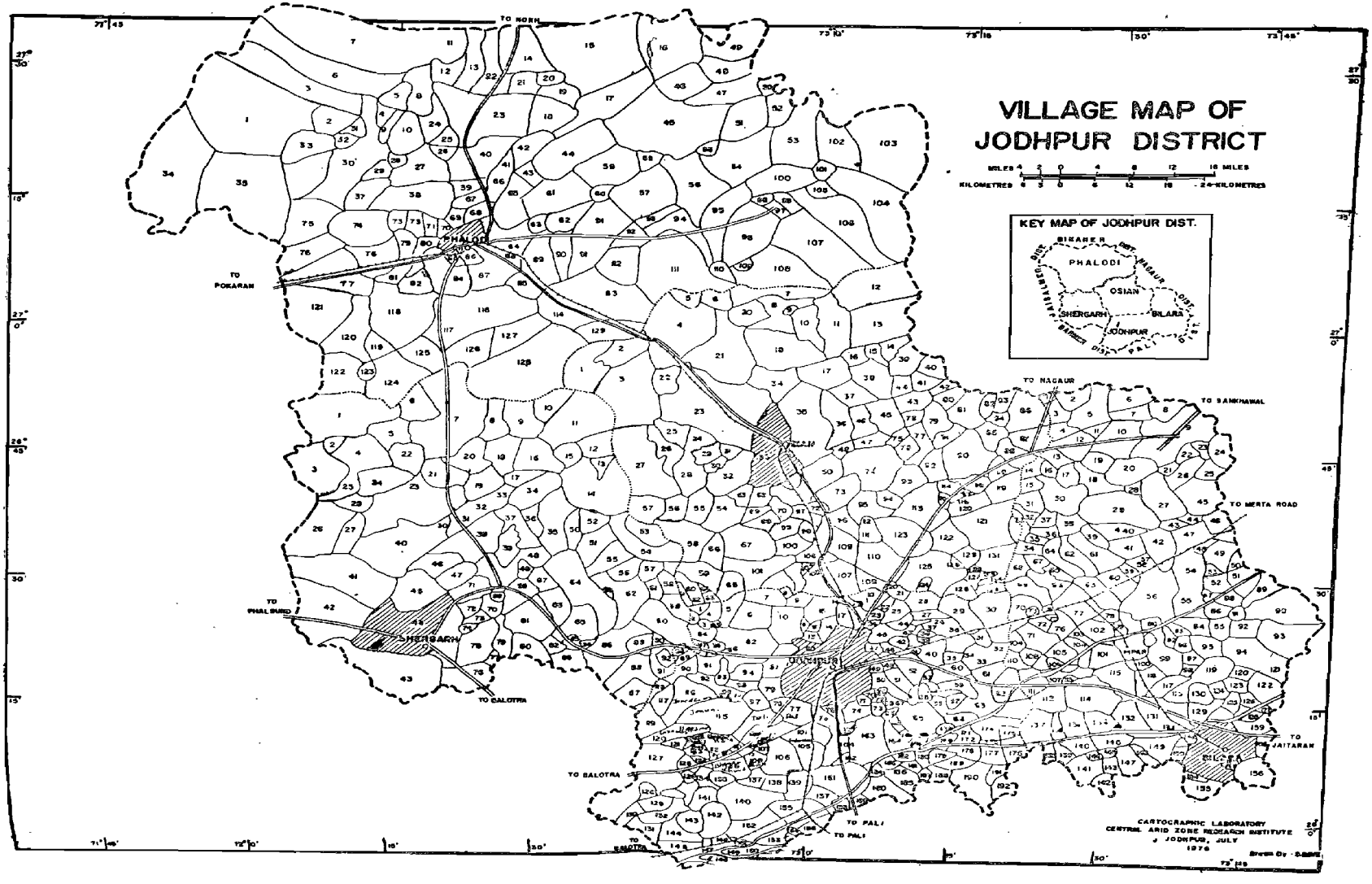
1	2	3	4	5	6	7	8	9	10	11	12	13
						Shergarh						
17.	Deriya	4 21	14.06	11.25	42.19	28.12	0.000	2.812	28.12	5.625	5.625	14.20
18.	Bastua	6.32	21.09	16.86	63.26	42.18	0.000	4.218	42.18	8.448	8.448	21.30
19.	Bhojon Ka Bas	5.25	17.50	14.00	52.5	53.0	0.000	3·50	35.00	7.00	7.00	17.68
20.	Balesar	12.48	42.81	34 25	128.4	85 6	0 000	8.56	85.6	17.12	17.12	43.19
21.	Bhardu Joti	10.87	36.25	29.0	108.7	72.5	0 000	7.25	72.5	14 5	14.5	36.6
22.	Rajwaton ki dhani	16.87	56.25	45.0	168.7	112 5	0.000	11 25	112 5	22,5	22.5	56.80
		56.00	187.96	150.36	563.75	375.90	0.000	37.59	375.90	75.9	75.19	
						Osian						
23.	Monglio ki dhani	39.83	7.97	63.72	15.93	24.40	39 83	7.97	24.40	2.44	15.93	24.24
24.	Hardani	122.5	24.5	196.0	49.0	73 5	122.5	24.5	73.5	7.35	49.0	74.24
		162.33	32.47	259.72	64.93	97.90	162.33	32.47	97.9	9.79	64.93	
Total of all the catchments		1482 39	7291.85	5134.06	3612.65	6192.62	3435·36	1465.26	11993.30	691.90	2938.08	

ERRATA

Page	Para and line	for	read
10	Rt. Col., para 2, 5th line	darinage	drainage
,,	,, , ,, , last but one line	10 to m	10 to 20 m
11	Lt. Col. para 2, 14th line	allavial	alluvial
12	Lt. Col. para 2, last but one line	graxing	grazing
14	Title of the table	Eisting	Existing
16	Rt. Col. para 2, 4th line	Quinnenial	Quinquennial
24	Lt. Col. para 2, 5th line	Freqency	Frequency
26	Rt. Col. para 2, 12th line	Salide	Saline
28	Lt. Col., para 1, top line	prmie	prime
,,	,, para 1, 9th line	varieites	varieties
31	Lt. Col., para 1, 7th line	connections	concretions
41	Rt. col., para 1, 3rd line	irrigational	irratonal
56	Rt. col., para 2, 4th line from bottom	ground	ground water use
68	Lt. col., para 1, 6th line	cushious	cushions
73	Lt. col., para 1, 3rd line	scattseed	scattered
91	Rt. col., para 2, 4th line	the in	the increase in
92	Rt. col., top line	dificit	deficit
103	Rt. col., para 1, 1st line	frequancy	frequency
,,	,, ,, , 3rd line	waeks	weeks
116	Lt. col., para 1, 10th line	Blateaux	Plateaux
128	Lt. col., para 3, 1st line	Sono lime	Sour lime


PROPOSED LAND MANAGEMENT MAP
OF JODHPUR DISTRICT
(MAP-2)
KEY MAP OF JODHPUR DIST.
BIKANER DIST
NAGAUR DIST
JAISALMER DIST
BARMER DIST
PALI DIST
Phalodi
Osian
Shergarh
Bilara
Jodhpur
TO POKARAN
TO BALOTRA
TO PALI
TO SANKHWAL
TO SHERGARH
HILLS
SALINE DEPRESSION
PREDOMINANTLY CULTIVATION WITH STRICT WIND EROSION CONTROL
CULTIVATION WITH MODERATE WIND EROSION CONTROL
CULTIVATION WITH WATER CONSERVATION
(FIELD AND CONTOUR BUNDING)
CULTIVATION WITH WATER CONSERVATION
(INTRA FIELD RUN OFF SYSTEM)
POTENTIAL AREAS WITH GROUND WATER EXPLOITATION AND
IRRIGATION MANAGEMENT


PROPOSED LAND MANAGEMENT MAP
OF JODHPUR DISTRICT
(MAP-I)
MILES 4 2 0 4 8 12 16 MILES
KILOMETRES 6 3 0 6 12 18 24 KILOMETRES
KEY MAP OF JODHPUR DIST.
BIKANER DIST.
NAGAUR DIST.
JAISALMER DIST.
BARMER DIST.
PALI DIST.
Phalodi
Osian
Shergarh
Jodhpur
Bilara
TO MOKIN
TO POKARAN
TO POKARAN
TO NAGAUR
TO SANKHAWAL
TO MERTA ROAD
TO PHALSUND
TO SALOTRA
TO SALOTRA
TO PALI
TO PALI
TO JAITARAN
BILARA
MANAGEMENT SUGGESTED
PREDOMINANTLY SILVI PASTURAL
PREDOMINANTLY PASTURAL
PASTURE WITH WATER CONSERVATION, KHADINS
PASTURE WITH WATER CONSERVATION
SALINE DEPRESSION
HILLS


VILLAGE MAP OF
JODHPUR DISTRICT
MILES 4 2 0 4 8 12 16 MILES
KILOMETRES 6 3 0 6 12 18 24 KILOMETRES
KEY MAP OF JODHPUR DIST.
BIKANER
PHALODI
OSIAN
SHERGARH
BILARA
JODHPUR
PALI
NAGAUR
BARMER
JALORE
SIROHI
DIST.
TO NOKH
TO POKARAN
TO PHAL SUND
TO SANKHAWAL
TO MERTA ROAD
TO JAITARAN
TO SALOTRA
TO PALI
CARTOGRAPHIC LABORATORY
CENTRAL ARID ZONE RESEARCH INSTITUTE
JODHPUR, JULY
1976