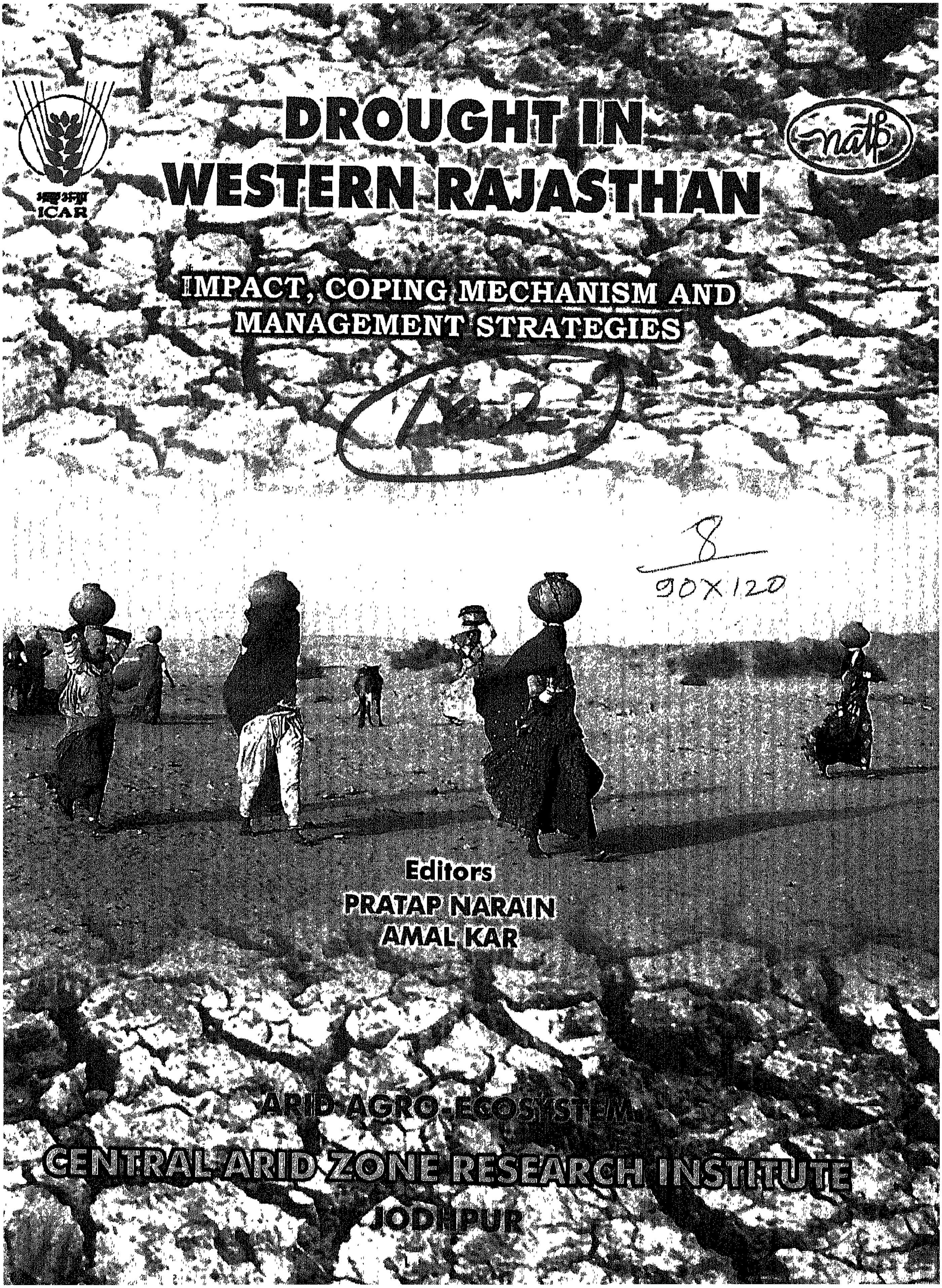

DROUGHT IN WESTERN RAJASTHAN

IMPACT, COPING MECHANISM AND MANAGEMENT STRATEGIES

Editors
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DTP by S.B. Sharma

Front cover shows a drought-affected plain (background), and fetching of water by women from long distance (foreground).
Back cover inset shows a permanent pasture (Oran) in good condition in western Rajasthan.

Front cover by Vijendra Jayalwal

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CONTENTS

FOREWORD

In a country like India, where agriculture is one of the major sources of livelihood, that by and large depends on the monsoon, drought often leads not only to shortage of food, fodder and water, but also to livelihood sources. Although it is a natural disaster, it does not impact the society as suddenly as an earthquake or a cyclone. There are historical records of thousands of human lives being loss due to drought-related famine, and of millions others seriously disadvantaged by its impact. Fortunately, our country is now better equipped than previously in management of droughts, especially after the Green Revolution of the 1970s that ushered in an era of food security. Even though we have sound agricultural technologies, yet, the impacts of drought are still felt, and precious resources are spent by the country in relief work during droughts, especially in the rain-fed areas. To combat droughts one needs a long-term policy of land and water management, complementary developments in infrastructural sectors and a strong economy, which make the society more impervious to drought impacts. A well thought of long term drought policy need to be put in place.

One of the worst droughts in last one hundred years occurred in 2002, when 21 out of the 36 meteorological subdivisions of our country received deficient rainfall, affecting 300 million people and 700 million livestock. Western Rajasthan with a long history of droughts and people's ingenious ways to combat it, was the worst hit regions. During post-independence era many of the traditional ways of long-term drought combating mechanism have been forgotten in the process of rapid progress made in agricultural and other spheres of economic and industrial activities.

In order to assess the impact of year 2002 drought on the livelihood of farming communities in arid western part of Rajasthan, as well as to find out how the affected rural people and the government coped with the adverse situation, a study was carried out by Central Arid Zone Research Institute, Jodhpur. This volume entitled "Drought in Western Rajasthan: Impact, Coping Mechanism and Management Strategies", provides an analysis of the results from the study, and suggests some means for long term mechanisms as well as short-term contingency planning to cope with droughts.

The perspectives provided in the volume are important and may be helpful in developing policy frameworks for a long-term drought mitigation programme, including a drought early warming system.

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EXECUTIVE SUMMARY

Drought is a normal climatic phenomenon that occurs in all climatic zones, but its intensity and frequency usually increases towards drier climatic zones. Agriculture is usually the first sector to get affected by drought, and more so in the rain-fed drylands. In regions where the economy depends mostly on rain-fed agriculture, a cascading effect of drought is seen through reduced production, reduced availability of feed, fodder and drinking water, worsening human and animal health, their mortality and out-migration, fewer employments, and lower purchasing power, which together can lead to poverty and disruption in the national growth rates. Arid western part of Rajasthan is one of the most chronically drought-prone areas in India. Since it also has a poor resource endowment, people of the region developed through centuries of learning, many ingenious ways to cope with drought. With modernization, especially after the independence, new opportunities driven by the progress made in research and development, democratic values and social justice, as well as improvements in infrastructural facilities, have triggered a gradual loss of traditional values and systems, including traditional drought coping mechanism. However, government interventions through a number of relief measures, including supply of drinking water, subsidies on food and fodder resources, organising cattle camps, wage employment to needy people, food for work programme, nutrition and health improvement programme, etc., help people to withstand the impact of drought. The measures are short-term contingency plans, and do not necessarily lead to any long-term strategies for coping with future droughts.

In 2002 India was hit by a major drought that was widespread, affecting 21 out of the 36 meteorological subdivisions of the country, that led to a drop in food grain production by 24 million tonnes (12% less than the normal). Western Rajasthan was worst hit. Kharif rainfall was 69% less than that during normal years, as compared to 65% less than normal during the previous severe drought of 1987. About 80% of the tehsils received scanty rainfall. Area under kharif crops declined by 56% from the 2001 level and production by 87%.

Impact of this century-scale drought on rural livelihood, especially on the farming community, was assessed in 128 villages across western Rajasthan. Small farmers (1-2 ha land) constituted 30-35% of the total workers, followed by middle farmers (2-4 ha; 28-30%) and large farmers (>4 ha; 15-20%). Landless and below-poverty-line (BPL) families constituted 15-25% of the total. Irrigated croplands belonged mostly to large and medium farmers.

Since kharif rainfall was not sufficient in 2002 even for sowing, rainfed crops failed almost totally. Production of pearl millet was reduced by 91% from the previous year, while mung and moth bean production declined by 86-90%. Only some irrigated crops survived. Sesame (til) and clusterbean (guar) failed almost totally (97% reduction in both the crops). In some areas farmers carried out sowing operations twice, first during June and then in August, and lost seed and other inputs. Farmers in the areas normally receiving higher and somewhat assured rainfall took a greater risk and lost more as compared to farmers in the areas receiving less assured rainfall. By contrast, in the chronically waterlogged areas of canal-irrigated Ganganagar and Hanumangarh

districts rice cultivation was possible after many years due to recession of water. Overall, kharif cereal crops were sown in 55% of the area sown during 2001, but the production was only 11% of the 2001 level.

Large farmers having access to groundwater wells produced pearl millet and sorghum essentially for fodder, but the major irrigated kharif crops were groundnut and cotton, both of which had reduced production (34% and 3% reduction, respectively, from 2001 level). Increased withdrawal of groundwater and negligible monsoon recharge of the aquifer led to an average 3-8 m drop in water level in the wells.

Drinking water became a scarce commodity in many areas. In Pali district, special trains and tankers had to be engaged by government for daily supply of water to 6 major towns and at least 170 villages. Most other districts had also to be regularly supplied water through tankers, but the quality was poor in many areas. Private water supply cost the villagers ~Rs.300 per tanker. Villages not properly connected through roads faced acute shortage of water. Dysfunctional traditional water harvesting system aggravated the problem. Lack of maintenance of the traditional ponds (nadis) and storage tanks (tankas), as well as their catchments, after pipe water supply reached a large number of villages, led to reduced capacity of the traditional structures to hold whatever runoff was generated.

Fodder situation was bad in almost all the districts due to crop failure and drying of grasses. Only the indigenous top-feed trees and shrubs provided fodder despite severity of drought. Districts like Churu, where traditional agro-forestry is practiced, had a better supply of green fodder in surveyed villages than in the dominantly irrigated districts of Ganganagar, Hanumangarh and Sikar, which became more vulnerable because fallow land was very few and stands of natural vegetation almost negligible. This highlights the role of agro-forestry, which used to be practiced traditionally in larger parts of the region for coping with drought, but is getting gradually replaced under changing land uses. Purchase of feed and fodder cost the farmers much higher than in normal times. For example, the price of dry fodder shot up to Rs.300-400 q^{-1}, as compared to ~Rs.200 q^{-1} during normal years. On an average, large farmers had higher grain and stover yields, essentially from crop fields, and also better access to top feed resources. So, they had to spend less on fodder purchase. The exceptions were noticed in irrigated districts (e.g. Ganganagar) where severe paucity of top feed resources and compulsion to feed a large number of cattle forced the large farmers to spend very high on fodder purchase. Small farmers adjusted to the crisis by selling part of their stock, and many opting for labour as an alternate strategy for survival. Medium farmers, on the other hand, depended more on livestock during the year, and in the wake of crop failure they had to spend more on fodder purchase. In other words, medium farmers stretched their resources more as compared to large and small farmers for fodder.

Drought had its toll of livestock population in the region. Distress sale, leaving the animals to cattle camps, and mortality due to hunger and disease were the major causes of reduction in livestock number. As fodder and water became scarce, many farmers left their unproductive animals to fend for themselves, which led to death in hunger. About 20% mortality in sample villages was due to drought-related diseases, the rest being due to hunger. Yet, animal mortality during 2002-03 was lesser than during 1986-87. In sample villages ~26% animal population was reduced from the 2001-02 level. This involved 29% of the cow population, 27% of the buffaloe, and 23-26% of goat and sheep. Young kids of sheep and goats were sold in larger numbers than during normal year. Although buffaloe population was much less than the other animals, fast increase in their number is taking place, especially in irrigated areas, due to their higher milk yield, better infrastructure and market facilities. Significantly, southern districts of Barmer and Jalor reported least decline in buffalo population as compared to the other animals.

Migration of small ruminants is an annual feature in the region, and migration of large herds is a known coping mechanism during drought. During 2002-03 migration of animals from western districts of the desert was higher than that during 2001-02, but eastern districts had less out-migration. Widespread failure of rain during the early part of monsoon in 2002, especially in Haryana, Madhya Pradesh and eastern part of Rajasthan, which are frequented by the migrating animals, was a compulsive reason for restricted out-migration that led to higher pressure on the fodder and water resources in the villages. Fortunately, drought situation in the neighbouring states eased somewhat during the later half of the monsoon, and it was possible for the state to get fodder, and migration to continue.

The sources of rural income in western Rajasthan are usually agriculture, livestock, agricultural labour and other labour. Since crop production during kharif 2002 was almost negligible, animals became a major source of income, but the total income was severely restricted. In sample villages the income fell by 25-46% from the 2001-02 level. Different categories of farmers had different sources of income. In rain-fed as well as irrigated areas maximum income from agriculture during normal year (2001-02) was dominantly in the hands of large farmers. The pattern remained almost the same during the drought year (2002-03). This was due to better access of large farmers to irrigation facilities, although their total income from agriculture declined. Most large farmers had requisite capital to bear the brunt of this worst drought and could keep their livestock, but the middle and small farmers could not. Consequently, distress sale of animals was more common with them. Also, sampled small and medium farmers sold milk and milk products for income generation, which normally villagers use to keep for home consumption. In the very dry western districts (e.g. Barmer) there was 79% reduction in income of the sample farmers from agriculture during 2002-03, as compared to the income during 2001-02, while in the less dry eastern district (e.g. Churu) the reduction was 42%, and in the dominantly irrigated district (e.g. Hanumangarh) 13%. Thus, spatially, a positive relationship was noticed between the degree of vulnerability of economy and the climate/water availability.

Income from agriculture labour was almost exclusively earned by the BPL households and small farmers. *Despite the severity of drought, in both the districts there was increase in income* from this sector during 2002-03, especially because out-migration took place to neighbouring states, especially for work in irrigated areas.

Income from 'other labours' was also controlled to a large extent by the BPL households and small farmers. In 2002-03 this component was mostly related to drought relief programme of the state government with funds made available by the central government. Out-migration to other parts of the state and to megalopolis like Ahmedabad and Mumbai was also prominent. In drought relief programme people were engaged mostly in constructions related to water resources development (i.e. deepening/cleaning of nadis, construction of khadins, anicuts, etc.) and infrastructure development (e.g. road construction). Thus, unlike in many previous occasions, the strategies were for improving the coping mechanism with a long-term perspective. Labourers were provided some cash and food items. Government decided that 75% of the labour opportunities would be reserved for BPL families, as well as people belonging to the Scheduled Castes and Scheduled Tribes categories. The remaining 40% would be reserved for people in Other Backward Classes and the poor people in general category. The state relief department had planned to generate between August 2002 and June 2003 employment of 22.4 million, equivalent to 560 million person-days in the state as a whole, involving 5.6 million tonnes of wheat (@ 10 kg wheat per labour per day) plus Rs. 7840 million as wage, but the actual labour employed was 3.796 million, equivalent to 398 million person-days.

To conclude, an assessment of the impact of drought 2002-03 brings out the following points:

- A number of successful traditional coping strategies were available earlier to the rural communities in the region, but many are becoming defunct with modernisation.
- Among these, the construction and maintenance of rainwater harvesting and storage structures need to be given high attention.
- Presently coping strategies of farmers depend on resources available to them. When crops fail, small farmers try to adjust their economy through livestock sale and de-stocking, while medium farmers tend to generate income through sale of milk and other animal by-products, especially in areas having dairy and improved transport network.
- Livestock farming is a more secured economic activity in the region than rain-fed cropping, especially during drought, but is not organised. Shrinking areas for grazing is fast becoming a problem for animal rearing. Animal migration is also facing acute problem. All these are now leading to a fast change in animal composition and number.
- Policy instruments are necessary to organise animal migration in such a way that the symbiotic relationship between graziers and the hosts is strengthened.
- The Famine Code, which is followed by drought relief in the state, speaks of relief for cattle during the drought, but not for sheep and goats, which are the major animals in the region. As a result, there is hardly any relief for sheep and goat rearing, despite their role in village economy.
- Grazing land improvement needs to be taken up for better livestock management, and awaits a workable policy framework. Fodder banks need also to be established in adequate number and managed properly.
- Agro-forestry, which is a successful traditional system in the region, and arid horticulture proved to be paying propositions during the drought. Cropping strategies in rainfed areas should include agro-forestry that ensures top-feed resources and economic returns from fruits, etc., during drought years. CAZRI has evolved a number of alternate farming systems as well

as plant varieties that combat drought successfully and provide better economic returns. Other strategies like leaving part of the land for growing grasses and fodder crops, and land fallowing need also to be followed.

- High dependence on groundwater for drinking and growing of high water demanding crops has led to fast depletion of aquifer. If not managed properly through a policy instrument, this will lead to a major crisis in near-future.
- It is necessary to find alternate sources of sustainable rural income. Too much dependence on cropland is leading to a serious livelihood problem during drought. Therefore, potentials of the village artisans and rural handicrafts need also to be cultivated and such skills need to be groomed for marketing. Agri-tourism in the vicinity of popular tourist destinations could be another means of income supplementation.
- Policy framework for a long-term drought management is necessary. Ensuring employment for the rural youth and use their potentials for sustainable land development will help in combating drought.
- Very high dependence on government-run drought relief programme is weakening the coping mechanism of rural society. Since such programmes cannot address long-term drought-coping strategies, it is necessary to prepare sound drought preparedness strategies that provide rural community with enough resources to cope with drought.

Research on drought forecasting and early warning system, as well as monitoring and assessment of drought impact, identification of drought-vulnerable areas, as well as post-drought evaluation of socio-economic and environmental consequences need strengthening. Drought mitigation strategies are to be evolved on the basis of lessons learnt.

INTRODUCTION

Drought is a regional weather phenomenon, creeping gradually and almost mysteriously on society, with adverse consequences for human, animal and natural resource systems. It is not a disaster in the sense an earthquake, a cyclone, or a landslide is, because it does not strike with that suddenness, Yet, it is a calamity that spreads slowly over a wide area, affecting the two basic production systems for survival: food and water, and thus impairing the livelihood of the affected people. Impact of drought gets cascaded when it occurs in consecutive years. Data compiled from 107 countries suggest that on an average 220 million people are globally exposed to drought per annum, the maximum vulnerability being occurring in sub-Saharan Africa (Samra, 2004). Drought is an integral part of climate, but its frequency and intensity usually varies with the climatic zones. In weather terms, drought occurs when rainfall received is a certain percentage lower than the long-term average for the area. In India, where the rural economy is mostly dependent on agriculture and monsoon behaviour, drought during the kharif season assumes national significance, depending on its geographic location and severity.

Categories of Drought

Drought can broadly be classified into four major types: meteorological, agricultural, hydrological and societal.

Meteorological drought

Meteorological drought is usually defined on the basis of rainfall departure from the long-term average in a region. According to IMD, rainfall distribution is considered 'normal' when its deviation from the long-term average in a particular year is between 0 and 19 per cent. When rainfall deficiency is between 20 and 59 per cent of the long-term average, it is termed as 'deficit', while a deficiency of 60 per cent or more qualifies for the term 'scanty'. For meteorological drought, IMD considers a rainfall departure of –26 to –50 per cent from the normal as 'moderate drought', while a departure of more than - 50 per cent is termed as 'severe drought' (Sikka, 2004). Areas where more than 40% of the rainfall-recording years have experienced drought are classified as chronically drought-prone, while those experiencing drought for 20-40% years are termed as drought-prone.

Agricultural drought

Agricultural drought refers to a condition where soil moisture is insufficient to meet the requirements of a particular crop or group of crops at its different growth stages. It may result from shortfall in rain, its ill distribution, and late onset or early recession of the monsoon, which can lead to wilting of crops, decline in yield, or total failure of crops in extreme cases. There are different procedures to calculate agricultural drought, but due to complexities involved in measuring a number of crucial parameters no universal procedure has yet been accepted. India Meteorological Department (IMD) calculates agricultural drought in terms of aridity index (Ia), measured as ((AE-PE) x 100/PE), where AE is mean evapo-transpiration, and PE is potential evapo-transpiration. Ia is calculated on weekly basis. If the value is <26% agricultural drought is mild; if between 26 and 50% it is moderate, and if >50% it is severe (Sikka, 2004). In north India, agricultural drought is determined on the basis of rainfall during the summer monsoon, which leads to decline in kharif crop production, or failure of some or all the kharif crops, because the tender plants do not get requisite moisture either at sowing time or during some of the crucial growth phases. For the Indian arid zone CAZRI proposed that AE/PE be calculated during different phenophases of crop growth, to arrive at the status of agricultural drought as mild, moderate and severe (Ramana Rao *et al.*, 1981; Sastri *et al.*, 1982; Ramakrishna, 1993; Rao, 1997; Table 1).

Table 1. Classification of agricultural drought

AE/PE (%) during different phenophases	Drought intensity	Drought code		
		Seedling (S)	Vegetative (V)	Reproductive (R)
76 – 100	Nil	S_0	V_0	R_0
51 – 75	Mild	S_1	V_1	R_1
26 – 50	Moderate	S_2	V_2	R_2
25 or less	Severe	S_3	V_3	R_3

The above is a generalised classification, without specifying any crop, and agricultural drought (A) is characterised on the basis of different combinations of S, V and R codes. For example, $S_0+V_1+R_2 = A_1$; (mild agricultural drought); $S_3+V_2+R_3 = A_3$. (severe agricultural drought). The scheme has been used for specific crops like pearl millet, which is the major food crop in western Rajasthan. The average growing season of the crop is 14 weeks that can be broadly be divided into pheno-phases: S = 3 weeks; V = 4 weeks; R = 4 weeks; and maturity (M) = 3 weeks. Using this criteria, calculation of probability and intensity of drought for pearl millet at different locations revealed highest probability of severe drought at Jaisalmer, followed by Barmer and Jodhpur, that of moderate drought at Jodhpur, and mild drought at Barmer and Sikar (Table 2). The high probability percentage of mild drought at Barmer for the crop is possibly due to the periodic incursion of the Arabian Sea branch of the monsoon current in the lower half of the district. Sikar district in the east has the least probability of moderate to severe drought for pearl millet.

Table 2. Probability of agricultural drought for pearl millet at some stations in western Rajasthan

Station	Mean annual rainfall (mm)	Probability of agricultural drought (%)			
		No drought (A_0)	Mild (A_1)	Moderate (A_2)	Severe (A_3)
Sikar	468	31	44	3	22
Jodhpur	368	16	28	16	40
Barmer	260	7	46	7	40
Jaisalmer	189	1	11	9	79

Source: Sastri *et al.* (1982).

Hydrological drought

Hydrological drought refers to deficiency in surface and subsurface water availability, as deciphered from lake and reservoir levels, ground water level, stream flow, etc. Although it results from rainfall deficiency, hydrological drought has a phase lag with the meteorological and agricultural droughts, because hydrological drought takes a longer time than agricultural or meteorological droughts to manifest.

Societal drought

Societal drought relates to the impact of agricultural, meteorological and hydrological droughts on society, especially in terms of supply and demand of commodities and purchasing power of the people. The worst-hit sections of the society during drought are the people below the poverty line and the landless people. A country depending too heavily on agriculture, with emphasis on rain-fed agriculture, than on the other sectors of the economy, like manufacturing industry, etc., becomes more vulnerable to drought, because once the agricultural production declines due to drought it sets in a chain reaction leading to lower availability of commodities, lower purchasing power and lower economic growth. Severe societal drought may even lead to mass migration in search of food, fodder, water and work, leading to famine, death and social unrest.

Human Mortality during Droughts

Deaths due to drought-related famine were a regular feature during the pre-independence era, but are now rare. According to one estimate, major droughts in India during the Twentieth Century have killed more than 3 million people, and affected 10.9 billion. Droughts of 1877, 1901, 1918 and 1987 were the most widespread, affecting 67, 66, 69 and 53 per cent area of the country, respectively. In post-independent era, the maximum drought-related deaths took place between 1965 and 1967, when the country was more dependent on international food aid, and its agriculture was more rain-dependent and subsistence-bound. Improvements in agricultural research and development since then resulted in a green revolution, and production of enough food for scarce regions or scarcity periods, while developments in infrastructural facilities increased the irrigated command areas, resulting in self-sufficiency in food grain production, storage and public distribution systems, which together gradually improved the scenario. For example, the total food grain production in Rajasthan during the Third Five-Year Plan (1961-66) was 4.78 million tonnes, which increased to 12.33 million tonnes by the end of the Ninth Five-Year Plan (1997-2002). Oilseed production increased from 0.26 million tonnes to 3.14 million tonnes during the same period.

DROUGHT OF 2002

Country Scenario

The drought of 2002 was a very severe one in India, and very widespread. For the country as a whole 21 out of 36 meteorological subdivisions received deficient or scanty rainfall. About 62 million hectare of crop area (i.e., 30% of the total crop area) was affected, leading to a fall in food grain production by 24 million tonnes (12% less than the normal), and affecting 300 million people and 700 million livestock. The last severe drought in 1987 had led to 2.1% reduction in food grain production from the normal, but the drought of 2002 led to a reduction in food grain production by ~14%. About 120000 rural habitations and 500 towns were affected by shortage of drinking water.

Scenario for Rajasthan

For Rajasthan it was a century-scale drought year. The state average for the monsoon rainfall was 220.4 mm, which was the lowest during the recorded period of 136 years. The earlier record was held by the year 1905 when the state's rainfall was 231.5 mm, followed by 1908 (239.1 mm). Rainfall departure from the normal in 2002 was as high as –64%. The districtwise spatially averaged annual rainfall during 2002 (averaged from rainfall recorded at different stations in each district) and its departure from the normal is given in Table 3.

Government of Rajasthan assessed that all the 32 districts of the state were under the grip of drought, and declared them scarcity-affected as early as on 29th July 2002. It was estimated that 44.8 million human and 45.2 million animal populations were affected by the drought. Out of 2341 irrigation tanks of different sizes, only 16 were full. Major dams like Bisalpur, Mahi Bajaj Sagar and Rana Pratap Sagar received 12%, 35% and 57% of their gross storage capacity, respectively. Even the canal systems in the north (Gang, Bhakra and Indira Gandhi Canal systems) had restricted water flow due to poor availability in the Bhakra and Pong dams in Punjab, so much so that the canal command areas had to be declared scarcity-affected, and the available water was reserved for drinking purpose. Drinking water scarcity compelled water transportation to more than 10000 villages and hamlets in the state, as well as 20 towns, costing Rs. 5080 million. Groundwater table was declined by 3.5 to 6.0 metres at different places. Crops were damaged almost totally in 11.7 million ha area during kharif, the loss being estimated as Rs. 44140 million. During the succeeding rabi season (i.e., winter cropping) of 2002-03 only 4.07 million ha area was sown against the normal of 8.21 million ha. The estimated loss of rural employment due to crop failure was 80.43 million man-days. About 7.8 million families, depending on agriculture and animal husbandry, were thus severely affected.

Table 3. Districtwise annual rainfall during 2002 and its departure from normal in Rajasthan (spatial average)

District	Normal rainfall (mm)	Rainfall during 2002 (mm)	Departure from normal (%)
Ajmer	398.4	142.6	-65
Alwar	548.6	156.9	-72
Banswara	833.2	519.0	-38
Baran	841.1	297.9	-62
Bharatpur	609.5	302.1	-50
Bhilwara	570.0	248.5	-56
Bundi	681.8	302.0	-56
Chittorgarh	718.6	369.0	-51
Dausa	568.4	215.9	-62
Dholpur	634.9	336.3	-44
Dungarpur	589.8	379.1	-37
Jaipur	482.4	145.9	-71
Jhalawar	868.5	478.4	-46
Karauli	599.6	196.1	-69
Kota	768.3	367.6	-53
Rajsamand	518.9	268.4	-49
Sawai Madhopur	656.0	173.7	-71
Tonk	557.7	163.0	-69
Udaipur	584.0	373.7	-36
Sirohi	760.7	227.6	-71
Barmer	238.5	85.9	-69
Bikaner	216.0	33.4	-85
Churu	298.3	99.0	-64
Ganganagar	211.3	52.8	-76
Hanumangarh	242.7	53.7	-79
Jaisalmer	145.2	24.3	-83
Jalor	369.5	165.5	-59
Jhunjhunun	400.0	101.7	-75
Jodhpur	284.7	75.6	-76
Nagaur	337.3	107.6	-69
Pali	453.0	132.3	-68
Sikar	425.1	141.3	-67

Source: Govt. of Rajasthan.

Impact on State Economy

The impact of the drought was so high on the economy of the state that the Net State Domestic Product (NSDP) at constant prices dipped from Rs. 50563 crore (1 crore = 10 million) in 2001-02 to an estimated Rs. 46666 crore during 2002-03, while the per capita income (PCI) at constant prices fell from Rs. 8819 (2001-02) to Rs. 7930 (2002-03). Thus, economy of the state, which was in a constant upswing mood for the last one decade, nose-dived as a consequence of the drought of 2002-03 (Table 4).

Table 4. NSDP and PCI of Rajasthan during last one decade at constant prices 1993-94)

Financial year	NSDP (Rs. crore)	PCI (Rs.)
1993-94	28977	6182
1994-95	34269	7134
1995-96	35530	7216
1996-97	39682	7862
1997-98	44509	8601
1998-99	45946	8657
1999-2000	46545	8550
2000-01	45610	8165
2001-02	50563	8819
2002-03	**46666**	**7930**

Source: www.cdmraj.nic.in/index.htm.

Drought in Western Rajasthan

Western Rajasthan is one of the most chronically drought-prone areas in India (Fig. 1). The long-term average of annual rainfall in western Rajasthan is 330 mm, and 85% of the rain (i.e., 280 mm) is received during the main rainy season of southwest monsoon (June to September). Long-term analysis of droughts shows that on an average every 2.5 years is a drought year in the region (Narain and Singh, 2002). Therefore, drought is no stranger in the region.

Annals of droughts in western Rajasthan

Historical record of droughts in the region is fragmentary, but a compilation suggests the following major droughts in Rajasthan between the middle of 14th century and the middle of 18th century: 1362-63, 1648-49, 1659-60, 1747-48 (Sikka, 2004). According to Kachchhawaha (1985), Marwar region faced several major droughts and attendant famine during 14th to 19th century. There is historical record of a major drought between 1309 and 1313 when Rao Rajpal opened grain depots for his subjects, and also of droughts in 1570 when Emperor Akbar ordered the digging of Kukar Talav at Nagaur. A very severe drought occurred in 1660-61, followed by major ones in 1698, 1747, 1756, 1783 (remembered as Chalisa), 1796 (remembered as Trepanya), 1812-13 (remembered as Panchkal, and as severe as that of 1660-61, with very high human and livestock mortality), 1868-70 (remembered as Trical), 1877-78, 1891-92, 1896-97 and 1898-1900 (remembered as Chhappanya Kal, a Trikal). The last one was so severe that the human death was estimated to be 1 million (Kachchhawaha, 1985). The first famine relief work by British government was started in the region during the famine of 1868-70, but an organised Famine Code, named the "Draft Famine Code for Native States" was issued in 1885. In 1897 this code was emulated to issue the Rajputana Famine Code. Since then the Famine Codes have been revised several time for assessing damages and to provide relief to the affected people. These have been consulted even during the post-independent era for assessing drought-related damages and relief.

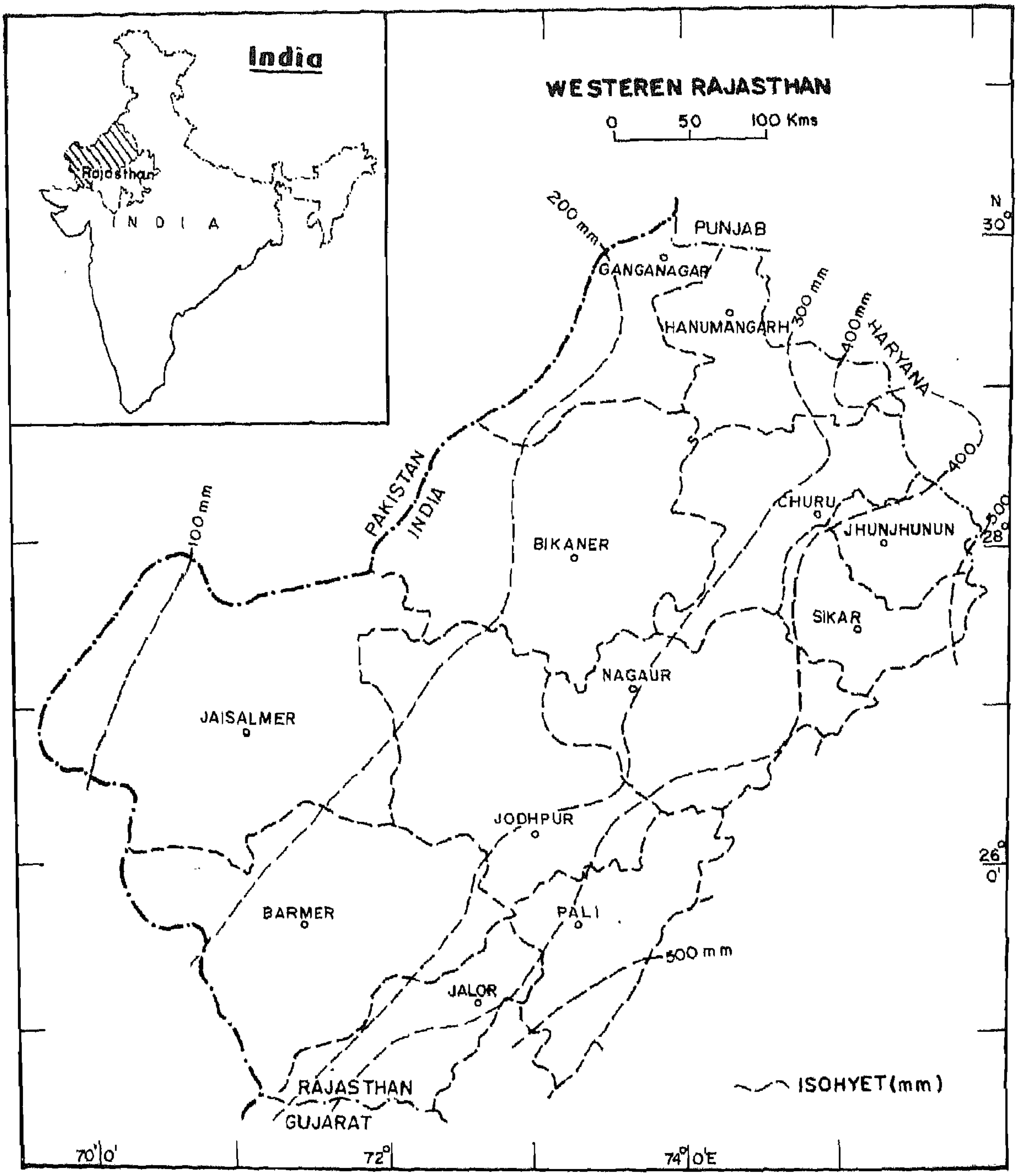


Fig. 1. Western Rajasthan in India.

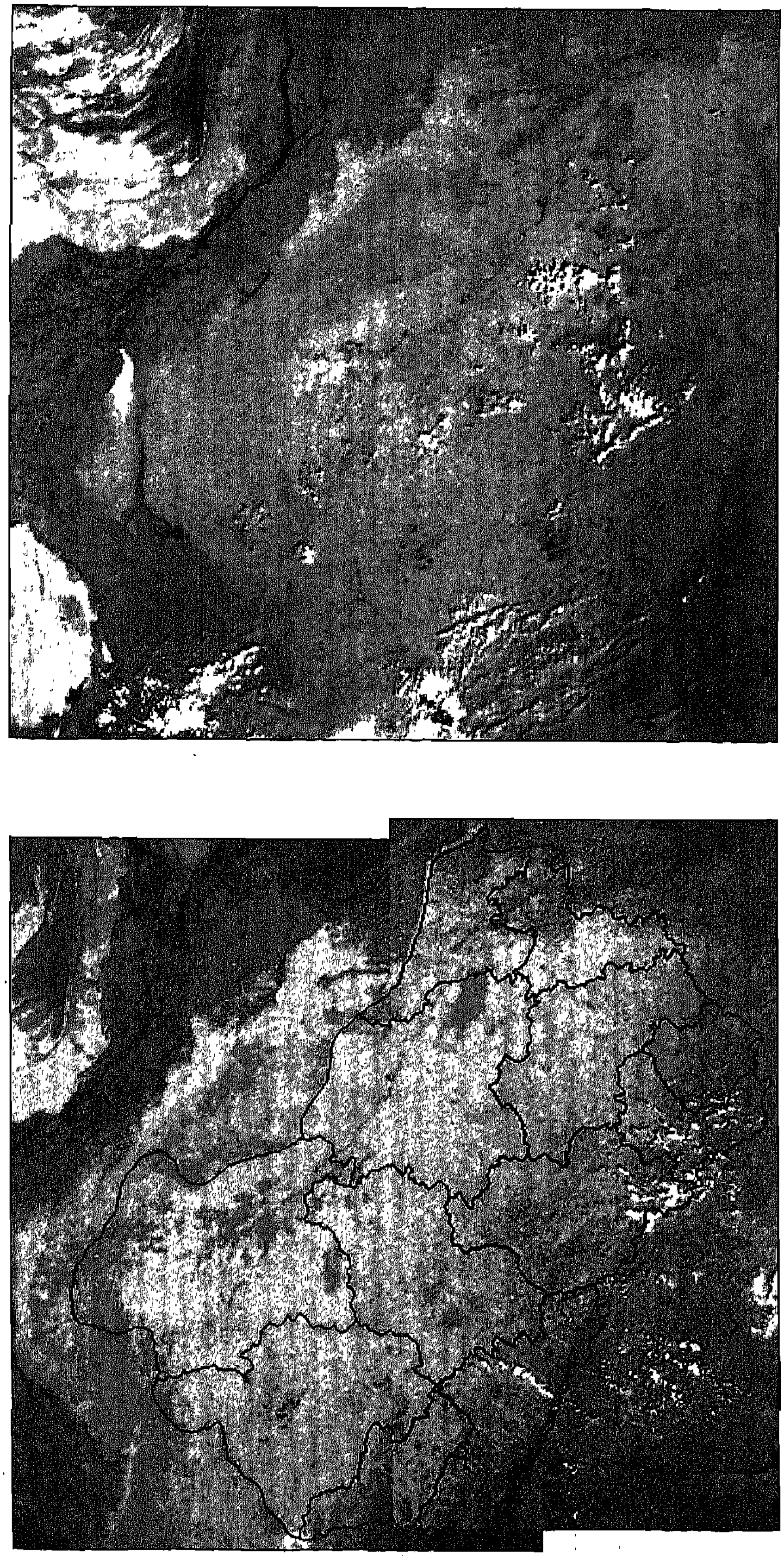


Fig. 2. Enhanced IRS WiFS False Colour Composite images of western Rajasthan and adjoining areas for 6 October 2001 (top) and 1 October 2002 (blow).
Green colour indicates good vegetation.

Between 1901 and 2000 western Rajasthan experienced 11 severe droughts (Narain and Singh, 2002). Drought of 1918 was disastrous in nature. During the twentieth century there were 5 occasions when successive years of drought struck the region: 1903-05, 1957-60, 1966-71, 1984-87, 1998-2000. Such long droughts have greater impact on the society because food, fodder and water resources get severely depleted.

The major factors that accentuate the impact of drought in the region were summarised in an earlier report of Central Arid Zone Research Institute (CAZRI) as: poor water holding capacity of soils, absence of perennial rivers and forests, poor groundwater quality, high withdrawal from limited groundwater reserve, a paradigm shift in land use and neglect of the traditional coping mechanism that were basic to survival in an arid ecosystem (Narain *et al.*, 2000).

Rainfall pattern during 2002

Drought of 2002 will be remembered for its disastrous proportion, influencing both crop production and water availability, and thus impacting the livelihood system of the people (Fig. 2). The spatially averaged annual rainfall for the region during 2002 was 127 mm, which was a mere 38% of the long-term average. SW monsoon rainfall (or kharif rainfall) for the region during the year was 90 mm, against the normal of 280 mm (i.e., 69% deficit from the normal for the period). By contrast, 377 mm of annual rainfall was received during 2001 (14% more than the normal), 82% of which was received during the kharif season. The stationwise rainfall in western Rajasthan during 2001 and 2002 is provided in Appendix 1. During 2001 only one tehsil was affected by severe drought and 14 moderately, while during 2002 all the tehsils except 6 were severely affected (Fig. 3).

The drought of 2002 was preceded by a normal pre-monsoon shower, except in Bikaner district, which provoked farmers to start sowing operations, especially in Barmer, Jalor and Pali. Unfortunately, the peak rainy month of July had almost no rainfall, while August received low and erratic rain. Consequently, whatever crops germinated, suffered wilting and died, and almost no new sowing was possible. The entire rainfall was received in 5-7 events only. Among the districts, kharif rainfall was deficit (20-59% less rainfall than the normal) in Jalor in the south (167 mm), and scanty (60-99% less rainfall than normal) in the other 11 districts of Jodhpur (77), Bikaner (9), Churu (198), Sikar (109), Ganganagar (52), Hanumangarh (67), Barmer (105), Jaisalmer (25), Pali (74), Nagaur (87) and Jhunjhunu (66). Out of 90 tehsils in the region, 72 received scanty kharif rainfall. Jaisalmer district and large parts of Bikaner, Ganganagar and Churu districts received less than 50 mm rainfall during the season, while large parts of Barmer and Jodhpur districts received 50-100 mm rainfall (Fig. 4).

Climatic water balance and crop yield

Analysis of climatic water balance of the region for SW monsoon period revealed that typically kharif crop growing period during above-rainfall years is 13 weeks or more, while that during normal years is ~10 weeks. During sub-normal years, when agricultural drought takes place, the crop-growing period often declines to 7 weeks or less (Fig. 5). Between 1901 and 2001 the above-normal kharif rainfall years (i.e., greater than 20% of the normal) at Jodhpur were 30, normal years (±20% of the normal) 25, below-normal years (greater than –20% of the normal) 32, and poor rainfall (greater than –50% of the normal) 14 years.

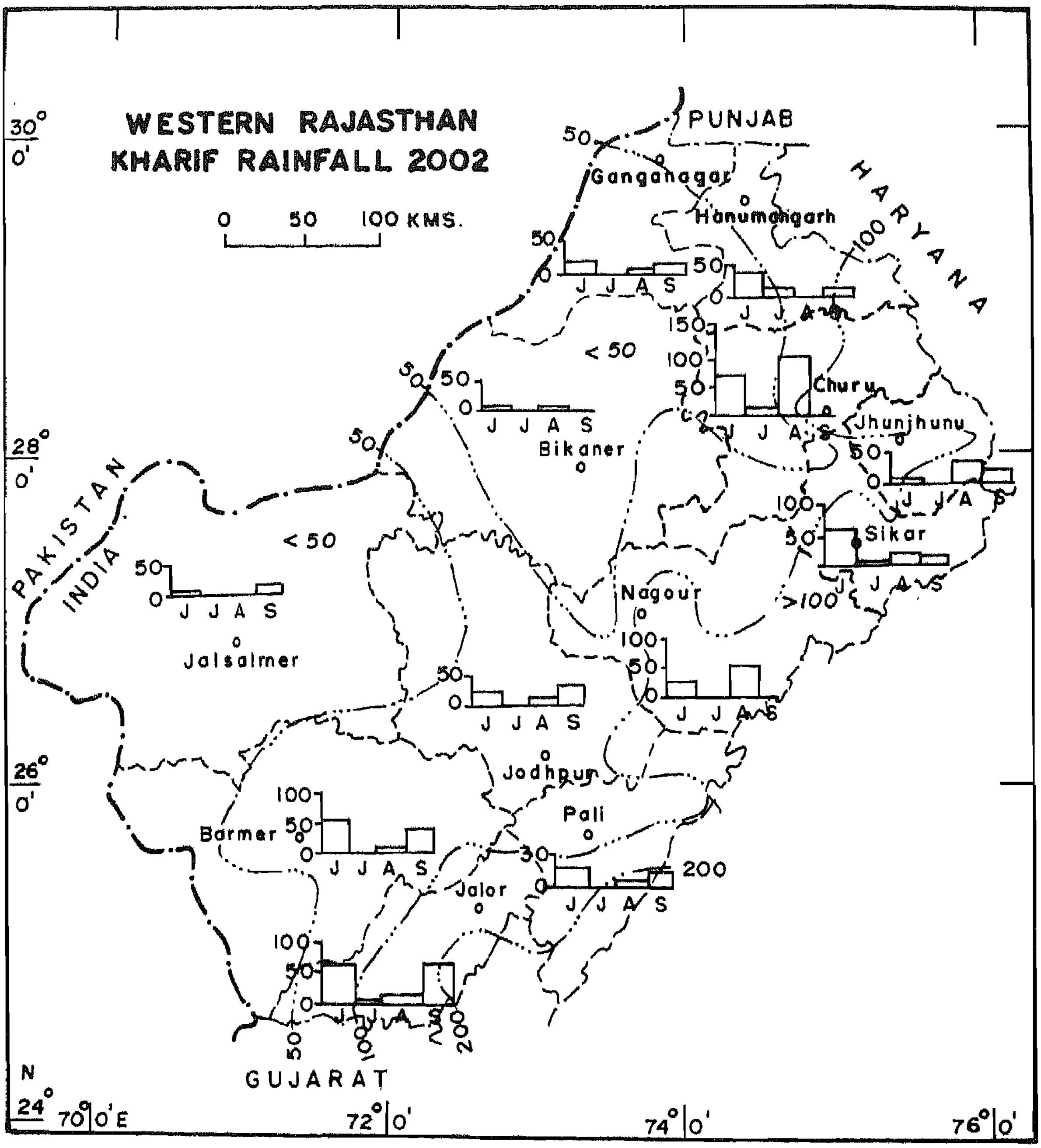


Fig. 4. Western Rajasthan: Kharif rainfall, 2002.

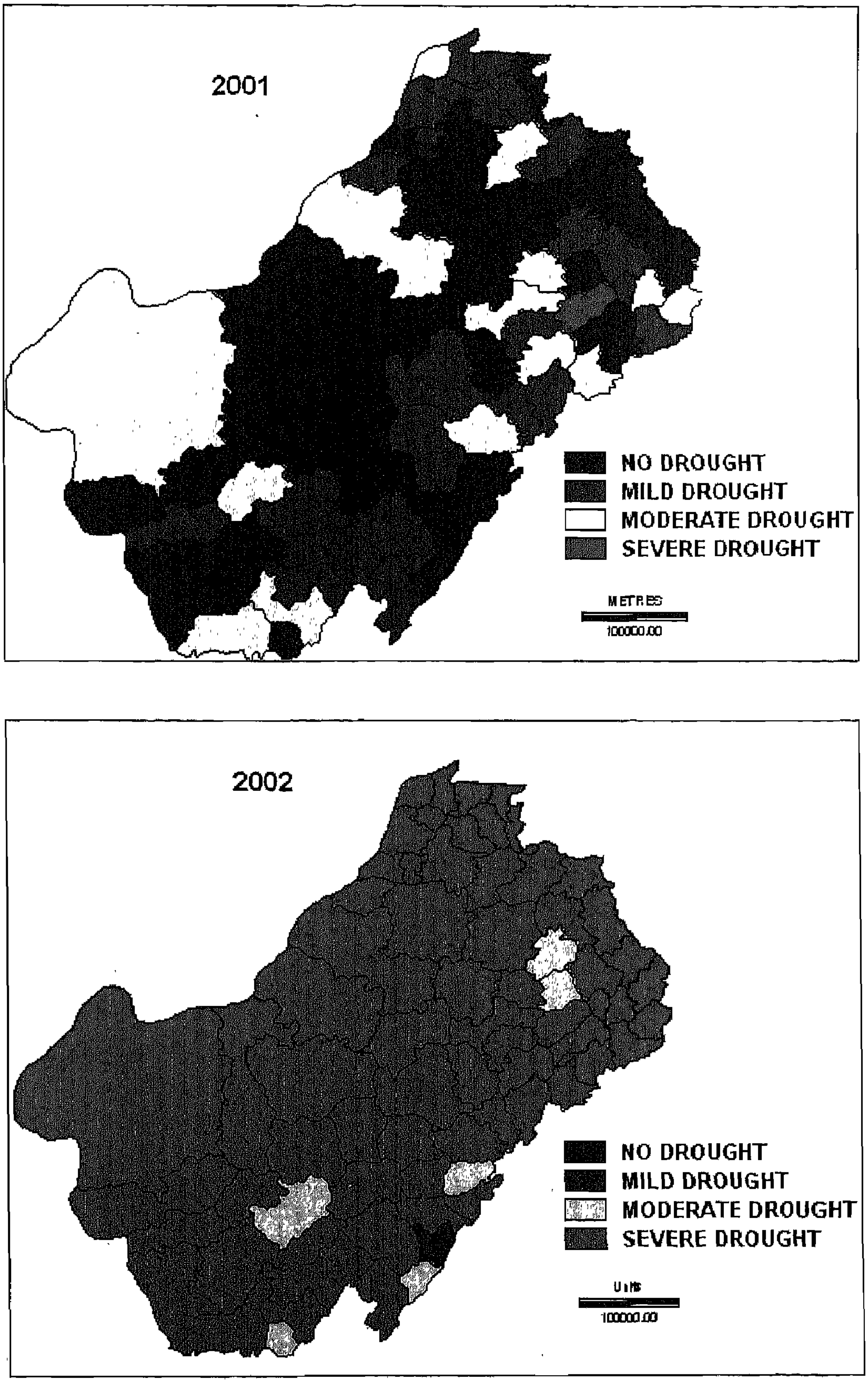


Fig. 3. Tehsilwise intensity of drought in western Rajasthan during 2001 and 2002.

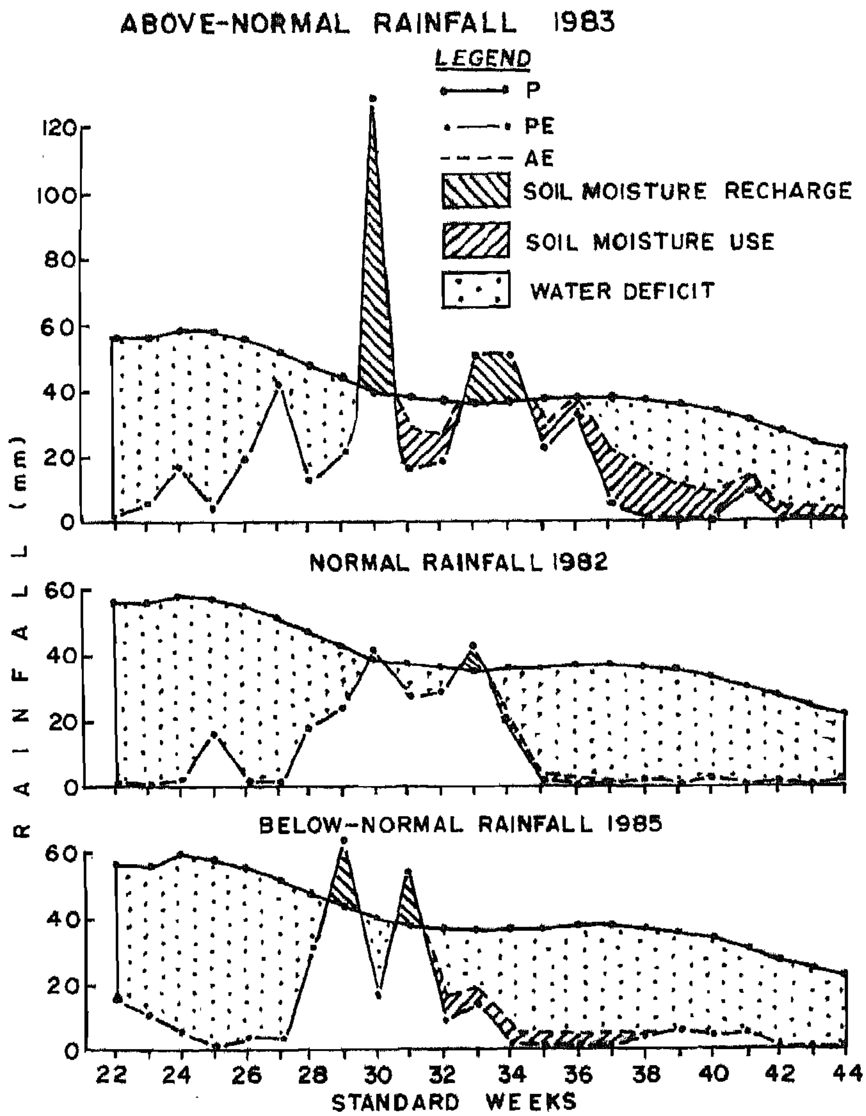


Fig. 5. Climatic water balance during different monsoon rainfall years in western Rajasthan.

The histograms for average weekly rainfall distribution during the above periods are shown in Fig. 6. When the weekly rainfall distribution pattern is seen with the climatic water balance curve it becomes apparent that a good harvest of pearl millet and kharif pulses (including mung bean and moth bean) is possible during the above-normal kharif rainfall years because of appropriate duration of temperature and moisture regimes that determine the healthy growth of these crops with maximum yields. During the normal rainfall years only short-duration pearl millet and kharif pulses are successful, while during sub-normal years pearl millet for fodder and short duration kharif pulses could be grown with some confidence. Correspondingly, there is decline in herbage production from grasses, shrubs and perennial vegetation, which are the major sources of fodder in a normal rainfall year.

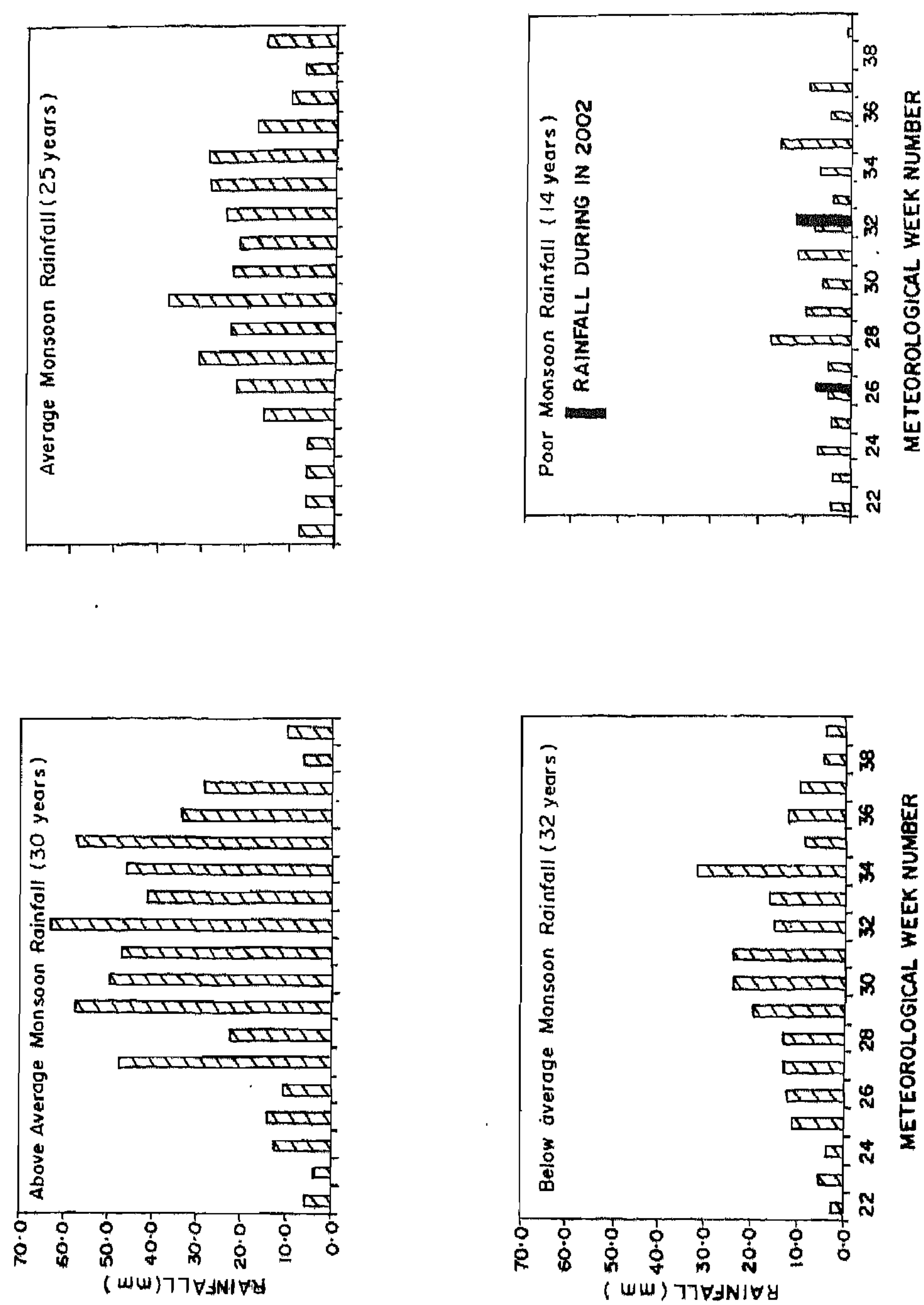


Fig. 6. Weekly distribution model under different categories of monsoon over Jodhpur (1901-2001).

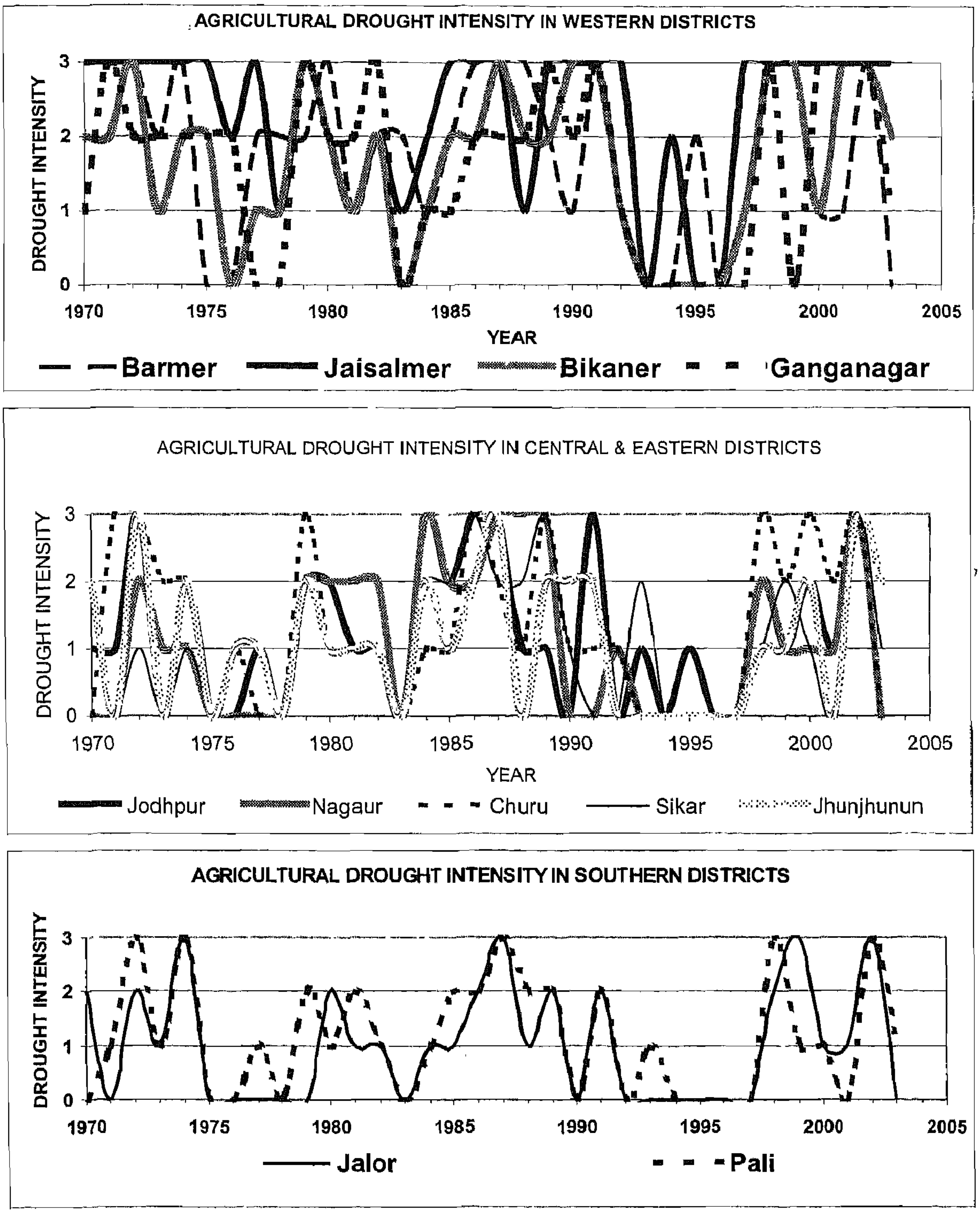


Fig. 7. Intensity of agricultural drought in districts of western Rajasthan.

When the climatic pattern is compared with crop yield data, it transpires that an average yield of pearl millet can be expected at Jodhpur once in 3 years, while at Bikaner and Barmer such probability is once in 4 years. At Jaisalmer the probability is once in 10 years. In the case of kharif pulses, Jodhpur can expect an average yield twice in 3 years, Bikaner and Barmer every alternate year, and Jaisalmer once in 5 years. However, a severe drought like that of 2002 can hardly produce any crop in any of these locations.

Based on the procedures followed by CAZRI (Ramana Rao *et al.*, 1981), the intensity of agricultural drought in different districts of western Rajasthan since 1970 was calculated, which revealed large spatial variability (Rao, 1997; Fig. 7). The study showed that all the districts did not experience similar intensity of agricultural drought in a year. Jaisalmer district in the west had more incidence of severe agricultural drought. It also confirmed that despite a popular belief in the contrary, there was no discernible trend in agricultural drought intensity with time.

Comparison with past major droughts

There were only two previous occasions during the recorded 100 years period when annual rainfall was almost similarly low: in 1918 and 1987. An analysis of the rainfall departure from normal during the major drought years between 1972 and 2002 revealed that the year 2002 had the largest departure of -69% from normal, as compared to -65% during 1987 (Fig. 8). While 80% of the tehsils received scanty kharif rainfall during 2002, in 1987 this was confined to 75% of the tehsils. The annual total rainfall at Jodhpur during 2002 was 91 mm, or 23% of the long-term average. CAZRI Research Farm received 32.5 mm rain between June and September 2002. The earlier lowest kharif rainfall at Jodhpur was 37.0 mm in 1918. During 1987 it received 64.4 mm kharif rainfall. The highest one-day rainfall at Jodhpur was 9.0 mm on 9 August 2002, but it was inadequate for sowing. By contrast, the 2001 monsoon rainfall at Jodhpur was 431 mm.

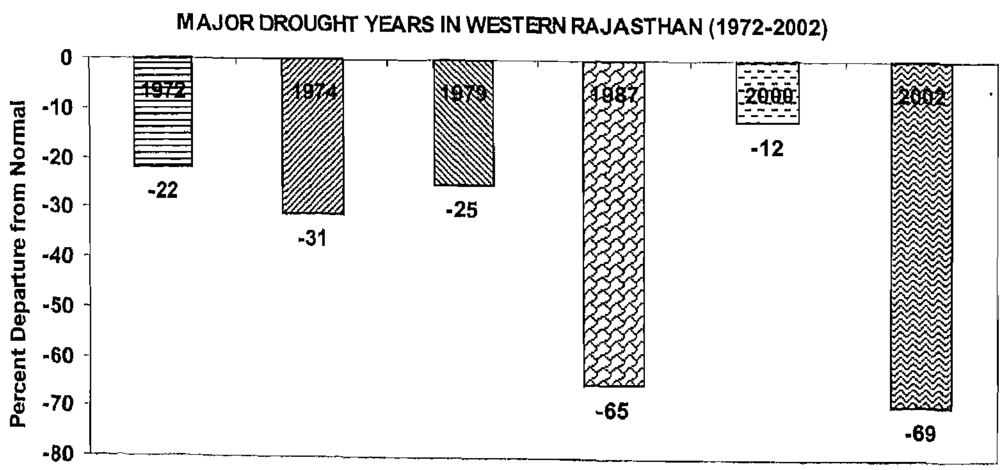


Fig. 8. Per cent deviation of rainfall from normal in western Rajasthan during major droughts (1972-2002).

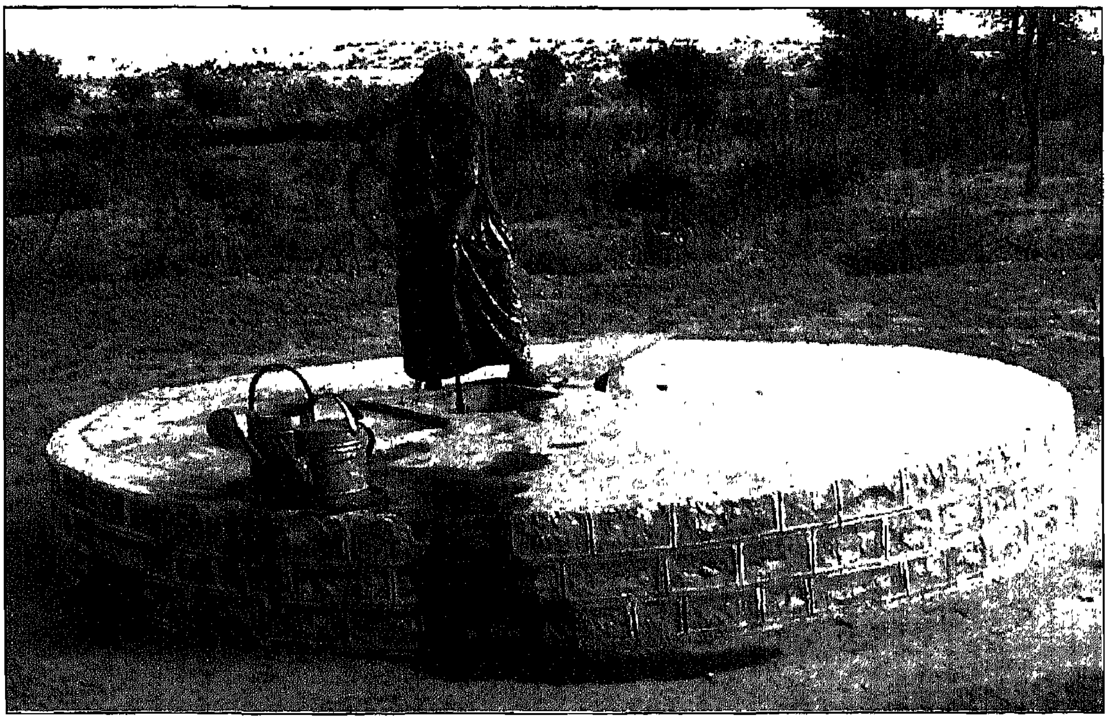


Fig. 9. A recently constructed tanka.

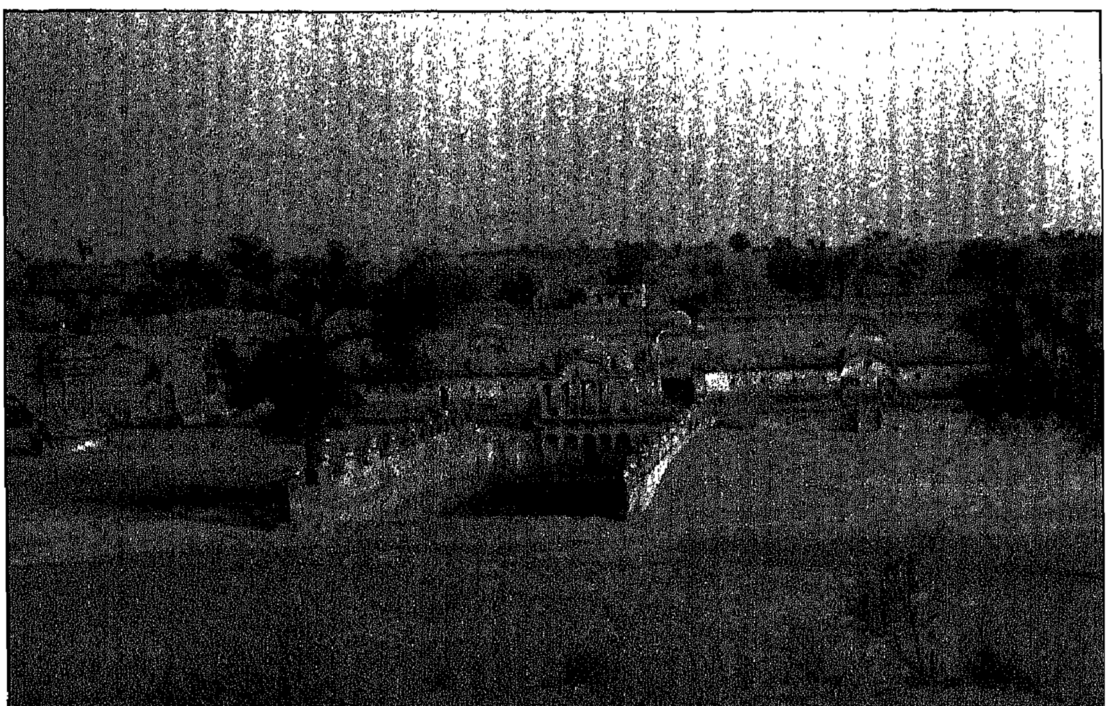


Fig. 10. A dry, old tank complex in Churu district.

TRADITIONAL DROUGHT COPING MECHANISM

Folklores in western Rajasthan sum up the occurrence of drought in the region as follows: during a span of 100 years 7 are famine years, 27 good years, 63 are likely to have less than normal rainfall, and 3 are destined to have such disastrous famine that people have to leave home and hearth without any possibility of returning (Singh *et al.*, 2004). Since climate is harsh in the region, and resource endowments are poorer than in other wetter parts of the country, recurrence of drought has compelled the local population of western Rajasthan to device through centuries of learning, ingenious ways to cope with this vagary of nature. Keeping the land fallow for a certain period (but used for grazing), livestock farming, mixed farming, agro-forestry, traditional water harvesting in ponds, covered tanks, etc., provision for grain and fodder storage, animal migration and food for work strategies are some of the mechanism through which desert dwellers used to mellow the effects of drought and at the same time ensure long-term sustainability of the resources.

Traditional Rainwater Harvesting

Water is the key and precious commodity for desert dwellers. For coping drought, desert dwellers have a wealth of traditional wisdom in store, which was developed through ingenuity and experience to save, conserve and use each drop of water.

Tanka, an underground cistern, is one of the ancient and extensively used rainwater harvesting systems for storing drinking water, particularly in areas where groundwater is brackish. A typical traditional tanka is plastered with lime-murram-gypsum inside and is covered with brush at the top. Presently the structures are often cemented, and integrated with roof water harvesting (Fig. 9).

Talai, Tal, Nada, Nadi and Talab are village ponds/tanks of different capacities, which are used for drinking water by animals, humans, and sometimes for supplemental irrigation to vegetables, nurseries and horticultural crops. In the olden days many landlords and other influential people used to construct tanks at grand scale for drinking water as well as recreation purposes (Fig. 10). The ponds are constructed in low-lying areas. An earthen embankment called 'Agore' is constructed out of the dug out soil, with escape arrangement for surplus water. Existence of a murram/hard rock layer at the bottom of the pond reduces seepage naturally, otherwise the seepage is reduced by depositing silt at the bottom. Besides being a source of water, these community structures are excellent sites for groundwater recharge. Their maintenance and desilting operation before the monsoon is taken care of by the community.

Khadin system of cultivation is popular in the very dry district of Jaisalmer since times of Paliwal rulers of 16^{th} century. In this system runoff water from large rocky catchment is stored against an embankment and crops are grown from ridge to valley on receding soil moisture (Fig. 11). Khadin system is very valuable for recharging groundwater and wells in their zones of influence.

Sar, Sagar and Samand are large rainwater harvesting structures created by erstwhile rulers by blocking stream flows, or at the mouth of gorges by constructing earthen bunds. These large structures provide drinking water to townships and are sources of irrigation and ground water recharge. These were also used for amusement and recreation purposes.

In earlier times water had to be transported from long distances, or had to be fetched by women from considerable distance. Hence people used to economise on water to the maximum possible, and wasteful use of water was rare. Presently PHED supplies water through pipelines, using in most cases the precious groundwater. This easy availability of water is gradually making people forget the value of water, especially the younger generation that did not have the experience of hauling water from long distances, and rarely face water shortage. Since the time Indira Gandhi Canal water reached arid Rajasthan, a paradigm shift in cropping pattern has taken place. Low water requiring crops are being replaced by high water requiring crops in command areas, and well irrigation is increasing due to tremendous increase in diesel pump sets and electricity. As a result of high tapping, groundwater depletion has become a major concern in rural and urban areas and has set in a mis-match between available and utilizable water resources. This needs serious thinking and policy intervention by the state for a long-term solution.

Systems of Cultivation

Traditionally farmers of the region used indigenous country plough or a double-bottom plough, called 'durfan', which used to be drawn by camel or bullock for shallow ploughing. A funnel used to be attached as a sowing device. Since seed used to be placed at a shallow depth, covered by a thin layer of soil, chances of encrustation due to post-sowing rains were few. The system encouraged minimum tillage with low energy that caused least damage to soil structure. Farmers in arid zone get only 2-3 days' time for sowing due to fast drying of land surface. With traditional system, sowing of small acreage was possible, leaving large chunks of fallow lands with grasses and bushes to serve as grazing ground for animals. Regeneration of trees like khejri (*Prosopis cineraria*), as well as of bushes and grasses was possible, serving excellent fodder in different agroforestry systems. This coping system is still noticed in some rudimentary forms. To hasten the process of sowing, local artisans have developed an 8-row tractor-operated seeding device, which is similar to a seed drill. It has 8 PVC tubes with a pointed cylindrical cone- like structure that is designed for equi-distribution of seeds, monitored by a farmer sitting on the device.

With tractorization and heavy machinery sowing every inch of land, and re-sowing if needed, is leading to disappearance of the tradition systems of cultivation, adversely affecting soil structure and increasing wind erosion hazard.

The competition of weeds with crops was controlled generally through hand weeding and using the biomass for animals, or leaving it on land as mulch for moisture conservation. Use of tractors, hand-operated weeders and weedicides are disallowing the earlier conservation strategies.

Fig. 11. A newly developed Khadin near Jodhpur.

Fig. 12. Birani badi system used for growing water melon with limited water during summer near Bikaner.

Birani badi - Farming of Watermelons and Cucurbits

Traditional cultivation of watermelons and cucurbits in small areas with limited water during summer, particularly in Bikaner Division, is called 'Birani badi', which is practiced by the 'Mali' community to evade the effects of drought and to generate income up to Rs. 10,000 ha^{-1} (Fig. 12). The practice consists of making ring basins at 1 x 1 m on the northeast aspect and erecting wind breaks of khimp in between two rows (Kavia *et al.*, 2004). The system helps moisture conservation in post-rainy season, and if rain comes during winter, one harrowing and planking is done. At Shivaratri (end of February or early March) each basin is given 4 litres of water in the centre and two pre-soaked seeds are pressed in a 15-cm deep pit and covered first with wet soil and then with dry soil. After 2 months, 5 litres of water is again given after two months. Crop becomes ready after 2.5-3.0 months.

Storage of Food Grains and Seed Bank

About 10-12% food grains produced in the region are lost during storage despite an arid environment. Traditional grain storage bins, called 'Kinara', which is weaved using branches of shrubs and trees, are mud plastered from outside and kept at raised platform to protect from moisture. Similarly, the earthen structure 'kothi' is in vogue for storage (Singh and Kavia, 2004). Traditionally a thin layer of mustard or castor oil is mixed with seeds, fine ash is mixed with cereals and sand with legumes. Mixing or placement of dry neem leaves provides additional protection during storage. Some farmers provide a 150 mm layer of sand, a 150 mm layer of ash at top for downward percolation. A lamp full of castor/mustard oil is lit in the empty space and the kothi is sealed tightly using cow dung + clay paste.

Storage of onion in gunny bags under a thatched roof, or on a raised platform covered with dry onion leaves was a traditional practice. 'Kiradi', a cylindrical/ conical bin, is made up of 'khimp'. Its conical cap makes it rain-proof. About 150-300 mm thick layer of khejri leaves is spread at the bottom and sides of Khirandi, which is packed with soil at the base from outside.

Fodder Bank

During good rainfall years, excess fodder of pearl millet, wheat, barley or any other crop is stored for adverse years (Fig. 13). The cereals are stored in huge structures called 'Karai' or 'Pachave', which are made-up of crop stalks/branches, either in conical shape with a circular base, or as a rectangle at base and top like a hut shape. Chaffed stover is tightly packed in such structures.

As animals are first casualties during drought due to fodder scarcity, fodder banks are the best coping mechanism in arid region. These have to be integrated with 'Gaushalas' or Panchayat Samitis for collection and distribution. Machines are available to make compact block or bail the grass as rolls for storage.

Animal Management

Due to low and erratic rainfall and frequent droughts agriculture is not a dependable source of livelihood. Nearly 30 million livestock, including huge population of sheep and goat, provide sustainability in the region, and helps to cope with drought. As animals are first casualty during drought issues related to animal management are of paramount importance.

As a coping mechanism, sale of animals and animal products like milk and milk products is traditional. Unproductive animals are let loose or sent to Gaushalas as social taboos are against culling or slaughtering. Philanthropists care for cattle in Gaushalas, but this is not a permanent solution.

Traditional coping system relied more on drought-hardy and well-adapted breeds of animals like Tharparkar, Rathi, Kankrej, Malvi and Nagauri cows, Marwari, Magra, Chokla Nali, Malpura and Sonadi sheep, and Marwari, Jakharana and Sirohi goats. People also relied on traditional system of medicines and management of native breeds.

Migration and Nomadism

During periods of scarcity of fodder, feed, water and work, migration of people and animals from resource-poor to resource-rich neighbouring states has been a well-established way of life and coping mechanism. Pastoral nomads (Raikas, Sindhis, etc.) in the border areas of Barmer, Jaisalmer and Bikaner used to subsist on sale of milk, cattle, ghee, wool and mutton. These systems are facing difficulties due to shrinkage of common grazing land, forcing people to shift to sedentary ways of life, especially after the commissioning of Indira Gandhi Canal system. Regeneration of pastures by reseeding of anjan (*Cenchrus ciliaris*), dhaman (*Cenchrus setigerus*) and sewan (*Lasiurus sindicus*) will help these graziers/nomads. Besides these, trading nomads (Banjara, Gawarias), artisan nomads (Gadoliya Lohars, Sansis) and miscellaneous tribes (Nats, Kalbeliyas) also migrate in search of business and work.

The out-migration with livestock has definite routes to M.P., U.P., Haryana, Punjab and Gujarat. Migrating herds are allowed to camp in fields for small money to improve soil fertility. Migrants return back to their native places with the onset of rainfall. This practice is also dwindling in favour of sedentary way of life, thus exerting huge pressure on limited resources of arid region.

Pasture/ Grazing Lands

Pasture lands are community lands which occupy nearly 4% of geographical area. These used to sustain the animal population in the region and through that the humans. Presently these are severely degraded, but can be managed with effective participation of communities. Orans and Gochars (sacred forests) are also the village pasture lands allotted to deity. Their management rests with a trust or the village community. Conventionally, felling of trees is prohibited in orans and gochars, but is now encroached upon. An estimate through remote sensing revealed that orans and gochars occupy 62158 ha area in Jodhpur district. These were excellent traditional coping systems during droughts, and were also beautiful reserves of arid biodiversity. Due to high encroachment and loss of religious values the orans are losing area and quality. Special efforts are therefore required for their management.

Agroforestry

Traditional agroforestry systems provide unique basis of life support in arid region. During droughts when crops fail, the much-needed fodder, fuel, timber, food (fruits/seeds/pods) and income from minor forest products, like gum and medicinal products, are provided by multipurpose perennial trees, bushes and weeds. Trees like *Prosopis cineraria, Tecomella undulata* and *Salvadora oleoides* have been the life line of the desert. As intensive agriculture is now widely practised the traditional systems are on decline. With tractorization, the regeneration of native vegetation is also declining.

Diversified Agriculture

To avoid total crop failure during drought, the traditional rainfed cropping practice during kharif season in the region is to mix the seeds of pearl millet, moth bean, mung bean, clusterbean, sesame and *kachri* (a local vegetable crop) for sowing (Faroda, 2002). Arid zone farmer has also coping system through some cash crops like isabgol, cumin, spices and condiments, as well as medicinal herbs and shrubs. Some of these plants are fairly drought-tolerant and provide livelihood during adverse time.

Besides, many shrubs like *Lawsonia alba, Capparis decidua, Cassia angustifolia, Commiphora wightii* and a variety of medicinal and aromatic plants have been utilized by the people for income generation through fruits, leaves, exudates, etc. These are sources of survival and for coping drought.

The multipurpose trees are generally grown on cropland. Many fodder trees, shrubs and grasses are traditionally grown as border rows or live hedges. These prevent wind erosion and provide fodder and feed for livestock and humans and fuel for cooking. Sowing strips of grasses around the fields and pearl millet in the centre is a traditional practice for controlling wind erosion and producing fodder for livestock.

Impact on Modernisation on Traditional Wisdom

With modernization, especially after the independence, new opportunities driven by the progress made in research and development, democratic values and social justice, as well as improvements in infrastructural facilities, have led to overall economic well-being of the people.

Electrification

There has been phenomenal increase in electricity consumption by the rural sector, which is an indicator of development. In 1957 only 94 villages of the state were electrified. By the mid-nineties more than 34,500 villages were electrified (~87% of the total), while by 2000-01 more than

37,000 villages (93%) became electrified. All the villages in Jodhpur, Jhunjhunun, Nagaur, Pail and Sikar districts were electrified, while in Jalor and Churu district more than 95% villages became electrified. With the spread of rural electrification there has been an increase in energised wells. In 1957 the state did not have any energised well. By 1980-81 about 200,000 wells were energised, while by the mid-nineties ~450,000 wells (~75% of the total) got energised, leading to spread of irrigated cropping. During 1964-65 electricity consumption by agriculture sector was ~3% of the total consumption in the state; by the mid-nineties 4737 million KW of electricity was used by agriculture, an increase of 149% over the mid-nineties values. By the end of the Twentieth Century an estimated 3.72 million ha area of the state was under well irrigation, western Rajasthan accounting for ~36% of the total.

Tractorization

Another major shift took place in the use of implement for ploughing the land and sowing activities. Traditionally ploughing used to be carried out through bullocks or camels, but sowing rain in the region is usually for short duration, as terrain is dominantly sandy, As a result, period for utilising the soil moisture here is very short. Use of animal-driven traditional plough under such circumstances made it difficult for individual farmers to cover large areas for ploughing, unless one had a fleet of men and animals. Therefore, keeping a part of the land fallow was also a compulsion, driven partly by the resources available for ploughing. With modernisation, tractor has gradually replaced the animal-driven wooden plough. It has not only helped a single person to plough a larger area with little effort and in a much shorter time span, and thus helping to utilise the soil moisture over a wider area in the field, but also in sowing the seeds automatically through seed drills, thus minimising humán drudgery in agricultural operations. In 1980 there were 14535 tractors in western Rajasthan, about half of which was in Ganganagar district (Table 5).

Table 5. Number of tractors in western Rajasthan

District	1980	1991	1997	% increase from 1980 to 1997
Barmer	429	1505	7280	1597
Bikaner	108	1567	4819	4362
Churu	104	1039	3569	3332
Ganganagar & Hanumangarh	7488	21203	42795	472
Jaisalmer	41	277	1141	2683
Jalor	798	3285	12094	1416
Jhunjhunun	161	748	2737	1600
Jodhpur	2120	5052	14093	565
Nagaur	1498	4947	11562	672
Pali	1387	3477	7223	421
Sikar	401	1658	4862	1113
Total	14535	44758	112175	672

Source: Govt. of Rajasthan.

By 1997 the number increased to 112175 (672% increase), which meant 1.05 tractors per square kilometre of net sown area. Although this change has vastly increased the area under cultivation, it has also made a large area vulnerable to wind erosion through deep ploughing of the sandy terrain. Thus, if there is crop failure due to deficient rainfall, no biomass in the form of grasses/bushes is available, resulting in a precarious situation for livestock feeding.

Another impact of tractorization being felt now is the gradual loss of plant biodiversity in the crop fields. When the land was under the traditional plough, traditional agro-forestry could be practiced without much hindrance to ploughing operations. This facilitated the presence of a large number of trees and shrubs in the crop fields. Mechanisation of ploughing operation has lead to clearing of many shrubs and trees in the crop fields, while ploughing of the same land every year and trampling by the heavy equipment has lead to lesser and lesser regeneration of natural trees and shrubs. Consequently, regeneration of new trees/shrubs and replacement of the dying old ones is extremely slow, which will impact the availability of fodder, fuel and wood. In other words, the twin factor of rural electrification and tractorization has increased the agricultural production many-fold, and has gradually strengthened the state's economy, but at the same time has ushered in new problems.

Growth in development index

The rate of growth for Gross Domestic Products (GDP) in agriculture and allied activities in Rajasthan was –0.53% during the period 1980-81 to 1990-91, which increased to +2.72% during the period 1990-91 to 2000-01 (Dev, 2003). At the same time, there have been increases in the rural per capita income, and improvement in health and education levels, all of which led to improvements in living standard. Yet, there is significant inter-district variations in development, as has been brought out in a study of the scenario during the mid-nineties by Acharya and Singhi (1999). Table 6 depicts the variations in development indices in western Rajasthan.

Table 6. Development indices for districts in western Rajasthan

District	RPCI	IOD	ESI	LSI	HSI	DSI
Barmer	1984	0.44	1.07	0.16	0.80	0.51
Bikaner	3697	-0.04	0.82	0.25	1.02	0.59
Churu	2626	0.26	0.82	0.22	0.91	0.55
Ganganagar & Hanumangarh	4605	-0.30	1.38	0.29	0.94	0.72
Jaisalmer	2239	0.37	0.97	0.19	0.93	0.56
Jalor	2275	0.36	1.33	0.17	0.80	0.56
Jhunjhunun	2390	0.33	1.04	0.33	0.86	0.66
Jodhpur	3436	0.03	1.03	0.25	0.89	0.61
Nagaur	2547	0.28	1.12	0.21	0.82	0.58
Pali	2955	0.17	1.01	0.25	0.62	0.54
Sikar	1804	0.49	0.91	0.28	0.82	0.60

RPCI = Rural per capita income; IOD = Index of deprivation; ESI = Economic status index (including rural and urban); LSI = Literacy status index; HIS = Health status index; DSI = Development status index. Source: Acharya and Singhi, 1999.

Impact on water availability

The overall growth of economy in the state is laudable. However, at the same time it has triggered a gradual loss of the traditional values and systems, including the traditional drought coping mechanism. Piped water supply to villages has made many of the traditional water harvesting structures redundant, while expanding areas under market-driven irrigated farming has put more pressure on available land, as well as on groundwater reserve, with implications for grazing/fodder availability. Economy in use of water has almost been forgotten in many parts. One of the major problems facing the state today is falling groundwater reserve. At present the draft for irrigation in the state is ~10455 mcm, which in 1991 stood at ~5411 mcm. The stage of groundwater exploitation is now 104% of the amount that is expected to be replenished annually, as against ~54% in 1991. Lesser reliance on small ruminants and other local livestock breeds has encouraged a gradual shift in livestock composition, threatening the endemic drought-hardy species, increasing the number of cross-bred and otherwise high milk-yielding cattle, and changing the sheep and goat matrix in the villages, with attendant social complexities. Although agricultural economy has turned brighter, the induced changes due to unplanned exploitation of resources and gradual disregard to the traditional practices have not only exacerbated the resource base, but have also increased the vulnerability of the society.

Therefore, people in western Rajasthan continue to suffer as drought strikes at regular intervals. In order to help people withstand the severity of drought, government provides a number of relief measures, including supply of drinking water, subsidies on food and fodder resources, organising cattle camps, wage employment to needy people, food for work programme, nutrition and health improvement programme, etc. Yet, there is hardly any long-term drought management programme. Dependence on government relief measures has increased, while the inherent capacity of the society to withstand drought has diminished.

Fig. 13. A hay stack for use during scarcity period.

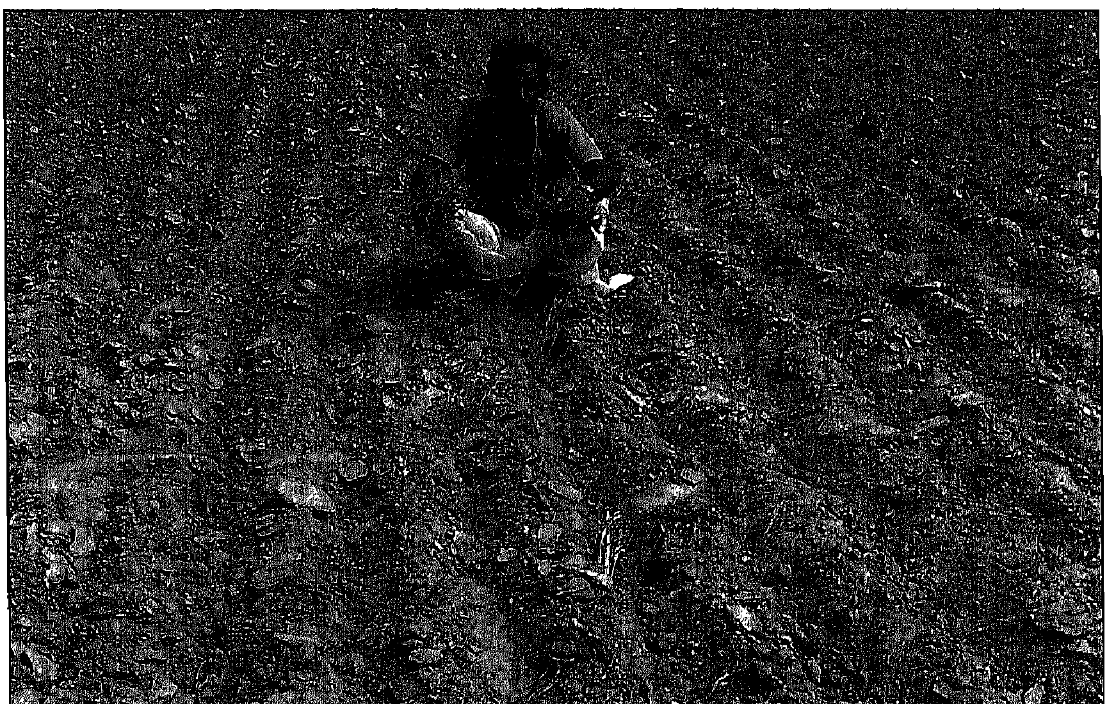


Fig. 15. Crops sown after the June rainfall in southern part failed to survive severe drought thereafter.

IMPACT OF DROUGHT ON AGRICULTURE

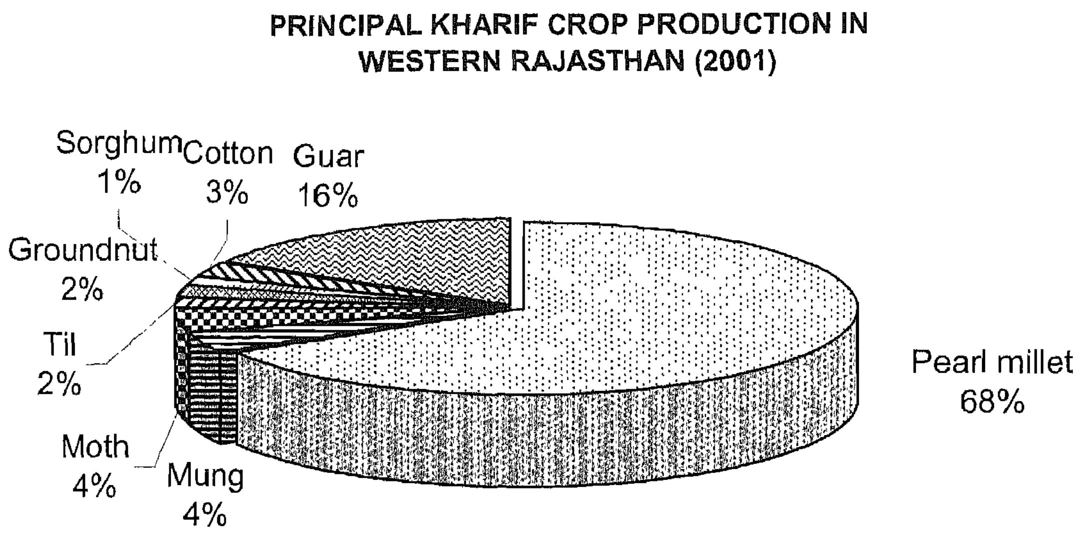
Drought of 2002 had widespread impact on agriculture and livelihood of the people in western Rajasthan. Area under the principal kharif crops, including cereals (pearl millet), pulses (mung and moth), oilseeds (groundnut) and other cash crops like cluster bean (guar), dwindled from about 8.2 million ha in 2001 to nearly 3.4 million ha. Overall, the area under kharif crops declined by ~56% from the 2001 level, while production declined by ~87% (Table 7).

Table 7. Decline in area and production of major kharif crops in western Rajasthan during 2002 from the 2001 level

Crop	Per cent change in area and production from 2001 level	
	Area	Production
Pearl millet	-45.5	-90.6
Mung	-43.9	-86.3
Moth	-67.1	-89.5
Til	-60.1	-96.6
Groundnut	25.1	-34.1
Sorghum	-37.8	-82.8
Cotton	-27.1	-3.0
Guar	-80.4	-96.8
Total	-55.8	-87.4

During both the years cereals and pulses together had the largest share of kharif-sown area (~73% in 2001; ~86% in 2002). While cereals accounted for 69% of the total area under the two crops in 2001, pulses had 31%; in 2002 their relative sown areas were 75% and 25%, respectively. This ratio was maintained even for production during the two years. In 2001, cereals contributed 84% of the cereal-pulses production, pulses contributing the rest 16%, while in 2002 the relative contributions of the two were 86% and 14%, respectively. In other words, despite the severity of drought, relative share of the area and production of these crops remained almost unchanged (Fig. 14). At local level, however, the farmers, depending on resources available to them, made some adjustments. For example, when sowing rains failed in July 2002, many farmers in Jodhpur-Nagaur tract, with access to groundwater wells, shifted to sorghum cultivation for fodder.

During the middle of June 2002, there was some rain in parts of western Rajasthan, especially in the southern part, which provoked farmers to sow crops. Unfortunately, it was followed by a very long dry spell that led to drying of whatever plants had germinated, and thus a loss of precious seeds (Fig. 15). In some areas a little rain during August compelled the farmers to sow for a second time whatever seeds they managed to get, especially of pulses and fodder crops, but much of the effort again went in vain.



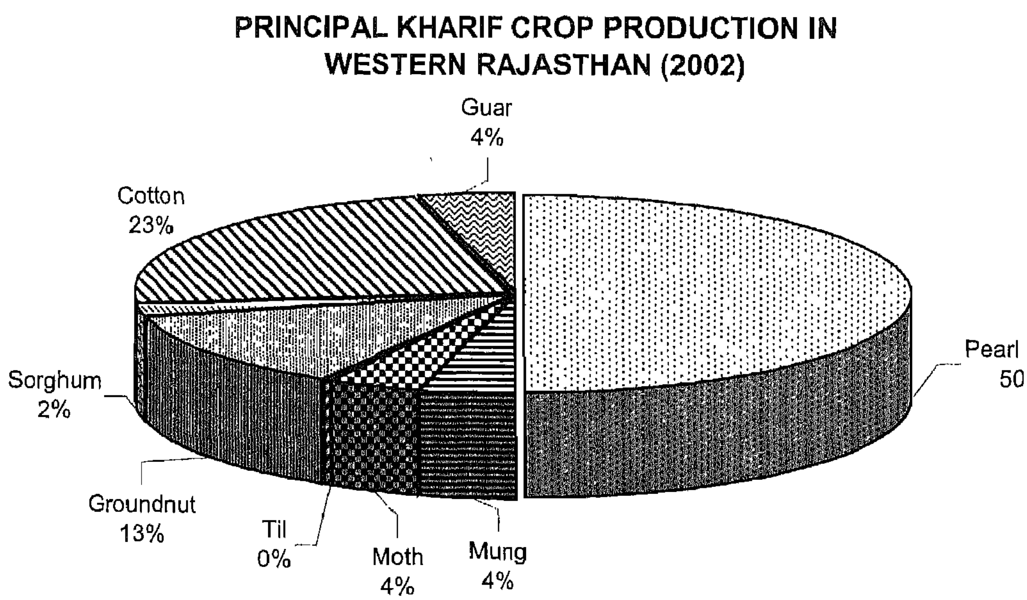


Fig. 14. Principal kharif crop production in western Rajasthan during 2001 and 2002.

Pearl millet

Staple crop of western Rajasthan, pearl millet (locally called bajra), was sown in 2.24 million ha (mha) against 4.12 mha during the normal year 2001, which yielded a meagre 0.236

million tonnes (mt) of grain against 2.510 mt in 2001. The spottiness and erratic behaviour of rainfall was reflected in the spatial pattern of area sown for pearl millet during the year, vis-à-vis its production, and could be better appreciated when compared with the figures for the normal year, 2001. In most of the eastern districts of the region area sown for pearl millet was 60-75% of that during the normal year 2001, but the production varied between 1 and 20% of the amount in 2001. Compared to this, the westernmost districts had covered only 5-8% of the area sown during 2001, producing 5-7% of that in 2001 (Table 8).

Table 8. Districtwise pearl millet production during 2001 and 2002

District	Pearl millet 2001 Area sown (000 ha)	Pearl millet 2001 Production (000 tonnes)	Pearl millet 2002 Area sown (000 ha)	Pearl millet 2002 Production (000 tonnes)
Barmer	957.673	249.075	771.540	5.761
Bikaner	274.451	107.237	14.645	2.221
Churu	483.246	351.589	294.215	5.229
Ganganagar	8.566	6.378	1.535	0.344
Hanumangarh	96.464	74.769	59.705	4.516
Jaisalmer	138.691	25.550	11.773	1.489
Jalor	366.428	205.234	353.086	55.873
Jhunjhunun	279.789	290.003	174.736	20.632
Jodhpur	652.067	444.578	45.060	31.626
Nagaur	472.041	391.600	240.899	47.436
Pali	104.918	57.809	63.433	0.000
Sikar	285.738	306.473	214.229	61.305

Source: Govt. of Rajasthan.

The spatial pattern of sowing and production of the crop reflects the high stakes put by the farmers in it with the June rains, and the disastrous results thereafter. In Barmer district in the southwest, the crop was sown in 80% of the area covered during 2001, but yielded only 2.3% of the grain produced during 2001, thus showing very large gap between sown area and production. Large gaps between sown area and production were also noticed in Pali (sown area 65% of that during 2001; production 4.7% of that in 2001), Churu (60.9% and 1.5%), and Jhunjhunun districts (62.5% and 7.1%). Situation was somewhat better in Jalor (97.3% and 27.6%), Sikar (75.0% and 20.0%), Nagaur (54.7% and 13.1%), Hanumangarh (65.6% and 26.8%) and Ganganagar districts (70.6% and 38.7%). In the western and central parts, Bikaner, Jaisalmer and Jodhpur districts had much smaller area under sowing (5-8% of that in 2001), and also similarly low production (5-7% of that during 2001). In other words, farmers in the areas normally receiving higher and somewhat assured rainfall took a greater risk and lost more as compared to the farmers in the areas receiving less assured rainfall. It also implies that farmers invested a huge capital to survive the drought, but lost in the gamble. Overall, kharif cereal crops were sown in 55.4% of the area sown during 2001, while production was 10.9% of 2001.

Kharif Pulses

The kharif pulses also suffered similarly (Table 9). In Pali district pulses were sown in 10% more area than during 2001, but the yield was only 0.5% of that during 2001. In Churu district the figures were 52.3% and 0%, respectively. The other notable districts for almost total crop failure were Jalor (67.4%; 2.2%) and Barmer (57.5%; 2.4%). Jodhpur had sown 5.3% of the area sown during 2001, and reaped 1% of the previous year's harvest, while for Bikaner the figures were 10.1 and 2.1 per cent, respectively. Ganganagar, Hanumangarh, Jhunjhunun and Nagaur districts had sown the crop in 50-60% of the sown area in 2001, and harvested 25-50% of the grains produced during 2001. Jaisalmer in the west and Sikar in the east had sown the crop in 80-96% of the 2001 area, but produced only ~20% of the 2001 total. Overall, kharif pulses were sown in 42% of the area sown during 2001, but production figure reached a meagre 10% of the 2001 production level.

Table 9. Districtwise area and production of kharif pulses in western Rajasthan during 2001 and 2002

District	Mung		Moth		Mung		Moth	
	2001-02		2001-02		2002-03		2002-03	
	a*	b*	a	b	a	b	a	b
	(000 ha)	(000 t)	(000 ha)	(000 t)	(000 ha)	(000 t)	(000 ha)	(000 t)
Barmer	56.377	7.566	262.866	0.005	33.217	2.096	150.335	0.000
Bikaner	2.757	0.814	331.151	0.001	1.175	0.074	32.658	0.000
Churu	39.751	36.603	207.503	55.904	28.352	0.000	101.190	0.000
Ganganagar	10.979	1.988	5.550	1.315	4.551	1.372	5.858	0.257
Hanumangarh	6.877	2.029	47.599	19.540	6.337	1.757	23.273	3.739
Jaisalmer	1.708	0.504	2.283	0.541	2.162	0.136	1.512	0.066
Jalor	67.790	17.800	16.048	1.698	49.422	0.410	7.184	0.000
Jhunjhunun	33.036	8.360	0.426	0.058	10.229	1.219	0.250	0.000
Jodhpur	84.031	23.262	170.238	37.864	3.650	0.349	9.682	0.237
Nagaur	171.510	38.146	247.052	50.723	105.915	12.394	88.250	13.381
Pali	39.927	8.846	3.554	0.634	45.640	0.000	0.760	0.000
Sikar	15.797	2.993	5.562	1.017	7.153	0.646	7.116	0.025

* a = area; b = production. Source: Govt. of Rajasthan.

Groundnut

During both the years groundnut was sown in 1-2% of the total sown area, while guar was sown in 26% area in 2001 and 12% in 2002. Groundnut being mostly an irrigated crop in the region did not suffer much due to the drought, and could reach 66% of the production level of 2001. Bikaner and Sikar districts had the maximum area as well as production of the crop during both the years, Jodhpur and Churu following much behind (Table 10).

Table 10. Districtwise groundnut production during 2001 and 2002

District	Groundnut 2001-02 Area sown (000 ha)	Groundnut 2001-02 Production (000 t)	Groundnut 2002-03 Area sown (000 ha)	Groundnut 2002-03 Production (000 t)
Barmer	0.010	0.012	0.018	0.012
Bikaner	23.866	31.309	30.861	19.626
Churu	6.178	9.951	6.866	6.173
Ganganagar	0.736	0.597	2.008	1.996
Hanumangarh	0.146	0.179	2.580	1.771
Jaisalmer	1.546	1.897	2.057	1.412
Jalor	0.039	0.048	0.070	0.048
Jhunjhunun	0.724	6.888	1.041	0.714
Jodhpur	3.741	4.589	4.843	6.359
Nagaur	7.068	6.482	6.626	2.577
Pali	3.914	6.610	2.798	0.107
Sikar	1.197	22.070	1.746	18.888

Source: Govt. of Rajasthan

Total Shortfall

Clusterbean (guar) seed production suffered much during 2002, and was only 3% of the 2001 level. In the state as a whole, kharif crops in 2002 were sown in ~610,000 ha area only, against the normal 12.9 million ha. There was approximately 10-fold shortfall in kharif crop production in western Rajasthan during 2002. Looking to the gravity of the situation, Government of Rajasthan declared all the 32 districts scarcity-affected.

PRIMARY SAMPLE SURVEY

In order to understand the impact of the century-scale drought of 2002 on the livelihood of the farming community a rapid sample survey was undertaken by Central Arid Zone Research Institute (CAZRI) in 12 districts of western Rajasthan, using a standard set of questionnaire. A total of 128 villages were selected on the basis of their terrain characteristics and land use, with an emphasis on irrigated/un-irrigated land (Fig. 16). The surveyed villages are listed in Appendix-2.

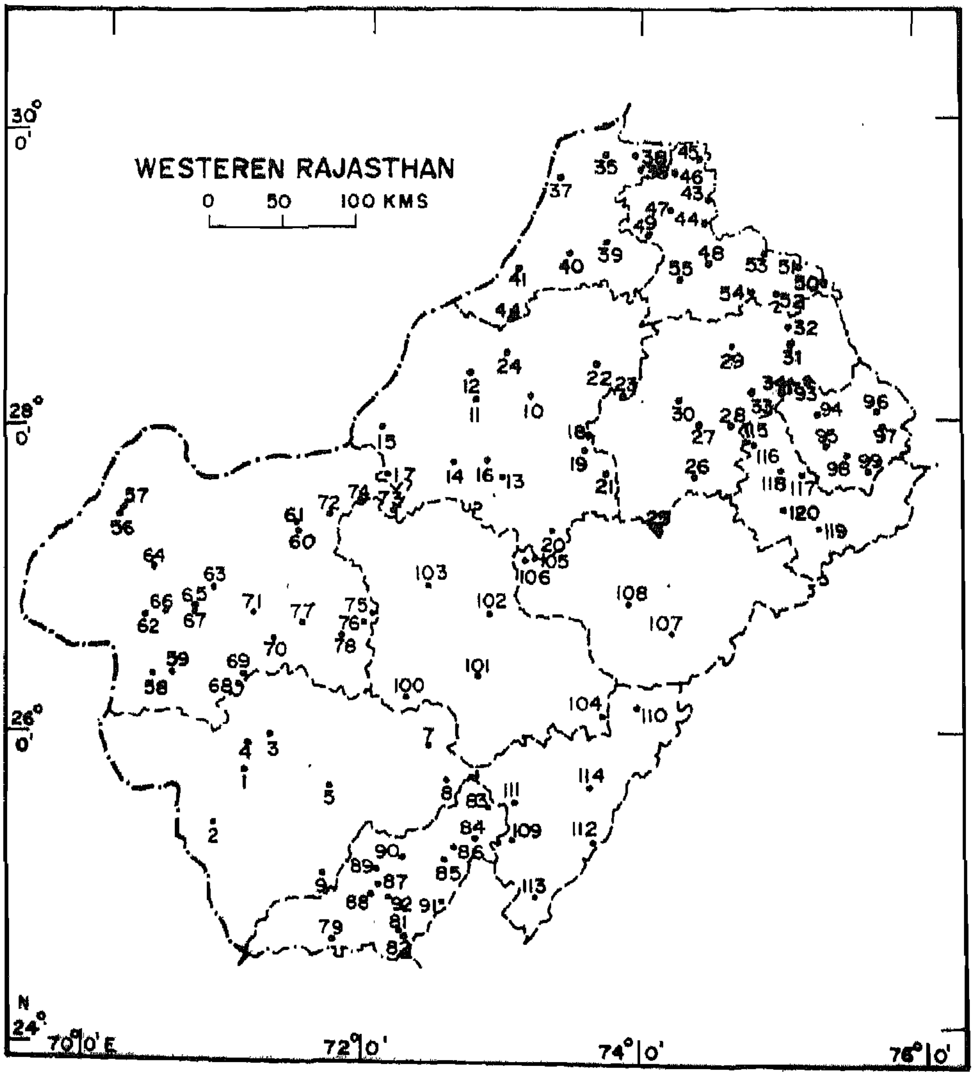


Fig. 16. Sample villages where information on drought of 2002-03 was collected.

Information was collected on categories of farmers, their land holdings, land use and crops grown, water sources and availability, status of livestock population, fodder and fuel wood availability, agriculture input sources and availability, sources of income during drought, migration, government support for drought relief, and general opinion of villagers regarding expectations from the Government.

A set of questionnaire at village and household levels was formulated and used to gather the data from different strata of the society. For village-level information, some key persons from sample villages (i.e., Sarpanch, Pradhan, Patwari, Gram Sevak and School teachers) were contacted, while for household survey, four categories of farmers (BPL/marginal, small, medium and large) from each village were interviewed with respect to their socio-economic status and condition during the drought period.

Farm Families and Land Holdings

The maximum number of farm families (55-58%) in the surveyed villages belonged to small farmer group (1-2 ha land), followed by medium farmers (2-4 ha; 28-31%) and large farmers (>4 ha; 14-20%). Families below poverty line (BPL), mainly the landless labourers, constituted 15-25% of the total household, and matched with the average for the region (23%). Most of these families were found to be the landless farmers. Raikas, the dominantly pastoral community, were found to dominate the landless households in two sample villages of Pali district (Bhatund and Dudod), and had alternate sources of income. Otherwise, the landless households, mostly agricultural labourers and belonging to BPL category, were reported to be high in some sample villages of the district (44% in Banja Kudi, 46% in Manihari and 52% in Bagol). Going strictly by the above classification of farmers according to land holdings, large farmers in Jaisalmer district constituted 31% of the respondents, while medium and small farmers constituted 37% and 15%, respectively, and BPL families constituted the rest 17% respondents. Irrigated croplands everywhere in the region belonged mostly to the large and medium farmers. Very few small farmers in the sample villages had irrigated cropland. For example, in sample villages of Churu district 51% of the irrigated croplands belonged to medium farmers, and 49% to the large farmers. The major exception was noticed in the well-watered areas like Sanchor, Bagoda and Sayla tehsils of Jalor district where most small farmers in sample villages also had some irrigated cropland. In Jaisalmer district, out of 194 respondent households in 23 sample villages 21% reported access to canal irrigation from the Indira Gandhi Canal network (IGNP), while 2% had tube well irrigation facilities.

BPL families

The broad patterns of land holding size in the different districts of western Rajasthan and the percentage of rural BPL families are provided in Table 11, which indicate that Jhunjhunun and Sikar districts in the east, despite having smaller average land holdings, and higher population densities, have least percentages of BPL households, even lesser than the largely canal-irrigated, and hence supposedly prosperous, Ganganagar and Hanumangarh districts. Bikaner and Jalor districts, which are partly covered by either groundwater or surface water irrigation facilities, still have large percentages of BPL households. Compared to this, Barmer and Jaisalmer districts, having poorer resource endowments, have comparatively less percentages of BPL households, possibly because of the adoption of animal husbandry as a major source of livelihood, which is more environment-friendly in the region, out-sourcing of income and eco-tourism.

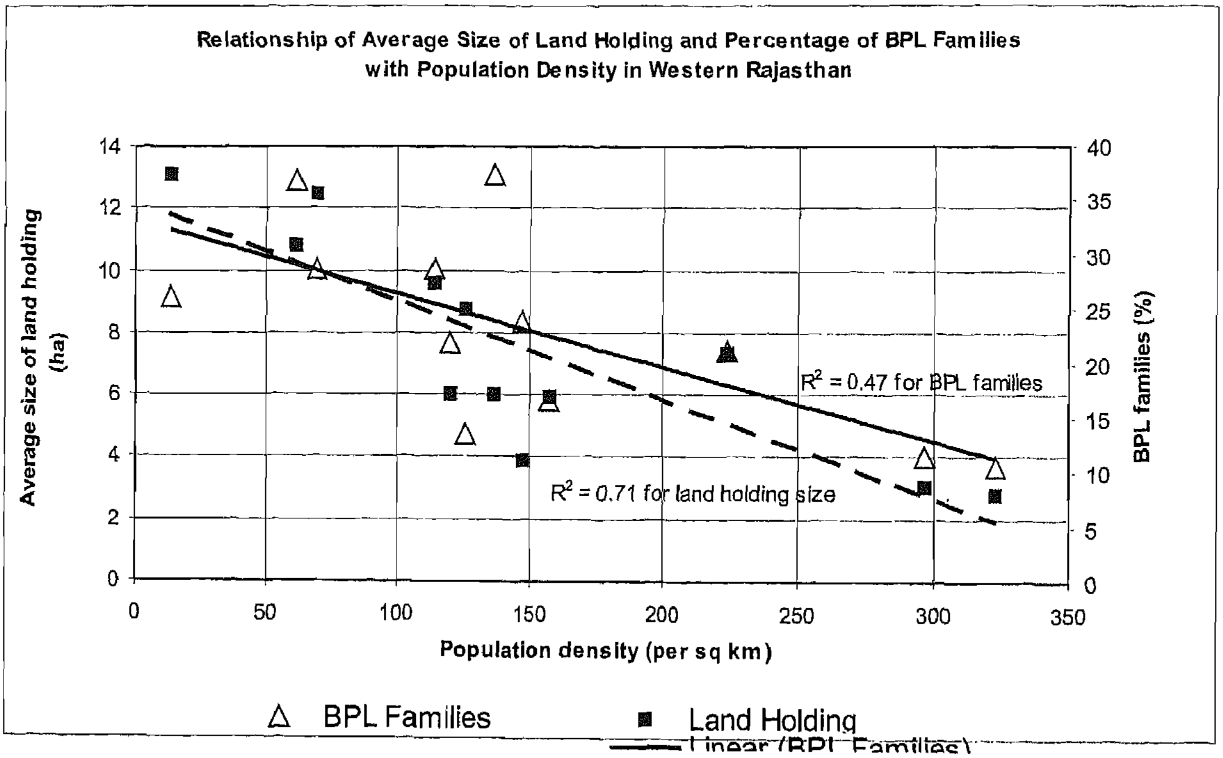


Fig. 17. Relationship of average size of land holding and percentage of BPL families with population density in western Rajasthan.

The above pattern is also noticed in the statistical relationship of average size of land holding (ha) and average percentage of rural BPL households with the districtwise population density (Fig. 17). Although the relationships are not very significant, it shows that in the poorly endowed western Rajasthan percentage of rural BPL families is poorly related to population density, but land holding size is better and inversely related to population density. As population density increases, land holding size decreases. However, land holding size does not appear to be a good determinant of rural BPL households, and by implication poverty. One of the major segments of population at distress during the calamities like drought is the BPL household. The enumerated figures of the State on land holdings and rural BPL families are, therefore, significant in mediating relief and for working out a proper long-term plan of action to combat hunger. Going by the BPL standards, Bikaner, Jalor, Barmer, Jaisalmer, Churu and Pali require greater relief attention than the other districts in western Rajasthan.

Table 11. Average land holding per family and rural BPL household in western Rajasthan

District	Population density (per km^2)	Average size of holdings (ha)				Rural BPL household (%)
		Marginal	Small	Medium & large	Total	
Barmer	69	0.48	1.53	13.61	12.44	28.71
Bikaner	61	0.60	1.50	11.28	10.83	36.84
Churu	114	0.61	1.55	10.12	9.56	28.62
Ganganagar	224	0.60	1.49	7.94	7.32	21.26
Hanumangarh	120	0.59	1.47	7.22	6.02	21.88
Jaisalmer	13	0.72	1.48	14.85	13.10	26.11
Jalor	136	0.56	1.52	7.54	6.03	37.50
Jhunjhunun	323	0.60	1.46	4.38	2.80	10.57
Jodhpur	126	0.56	1.51	10.41	8.73	13.60
Nagaur	157	0.47	1.51	7.52	5.96	16.53
Pali	147	0.54	1.46	6.97	3.93	24.01
Sikar	296	0.57	1.45	4.79	3.08	11.43
Average		0.58	1.49	8.89	7.48	23.09

Source: Govt. of Rajasthan.

Dominant farm sizes

The percentage of small and marginal farmers (as per holding size) is usually less in the region as compared to large and medium farmers. While 24.6% farmers own less than 2 ha land each, 22.1% have 2-4 ha land, and 53.3% more than 4 ha. This pattern was broadly mirrored in the sample villages of Churu district where 26.9% farmers possessed less than 2 ha land each, while 29.7% had 2-4 ha land each, and 43.4% had more than 4 ha each, but in the sample villages of the neighbouring Jhunjhunun district, where population density is much higher and resource endowment better than in the west, the values change to 58%, 28% and 14%, respectively. Sikar district, with high population density and better resource endowments, also had a similar composition (49.7% small farmers, 34.4% medium farmers, and 15.9% large farmers). The pattern was also partly replicated in Jalor district in the wetter south, where small farmers account for 57.1% of the total, followed by medium farmers (31.3%) and large farmers (27.7%). Except Ahore tehsil, which was dominated by large farmers (46.1%), and Bhinmal tehsil, dominated by medium farmers (42.4%), all other tehsils were dominated by small farmers. In the central part, sample villages of Jodhpur district reported 24.7% small farmers, 28.4% medium farmers and 46.9% large farmers, while in the neighbouring Nagaur district, the values changed to 16.6%, 25.2% and 58.2%, respectively.

The large farm size does not always imply affluence of the farmers but a necessity imposed by the needs of the household to optimise output from an inherently resource-poor land. In fact, an assumption that farmers with large holdings are better equipped to cope with the drought may not hold true in many cases in the region. It is the net income from a farming system and out-sourcing, which largely decide the capacity of farmers to endure drought. As a result, when drought strikes, the large and medium farmers are not always able to evade its impact as smoothly as the farm size would usually imply, although they are in a somewhat better position as compared to the small farmers (Table 12).

Table 12. Categories of farmers in some sample villages of western Rajasthan

District	Tehsil	Village	Category of farmers		
			Small	Medium	Large
Churu	Sujangarh	Chadwas	38.9	39.2	21.9
	Sujangarh	Magrasar	7.1	31.4	61.4
	Sardarshahr	Bhadasar	30.7	17.6	51.7
	Sardarshahr	Dulman	48.3	16.8	34.9
	Taranagar	Jigsana Tal	28.3	38.7	33.0
	Taranagar	Tal Pandreu	8.4	34.3	57.3
Jhunjhunun	Jhunjhunun	Abusar	49.8	44.8	5.4
	Jhunjhunun	Luna	16.7	16.7	66.7
	Nawalgarh	Dabri Baloda	46.2	43.0	10.8
	Chirawa	Pichanwa	69.3	20.5	10.2
	Buhana	Moe Bharu	95.5	4.0	0.5
	Udaipur Wati	Khinvsar	35.9	63.1	1.0
	Khetri	Madhogarh	92.6	6.2	1.2
Sikar	Fatehpur	Hudera	54.4	26.7	18.7
	Fatehpur	Shekhisar	59.8	26.5	13.7
	Lachmangarh	Basni	57.1	22.8	20.1
	Lachmangarh	Singodhara	38.9	33.3	27.8
	Ramgarh	Karamsura	66.7	28.2	5.1
	Sikar	Kasali	42.1	43.2	14.7
Jodhpur	Osian	Osian	23.8	29.7	46.5
	Osian	Parasla	21.7	14.5	63.8
	Shergarh	Shergarh	40.0	50.0	10.0
	Phalodi	Lordiyan	3.1	10.2	86.7
	Bilara	Khariya Mithapur	34.7	37.6	27.7
Nagaur	Khimsar	Bhojas	12.6	8.3	79.1
	Khimsar	Pabusar	12.0	5.1	83.0
	Nagaur	Gajju	28.2	60.2	11.6
	Merta	Bhaggar	13.8	27.3	58.9

Land Use and Cropping Pattern

Condition of rain-fed cropping in Jodhpur and Nagaur districts

In all the sample villages agriculture is the dominant land use and pearl millet the major kharif crop, grown partly as a sole crop and partly with moth, mung, guar, groundnut, til, etc. In most villages un-irrigated crops failed almost totally, but irrigated crops survived. This could be better appreciated from an example of sample villages in Jodhpur and Nagaur districts (Table 13 and 14).

Table 13. Crop yield during kharif 2001 and 2002 in 4 sample villages of Jodhpur district

Village	Crop	Grain yield ($q\ h^{-1}$)		Straw yield ($q\ h^{-1}$)		Total biomass ($q\ h^{-1}$)	
		2001	2002	2001	2002	2001	2002
Malunga	Pearl millet	7.3	0.0	15.2	0.0	22.5	0.0
	Mung bean	0.3	0.0	0.6	0.0	0.9	0.0
	Moth bean	1.3	0.0	4.7	0.0	6.0	0.0
	Clusterbean	3.1	0.0	6.3	0.0	9.4	0.0
Shergarh	Pearl millet	3.7	0.0	10.6	0.0	14.3	0.0
	Moth bean	2.7	0.0	6.7	0.0	9.4	0.0
	Clusterbean	0.6	0.0	0.7	0.0	1.3	0.0
Parasla	Pearl millet	6.1	0.0	10.2	0.0	16.3	0.0
	Moth bean	3.3	0.0	6.3	0.0	9.6	0.0
	Clusterbean	2.7	0.0	5.1	0.0	7.8	0.0
Kharia Mithapur	Fodder sorghum	0.0	0.0	89.2	74.2	89.2	74.2
	Pearl millet	23.0	20.3	74.3	68.3	97.3	88.6
	Cotton	23.4	20.0	0.0	0.0	23.4	20.0

Table 14. Crop yield during kharif 2001 and 2002 in 4 sample villages of Nagaur district

Village	Crop	Grain yield ($q\ h^{-1}$)		Straw yield ($q\ h^{-1}$)		Total biomass ($q\ h^{-1}$)	
		2001	2002	2001	2002	2001	2002
Bhojas	Pearl millet	2.0	0.0	2.6	0.0	4.6	0.0
	Mung bean	0.0	0.0	0.0	0.0	0.0	0.0
	Moth bean	2.2	0.0	2.8	0.0	5.0	0.0
	Clusterbean	1.1	0.0	1.1	0.0	2.2	0.0
Pabusar	Pearl millet	3.1	0.0	5.0	0.0	8.1	0.0
	Mung bean	0.0	0.0	0.0	0.0	0.0	0.0
	Moth bean	1.9	0.0	1.5	0.0	3.4	0.0
	Clusterbean	1.3	0.0	1.4	0.0	2.7	0.0
Bhaggar	Pearl millet	8.7	0.0	19.1	0.0	27.8	0.0
	Mung bean	5.0	0.3	6.1	0.4	11.1	0.7
	Groundnut	2.2	2.2	0.0	4.5	2.2	6.7
	Moth bean	5.4	1.4	10.9	2.8	16.3	4.2
	Clusterbean	3.5	0.0	5.8	0.0	9.3	0.0
	Sesame	1.2	0.0	0.0	0.0	1.2	0.0
Gajju	Pearl millet	14.0	10.5	24.5	26.3	38.5	36.8
	Mung bean	2.7	0.0	4.0	0.0	6.7	0.0
	Moth bean	1.9	0.9	2.1	1.1	4.1	2.0
	Clusterbean	2.1	0.0	3.1	0.0	5.2	0.0
	Sesame	3.1	0.0	0.0	0.0	3.1	0.0
	Fodder sorghum	12.4	9.0	22.7	20.7	35.1	29.6

Irrigated Cropping in Jodhpur and Nagaur districts

Crops survived mostly under irrigated condition (e.g., at Kharia Mithapur in Jodhpur district and Gajju in Nagaur district), where farmers shifted to irrigated sorghum to produce fodder as soon as the time for sowing pearl millet expired. To get some returns, farmers provided life-saving irrigation even to pearl millet crop, wherever they had access to groundwater, but the major gain was in production of fodder. Sowing of high-yielding crop varieties, which is now a common practice in the region, especially during normal rainfall years, was given preference in irrigated tract only due to high risk of crop failure in other areas. The yield per ha was much better than in case of other crops.

Crop performance in Bikaner district

Groundnut was not much affected by the drought as it was taken under irrigation. A similar situation was reported from the 15 sample villages of Bikaner district (Table 15).

Table 15. Average yield of major crops in 15 sample villages of Bikaner district

Crop	Grain yield (q ha^{-1})		Straw yield (q ha^{-1})		Total biomass (q h^{-1})	
	2001	2002	2001	2002	2001	2002
Pearl millet	1.0	0.0	3.4	0.0	4.4	0.0
Moth	1.0	0.0	1.5	0.0	2.5	0.0
Mung	9.3	1.3	0.0	0.0	9.3	1.3
Clusterbean	2.4	0.8	3.4	0.8	5.8	1.6
Groundnut	24.8	22.8	32.8	32.0	47.6	54.8

Maximum reduction in crop area in Bikaner district was observed in clusterbean (73%), followed by moth (58%) and pearl millet (59%), and production of moth bean, mung bean and pearl millet registered a 100% loss. Only clusterbean seed production could reach 32% of the 2001 level.

Khadin cultivation in Jaisalmer

In the sample villages of Jaisalmer district, there was very little cropping during kharif 2002. Pearl millet and clusterbean were the only major crops and survived only in few Khadins. Khadin is a traditional runoff farming system popular in the drier part of the region, in which an embankment is constructed across the dry valley of an upland stream for rainwater conservation during summer monsoon, and utilization of the conserved moisture in soil to grow crops mostly during the winter months, but also during summer monsoon if the runoff collection is meagre. An overflow arrangement in the structure allows excess water to spill over to the Khadins downstream. This practice is a time-tested traditional coping mechanism for drought and otherwise low rainfall situations in the district.

Khadin cultivation in sample villages of Jaisalmer district during kharif 2002 led to an average pearl millet yield of 1.7 q ha^{-1}, as compared to 2.3 q ha^{-1} during 2001. Its straw yield increased from 3.5 q ha^{-1} during 2001 to 5.0 q ha^{-1} during 2002. In the canal-irrigated area, clusterbean was grown through irrigation in few plots where average seed yield was ~0.5 q ha^{-1}, as compared to 0.1 q ha^{-1} under rain-fed condition during 2001, but the straw yield decreased from 4.2 q ha^{-1} during 2001 to 0.5 q ha^{-1} during 2002.

Alternate farming in Ganganagar: In Ganganagar district, which has large area under irrigation and where fruit orchards are a major source of income, kinnow plants dried up in many orchards, especially because release of canal water was severely restricted and the farmers had to use groundwater, which is brackish to saline, adversely affecting the horticultural plant (Fig. 18). Despite this set back, however, farmers of the district tried, wherever possible, to evade the drought impact by shifting to alternate crops. Vegetables were grown with irrigation in the Ghaggar valley (Fig. 19), while few farmers in parts of Anupgarh and Vijaynagar tehsils grew *Haloxylon recurvum* (Sajji), a naturally-growing salt-loving plant that is used as an ingredient in *papad* making (Fig. 20).

Drought as a blessing in waterlogged areas: In Hanumangarh district drought of 2002 proved to be a boon for villagers in Rawatsar-Manaktheri-Baropal area, which is chronically hit by the waterlogging problem. A large part of the waterlogged tract became partly dry, and the best location for growing rice. In sample villages, mostly the large farmers were found to have used the land for growing high yielding varieties (HYV) of rice, covering 11% more area than during the previous year, and recording a mere 8% decline in production. Among the other kharif crops, area under clusterbean (guar) did not show any change, while area under other crops registered sharp decline. However, production of almost all the kharif crops, except rice and cotton, was very severely affected. Cotton was partly successful, and showed overall increase in production, despite less sown area than during 2001. For almost all the crops farmers preferred HYV seeds to the local ones, and wherever the crops survived, the HYVs performed better that the local varieties.

Overall, the pattern that emerged from a majority of sample villages was a colossal failure of kharif crops, save and except where irrigated. The end result was an acute shortage of food and fodder production, and a high demand on whatever resources were available with the individual farm families.

Insects and Pests

Due to severe drought, attacks by insects and pests were less during the year. Yet, some incidence of aphid in clusterbean, yellow mosaic virus in moth bean, pod borer attack in chick pea, leaf curl virus and dieback in kinnow, and bollworm and aphid attack in cotton was reported, especially in Bikaner and Ganganagar districts. Tikka disease was reported from groundnut crop, mostly in Bikaner district, irrespective of whether the crop was taken with canal water or groundwater.

Water and its Availability

Water is the most crucial resource that gets attenuated during drought. In arid areas experiencing fast economic growth, the high demand for limited water often leads to more acute problems. Western Rajasthan does not have any perennial source of surface water. Its ephemeral streams from the Aravallis and other isolated hills depend solely on the monsoon rains. Traditional systems of surface water harvesting and conservation for drinking water include tankas (cisterns) and nadis (ponds), which also depend on monsoon rains. The other traditional source of drinking water is the dug well, having water at varying depths and with varying quality. Conjunctive use of surface and groundwater helps to mitigate the impact of drought, although even efficient nadis and tankas usually dry up after 9-10 months, and need replenishment from the next monsoon.

As the pace of development increased during the last few decades, and electricity became available across the region, drinking water for the rural areas began to be increasingly sourced from new-found groundwater reservoirs through pipe lines, and the traditional sources of drinking water began to be increasingly neglected due to disuse, and many fell in disrepair. Many medium-size surface water reservoirs began to command larger areas for irrigation, leaving little for drinking purpose. At the same time, heavy withdrawal of the limited groundwater, especially for irrigating the crops, led to a fast depletion of groundwater reserve and consequent resurfacing of acute water problem in many areas. The changes in groundwater exploitation were very sharp during the last one decade. In 1991 the overall exploitation was 48.3% of the net annual rechargeable reserve, but it increased to 121.8% in 2001, thus setting off a trend of increasingly deficit water budget. Jhunjhunun, Sikar, Nagaur, Jodhpur, Jalor and Barmer districts have already been classified as overexploited.

During 2002 water crisis was very severe in large parts of western Rajasthan. Irrigation tanks in the region, which also act as drinking water sources during periods of crisis, could be filled by only 5% of the gross storage capacity. In 2001 the storage was 43% of the total gross capacity, while in 2000 it was only 26% (Table 16).

Table 16. Surface water storage in irrigation tanks of western Rajasthan

District	Total gross storage capacity (mcft)	Per cent filled		
		2000	2001	2002
Barmer	164.35	2	10	1
Jalor	2015.60	6	25	2
Jodhpur	3038.00	13	6	0
Nagaur	301.00	44	45	0
Pali	17588.30	30	52	7
Jhunjhunun	364.80	28	1	0
Sikar	479.60	72	77	0
Total	23951.65	26	43	5

Source: Govt. of Rajasthan.

Drinking water crisis in Pali

The crisis of drinking water was acute in Pali district. The water reservoir on the Jawai river, which was primarily created half a century ago to supply drinking water to Jodhpur and Pali towns through a canal, is also being used for irrigated cropping in the Aravalli foothills. Although

Fig. 18. Drying of kinnow (a variety of citrus) in Ganganagar district.

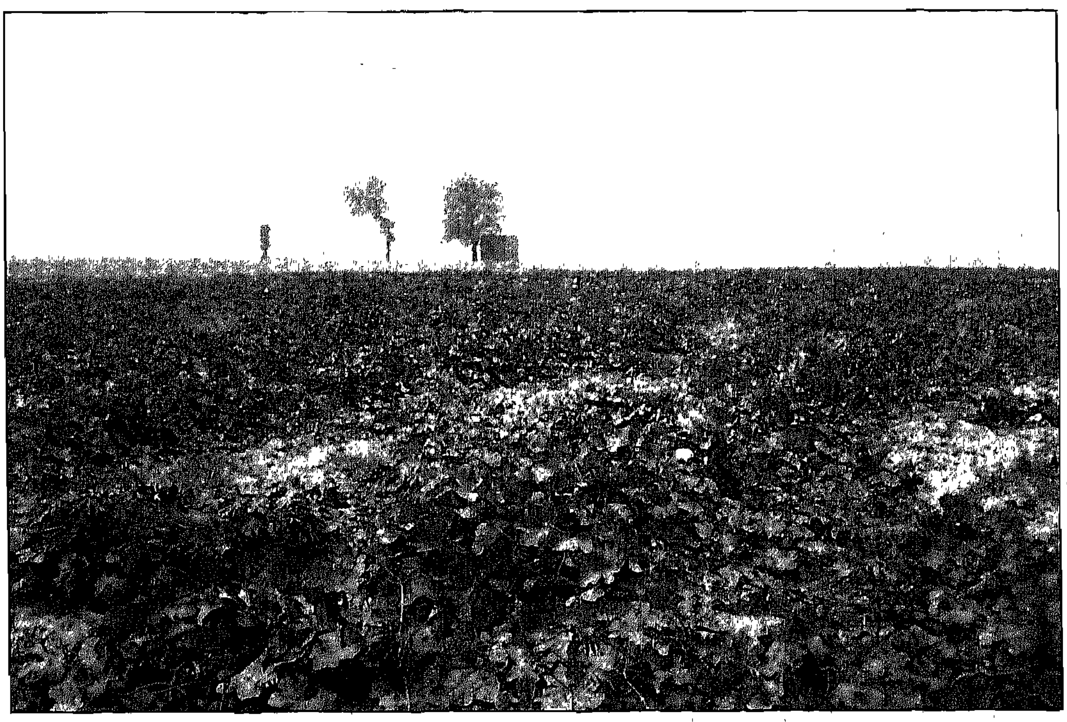


Fig. 19. Vegetable production along Ghaggar valley in Ganganagar district.

172 villages and 7 towns in Pali district are still supplied water from this reservoir during normal times, the almost total failure of monsoon during 2002 led to exhaustion of live storage by October that year. Additionally, Hemawas tank at Pali and Sardar Samand tank downstream of Sojat did not receive any runoff. Groundwater in the region is brackish to saline in most cases, which made the situation worse. Consequently, towns like Pali, Sojat, Sojat Road, Rani and Falna and about 170 villages in their surroundings faced a major water crisis.

Drinking water crisis in other districts

Water scarcity was acute in other districts also, as was found in the sample villages. Despite the fact that most villages were served by the piped water supply scheme, people in almost all sample villages spoke of very irregular supply, and many complained of highly brackish to saline water being supplied. People usually depended on the open wells and tube wells (if available), but in many areas the wells yielded brackish water, partly as a result of overexploitation over the years.

In Jalor district, 62% of the wells in sample villages yielded brackish water. In Barmer district a maximum of 614 villages and Dhanis were provided daily tanker service for drinking water supply. In Churu district, sample villages Tal Pandreu, Dudhwa Mitha, Magrasar, Dalman and Gothia Bari faced acute water shortage because these villages are neither served by the PHED water supply grids, nor by the other water supply scheme, Apni Yojna. Supply through tanker cost the villagers Rs. 300 per tanker. By contrast households in several villages of Rajgarh tehsil were found to have roof water harvesting system that collects rainwater and stores it in an underground tank of the household. This helped the villagers to withstand drought impact.

Sample villages in the neighbouring Jhunjhunun and Sikar districts had hand pumps and/or pipe water supply, as well as wells, which took care of the water availability. Sample villages in Bikaner district had sufficient drinking water for human and animal consumption, but the quality was not potable everywhere.

Transportation of drinking water

Tanker service: The enormity of the problem can be gauged from the details of districtwise daily transportation of drinking water to villages by the state government through tankers (Table 17). A total of 2952 villages were covered under this programme. Additionally, 3 towns in Pali district and 6 in Nagaur district and 2 in Sikar district were covered.

Water trains: For Pali district, state administration had to arrange special trains to transport water to Rohat, Pali, Sojat Road, Bomadra and Khimel, and construct large water reservoirs at those places for onward distribution. Pali town received four water trains daily that brought 5.2 million litres of water, while one train from Jawai Dam station carried about 1.2 million litre water daily to Bomadra and Khimel.

Table 17. Daily tanker supply of drinking water in western Rajasthan during 2002-03

District	Maximum number of villages covered per day	Maximum number of tanker trips per day to villages	Maximum number of tanker trips to towns per day
Barmer	614	806	0
Bikaner	133	171	0
Churu	51	89	0
Ganganagar	12	39	0
Hanumangarh	1	211	0
Jaisalmer	364	87	0
Jalor	525	417	0
Jhunjhunun	25	36	0
Jodhpur	361	233	0
Nagaur	406	596	26
Pali	322	124	122
Sikar	138	186	12

Source: Govt. of Rajasthan.

Other measures for augmenting drinking water supply

Besides providing emergency water supply through tankers and trains, state government also identified the following blocks in western Rajasthan for strengthening drinking water supply scheme through additional hand pumps and energised wells: Barmer, Baitu, Shiv, Dhorimanna, Chohtan and Sindhri of Barmer district, Bikaner, Dungargarh, Nokha, Lunkaransar and Kolayat of Bikaner district, Sujangarh of Churu district, Osian, Phalodi and Shergarh of Jodhpur district, Jaisalmer and Sam of Jaisalmer district, and Nagaur and Khimsar of Nagaur district. In the region as a whole, 1181 new tube wells were sunk, 4243 new hand pumps were installed, and 6799 traditional water sources were renovated. Districtwise number of new tube wells and hand pumps installed and traditional water sources renovated is provided in Table 18.

Table 18. Districtwise augmentation of drinking water supply during drought of 2002-03

District	Number of tube wells installed	Number of hand pumps installed	Number of traditional water sources renovated
Barmer	107	252	571
Bikaner	136	0	270
Churu	51	0	357
Ganganagar	0	28	85
Hanumangarh	0	77	95
Jaisalmer	53	164	477
Jalor	75	144	476
Jhunjhunun	146	751	878
Jodhpur	118	483	743
Nagaur	280	532	1038
Pali	129	1156	1187
Sikar	86	656	622
Total	1181	4243	6799

Source: Govt. of Rajasthan.

A 32-km long pipeline was constructed from Kuri village near Jodhpur to Rohat to supply canal water from Jodhpur to Pali district area. A fleet of water tankers from the distribution centres supplied water to the needy villages daily.

The State also geared up to renovate the traditional water harvesting systems in Pali district, although it was too late for the year. The following schemes were taken up in Pali district in the wake of the 2002 drought (Table 19).

Table 19. Water supply schemes initiated in three affected blocks of Pali district during drought 2002

Name of scheme	Villages covered			
	Sojat Block	Pali Block	Falna Block	Total
Regional scheme	129	193	41	363
Piped scheme	36	19	26	81
Panghat scheme	32	32	8	72
Traditional sources	3	5	46	54
Janta Jal scheme	35	3	67	105
Hand pump scheme	75	42	112	229
Total	310	294	300	904

Source: Govt. of Rajasthan.

Supply of canal water in IGNP command

In the dominantly canal-irrigated districts of Ganganagar and Hanumangarh, water allowances through canals were restricted in the wake of the drought. In Hanumangarh district the supply was reduced by 58-84% of the normal flow, which upset the crop planning in the command areas. Farmers in the tail end of canals and in tight-command areas (i.e., in the fringes of the command) suffered the most. Overall, availability of water in Gang Canal, Bhakra Canal and Indira Gandhi Canal systems in Ganganagar, Hanumangarh and Bikaner districts were reduced to 25% of that available during normal time, thus making the water available mainly for drinking purpose. Farmers in the tail end of the canals usually construct water storage structures called 'Diggis'. These are filled up during canal supply, and the water is used as and when required. During 2002-03 the canal supply was so much curtailed that most of the diggis remained empty throughout the season. This was the first time when canal command areas were also declared scarcity-affected (Anon., 2004a).

Irrigation of kharif crops from groundwater wells

Visualising the possible wipe-out of kharif cereals and pulses during 2002, many farmers with access to groundwater shifted to growing fodder sorghum through irrigation; many others used the water for growing groundnut, while few others provided life-saving irrigation to pearl millet or other survived crop plants. For example, in Jaisalmer district pearl millet crop was given life-saving irrigation in some sample villages that resulted in 175 kg ha^{-1} grain yield, and 500 kg ha^{-1} straw yield.

In general, use of groundwater for irrigating kharif crops increased during 2002. Increased demand for water and negligible monsoon recharge led to drop in well water level in all the districts of the region. Sample villages in Churu and Jhunjhunun districts experienced a drop of 3-8 m, while sample villages in Hanumangarh district experienced up to 3 m fall. In Pali and Jalor districts the average drop was by 9 m.

Status of groundwater exploitation

Tapping of groundwater for irrigation has increased tremendously during the last one decade. Many areas have over-exploited the groundwater reserve (i.e., exploitation >100% of net annual available), while many others have reached critical limits of exploitation (i.e., exploitation >90% of net annual available, and groundwater level shows a falling trend). The situation becomes grim when it is recognised that large areas have also saline water, or water with harmful constituents like fluoride. In western Rajasthan as a whole, the stage of exploitation in 1991 was 48.3% (i.e., status: safe level), which increased to 121.8% (i.e., status: over-exploited) in 2001 (Table 20). The situation further deteriorated during 2002-03.

Table 20. Stage of groundwater exploitation in western Rajasthan (1991-2001)

District	Stage of exploitation (%)		Change from 1991 (%)
	1991	2001	
Barmer	34.66	102.44	195.6
Bikaner	0.13	73.13	56156.7
Churu	1.76	59.36	3272.8
Ganganagar*	31.28	76.31	144.0
Jaisalmer	0.33	75.29	22714.3
Jalor	88.36	195.34	121.1
Jhunjhunun	123.71	172.68	39.6
Jodhpur	35.43	168.10	374.5
Nagaur	82.29	134.07	62.9
Pali	49.50	79.91	61.4
Sikar	83.61	106.22	27.0
Total	48.28	121.77	152.2

* includes Hanumangarh district. Source: Rajasthan Ground Water Department.

It is apparent that districts like Jalor, Jhunjhunun, Jodhpur and Nagaur have extremely high level of exploitation, and may face a major crisis in not so distant future, while Barmer and Sikar districts have also over-exploited their reserve. Very fast changes have taken place in Bikaner, Churu and Jaisalmer districts, where exploitation is likely to reach critical level within this decade. If drought prolongs beyond one year, and long droughts like that of 1984-87 take place, there will be higher demands not only during kharif season, but also during rabi season, when farmers would like to produce more per unit area to compensate for the losses suffered during kharif season.

A major water crisis is imminent

The water scarcity faced by the region during 2002 was enormous and alarming. If such a situation continues for a longer duration, and if the exploitation of water continues at the same level, then any scheme for drinking water distribution will collapse due to non-availability. So much water is now consumed for producing irrigated cash crops that the state government has estimated that a mere 10% saving in the quantity would be enough to solve the drinking water problem. It is strongly felt that close coordination is required between the state departments of Irrigation, Agriculture and PHED for developing a comprehensive plan for efficient utilization of the available water. Perhaps, some bold decisions like a pricing policy for groundwater irrigation in better-endowed areas, and a cap on the use of groundwater for irrigation in other areas will be able to defer the crisis. Schemes for groundwater recharge should also be taken up at the earliest.

Fodder and Feed Availability

Availability of fodder and feed resources in the region is usually much below the requirement. According to one estimate, the availability of green fodder in the western dry zone of the country is 26.83% of the requirement, that of dry fodder 12.41% and concentrates 5.86% (Chawla *et al.*, 2004). The situation worsens during the drought, especially in the arid areas. Another estimation for western Rajasthan suggests that with current practices the fodder deficit during normal years would be as high as 60% of the demand, and might range from 55% in the western districts of Bikaner, Jaisalmer and Barmer to 69% in the central districts of Jodhpur, Nagaur and Churu, and 72% in the eastern districts of Pali and Sikar. During drought years the ovarall deficit might go as high as 76% of the demand, and range from 76% in wetern districts to 81% in the central districts and 82% in the eastern ones. The northern districts of Ganganagar and Hanumangarh are likely to face a deficit of 24% during normal years and 50% during drought years (Venkateswarlu *et al.*, 1992).

In almost all the districts of western Rajasthan fodder situation during 2002-03 was very bad. The major sources of fodder during normal years are the crop residues, as well as the natural vegetation in current fallows and unculturable lands. The permanent grazing lands (Orans) are usually in a severely degraded state, are heavily encroached, and are not always counted for fodder availability. The exceptions are the very few managed ones. Under such a scenario, the almost total crop failure during Kharif 2002, and drying of natural vegetation in the fallow lands meant a fodder crisis in many districts.

Types of fodder available

In order to find out the status of fodder availability in sample villages, the resources were classified into grasses, top feed, pala (leaf fodder of *Ziziphus nummularia*), loong (leaf fodder of *Prosopis cineraria*), bajra kadbi (fodder pearl millet) and wheat straw. Regeneration and re-growth of natural vegetation were very severely affected, especially because of non-availability of moisture and due to higher incidence of browsing, lopping and cutting of trees and shrubs for fodder and fuel purposes. For example, in Bikaner district regeneration of *Cenchrus setigerus* (Dhaman), *Cenchrus biflorus* (Bhurat) and *Dactyloctinum sindicum* (Gathiyan) grasses was badly affected.

Panicum antidotale (Murath) failed to sprout properly on the sand dunes, but *Lasiurus sindicus* (Sewan) performed satisfactorily in sandy habitat. In neighbouring Churu district *L. sindicus* failed to regenerate properly, while *C. ciliaris* and *C. setigerus* experienced a reduced vigour and density.

Among the shrubs, *Calligonum polygonoides* (Khimp) continued to be a favourite species for fuelwood purpose, especially in Bikaner and Churu districts, leading to further decimation of its stands, while *Z. nummularia* was excessively exploited for pala, leading to its failure to regenerate properly (Fig. 21). Common trees and shrubs like *Tecomella undulata, P. cineraria, Salvadora oleoides* and *Capparis decidua* were only slightly affected by drought anywhere. In the CAZRI-adopted villages, fields where Khejri (*Prosopis cineraria*) trees were present, appreciable quantity of leaf fodder was harvested for the livestock. Also, farmers collected pods of Khejri (called sangri), for use as a vegetable (Table 21).

Table 21. Yield of leaf fodder and pod from *Prosopis cineraria* in CAZRI-adopted villages

Village	Leaf fodder (kg/farmer)		Sangri (kg/farmer)	
	2001-02	2002-03	2001-02	2002-03
Doli	330	401	28	20
Kharda	178	229	20	15
Dhundara	389	542	32	25
Manai	165	315	4	3
Nathu Khan ki Dhani	1075	413	14	7
Bhawad	175	100	0	0
Lunawas	825	600	5	7

Many sample villages reported non-availability of grasses, pala and loong during 2002-03, although in some villages these were partially available during 2001-02. The status of top feed resources was somewhat better in many sample villages, while bajra kadbi was grown in few. Wheat straw, which was produced dominantly in the irrigated districts, had a slightly better position. Straw production from kharif crops suffered badly, which added to the problem.

In Barmer district, there was ~40-50% reduction in fodder availability from trees, shrubs and grasses during 2002-03, leading to a very severe problem. The availability status of fodder from different grasses and shrubs in sample villages is provided in Table 22. In general the growth of grasses was almost nil or negligible, and whatever sprouted, failed to produce seeds during 2002. Growth of shrubs was stunted.

In Jaisalmer district continuous drought had a serious impact on the fodder availability. Even top-feed resources like pala and loong were difficult to get. Only 10% of the sample farmers could produce an average dry fodder of 21 q per household, and only 7% respondents had dry fodder in their stock (average 15 q per household).

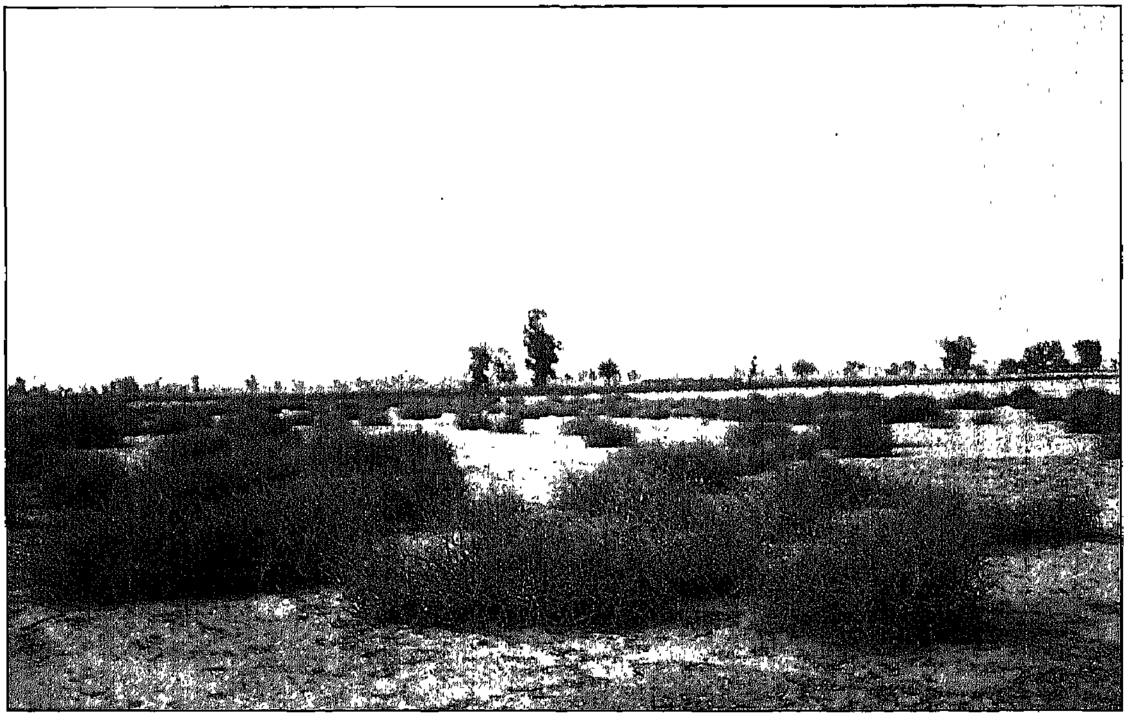


Fig. 20. Sajji (*Haloxylon recurvum*), a salt-loving plant, was cultivated by some farmers in Ganganagar district for extra income.

Fig. 21. Fuel wood collection by a farm family during drought of 2002.

Table 22. Fodder availability from grasses and shrubs in sample villages of Barmer district during 2001-02 and 2002-03

Village	Dominant grasses		Dominant shrubs	
	2001-02	2002-03	2001-02	2002-03
Derasar	Sewan (*Lasiurus sindicus*), Bhurat (*Cenchrus biflorus*), Lapda (*Aristida funiculate*), Kanti (*Tribulus terristris*), Dhaman (*Cenchrus ciliaris*)	Nil	Ker (*Capparis decidua*), Bordi (*Ziziphus nummularia*), Aak (*Calotropis procera*), Babool (*Acacia tortilis*), Thur (*Euphorbia caducifolia*), Bhu Bawali (*Acacia jacquemontii*)	Ker, Bordi, Aak, Babool, Thur, Bawari
Goniya	Sewan, Bhurat, Kuri	Nil	Bordi, Khejri (*Prosopis cineraria*)	Bordi, Khejri
Naya Nimbla	Bhakariya (*Indigofera* spp.), Bhurat, Kanti, Ganthiya (*Dactyloctenium sindicum*)	Nil	Ker, Aak, Bordi, Vilayati Babool (*Prosopis juliflora*), Khejri	Ker, Aak, Bordi, Vilayati Babool, Khejri
Dholkiya	Sewan, Bhurat, Bhakariya	Nil	Nil	Nil
Ahoniya Beniwalo ki Dhani	Kanti, Bhakariya, Bhurat	Nil	Rohida (*Tecomela undulata*), Khejri, Bordi, Aak, Vilayati Babool	Rohida, Khejri, Bordi, Aak, Vilayati Babool
Madasar	Dhaman, Sewan, Kanti	Nil	Rohida, Khejri, Bordi, Aak, Vilayati Babool	Rohida, Khejri, Bordi, Aak, Vilayati Babool
Sarvadi	Bhurat, Kanti, Bhakariya	Nil	Khejri, Bordi, Ker, Aak, Vilayati Babool	Khejri, Bordi, Ker, Aak, Vilayati Babool
Karnawas	Dhaman, Kuri, Bhurat, Ganthiya, Lapda	Nil	Bordi, Babool, Khejri, Ker, Jaal (*Salvadora oleoides*)	Bordi, Babool, Khejri, Ker, Jaal
Guda Malani	Bhurat	Bhurat	Jaal, Ker	Jaal, Ker

Churu district, which largely depends on rain-fed agriculture, and still practices traditional agro-forestry over considerable area, provided a better picture of fodder availability in its sample villages (Table 23; Fig. 22). In Jhunjhunun district loong production increased by 20-30% during the drought year.

Fodder situation in irrigated tract

Sample villages in the dominantly irrigated districts of Ganganagar, Hanumangarh and Sikar became more vulnerable in respect of grasses, pala and loong, because high intensity cropping left little fallow land and fewer stands of natural vegetation on cropland. Regeneration of commonly found *Cenchrus biflorus* and *Lasiurus sindicus* grasses was very much affected in the canal-irrigated tracts of Ganganagar and Hanumangarh districts, and sprouting of *Z. nummularia* and *C. polygonoides* was restricted. Many farmers in these two districts used part of their land for green fodder production (Fig. 23). Such a practice was also reported from the well-irrigated areas in Jodhpur, Nagaur and Jalor districts. Many farmers in Jalor district planted pearl millet and sorghum under irrigated condition during the zayad season of 2003, especially for fodder purpose.

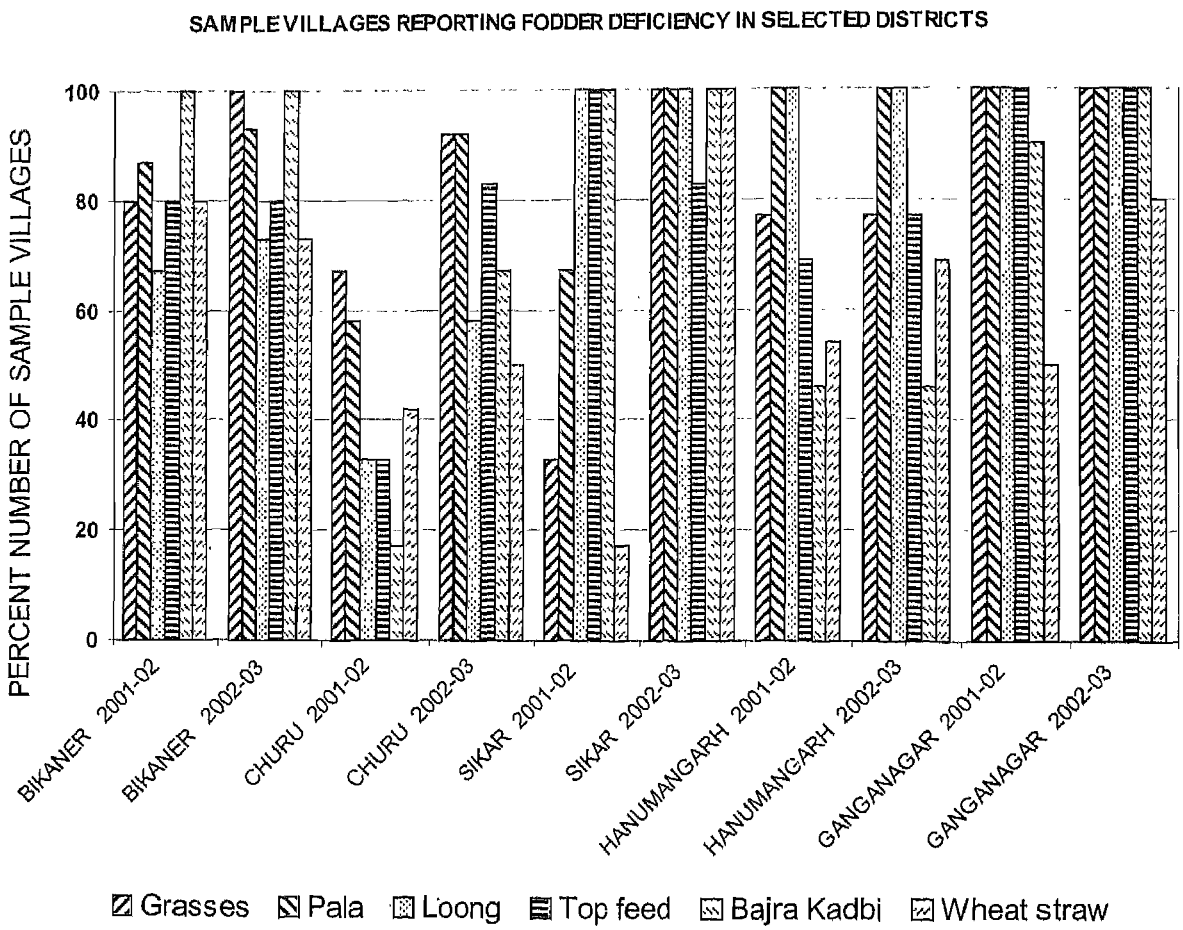


Fig. 22. Fodder deficiency reported from sample villages of selected districts during 2001-02 and 2002-03.

Enquiries on the per-family fodder availability and purchase by farmers provided interesting results. Green fodder (essentially the grasses and legumes, and top-feed resources like loong and pala) was very scarce in most villages, and dry fodder (consisting mostly of either wheat, paddy, pearl millet or lentil straw, or of the dried loong and pala) had to be purchased, save and except some quantities of bajra straw, which the farmers had in stock. There was, therefore, a very high demand of feed and fodder resources but lesser than normal supply, which governed the market price of the commodities. Because of the large gaps between demand and supply the quality of the fodder was mostly poor, and the rates were soaring high.

Table 23. Percent number of sample villages reporting fodder availability in selected northern districts of western Rajasthan

District	Year	Grasses	Pala	Loong	Top feed	Bajra Kadbi	Wheat straw
Bikaner	2001-02	20	13	33	20	0	20
	2002-03	0	7	27	20	0	27
Churu	2001-02	33	42	67	67	83	58
	2002-03	8	8	42	17	33	50
Sikar	2001-02	67	33	100	100	100	83
	2002-03	0	0	0	17	0	0
Hanumangarh	2001-02	23	0	0	31	54	46
	2002-03	23	0	0	23	54	31
Ganganagar	2001-02	0	0	0	0	10	50
	2002-03	0	0	0	0	0	20

Impact on different categories of farmers and individual families

Different categories of farmers were affected differently by the shortfall, but the resources of the medium farmers were, perhaps, a bit more stretched. For example, in Bikaner district individual farmers produced, on an average, ~55 q fodder of different kinds, had ~17 q in stock, and had to purchase, on an average, 18 q (essentially dry fodder and feed concentrates). The production varied from ~22 q for small farmers to 79 q for middle farmers and 63 q for large farmers (Table 24). The stock was, however, very low in case of medium farmers (4 q), as compared to large (24 q) and small farmers (23 q).

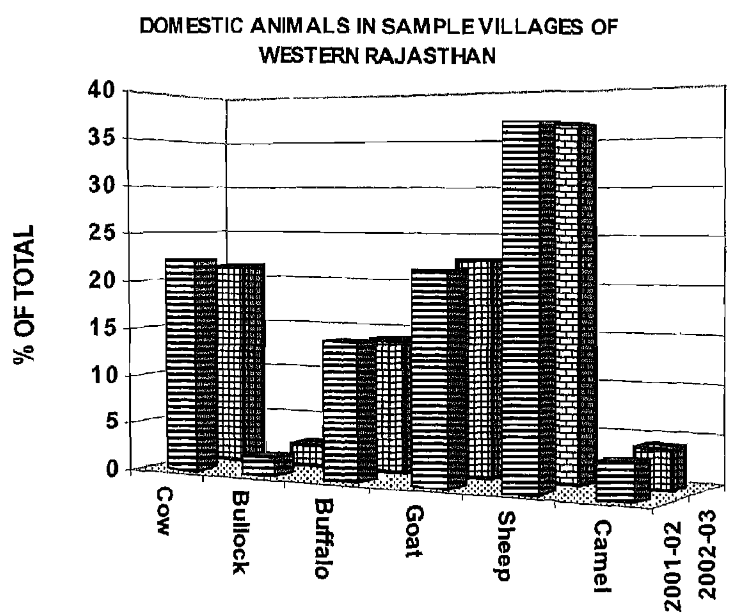


Fig. 24. Domestic animals in sample villages of western Rajasthan during 2001-02 and 2002-03.

Table 24. Feed resources available during 2002-03 in sample villages of Bikaner district

Item	Farmer category	Produced (q)	Stock (q)	Sold (q)	Purchased (q)	Deficit (%)
Feed concentrate	Large	0.0	2.0	0.0	25.9	100.0
	Medium	0.0	0.0	0.0	33.0	100.0
	Small	0.0	0.0	0.0	6.4	100.0
	Average	0.0	0.7	0.0	21.8	100.0
Dry fodder	Large	89.5	75.4	0.0	62.1	97.0
	Medium	13.0	13.0	0.0	64.8	100.0
	Small	10.3	8.8	0.0	25.0	100.0
	Average	37.6	32.4	0.0	50.6	99.0
Green fodder	Large	147.5	0.0	0.0	0.0	100.0
	Medium	300.0	0.0	0.0	0.0	100.0
	Small	76.7	80.0	0.0	0.0	100.0
	Average	174.7	26.7	0.0	0.0	100.0
Top feed	Large	12.8	19.3	0.0	0.0	97.0
	Medium	3.5	1.5	0.0	0.0	100.0
	Small	1.2	3.0	1.0	0.0	100.0
	Average	5.8	7.9	0.3	0.0	99.0

In the neighbouring canal-irrigated Ganganagar district, the production figures were slightly higher, but interestingly here also the medium farmers had the lowest stock (Table 25).

Table 25. Feed resources available during 2002-03 in sample villages of Ganganagar district

Item	Farmer category	Produced (q)	Stock (q)	Sold (q)	Purchased (q)	Deficit (%)
Feed concentrate	Large	0.0	20.0	0.0	21.0	90.0
	Medium	0.0	0.0	0.0	17.2	100.0
	Small	0.0	0.0	0.0	18.5	100.0
	Average	0.0	6.7	0.0	18.9	96.7
Dry fodder	Large	91.0	94.7	0.0	64.0	80.0
	Medium	39.7	35.1	10.0	33.3	100.0
	Small	21.8	22.5	0.0	13.8	90.0
	Average	50.8	50.8	3.3	37.0	90.0
Green fodder	Large	295.6	0.0	0.0	0.0	60.0
	Medium	198.6	0.0	100.0	0.0	88.8
	Small	71.7	0.0	0.0	0.0	100.0
	Average	188.6	0.0	33.3	0.0	82.9
Top feed	Large	0.0	0.0	0.0	0.0	100.0
	Medium	0.0	0.0	0.0	0.0	100.0
	Small	30.0	30.0	1.0	0.0	100.0
	Average	10.0	10.0	0.3	0.0	100.0

In the southern part of the desert, average farm families in Barmer district did not have any feed and fodder in stock during 2002-03, and purchased on an average 30 q dry fodder and 7 q feed concentrate. The medium farmers had to buy the maximum dry fodder and feed concentrate (38 q and 7 q per family, respectively), as compared to 24 q and 6 q, respectively, by small farmers, and 28 q and 7 q, respectively, by large farmers. In the neighbouring Jalor district fodder situation was found to be better, as an average farm family purchased only 9 q dry fodder, the figures ranging from 8 q (medium farmer) to 9 q (small and large farmer). Apart from purchasing the fodder, individual farmers had also to purchase at a premium feed concentrates, especially for the milch animals.

In Jaisalmer district 56% of the respondents had to purchase dry fodder, the average per household being 34 q. The requirement per household was estimated at 106 q, thus leaving a wide gap between the requirement and availability of fodder per household (Table 26). The most preferred dry fodder was wheat straw (92% respondents), followed by pearl millet straw and pulses straw (4% each). Among the feed concentrates feed blocks were the most sought after (75% respondents), followed by Pashu Ahar (23%). The average requirement of feed concentrate in sample households was ~16 q, which could be met by only 27% of the respondents.

Table 26. Average fodder/feed availability per household in sample villages of Jaisalmer district and purchased

Fodder/feed	Number reported	Average per household	
		Quantity (q)	Price (Rs.)
Dry fodder			
Produced	19	21	5539
Sold	0	0	0
Stock	13	15	4127
Purchased	105	34	10465
Requirement	171	106	31172
Deficit	160	87	24750
Feed concentrates			
Produced	0	0	0
Sold	0	0	0
Stock	12	3	1902
Purchased	50	20	14626
Requirement	157	16	11316
Deficit	135	14	11290

Fodder and feed distribution

Looking to the enormity of the problem, state government opened a large number of fodder depots in the districts, subsidised the cattle feed and arranged for their distribution in the different districts (Table 27). Maximum number of fodder depots was opened in Jodhpur district, followed by Barmer, but the maximum fodder was distributed in Barmer district, followed by Bikaner and Churu districts. Also, the state introduced a subsidy @ Rs. 2000 ha^{-1} for the farmers, who would grow fodder more than the area sown during the previous Rabi season. Support price for oat @ Rs. 80 q^{-1} and @ Rs.110 q^{-1} for barseem and Rijka were announced for the most scarceity-affected districts. Encouraged by this announcement, farmers produced 3.643 million tonnes of fodder between December and March. Such a strategy is needed at the beginning of the kharif season to ensure fodder production in case there is normal monsoon, and for stocking for the next monsoon if the rains fail.

Table 27. Fodder and feed distribution in western Rajasthan during 2002-03

District	Number of fodder depots opened	Quantity of fodder distributed (tonnes)	Number of cattle benefited from cattle feed distribution
Barmer	478	440946	68740
Bikaner	396	213786	56000
Churu	256	223093	30000
Ganganagar	2	8	0
Hanumangarh	25	23773	0
Jaisalmer	324	134431	45000
Jalor	132	47695	16611
Jhunjhunun	124	35662	0
Jodhpur	555	145727	58320
Nagaur	165	35707	10000
Pali	328	83508	31985
Sikar	22	7373	2396
Total	2807	1391709	250312

Source: Govt. of Rajasthan.

Cost of feed resources

The purchase of feed and fodder cost the farmers much higher than during normal times. For example, the price of dry fodder shot up to Rs. 300-400 q^{-1}, as compared to ~Rs. 200 q^{-1} during normal years. Grasses were almost non-existent, but wherever marketed, fetched a price of ~Rs. 500 q^{-1}, while the average price of loong increased to Rs. 700 q^{-1}. Feed concentrates were also being sold at ~Rs. 700 q^{-1}. The medium farmers appeared to have spent higher than the other two categories of farmers. For example, in sample villages of Jodhpur district an average farmer had to spend ~Rs. 10500 on fodder. Medium farmers kept proportionately more number of livestock than the small and large farmers, and so had to spend on an average ~Rs.14100, as compared to ~Rs. 7700 by small farmers, and ~Rs. 9900 by large farmers. This pattern of an average medium farmer spending more on feed and fodder resources was found replicated in the sample villages of Nagaur, Barmer and Bikaner districts also, but not in districts like Ganganagar and Jalor, possibly due to the compulsion of large farmers in Ganganagar to feed their dominantly bovine population, and due to not so acute fodder situation in Jalor (Table 28). The pattern of medium farmers spending more in the dominantly rainfed districts suggests more severe stress on their economy than the actual numbers indicate. Medium farmers have lesser resources and lower purchasing power than the large farmers, and hence, in his compulsion to spend more than the large farmers or even almost similar to them possibly makes his economy more vulnerable in real term.

Table 28. Amount (Rs.) spent on dry fodder purchase by an average farmer of different categories in sample villages of western Rajasthan

District	Large farmer	Medium farmer	Small farmer	Average
Bikaner	18630	19440	7500	15190
Barmer	8532	11325	7080	4660
Jodhpur	9925	14063	7650	10546
Nagaur	7369	8095	2375	5947
Jalor	2678	2357	2614	2550
Ganganagar	19200	9990	4140	11100

Livestock keeping by farmer categories

The higher spending by medium farmers on livestock feed resources in sample villages could be due to the higher number of livestock they were keeping. For example, in Barmer district average number of livestock kept by medium farmers was 41% during 2002-03, as compared to 32% by small farmers and 27% by large farmers (Table 29).

Table 29. Average number of livestock kept by farmers in sample villages of Barmer district

Livestock	Small farmers		Medium farmers		Large farmers	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Cow	4.0	3.3	7.1	4.3	4.5	2.8
Buffalo	2.4	1.9	2.0	2.0	2.4	2.2
Goat	5.0	4.0	13.0	8.0	8.5	5.5
Sheep	50.0	30.0	51.2	29.4	35.0	11.0
% of total in village	25.6	31.8	45.5	41.3	28.9	26.9

In neighbouring Jaisalmer district, 98% of the sampled households reported keeping livestock in 2001-02, and 96% in 2002-03. The per-household mean animal number was 83 in 2001-02 (range 1-635), which was reduced to 27 in 2002-03 (range 1-431). Cattle were kept by 89% respondents during 2001-02, and by 87% during 2002-03. The next in preference was goat (75% respondents in both the years), followed by sheep (36% during 2001-02 and 27% during 2002-03) and camel (33% during 2001-02 and 26% during 2002-03). Such a drastic reduction in livestock was a major impact of the drought.

Status of Livestock Population

The worst sufferers during drought are the animals, including the domesticated ones. Enumeration of the dominant livestock population, consisting of cow, bullock, buffalo, goat, sheep and camel in sample villages of Bikaner, Barmer, Jalor, Sikar, Jhunjhunun, Hanumangarh and Ganganagar districts revealed a reduction in the total livestock during 2002-03 by 26.4% from the total in 2001-02. The percentage reduction was the maximum in case of cow (-30.4), followed by buffalo (-27.9), sheep (-25.9), goat (-23.8) and bullock (-15.1). Barmer district reported maximum reduction in 2002-03 from the district's total in 2001-02 (-34.9%), followed by Bikaner (-29.9%), Jalor (-25.4%), Hanumangarh (-24.4%), Ganganagar (-21.1%), Sikar (-18.2%), Jhunjhunun (-17.2%) and Churu (-5.7%). It is significant to note that the western districts of Barmer and Bikaner suffered the most in terms of animal mortality, as compared to the eastern districts like Churu, Sikar and Jhunjhunun, which were least affected. Camel population showed a decline of >25% in the sampled villages of Bikaner, Hanumangarh and Jalor districts (Table 30).

Table 30. Percent change in livestock from 2001-02 to 2002-03 in sample villages of selected districts in western Rajasthan

District	Cow	Bullock	Buffalo	Goat	Sheep	Camel	Total
Barmer	-31.1	-21.4	-8.6	-29.2	-46.0	-9.9	-34.9
Bikaner	-33.5	-28.9	-40.6	-26.2	-27.2	-27.8	-29.9
Churu	-5.0	-8.1	-7.9	-2.3	-9.1	-8.6	-5.7
Sikar	-32.8	-12.8	-16.7	-15.6	-16.1	-4.9	-18.2
Jhunjhunun	-80.7	0.0	-36.1	-8.3	+ 7.7	-6.5	-17.2
Pali	-37.8	-10.6	-11.3	-10.3	-13.0	-1.0	-15.0
Jalor	-41.1	-44.7	-11.1	-26.9	-24.0	-26.8	-25.4
Hanumangarh	-20.5	-0.4	-28.6	-23.0	-24.6	-37.5	-24.4
Ganganagar	-24.4	-19.8	-29.1	-29.1	-12.6	-4.4	-21.1

The pooled average reduction in the different categories of animals in sample villages across the districts was between 23 and 29 per cent, except in case of the bullocks, which recorded a reduction of ~15%, though their numbers were a mere 2% of the total livestock in both the years. Pooled data also reveal that at 36% of the total in each of the two years, sheep continued to be the major head in the sample villages despite large-scale mortality, followed by goat and cow population (~22% each in both the years). The relative contribution of buffalo population was ~14% in the two years, while that of camel and bullock populations were about 4 and 2 per cent, respectively (Fig. 24).

Sale of animals

In almost all sample villages young kids of sheep and goats were sold in larger number than during normal years, but fetched much lower price than in normal years. In Sikar district small farmers were reported to have left their unproductive cows to fend for themselves, but buffaloes were taken care of. In Jalor district cow population was decimated by 41%, maximum reduction being reported from Ahor and Jalor tehsils, which accounted for ~75% reduction. In most cases the cows were not sold in the district, but were left to the cattle camps and Gaushalas run by different civil societies. Some perished due to hunger and malnutrition. Buffaloes were sold in lesser number, because the milk production from buffaloes was 3-10 L day^{-1}, which was higher than that from cows.

Decline in camel population

Camel is considered to be the ship of the desert. Therefore, decline in its population in sample villages of all the districts is surprising. Opinion survey in many villages suggested that reduction in camel population was continuing for more than a decade due to automobiles replacing camel carts as the major form of rural transport, dwindling land for camel grazing and high demand for camel meat in the Middle East countries. Faced with such circumstances many villagers, especially the Raikas who are the traditional keepers of large camel herds, are selling their camels in large numbers at animal fairs.

Inter-census variations in livestock population

Comparison of livestock census of western Rajasthan for 1997 and 2003 reveals an overall decline of 18%, which is partly due to the drought years in between, but also suggests a gradual shift in the composition of domestic animals. The most prominent negative changes were in respect of camel and sheep populations, while buffalo population showed a rise (Table 31).

Camel: Camel population in western Rajasthan had reached its pinnacle of 639000 during the 1977 and 1983 animal census, but continued a gradual downslide thereafter, and was 535000 during 1997 census (16% decline from 1977). The estimated decline from 1997 to 2003 was 26%, which is alarming. Ganganagar district reported the largest reduction of ~63%, followed by Nagaur (41%), Barmer (39%), Churu (36%) and Jalor (34%).

Table 31. Changes (%) in livestock population in western Rajasthan between 1997 and 2003 census

District	Cattle	Buffalo	Sheep	Goat	Camel	Others
Barmer	-0.1	+40.7	-29.4	-21.8	-38.9	-20.9
Bikaner	+8.7	+24.1	-19.1	+6.9	+1.4	+33.2
Churu	-34.6	-6.0	-40.6	-28.7	-35.9	-12.7
Ganganagar	-29.3	-19.2	+16.1	+10.6	-62.6	-7.0
Hanumangarh	-16.6	-5.6	-25.6	-36.2	+61.9	+33.1
Jaisalmer	-21.5	+120.5	-26.3	-34.1	-14.1	-42.2
Jalor	-14.0	+12.8	-20.7	-3.37	-33.5	-20.8
Jhunjhunun	+0.7	+7.3	-27.1	-4.1	-18.4	-0.3
Jodhpur	-22.3	+3.6	-43.3	-20.1	-29.7	-15.0
Nagaur	-25.5	-3.9	-36.3	-0.5	-40.9	+6.5
Pali	-30.7	-8.9	-34.8	+4.3	-8.2	-10.2
Sikar	-8.4	+10.6	-22.5	+13.2	-26.6	+54.8
Total	-17.0	+1.5	-29.9	-12.2	-25.7	-7.0

Source: Govt. of Rajasthan.

Sheep and goat: Apart from camel, sheep rearing is also fast becoming a losing proposition due to scarce grazing resources, stiff competition from synthetic wool and problems during animal migration. Sheep are more vulnerable to environmental stress, while goats, which are browsers, can adjust to many adverse situations. Consequently, decline in the grazing/browsing resources has less effect on goat population than on sheep population. Also, as demand for meat is increasing, the market for goat is also increasing. While the sheep population in western Rajasthan declined by ~30% between 1997 and 2003 census, goat population declined by only 12%. Churu, Jodhpur, Nagaur and Pali districts suffered the most. Goat population declined more in Hanumangarh and Jaisalmer districts, but increased in Sikar, Ganganagar, Bikaner and Pali districts. Much of the decline in goat population during the 2002-03 drought was due to sale.

Status in Barmer and Jaisalmer districts

In Barmer and Jaisalmer districts, which are dominated by the traditional livestock-based farming systems and pastoralism, some major shifts in animal composition were seen between the two census years. In Barmer district the overall livestock population suffered a decline of 21% from the 1997 level. The largest reduction was in camel population (39%), followed by reduction in sheep (29%), and goat (22%) populations. The cattle population remained almost unchanged between the two census years. Its contribution to the total livestock, however, increased from 13% in 1997 to 17% in 2002. The most significant change despite three severe drought years between the census years 1997 and 2002 was a rise in buffalo population by 41%, although its contribution in total livestock population of the district during 2003 was still a meagre 4%. In 1997 its contribution to total livestock population was 2%.

In the neighbouring Jaisalmer district the overall decline in livestock population between the two census years was 28%, the maximum decline of 34% taking place in goat, followed by sheep (26%) and cattle (21%). By contrast, buffalo population increased by 120%, but their number was only about 0.1% of the total livestock in the district. Significant decline in livestock population also took place in Churu, Jodhpur and Pali districts that are dominated by mixed crop-livestock based farming systems.

Why buffalo population

The fast increase in buffalo population possibly reflects a paradigm shift in the farmer's perception of the role of bovine population in farm economy. Buffalos are perceived to be superior to cows in terms of average milk yield, its saleable quality and efficient feed conversion. Therefore, wherever irrigation facilities made changes in traditional land use and assured the water and fodder availability, buffalo population has started a rising trend. Complementary developments in transport network, dairy industry and sale outlets are strengthening the case for buffalo in a market-driven economy. Opinion survey in the villages where CAZRI was demonstrating its technologies revealed that about 90% farmers were interested to buy buffaloes, while only 10% were interested in keeping cow. It is significant to note that sample villages in the two southern districts of Barmer and Jalor reported least decline in buffalo population as compared to the other animals.

Animal Migration

Animal migration is an annual ritual in many villages across western Rajasthan. Usually animal migration starts during October-November every year and the flocks return to the village by March next year. During 2002-03 migration of animals from the western districts of the desert was higher than that during 2001-02. Despite this, the initial response to the drought was one against migration. This was because of widespread failure of rainfall. Neighbouring states like Haryana, Punjab, Gujarat, Uttar Pradesh and Madhya Pradesh, which usually supply fodder to Rajasthan during scarcity period, received less rain during the first half of the monsoon that diminished fodder production. As the news spread, pastoralists restricted their outward movement along traditional routes, leading to pressures on the existing resources. Fortunately, with time, drought situation eased somewhat in the neighbouring states, and it was possible for the state to get fodder.

Migration routes

In Bikaner district 14 out of 15 sample villages reported animal migration during 2002-03. About 85% of the sheep and 78% of goat population were reported to be on migration, the most favoured destinations being Punjab and Haryana. About 4% of the cow population was also taken on migration. No migration took place in case of bullock, buffalo and camel. In Churu district animal migration was restricted to sheep and goat only, and the number was slightly higher than during 2001-02, the most favoured destination being Haryana. The migration routes from major localities in Bikaner district are shown in Fig.25.

1. Kolayat → Suratgarh → Bhatinda → Rohtak → Bhiwani → back
2. Lakhusar → Ganganagar → Pilibanga → Ambala → back
3. Pugal → Chatargarh → Suratgarh → Hanumangarh → Ailanabad → Sirsa → back
4. Lunkaransar → Suratgarh → Ganganagar → Bhatinda → back
5. Lunkaransar → Suratgarh → Chak 7880 → back
6. Lunkaransar → Suratgarh → Malot → back
7. Lunkaransar → Suratgarh → Bhatinda → back
8. Lunkaransar → Suratgarh → Pilibanga → Hanumangarh → back
9. Sattasar → Anupgarh → Raisinghnagar → Ganganagar → Bhatinda → back

Fig. 25. Animal migration routes from key villages in Bikaner district.

In Barmer district, migration of small ruminants is an annual activity, the most favoured routes being towards Gujarat and Madhya Pradesh. Among the sample villages of the district, Guda Malani, Karmawas and Dholkiya reported very high migration during 2002-03. In Jaisalmer district out-migration of sheep, goat and cattle started from July 2002 onwards, the major flux taking place between September and November. Migration was also reported in January and February 2003. The major routes followed were (1) towards Ahmedabad through Barmer and Jalor districts; (2) towards Amritsar through Bikaner and Ganganagar districts; (3) towards Hisar through Jodhpur, Nagaur, Sikar and Jhunjhunun districts; (4) towards Mathura through Jaipur and Alwar districts; and (5) towards western Madhya Pradesh through Jaipur and Kota districts. In-migration to Jaisalmer district started from December 2002, and continued till July 2003. The major flux was during March, April and July.

In Pali and Jalor districts annual migration of small ruminants takes place towards Haryana, Gujarat, Madhya Pradesh and Uttar Pradesh. In 2002-03 about 50% more sheep and goats were taken on migration from sample villages of these districts than during 2001-02, because many households sent their animals with the migrating flocks.

In Jodhpur district, ~30% sheep and goat population from the unirrigated sample villages were sent on migration; no migration took place from the irrigated villages. In Nagaur district none of the sample villages reported animal migration, but this does not suggest that migration did not take place from the district. In Ganganagar district only two sample villages of Patroda and Rojri reported animal migration (Table 32).

Table 32. Animal migration from two sample villages in Ganganagar district

Animal	Year	Unit	Village	
			Patroda	Rojri
Cattle	2001-02	(Number)	50	1800
	2002-03	(Number)	100	2000
	Change	(%)	100	11
Sheep	2001-02	(Number)	70	1500
	2002-03	(Number)	100	1600
	Change	(%)	43	7
Goat	2001-02	(Number)	200	1800
	2002-03	(Number)	250	2000
	Change	(%)	25	11

Cattle migration: Rojri was the only sample village in Ganganagar district reporting large-scale migration of cattle and represented the pattern in western part of the district (Fig. 26). Other sample villages reporting significant cattle migration during 2001-02 and 2002-03 were Sattasar (1000 and 1000, respectively), Kallu (500, 500) and 5-PB (300, 400) in the northern part of Bikaner district. Jaisalmer district also reported a significant number of cattle migration.

Pastoral communities

Animal migration in western Rajasthan is typically controlled by some castes practicing animal grazing. In Barmer district, the dominant castes are the Bhils, Muslims and Rabaris, while in Bikaner district Raikas, Rebarai, Gujjar and Bhil-Raika are the major ones. In Pali-Jalor area

Fig. 23. Production of green fodder in irrigated tract of Ganganagar district.

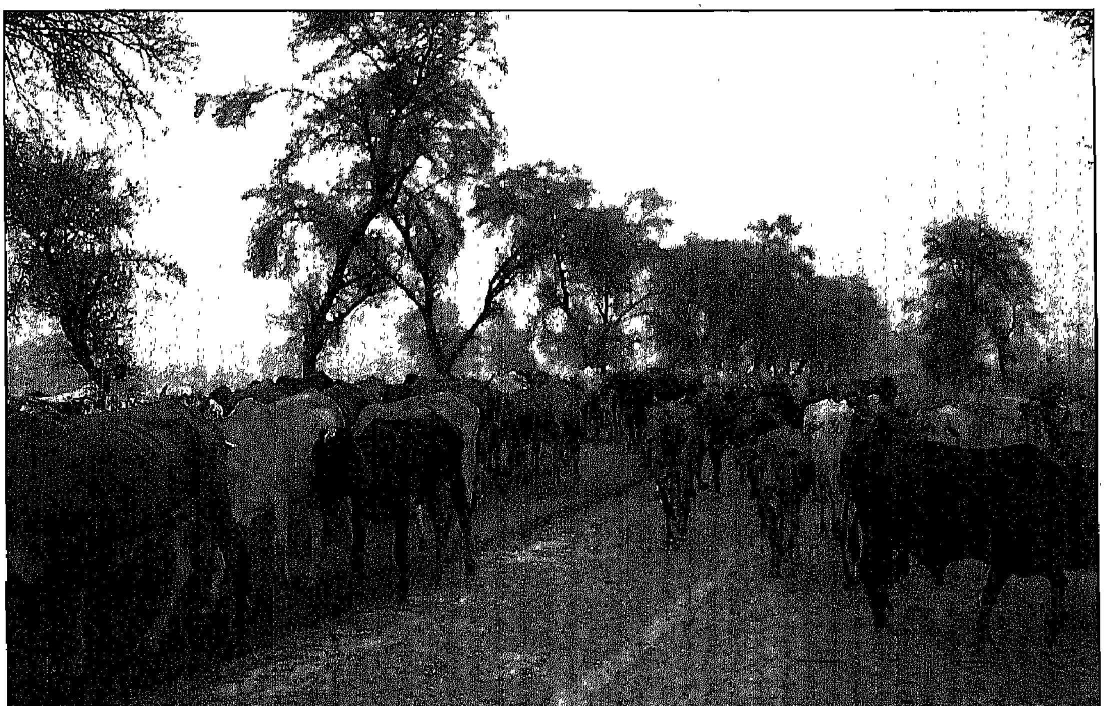


Fig. 26. Cattle migration from Ganganagar district during 2002 drought.

the major casts controlling animal migration are the Raikas, Rebaris, Gujjars and Bhil-Raikas, while in Churu district it is controlled by Jat, Rajput and Meghwal.

Migration period was found to be different for the different communities. Discussion in sample villages of Pali district revealed that the Raika-Rebaris usually leave their villages between December and April, and return by next July, when the monsoon sets in, while the Bhils usually leave by November and return by next August. Raikas prefer to leave by September-October and return by next July.

Herding charges

Charges for herding small ruminants from the village of the grazier usually vary from Rs.10-20 per animal, but were reported to be as high as Rs. 50-60 per animal for other villages. In contrast to migration on foot in most sample villages across western Rajasthan, use automobile transport for migrating animals to greener pastures in Punjab and Haryana, was reported from parts of Bikaner district, especially by the large farmers and animal raisers. The average transportation charges were Rs. 20-30 per small ruminant and Rs. 150 per cattle.

Issues of Grazing and Fodder Availability

Grazing by animals is fast becoming a major societal issue in rural areas of western Rajasthan that often reaches a flash point. With increasing population, fragmentation of croplands, and decreasing fallow there is now fewer areas left for uncontrolled grazing by the large herds of sheep and goats (Fig. 27). Most of the permanent pastures (Orans and Gochars) in the region are in a severely degraded state that makes condition worse. Pastoralists who take their animals on annual migration to the greener parts of the state and outside are facing increasing resistance from the farmers, which sometimes lead to clashes. Opinion on this important social issue was, therefore, sought from respondents during the primary village survey.

Grazing issues in Jaisalmer district

In Jaisalmer district, where traditional rural economy has a strong dependence on livestock production system, about 57% respondents showed their concern to shrinking grazing areas. The major change that has been viewed as detrimental to grazing is the conversion of vast natural grassland in northern part of the district, especially in Bahala – Mohangarh – Ramgarh – Sultana area, to irrigation command. The area was till recently a rich source of *Lasiurus sindicus*, *Panicum turgidum* and *Eleusine compressa* grasses that used to be frequented by the pastoralists of the region. About 45% respondents felt that fencing of the Desert National Park in the western part of the district, especially in Satta-Myajlar-Khuri area, and restrictions put by Forest Department on grazing in the park area is a major hindrance to grazing, while 44% respondents blamed the apathy towards the deteriorating conditions of the Orans and their illegal occupation in many villages as a cause for concern. All the three problems are area-specific, and need to be addressed locally for enhanced fodder production and bringing stability to the important livestock production system of the district. Respondents in the district also felt that increase in grazing fees in 'forest areas', which is imposed by the Forest Department from time to time, needs to be reviewed in the light of the fact that enough grazing resources are not available despite paying the demanded fees. The fees should match the resources made available to the graziers.

Grazing issues in Bikaner district

In the neighbouring Bikaner district, which also has a large dependence on livestock production system, ~36% respondents opined that perennial grasses and shrubs should be introduced for fodder availability. Also, 30% respondents suggested that encroachments on the Orans should be vacated, and their conditions improved through perennial grasses, along with development of the vast wastelands in the district. Non-command areas within the Indira Gandhi Canal command should be put under fodder production. Sand dunes and other wastelands should be developed for fodder, fuelwood and other economically important plants.

Grazing issues in Pali district

In Pali district about 80% of respondents reported that shrinking grazing lands and deteriorating conditions of the Orans were the major causes of animal migration and death. Also, ~8% respondents, mainly the herders, spoke about not being allowed to graze animals in the forest areas. Herders also complained that in most villages farmers now do not allow the animals to graze even in the fallow lands, fearing their intrusion in the cropped areas. Dislike of the farmers to grazing by the migrating animals has also been reported from other districts.

Prospect

The issues are serious in the sense that animal husbandry is a major source of income in the region. Recurrence of drought, changing land use and increasing demands from the land are also the realities of the time, in which the traditional pastoralism has found its niche that supports and helps running the livestock production system. Despite changing agricultural scenarios in the region pastoral practices have not died, as was expected in some quarters, and would most likely continue to thrive with adjustments to the changing scenarios (Robbins, 2004). Therefore, practices that do not encourage grazing, and that affect the fodder availability would most likely harm the economy of the region.

Animal Mortality

Drought of 2002 had a modest toll of domestic animals of all kinds. As feed resources became scarce from the end of kharif season and water sources began to dry up, villagers first tried distress sale of the vulnerable animals, especially cattle, buffalo, sheep and goat. Reduction in buffalo population in sample villages of Barmer and Bikaner districts was because of distress sale only; no mortality of buffalo and camel was reported from any sample village of the two districts.

Leaving cattle to their fate

Cattle population recorded a high reduction in almost all the districts, mainly due to shortage of water and fodder, although distress sale was another factor. Many farmers were compelled to let loose the cattle when they were unable to find any kind of fodder, and this resulted in casualties from hunger, thirst and associated diseases. Such a practice is common to the region, especially during major droughts, as was noticed during the long drought of 1984-87.

Some farmers were able to send their cattle on migration, while many others nearer to cattle camps left their infirm and unutilizable cattle to the camps. Buffaloes and milch cows received preference over others in getting home-care. Selling the cattle for culling was the last option, and was exercised in acute distress only.

Death during migration

In many villages sheep and goat were sent on annual migration, but this did not prevent drought-related mortality. In Jaisalmer district respondents reported the death of 1472 sheep, 222 goats and 8 cattle during migration.

Diseases

In sample villages of Pali district at least 10% animals, mostly sheep and goats, died due to foot-and-mouth disease (FMD) during migration. In Churu district animal mortality during migration period was reported to be lesser than during non-migration period. Sheep perished in larger number than goats during migration; hunger, malnutrition and FMD were reported to be the major causes. Sample villagers opined that excepting sheep mortality, there was lesser death of animals during 2002-03 than during 2001-02. In Ganganagar district 10-20% of cattle, sheep and goats in two sample villages were reported to have died due to diseases during migration, while in Bikaner district diseases like pneumonia, FMD, skin disease, PPR (paste des petit ruminant), bottle jaw, etc. took about 20% casualty of the migrating sheep, goats and cattle. The major diseases of migrating animals reported from sample villages of Bikaner district are listed in Table 33.

Table 33. Major diseases of migrating animals from sample villages of Bikaner district

Village	Major disease	Animals affected	Mortality (%)
Lakhusar	FMD, PPR, Pneumonia, Skin diseases	Cattle, Sheep, Goat	> 20
Jhajju	FMD, Skin disease, PPR	Sheep, Goat	20
Siyana	Pneumonia, skin disease	Sheep, Goat	20
Gosainsar	Pox	Cattle, Sheep, Goat	20
Mundsar	Pox, bottle jaw	Sheep, Goat	10
Bithnok	Pneumonia, Pox	Sheep, Goat	20
Bhikampur	FMD, Pox	Sheep, Goat	20
Amarpura	Enterotoximia, skin diseases, PPR	Sheep	20
5 PB	FMD	Sheep, Goat	10
Kakku	FMD	Sheep, Goat	15
Utmamdesar	Enterotoxin	Sheep, Goat	20
Ranjitpura	Unknown	Sheep	10
Kallu	FMD	Cattle, Sheep, Goat	10
Sattasar	Unknown	Cattle, Sheep, Goat	5

In Barmer district observations in cattle camps revealed many instances of mineral and vitamins deficiencies. Ecto-parasites like mites and bugs were found on weak cattle, while some others suffered from pica. In sample villages of Pali district diseases caused ~10% mortality, but 20% of cattle mortality was due to mineral deficiency.

Hunger, the major cause

Despite the disease-related mortality during migration, enquiries in sample villages of Bikaner district revealed that hunger and not the diseases was the major cause of drought-related animal mortality (Fig. 28). For example, in Jaisalmer district the maximum death in all the categories was because of hunger and non-availability of water. Among the non-migrating animals also the maximum deaths were reported to be due to hunger and non-availability of water (Table 34).

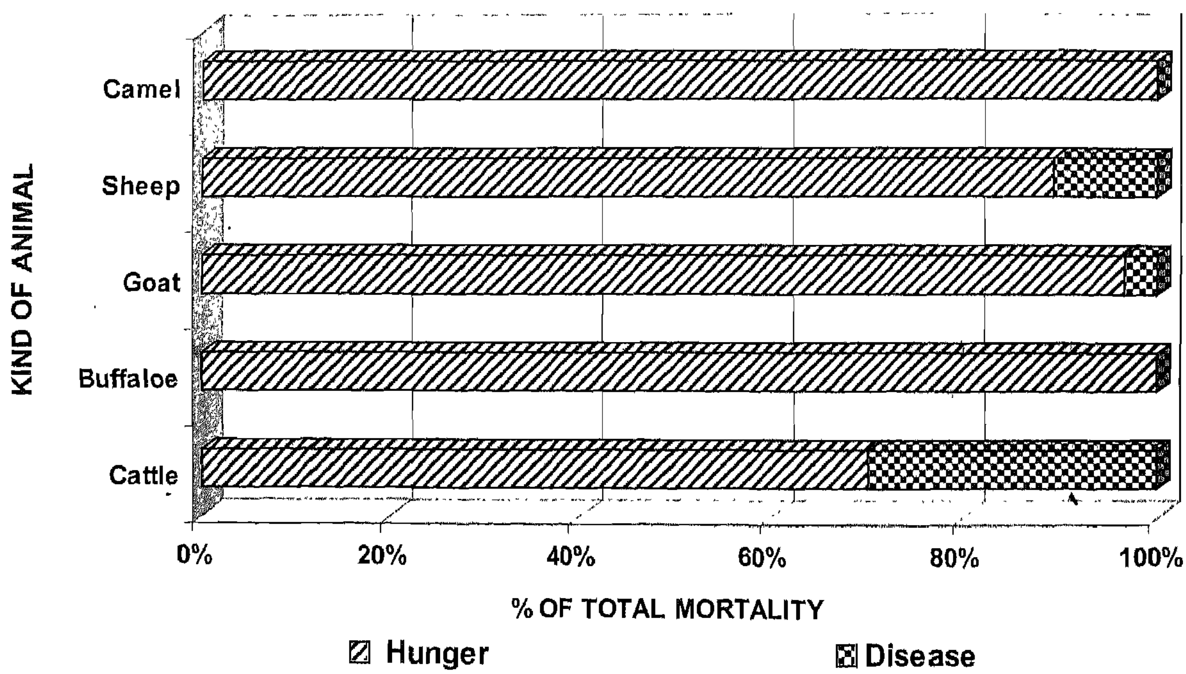


Fig. 28. Mortality of domestic animals in sample villages of Bikaner district (2002-03).

About 80% of the animal mortality in sample villages of Bikaner district and ~90% mortality in sample villages of Ganganagar district were due to hunger. In Pali district hunger and lack of water caused ~15% mortality during non-migration period. By contrast, sample villages in Churu and Sikar districts reported very few drought-related animal mortality. These districts had opened several large cattle camps where distressed cattle were left. Overall, animal mortality during 2002-03 in western Rajasthan was lesser than that during the mid-1980s.

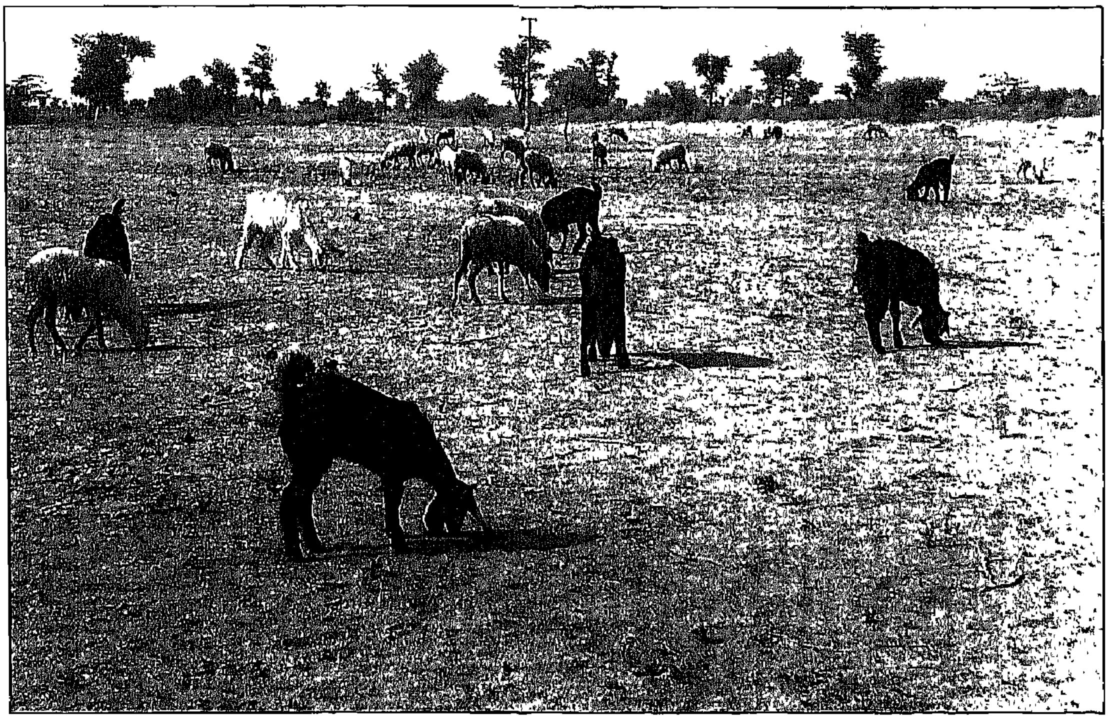


Fig. 27. Scarce grazing resources for sheep and goats.

Fig. 29. A cattle camp in Churu district.

Table 34. Mortality of livestock in sample villages of Jaisalmer district during 2002-03

Reason	Cattle		Sheep		Goat	
	Number	% of total	Number	% of total	Number	% of total
Migrating animals						
Diseases						
Foot & mouth	0	0.0	0	0.0	0	0.0
Vitamin deficiency	0	0.0	0	0.0	0	0.0
Stomach problem	0	0.0	300	20.4	10	4.5
Skin problem	0	0.0	198	13.4	56	25.2
Others	0	0.0	264	17.9	0	0.0
Hunger	8	100.0	590	40.1	66	29.7
Water deficiency	0	0.0	0	0.0	90	40.6
Other causes	0	0.0	120	8.2	0	0.0
Non-migrating animals						
Diseases						
Foot & mouth	155	3.4	92	2.2	24	0.4
Vitamin deficiency	56	1.2	135	3.3	5	0.1
Stomach problem	33	0.7	187	4.6	187	3.4
Skin problem	12	0.3	26	0.6	18	0.3
Others	24	0.5	90	2.2	13	0.2
Hunger	2325	50.4	3276	79.8	3400	61.1
Water deficiency	2001	43.4	275	6.7	1748	31.4
Other causes	6	0.1	25	0.6	168	3.0

Cattle Camps

Large-scale mortality of animals during 2002-03 was partly averted by the opening of a number of cattle camps and fodder depots (Fig. 29). A large number of cattle camps were opened with state support, especially in the Indira Gandhi Canal command area and near tube wells, where arrangement for fodder and water was made. A number of Gaushalas were also opened/strengthened.

Cost of maintaining cattle in camps

As discussed earlier, fodder depots were opened in all the districts, but considering the acute shortfall and the high demand, their numbers were not adequate to meet the demand. Many of the cattle brought to the camps were old, infirm, and otherwise unproductive, but had to be fed from the available resources. It was estimated that the monetary requirement for feeding an adult cattle for a month was Rs. 700-1000. Government subsidy per adult cow was Rs. 10 per day, and that for calf was Rs. 6 per day. This meant a sum of Rs. 360 per month for adult cattle, and Rs. 180 per calf per month. Since the market price of fodder was very high, government-managed fodder depots were not adequate, and the unproductive cattle numbers were very high, the cattle camps and Gaushalas faced enormous problem of livestock management.

Cattle benefited

An estimated 761,000 cattle were benefited from the cattle camps and Gaushalas in the region (Table 35). This was ~86% of the total cattle benefited from this programme in the state as a whole. A total of 642 Gaushalas operated in western Rajasthan, the total in the state being 868. Also, a total of 1799 cattle camps were opened in western Rajasthan, the state total being 1997 camps. In 1987-88 the number of cattle camps run in the state as a whole was 639, catering to the needs of >500,000 cattle (Misra, 1990).

Table 35. Number of cattle benefited from cattle camps and Gaushalas during 2002-03

District	Number of cattle camps opened	Number of cattle benefited	Number of Gaushala operating	Number of cattle benefited
Barmer	427	170220	18	10430
Bikaner	162	101754	31	18775
Churu	69	16002	28	8655
Ganganagar	35	8195	18	9951
Hanumangarh	42	7300	38	16266
Jaisalmer	594	120000	35	28640
Jalor	17	3820	38	43297
Jhunjhunun	14	4866	24	6535
Jodhpur	128	29829	181	47438
Nagaur	144	22600	121	21783
Pali	113	26964	57	18624
Sikar	54	7980	53	11068
Total	1799	519530	642	241462

Source: Govt. of Rajasthan.

Sources of Income

Rural livelihood in western Rajasthan is basically dependent on crops and livestock production. It gets disorganised during calamities like drought. The four major sources of income in the region are agriculture, livestock, agricultural labour and other labour activities. Agriculture with livestock farming being the dominant planks of the economy of villagers, the other sources of income, like services, business, mining, etc., are not so common. Drought of 2002 had put the farming community of western Rajasthan in a difficult situation. Crop production during kharif 2002-03 was almost negligible, save and except in few irrigated areas. Therefore, farming communities had to depend largely either on animal production system, or to seek other sources of income, like agricultural labour in neighbouring states, other labour activities in towns and cities, or wage labour in drought relief programmes. Many village folks preferred the last option because it helped people to stay nearer to their roots. According to an estimate by state government, 83.34 million man-days were lost in the state during 2002-03 due to the drought.

In sample villages the total income was found to have dropped by 25-46%. In rain-fed areas employment through drought relief programme became a major source of livelihood for the BPL households and small farmers, but in irrigated areas this income was not so prominent. For example, in Jodhpur district the average alternate income in sample villages was ~Rs.3375 per household in 2001-02, which increased to ~Rs.5458 in 2002-03. About 57% of the total (i.e., Rs.3112) was contributed by drought relief programme.

Changes in income sources

The changes in income sources of different categories of farmers during drought can best be appreciated from a comparison with the income pattern during 2001-02, as exemplified from Barmer, Churu and Hanumangarh districts (Figs. 30-32). Sample survey showed that in rain-fed as well as irrigated areas maximum income from agriculture during normal year (i.e., 2001-02) was dominantly in the hands of large farmers (52% in Barmer, 86% in Churu and 44% in Hanumangarh). The pattern remained almost the same during the drought year (2002-03) also (54% in Barmer, 86% in Churu and 44% in Hanumangarh). There was 79% reduction in income from agriculture of the sample farmers in Barmer district during 2002-03, as compared to the income during 2001-02; in Churu district the reduction was 42%, and in Hanumangarh district 13%.

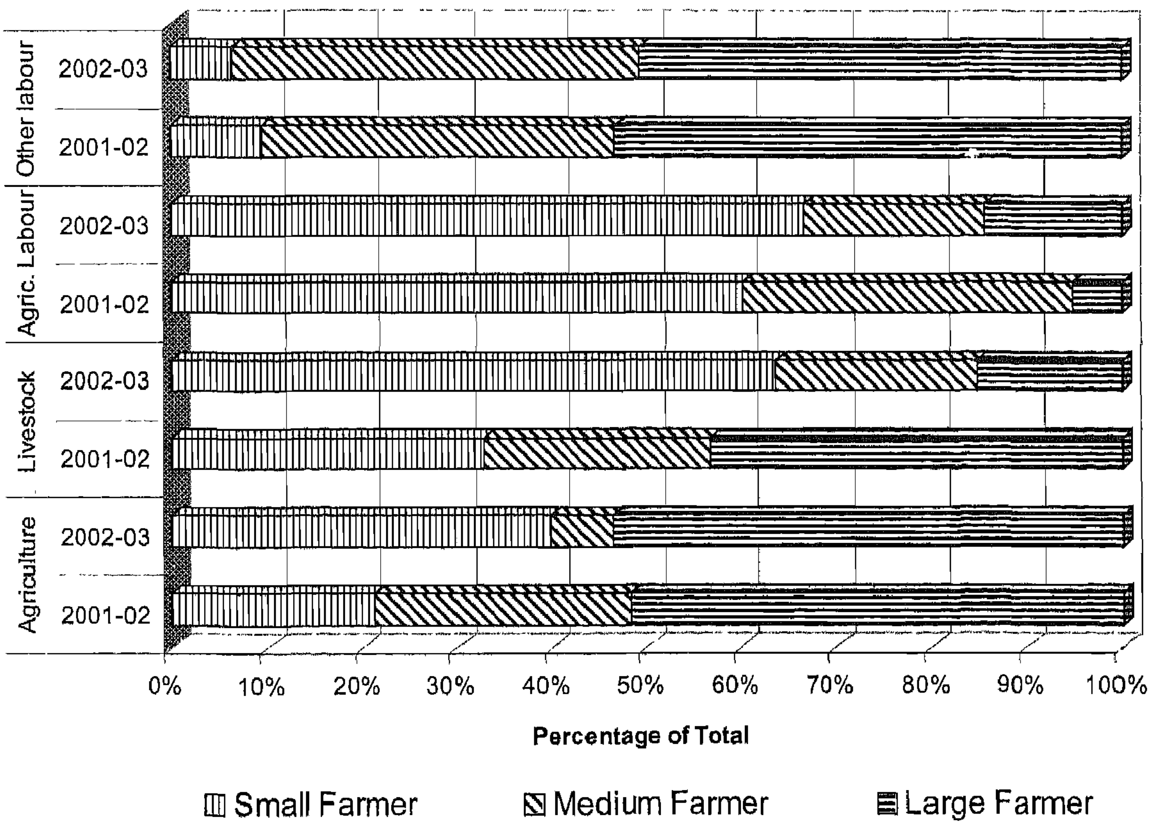


Fig. 30. Major sources of income in sample villages of Barmer district during 2001-02 and 2002-03.

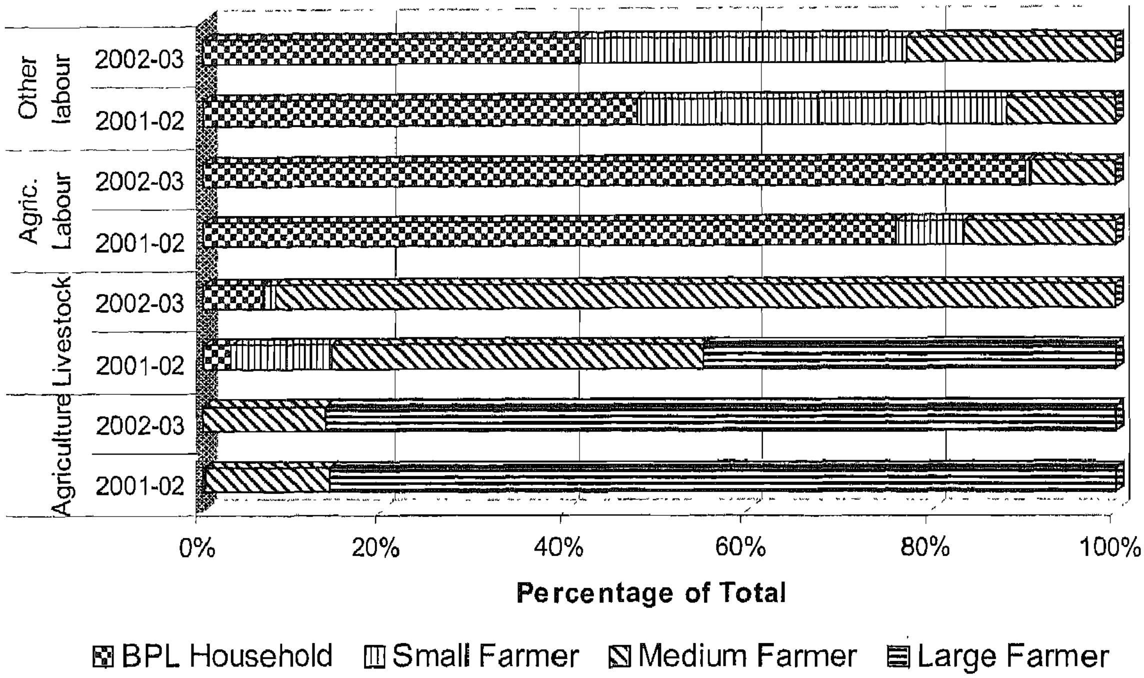


Fig. 31. Major sources of income in sample villages of Churu district during 2001-02 and 2002-03.

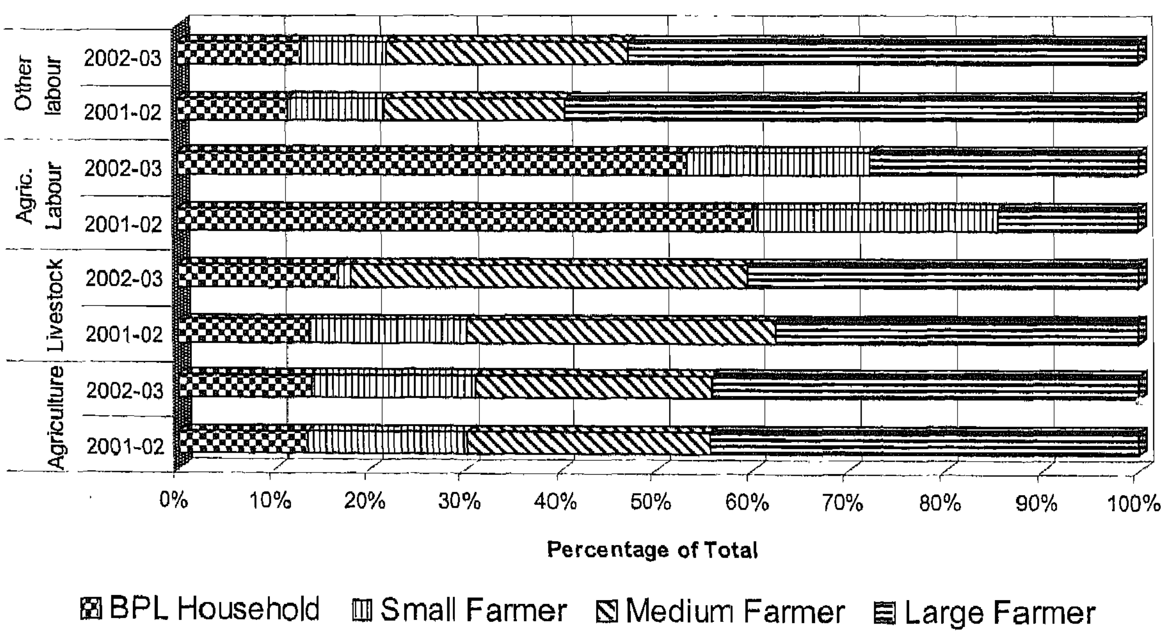


Fig. 32. Major sources of income in sample villages of Hanumangarh district during 2001-02 and 2002-03.

Income sources in Jaisalmer district

In the sample villages of very dry Jaisalmer district, agricultural income dropped from 2001-02 level by 56%, and income from agricultural labour by 77%, but livestock income declined by only 8%, which demonstrate once again the relative strength of animal husbandry in withstanding drought. There was phenomenal increase in income from drought-related work. Considering the income from agriculture, animal husbandry, agricultural labour, other labour and relief work together, but barring the income from custom hiring, mining and services, which are usually more stable, it was found that income from agriculture in 2001-02 was 70% of the total, while animal husbandry accounted for 25% of the total. Agricultural labour accounted for 3% of the total and other labour 0.6%. In 2002-03, agricultural income dwindled to 23% of the total, and that from animal husbandry to 17%. Income from agricultural labour was a mere 0.5%, but that from other labour was 33%, and from relief work 27%. The highest agricultural income by a household in the sample villages of the district during both 2001-02 and 2002-03 was from the Khadins with tube well facilities. In 2001-02 the highest income was Rs. 800,000, while in 2002-03 it was Rs. 350,000.

Income from livestock in other districts

Income from livestock was variable in the farmer groups. In Barmer district higher earning (43%) from livestock during 2001-02 was in the hands of sampled large farmers, but during 2002-03 the highest income (64%) from this sector was in the hands of small farmers, followed by medium farmers (35%). In Churu district earning from livestock sector was higher with large farmers during 2001-02 (45%), but during 2002-03 the higher income was in the hands of the medium farmers (92%). A similar pattern was noticed in the sample villages of Hanumangarh district also (38% in 2001-02 with large farmers; 42% in 2002-03 with medium farmers).

The pattern reflects relative stability of the economy of the farmers in different categories. Large farmers had requisite capital to bear the brunt of this worst drought and could keep their livestock, but the middle and small farmers could not. Consequently, distress sale was more common with the small and medium farmers. Also, milk and milk products, which normally villagers used to keep for home consumption, had to be sold for income generation, especially by the small and medium farmers. Thus, livestock provides a crucial means to withstand the drought, despite increasing the pressure on existing resources. The choice of livestock for keeping/disposal is in large measure a reflection of the economic stratification within the farming communities (see e.g., Henderson, 1999).

It is notable that in Churu district income from livestock during the drought year was maximum in case of the sampled medium farmers, whereas in Barmer district this distinction was held by the sampled small farmers. Both these categories of farmers usually keep high numbers of sheep and goats, and higher income from livestock sector being in their hands essentially suggest that failure of monsoon forced these farmers to depend largely on animals. Despite the distress sale of small ruminants and other livestock, the income from livestock sector in sample villages of the two representative rain-fed districts declined significantly. In Barmer district the reduction was by 51%, while in Churu district it was 37%. On the other hand, livestock income in sample villages of Hanumangarh district registered a marginal rise of 8%.

Income from agricultural labour

Income from agriculture labour was almost exclusively earned by the BPL households and small farmers. In Churu district BPL households controlled 76-90% of the income in this sector during 2001-02 and 2002-03, while in neighbouring Hanumangarh district BPL households controlled 53-60% of the total during the two years. Despite the severity of drought, in both the districts there was increase in the income from this sector during 2002-03 (9% in sample villages of Churu district; 33% in sample villages of Hanumangarh district). The rise in income was principally due to human migration as agricultural labour to better-endowed areas within the state and outside it, especially to the canal-irrigated areas. In Barmer district small and marginal farmers controlled 60-67% of the income in the sector in both the years, but there was 41% reduction in total income from this sector in 2002-03, as compared to that in 2001-02. Although there was large out-migration of people from the district during 2002-03, this was less related to agricultural labour.

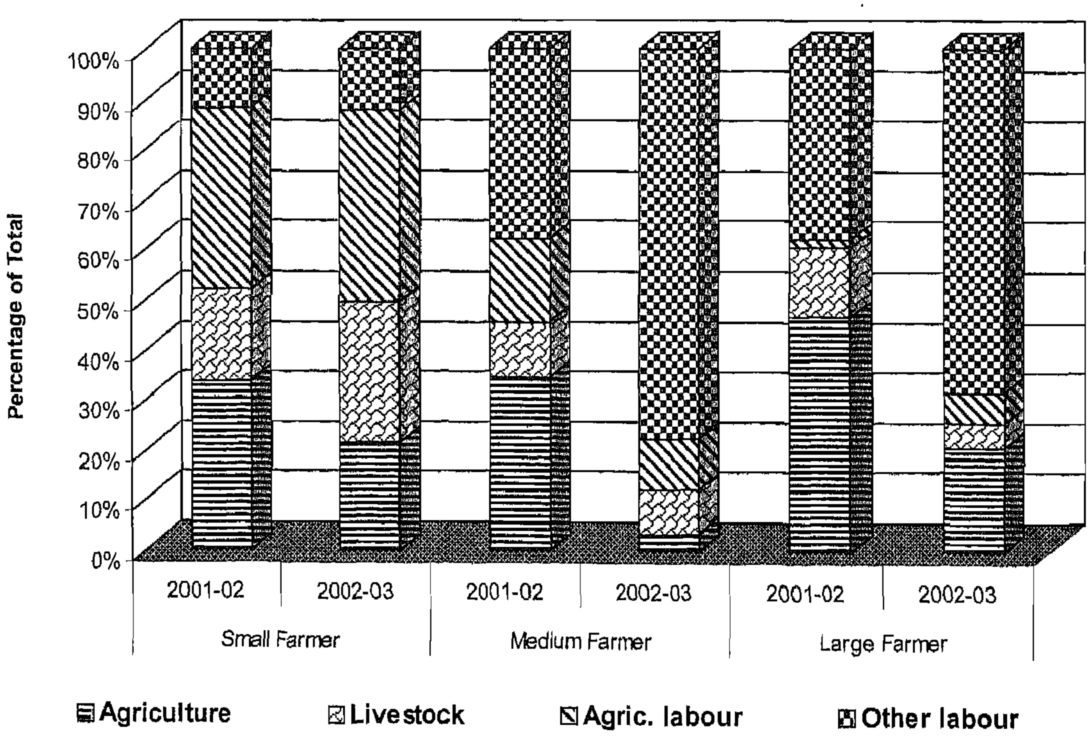


Fig. 33. Average income of sample farmers in Barmer district from different sources during 2001-02 and 2002-03.

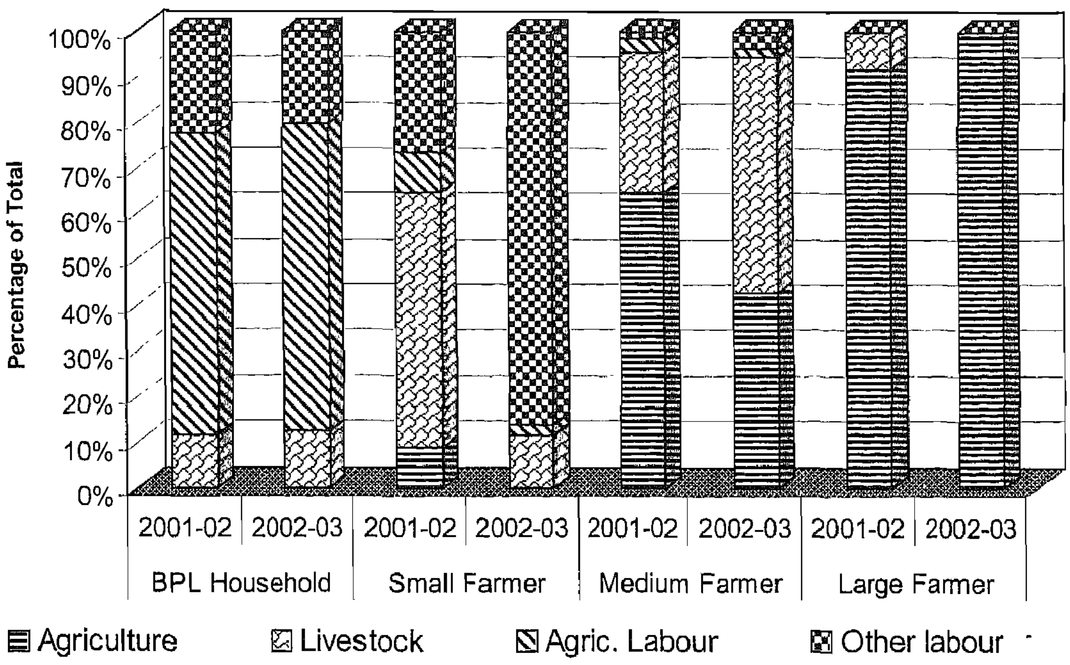


Fig. 34. Average income of sample farmers in Churu district from different sources during 2001-02 and 2002-03.

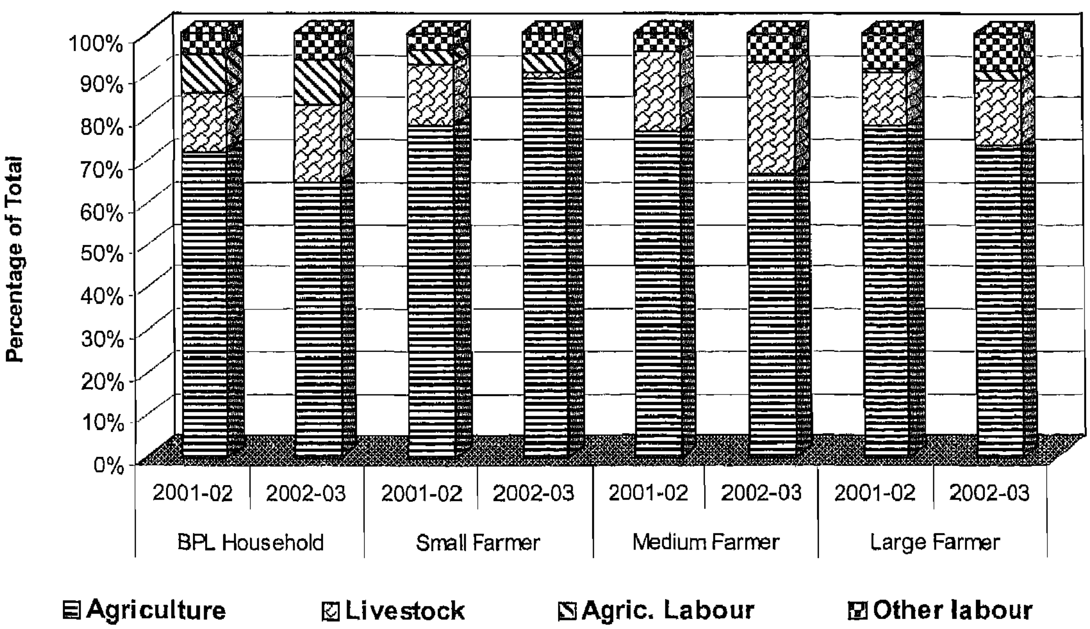


Fig. 35. Average income of sample farmers in Hanumangarh district from different sources during 2001-02 and 2002-03.

Income from other labour

Income under the head 'other labour', which included drought relief work, was controlled to a large extent by the BPL households and small farmers. In 2002-03 this component was mostly related to drought relief programme, but in 2001-02 it denoted activities essentially as daily wage labours in infrastructure sector, services, business houses, etc. In Churu district sample BPL households and small farmers controlled 36-42% of the total during 2002-03, and were largely the drought-relief workers, but in Barmer and Hanumangarh districts income under the category was mostly in the hands of large farmers (51-60% in the two years), and meant income mostly from sources other than drought relief. Economy of sample villagers in Barmer district relied mostly on 'agricultural labour' and 'other labour'. Out-migration to other parts of the state and to metropolitans like Ahmedabad and Mumbai was prominent. Overall, there was 28% increase in income under this head in the sample villages of Churu district during 2002-03, as compared to that in 2001-02, while in Hanumangarh district the increase was by 13% increase. In Barmer district there was a marginal fall of 5% from the figures in 2001-02. In sample villages of Jaisalmer district, income from 'other labour' increased from 0.3% of the averaged total per household during 2001-02 to 21% during 2002-03.

The average income of sample farmers in Barmer, Churu and Hanumangarh districts from four major sources is depicted in Figs. 33-35. Overall, the average income from different sources in sample households of Barmer district was reduced by 46% during 2002-03, while that in Churu district was reduced by 39% and in Hanumangarh district by 12%, thus reflecting a positive relationship of the degree of vulnerability of the economy with climate/water availability.

DROUGHT RELIEF

Providing relief to affected people during drought is an old practice in India. As we have mentioned earlier, the rulers of the erstwhile princely states in the present-day Rajasthan often used to provide relief to their subjects. Many of the water harvesting structures like Jhalras, Samands/Sagars, Khadins and Nadis, as also edifices like the Umaid Bhavan Palace at Jodhpur were constructed under food for work programme.

Past approaches

A systematic approach in drought relief was initiated during the British period, especially after the recommendations of the Indian Famine Commission in 1880, which led to the establishment of famine codes that determined the areas and quantity of famine relief based essentially on the decline in purchasing power of the people, rather than food availability. This concept of famine relief was revised soon after the independence as scarcity relief, when emphasis was given on the public distribution of food grains. Although famine codes continued to be in vogue, a humane approach in saving lives from starvation death was preferred over the strict rules on purchasing power. From the mid-1960s to mid-1980s the concept was changed to drought relief, wherein the capacity of the affected people was sought to be enhanced through programmes like soil and water conservation, pasture development, afforestation, etc. More reliance was put on indicators like crop loss, rise in food grain process, shortage of drinking water and fodder scarcity, which provided advanced information on the severity of drought.

Present approach

After the mid-1980s the emphasis has shifted to a holistic approach for drought management, with strategies for crop saving techniques, sowing of alternate short-duration crops, compensatory crop programmes in favourable areas and during subsequent rabi season, as well as management measures on water budgeting in reservoirs, energy support for tapping groundwater, supply of seeds, and extension support to farmers. This change in approach relies more on early warning of drought and timing of state interventions (Subbiah, 2004).

As elaborated by Samra (2004), there are distinct hierarchical drought monitoring and management mechanism at the central and state government levels. At the central level there is an apex body called the National Calamity Management Committee and a Crisis Management Group, which look into all the different kinds of disasters, including droughts and floods. Drought monitoring and forecasting is carried out by India Meteorological Department, with input from Department of Space. Medium range weather forecasting that includes forecasting of drought scenario, is also done by the National Center for Medium Range Weather Forecast (NCMRWF) in the Department of Science and Technology, with Indian Council of Agricultural Research (ICAR). Based on the forecast made and information generated on agricultural situations, a Crop Weather Watch Group in the Ministry of Agriculture prepares impact scenarios of impending drought and likely response mechanism. This, along with the input from affected states help the Central Relief Commissioner to decide about the quantum of relief to be given. A similar set up exists in the states also, where a Ministerial Committee oversees the different aspects of drought and other calamities, while a State Relief Commissioner coordinates the relief activities in different districts.

Drought declaration is a state subject, and the norms for agricultural losses, drought declaration and for deciding time and quantity of relief are not the same in every state. In Gujarat the losses are still estimated by a Annawari Committee, consisting of tehsil (taluka) level officers, village leaders, farmers' representatives, etc., through a crop condition score card, called the Annawari score. It is calculated on the basis of harvest data from fields with good, medium and poor crop yields, as:

*Annawari score = (12 * observer yield) / (Standard yield of the village).*

In Rajasthan the government relies on the reports of the Patwaris and Tehsildars for crop losses. The method followed is a visual assessment of crops and fodder by the village Patwaris, as well as of water availability, and reporting to the Land Record Inspector who checks and verifies the Patwaris' assessments, and then submits information to the Tehsildar. The tehsil-level assessment is then sent to District Magistrate (Collector), who sends it to the Relief Commissioner.

The present conceptual framework of drought management allows the government to intervene even during the middle of the monsoon season, rather than at the end of season, as used to be the case during earlier decades, and emphasises the need for creating assets that would help in combating the impact of future droughts in a much better way. Despite these conceptual changes, majority of the interventions are essentially to provide relief to the suffering population through contingency plans.

Funding

The funds are provided in large measure by the central government (~75%) from its Calamity Relief Fund and the Prime Minister's Relief Fund, while state government bears ~25%. Employment through drought relief programme is provided by the State Government as a temporary measure, wherein people are engaged in small construction work, and provided some cash and food items. In most cases, the work pertains to repairing of roads, digging/deepening/de-silting of ponds and deepening of wells. It has been usually found that the landless agricultural labourers, small and marginal farmers, artisans and other people below poverty line (BPL), are worst hit by drought, because agriculture and related operations get abandoned.

Selecting beneficiaries

During 2002-03 Government of Rajasthan decided that the selection of beneficiaries under drought relief programme would be made by a committee consisting of the Sarpanch of Gram Panchayat, village Patwari and Gram Sevak. The criteria for selection would be in the following order of priority: BPL family, landless agricultural labour, persons belonging to SC, ST and OBC communities, marginal farmers, rural artisans, small farmers and farmers with single crop area. Families belonging to BPL, SC and ST categories were to be given preference over the above-poverty-line (APL) families. It was decided that the list prepared by the committee would be displayed in the Panchayat offices, and labourers would be engaged from the list as per labour ceiling and priorities decided by the government from time to time. In order to use the opportunity for creating assets that help in long-term drought mitigation and overall development of the region, following categories of land-based activities were identified: water harvesting structures, soil conservation work, afforestation, pasture development, watershed development, rural road construction (gravel roads), and desilting of canals, nadis and tankas. It was decided that the relief works would be opened within 1.5 kms distance of a village, and that the proposals would be collected at Panchayat Samiti level and sent to the District Relief Committees for sanctioning of works from time to time, keeping in view the labour ceiling in operation. Relief works were to be opened in villages where there was no other work under any scheme of the central and state governments.

Employment generation

Initially it was decided to provide employment to one member of each vulnerable family for 15 days in a month, but due to shortage of resources, this was curtailed to 10 days in a month. It was decided to pay 75% of the wage in kind (especially food grain, wheat), and 25% in cash. The minimum wage was fixed at Rs. 60, but the average wage received per day was Rs. 55 (including cash and kind). Since there were many complaints of delays in wage payment by 1-4 months during the previous major drought relief operation in 1987, it was decided that the payment would be made within 10 days of the closer of a muster roll. The labourers were entitled to receive 7 days' food grains in advance. The working hours and tasks were reduced during the very hot summer months of May and June 2003. Unlike on previous occasions, an elaborate supervision and inspection system of relief works was put in place, under which district magistrates and revenue officers were to carry out inspection. A detailed monitoring mechanism was also put in place, involving the Minister-in-charge, the Relief Secretary and other authorities (Anon., 2004a). In order to create durable community assets besides creating additional employment, the state also partially integrated the programme with other government-run programmes like watershed development, wasteland development, district poverty initiative project, revival of traditional water sources under Rajiv Gandhi drinking water mission, etc., as well as with community works by NGOs, Trusts and Donors. Thus, 434.4 million man-days' employment was generated in the state, with a peak time labour strength of 7.5 million. Additionally, 48.9 million man-days' employment was generated under Sampoorna Gramin Rojgar Yojana (SGRY), which together checked starvation, enhanced food security, checked large-scale migration of people, and created durable community assets (Anon., 2004a). By contrast, 424.1 million man-days' employment was generated during the drought of 1987, with a peak per day employment of 2.04 million persons. The targeted vulnerable segment of the society, consisting of marginal farmers, small farmers, landless agricultural labourers, marginal workers, and the scheduled castes and scheduled tribes in rural areas, was 14.12 million people, but could not be served. Wages were paid at the rate of Rs.11-14 per head per day (Misra, 1990).

Scale of operation

The drought relief programme during 2002-03 was indeed run on a massive scale. In sample villages people spoke about labours being engaged @ Rs.10-30 plus ~50 kg wheat per head per cycle of engagement. The relief works started in August 2002, and ended in June 2003, costing ~Rs. 2807 million. One male and one female members from each identified vulnerable household were provided employment every alternate day.

In western Rajasthan as a whole, the state engaged 1.546 million labour through 91803 number of various relief works during 2002-03, against the targeted 1.488 million originally planned for such employment. Drought relief work was provided to 1.084 million people (or 70.1% of the total engaged) under 19086 number of works, against a target of 1.133 million people to be employed. The total number of works in drought relief was 20.8% of the total works executed during the period. This could be appreciated from the districtwise data on the works and the beneficiaries (Table 36). Barmer district had the largest number of beneficiaries (14.3% of the total in the region), followed by Pali (13.8%), Bikaner (12.7%), Jodhpur (12.7%), Nagaur (9.8%), Jalor (8.0%), Churu (7.8%), Jaisalmer (7.2%), Jhunjhunun (5.2%), Sikar (4.3%), Ganganagar (2.5%) and Hanumangarh (1.5%).

Table 36. Number of relief work and beneficiaries in western Rajasthan during 2002-03

District	Drought relief			Other programmes		
	Number of work	Labour ceiling	Labour engaged	Number of work	Labour ceiling	Labour engaged
Barmer	2662	157200	155023	12793	50800	78590
Bikaner	2802	133000	137214	13741	34400	78504
Churu	1767	104200	85024	16135	41500	83313
Ganganagar	323	25900	27607	840	7500	5696
Hanumangarh	257	34300	16256	1285	21500	21967
Jaisalmer	1647	79500	78500	6039	21800	21798
Jalor	1813	87900	86506	342	16800	6010
Jhunjhunun	1195	63200	56589	1368	20800	7351
Jodhpur	2047	138700	138091	6829	32600	42156
Nagaur	1864	109800	106111	7621	43800	51761
Pali	1739	139400	150075	1195	33000	18030
Sikar	970	60000	47123	4529	30200	47104
Total	19086	1133100	1084119	72717	354700	462280

Source: Govt. of Rajasthan.

The major works in western Rajasthan involved construction of water harvesting structures, or renovating the existing ones, as well as construction of gravel roads, both of which address drought mitigation in long term. However, execution of the works sometime put the existing infrastructures in trouble, leading to new problems. For example, deepening of ponds sometimes led to scrapping of an impervious clay-rich layer from the pond bed, threatening water conservation during the next monsoon.

Beneficiaries in sample villages

In Barmer district about 155,000 people were covered under such cash and food for work activities. In Jodhpur district approximately 138,000 labourers were engaged under the programme. In Jaisalmer district 77% of the total respondents worked in drought relief programme, especially in Khadin construction and Nadi digging/ bunding. The average earning per household per cycle was Rs.132 plus 65 kg wheat. In Jalor district about 69% of the sample households in vulnerable categories worked in drought relief programme, while in Churu district 77% of such farm families worked in drought relief programme. BPL families in Churu district got 41% of the total human-days, followed by medium (32%), large (16%) and small (11%) farmers.

Canal-irrigated areas did not have drought relief programme, but Ganganagar and Hanumangarh districts, where canal irrigation is dominant, run the programme in the rain-fed areas, where small farmer households outnumbered the BPL households in getting drought relief work. For example, in sample villages of Hanumangarh district 48% of the total drought relief work was received by the small farmers, as compared to 17% by the BPL families and 27% by the medium farmers.

Quantum of relief

The earnings received from drought relief were not shared in similar fashion. While small farmers received 47% of the money distributed and 39% of the wheat, BPL households received 6% of the money and 25% of the wheat. By contrast, medium farmers received 41% of the earnings, and 27% of the wheat. This apparent mismatch is due to the composition of the labour force from different segments of the rural agrarian society. Female labourers were dominant from the BPL households (58% of the total BPL labour) and almost nil from other categories of farmers. Wages received by female workers were usually lower than that received by the male workers, because quantum of work performed by female workers during a given time was judged to be less than that performed by a male worker for completing a job. As a result, engaging more number of female workers in drought relief work per household, as compared to the male workers, did not necessarily translate into commensurate amount of wages received for the village households (Fig. 36).

Although one member from a household was supposed to be engaged per cycle of drought relief work, with an emphasis on the most vulnerable segments of the society, local factors like show of strength and dominance sometimes influenced the decisions. Defining a family from a Ration Card also became suspect in some cases. Despite such cases of misappropriation at individual levels, a large number of families were benefited from drought relief work.

Other schemes

Relief was also provided under the schemes like 'Sampurna Gramin Rojgar Yojana', 'Antyodaya Anna Yojana' and 'Targeted Public Distribution System'. The state relief department had planned to generate between August 2002 and June 2003 employment of 22.4 million, equivalent to 560 million person-days in the state as a whole, involving 5.6 million tonnes of wheat (@ 10 kg wheat per labour per day) plus Rs. 7840 million as wage, but the actual labour employed was 3.796 million, equivalent to 398 millione person-days.

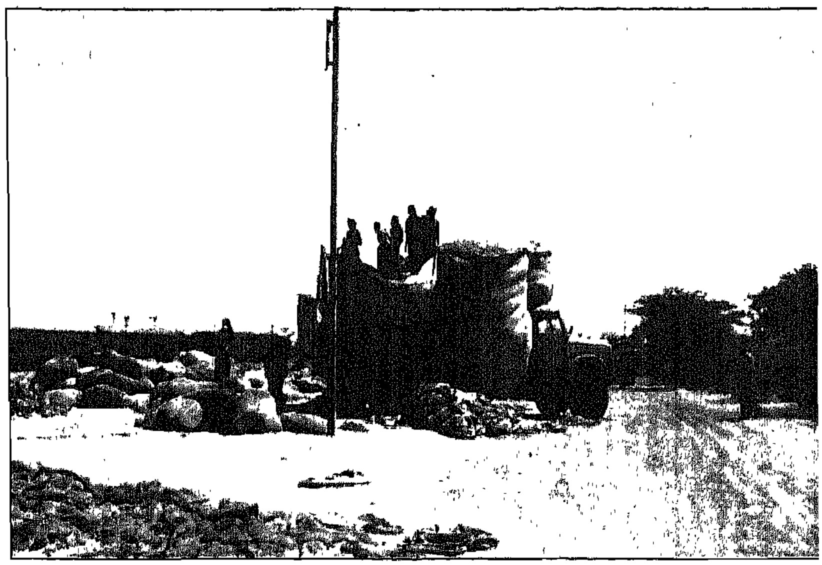
In Pali district 9020 destitute families were given 10 kg wheat and Rs. 50 as cash per month. NGOs supported 10000 families through food grain distribution. Such government relief programmes and philanthropic activities helped to lessen the severity of drought impact.

Another major state intervention was providing interest-free loans to NGOs and other voluntary organizations for making fodder available to cattle camps in the drought-stricken areas. Loans worth Rs.17 million were made available in Jodhpur district, Rs. 14 million in Pali district, Rs.13 million in Churu district, Rs.12 million in Barmer district and Rs.10 million in Jaisalmer district. State government also encouraged growing of irrigated fodder crops, and arranged for free transportation of fodder to the numerous fodder depots across the region, especially from the neighbouring states (Fig. 37, 38).

Department of Animal Husbandry of the state government organised thousands of veterinary camps in the districts. CAZRI was a willing partner in this effort, especially in Jodhpur district. More than 500,000 livestock were benefited from these camps, especially in Jaisalmer, Barmer, Jalor, Pali and Jodhpur districts.

Fig. 36. Female labourers constituted a significant proportion of the total labour force.

Fig. 37. Transshipment of fodder from a railway train to waiting trucks at Bikaner.



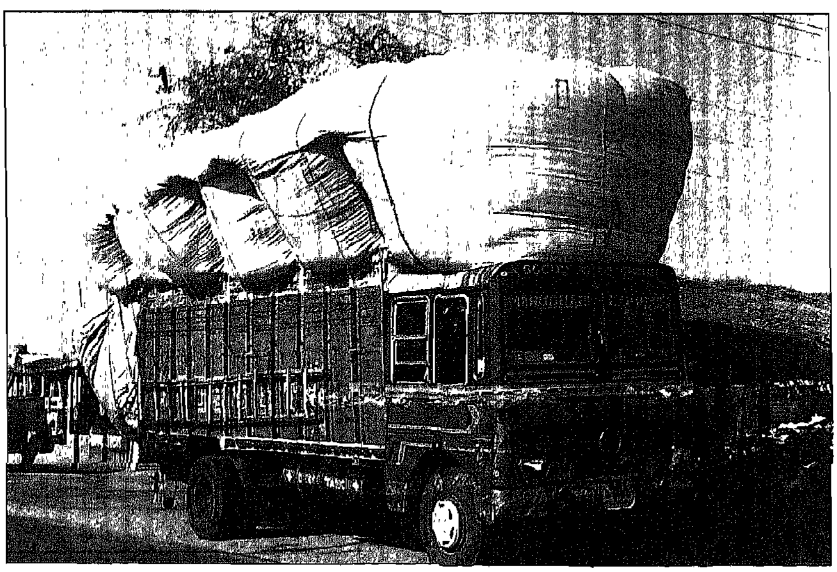


Fig. 38. Transportation of fodder through village roads.

EMPLOYMENT DILEMMA

Discussion with people in sample villages revealed that drought relief was well managed this time, and was far better than during the drought of 1987. However, one of the major concerns was employment.

Due to disruptions in agriculture-related activities a large section of working population became jobless, threatening livelihood security. Since rabi cultivation was also not picking up, the unemployment problem caused more concern. Employment under drought relief programme did not benefit all sections of people, as it was largely reserved for certain vulnerable segments of the society. Also, respondents in many villages across the desert complained that the amounts received were insufficient for sustenance of a large-sized family beyond three weeks. According to villagers, sustaining a family of five required employment for 25 days in a month, as against the average of 10 days provided under the drought relief programme.

Perspective on BPL and marginal farmers

Villagers felt that because of employment support to the weaker segment of the society many of them became less vulnerable with the progress of the drought, but resources of people in other categories became precarious. The general consensus was that the BPL/marginal farmers had maximum opportunities of employment under the scheme. Our survey also found that in many cases the resources of BPL households increased marginally during the drought year due to cash and food grains provided in lieu of drought relief work. They would continue to be assured of this opportunity and would be less vulnerable if the drought persisted and the programme continued.

Perspective on small farmers

The small farmers had more problems in adjusting to the situation, and suffered the most. Distress sell of assets like sheep and goats was the first option with them when crops failed and fodder resources became scarce. This was followed by search for labour opportunities, but in the absence of agricultural labour opportunities and lesser availability of drought relief work, their resources were stretched. Many were compelled to search for other jobs in towns and cities, which were again very scarce, or go to better endowed areas for agricultural labour.

Perspective on medium farmers

Respondents felt that medium farmers would be the worst sufferers if drought continued for yet another year. Apart from sheer economic reasons, this was because of a host of socio-cultural factors also. As we have noted in earlier sections, after the crop failure many respondent medium farmers managed to survive the drought through animal husbandry, especially through sale of milk, milk products, and even animals, etc., despite the fact that a strong cooperative dairy was not available. These were perhaps the last decent options available to them, and could be called distress sale. Those who did not have this option became more vulnerable. Their classification as 'above poverty line' (APL) people made them least suitable for drought relief. Even if they got jobs as wage labourers socio-cultural taboos prevented many from taking the opportunities, especially for the women and the middle-aged men. Under such circumstances the choice left would be sale/mortgage of assets.

Views on large farmers

Large farmers, with access to irrigation facilities, business connections and assets, would be able to bear the brunt of a continued drought, but not beyond 2-3 years.

Level of satisfaction

Despite the above, there was a general sense of satisfaction among the beneficiaries, because food grains and some cash were received when no wage labour from agriculture was in sight. For example, in Churu district sampled BPL households reported 12% more income from 'other labour' than during 2001-02, their total income increasing by ~26% over the 2001-02 figure. Although this increase in income did not make much difference to their poor status, the safety net was wider and more effective than during 1987.

Impact of development

One of the factors why the impact of this century-scale drought was felt less than that during 1987 was because the overall development of the state had improved from the 1987 level. During 1987-88 the rural poverty ratio in the state was 33.2%, which improved to 16.2% during 1993-94. During 1972-73 the rural poverty ratio was 44.8% (Anon., 2002). According to the estimates of Planning Commission, Govt of India, the poverty ratio during 2002 was 15.28% (Anon., 2004a). In 1973-74, the state had 44.76% of its population below poverty line. In western Rajasthan, rural poverty ratio during 1991 was calculated as 25.5% (medium poverty), which was less than that in the southern (46%) and south-eastern (35%) parts (Rajakutty *et al.*, 1999). There have also been improvements in infrastructural facilities, including rural electrification, irrigation facilities, road networks, etc., all of which gradually translated into improved production and better access to market facilities, leading to improvements in the living standard, and creation of assets.

Gaps to be filled up

Despite the above benefits, opinion surveys brought out large gaps in rural employment during the drought. This is because of the higher dependence on agriculture in the villages. Also, as population is increasing and pressure on cropland is increasing, there is a rise in demand for alternate sources of income, especially through employment, but avenues are less. A recent survey by UNDP suggests that under-employment is widespread in the rural agricultural sector in the state (Anon., 2002), while the 2001 Census data on workers in the districts of western Rajasthan reveal that some of the districts like Ganganagar and Pali have more than 20% of the rural workers as agricultural labourers (Table 37). This implies that a greater percentage of the rural population in these districts is liable to become unemployed during droughts. Fortunately, these districts, as well as Jaisalmer have significantly higher work force in 'other' sectors that might help in compensating the losses. The growth rate of rural employment in the state was 2.5% during 1983-84 to 1993-94, which declined to 1.4% during 1993-94 to 1999-2000 (Joshi, 2004).

Table 37. Composition of rural workers in western Rajasthan, 2001

District	Total rural workers as % of rural population	Percentage of total rural workers			
		Cultivators	Agric. labourers	Household industry workers	Other workers
Barmer	48.25	76.83	4.72	2.51	15.93
Bikaner	45.51	74.44	7.15	2.07	16.34
Churu	50.99	84.69	4.90	1.19	9.22
Ganganagar	43.46	46.33	27.76	1.72	24.19
Hanumangarh	41.39	60.22	15.92	1.98	21.89
Jaisalmer	43.40	53.00	9.03	2.20	35.76
Jalor	51.85	68.94	11.46	2.77	16.83
Jhunjhunun	43.72	70.19	7.88	1.96	19.96
Jodhpur	43.00	65.38	12.72	2.06	19.83
Nagaur	43.47	68.38	11.52	2.27	17.82
Pali	42.02	42.05	23.24	3.92	30.79
Sikar	42.28	68.54	6.52	2.50	22.44
West Rajasthan	45.13	67.10	11.67	2.25	18.98

Source: Census 2001.

The state has a major wage employment generation programme called Sampurna Gramin Rojgar Yojana (SGRY), which now includes Jawahar Gram Samriddhi Yojana (JGSY), with a motto of ensuring "minimum employment guarantee of hundred days employment to landless agricultural labourers to provide off-season employment" (Anon., 2004a). It also has a number of Rural Poverty Alleviation Programmes, including Desert Development Programme (DDP), Swarna Jayanti Gram Swarozgar Yojana (earlier known as IRDP), Indira Awas Yojana, Pradhan Mantri Gramodya Yojana – rural housing, etc., through which rural employment and benefits are envisaged.

Unfortunately, most of these have so far failed to provide much headway in employment generation. Govt. of Rajasthan estimated that at the current level, providing wage labour to ~2 million BPL and landless agricultural labourers for 100 days in a year would cost Rs. 15000 million (Anon., 2004a)! In other words, despite overall economic development, a large section of the society will continue to be deprived and hence highly vulnerable to calamities like drought.

Diminishing the pressure on cropland and creating durable opportunities

Most respondents emphasised the need for creating durable employment opportunities for the rural people, which would stabilize the income despite droughts and other such calamities. Although there was more stress on government job, there could be many different opportunities. One of the possibilities is to generate job opportunities in non-agricultural sector, so that pressure on cropland is diminished.

The other possibility is to strengthen the sectors complimentary and subsidiary to agriculture (e.g., dairy, agro-processing, etc.) and generate market opportunities for the products, so that employment is self-generated and sustained over a longer period of time. This calls for a holistic science-mediated agricultural growth in the region, involving improved dryland practices (with limited irrigation of crops wherever necessary, but not necessarily an irrigation-based intensive cropping that empties the groundwater aquifers, or create problems of salinization, soil fertility loss, etc.), as well as wasteland development, rangeland improvement and livestock development. Such an approach would not only create self-sustained employment opportunities, but also many durable assets that will ensure relief from drought.

PEOPLE'S EXPECTATIONS ON DROUGHT MANAGEMENT

The drought of 2002-03 was possibly better managed than the previous droughts, in the region, as was revealed from discussion with rural inhabitants. Despite this, many inhabitants suggested that although contingency plans for countering the ill-effects of drought should be continued, there was a need for creating some long-term resource base in villages that would help people to withstand drought effects more efficiently. As we have mentioned in an earlier chapter, the present concept of drought management also focuses on creation of durable assets in the affected region, so that drought effects become less conspicuous. Foremost among the demands of the villagers was strengthening of the agricultural support system and infrastructural facilities. In most cases the expectations reflected local resource potentials.

Expectations in the western districts

In the very dry Jaisalmer district the main concern was about the animals. Most respondents suggested that programmes on animal breed improvement and animal health should be strengthened. Quality feed should be made available, as also drinking water. There was also a suggestion to initiate insurance scheme for the domestic animals. Another major demand was for establishment of a cooperative dairy to stabilize the economy, with milk collection centres all over the district, and better road network. The other major demand was for water availability. About 24% respondents felt that with the introduction of canal system, traditional nadis and tankas were getting ignored and many structures were in disrepair. Also, mining activities in the rocky catchment areas of the water harvesting structures created disturbance to the catchments of khadins. This led to lesser water inflow to the khadins. It was felt by many respondents that the traditional water harvesting systems should be revived.

In Bikaner district respondents appreciated the drought relief programme, but demanded that quality seeds should be made available at the time of sowing. Most respondents also felt that permanent pastures should be developed through improved varieties of grasses and shrubs. *Cenchrus ciliaris* and *C. setigerus* were the preferred species. They also suggested that government, rather than the villagers, should develop sand dunes through plant species suitable for fodder, fuelwood and other economic uses. Green fodder production should be a major programme of the government during drought, especially in canal command areas, from where the fodder could be distributed to rainfed areas.

Expectations in a southern district

In Jalor district in the south, most respondents felt the need for quality seeds of kharif crops. It was also felt that improvement in the status of grazing lands would not only make fodder available, but also improve animal health. Development of watersheds was another major felt need, especially because groundwater level was going down alarmingly, and, therefore, water harvesting structures were needed to increase the recharge.

Expectations in the north-eastern districts

In Churu and Jhunjhunun districts in the north-east, many farmers demanded HYV of pearl millet, clusterbean and moth bean. There was also demand for animal breed improvement, development of permanent pastures, field bunding and bund plantation. Villagers also suggested that government should enlarge the scope of drought relief, and provide employment opportunities to a larger section of the society. This was also demanded by villagers in Jodhpur and Nagaur districts.

Expectations in canal-dominated districts

In the canal-dominated Ganganagar district 83% respondents identified scarcity of irrigation water as the cause of their plight. According to them, the discharge in the canals gradually dwindled over the years, creating problem for the farmers. However, 20% of the respondents opined that it was time to switch to low-water requiring crops, and 7% suggested that short-duration crops should be introduced. Need for good quality pesticides was felt by 33% respondents, who also demanded better pest-resistant varieties of cotton. There was also demand for certified/quality seeds through cooperatives. It was felt that permanent pastures need improvement through the introduction of quality grass and shrub varieties.

FUTURE STRATEGIES

Despite the sincere efforts of successive governments, resource mobilisation at a grand scale, and spending of huge amounts during every drought, people in western Rajasthan still continue to suffer from the vagaries of drought. Relief expenditure in the country from 1951-52 to 2000-01 was about Rs. 250,000 million. Nearly 60% of this was spent to provide employment to the drought-affected people, 15% on cattle conservation, 5% for providing agricultural input subsidies for taking up farming in the subsequent good season, and the rest amount for other programmes (Subbiah, 2004). The contingency relief expenditure during 2002-03 was about Rs. 200,000 million. About 71% of this amount was spent employment generation, 17% on agriculture input subsidy, 6% on cattle conservation, and 3% on drinking water supply and other provisions (Anon., 2004b). For Rajasthan state, the assistance provided by Government of India was Rs. 9114. 8 million from National Calamity Contingency Fund, Rs. 45.8 million from Prime Minister's Relief Fund, allocation of 3.205 million tonnes of food grains under Sampoorna Gramin Rojgar Yojana, 30,000 tonnes of damaged wheat and rice as cattle feed, and free transport of fodder and drinking water through railways, although the demand was for Rs. 75,197.6 million (Anon., 2004 a, b).

As we have noted in earlier chapters, drought relief in Rajasthan during 2002-03 was considered much better than the previous relief works, thanks to a change in the approaches to the problem, and also due to higher financial outlays and financial management. Dovetailing of different plan schemes of central and state governments for creation of durable community assets and for additional employment also helped in the matter. Apart from contingency relief to the suffering people, emphasis was laid on following works for durable asset creation: digging of tanks and nadis, earth work on rural roads, forest enclosures, trench fencing of pasture lands, construction of khadins, de-silting and cleaning of canals. Another factor that helped to somewhat mellow the effects of this century-scale drought was the beneficial effects of many development programmes being run for decades in the state, which not only increased the net state domestic products over the years, but also enhanced the per capita income and overall development index of the state.

Despite these developments colossal efforts will still be needed when the drought strikes next time, as population will continue to suffer and some key segments like drinking water, feed and fodder, crops and employment will again be at greater risk, as is being noticed during the 2004-05 drought. In other words, the region will continue to suffer from drought impact despite the state interventions. This is partly due to break down of a time-tested and ingenious traditional system of coping with drought, especially as a consequence of population pressure, technological advances, aggressive market forces and too much dependence on government-sponsored drought relief.

In the rain-fed areas of the western Rajasthan people never used to rely on crops alone, nor they used to depend on a finite source of water (groundwater). Technology and market forces have changed the earlier held perspective in the matter. Although crop cultivation formed the primary livelihood support base, animal husbandry was also a major production system, which used to rely on vast open grazing lands, and had the capacity to absorb moderate drought impacts. Its importance in farmer's economy increased with decreasing rainfall westward.

As irrigation water became available, mechanisation started, other infrastructure facilities developed, and market became more open, agricultural land uses started changing fast over the decades and cropping patterns also registered changes from a dominantly subsistence-oriented kharif cereals and pulses to a dominantly cash-crop oriented schedule. This put more demand on land for growing high water and other input-demanding crops, especially on those lands that traditionally formed the village grazing lands. Ultimately, the livestock support system became more vulnerable due to shrinking grazing land, decreasing fodder, redundancy of bullocks, etc.

Modernisation in agriculture revolved mostly around crop cultivation, including improvements in input and processing of output, as well as their marketing, but livestock management and livestock production system did not get much encouragement. As a result, this secondary support system in a farmer's economy gradually became less remunerative, although it still continues to provide the individual farmers the needed respite from drought.

Another safety valve in this drought-stricken region was engaging part of the population in non-farm employments, so that the resources of croplands did not get stretched, and the effects did not spill over to the livestock production system. The major avenue of alternate employment in the region was trade and commerce. As population increased many-fold the non-farm employment became highly competitive despite modernisation and demands of the time. Pressure on the croplands mounted, with a cascading effect on the livestock support system, and the livelihood became more vulnerable, especially during droughts.

Too much dependence on drought relief has also played a role in making people more vulnerable to drought. It has made people expect government to dole out help as soon as drought strikes, although the government of a welfare state is expected to provide help to the needy people. It gradually makes people forget the time-tested drought coping mechanism, or improve upon the practices.

The situation therefore, calls for strategies that sustain the systems followed by rural people, as well as improve upon those systems. Technologies and policies can be helpful only when these become supportive to the livelihood systems that are being followed by people at farm level. Strategies could be:

Short-term, including contingency crop planning, water, food and feed supply, growing of fodder, providing of need-based employment, animal health care, management of animal migration routes, providing soft-term credit facilities, etc.

Medium-term, including development of a workable drought monitoring and early warning system, identification of drought-vulnerable areas, sustainable land management to ensure agricultural diversification, promotion of arid horticulture, development of grazing resources, water resources development, water harvesting structures, promoting water use efficiency of crops, management of animal production system, development of market facilities for animal products, providing agricultural extension services on improved practices, etc., as well as infrastructure development, institutional reforms, ensuring crop insurance, capacity building, etc.

Long-term, including development of durable natural resource assets, research and development for agricultural improvements, especially drought-resistant and low water-requiring crop varieties, development of productive and adaptable animal breeds, cooperative development, especially for a network of dairy, marketing facilities, development of a strong information network for villages to interact with market for their diversified products, infrastructure development, creation of large surface water storage and utilisation facilities, groundwater augmentation and recharge, drought preparedness, etc.

Some of the major issues in strategic planning for arid region are discussed below.

Early warning of drought

Correct early warning of drought is a major requirement for advanced planning for drought. Several drought early warning systems are followed at global level, especially for the African countries (e.g., Alerte Precoce et Prevision des Production Agricoles by AGRHYMET, Food Insecurity and Vulnerability Information and Mapping Systems by FAO, Famine Early Warning System by USAID, Vulnerability Analysis and Mapping by WFP, and a system followed by Southern Africa Development Community in Zimbabwe). These are based partly on ground-level information on relevant physical and socio-economic aspects, and partly on regional-scale satellite remote sensing. In India a remote sensing based monitoring of actual scenario follows an integrated evaluation of meteorological parameters for drought forecasting. While the forecasting system needs vast improvements, the satellite monitoring provides information as the situation unfolds, and hence becomes slightly dated for advanced planning. Nevertheless, these tools need to be improved upon on the basis of recent researches (e.g., use of MODIS data for drought assessment and monitoring in southwest Asia, by Thenkabail *et al.*, 2004, or application of a new spatial time series information modelling for drought index for south Asia, by Smakhtin and Hughes, 2004). Post-drought evaluation of the socio-economic and environmental consequences should also be carried out systematically for satisfactory drought preparedness and mitigation strategies.

Drought vulnerability assessment

Similarly, there is an urgent need for improving upon drought vulnerability assessment at tehsil level or lower, which should be based on physical and socio-economic factors. Such an assessment helps the planners to identify the areas that may need of certain kinds of assistance.

Grazing land improvement and fodder bank

One of the major issues that need greater attention in the region is fodder bank creation. Sustainable development in this field involves development of permanent pastures and other grazing lands (e.g. orans, gochars, etc.), but needs certain policy initiatives and people's participation. As we have noted earlier, the present fodder availability scenario in western Rajasthan is grim, and the projected future demands for normal and drought years suggest a wider gap between supply and demand. Although it is illegal to encroach upon the permanent pastures, instances of encroachment occur. Also, the pastures are highly degraded and in very poor condition due to unrestricted use. To improve the conditions of the pastures, it is necessary to develop a grazing policy for the region, a policy for use of the permanen pastures, as well as a policy for animal migration. Strict enforcement of the policy decisions through dialogue and attractive schemes may help to ease the pressure on degraded grazing lands. During 2002-03 state government had wisely declared support price and input subsidy for fodder cultivation during Rabi season, which made available 3.6 million additional fodder. It also stocked the sugarcane stover in Ganganagar and Hanumangarh districts for fodder purpose. However, it is necessary to make permanent arrangements for good quality fodder for the region's livestock wealth. Timely availability of quality grass seeds is also to be ensured.

Dairy and associated livestock development

Related to the fodder bank creation is the issue of development in livestock sector, especially establishment of a dairy network, related market and other infrastructure facilities, as well as animal health improvement. If we look back at the list of durable assets that were taken up for creation during the 2002-03 drought, we find that creation of assets for strengthening the livestock sector was not there, save and except a small programme on 'trench fencing of pasture lands'. Although western Rajasthan produced at least 3.35 million tonnes of milk during 2001-02, and eastern Rajasthan at least 4.28 million tonnes, and although the state ranks third in milk production in the country, surprisingly it does not have a strong milk co-operative movement like that in Gujarat. Rajasthan Cooperative Dairy Federation Ltd. has only 10 milk plants across the state, and 23 chilling centres. Only 5.4% of the total production is procured by the cooperatives for processing and distribution. Once the dairy cooperatives are boosted and marketing facilities for dairy products are improved, all the other related developments, including breed improvement, fodder resources development, etc., will get accelerated, because the potentials for these developments already exist in the region.

Water resources development

Potable groundwater is fast becoming a scarce commodity in western Rajasthan. With the current level of groundwater exploitation for irrigation, much of the arid area will have no replenishable groundwater reserve in near-future. Since surface water in-flow through Indira Gandhi Canal network and the yet to be completed Narmada canal network have limited areas under their command, drying groundwater reserves mean an imminent major crisis.

The problem has been aggravated not by the Accelerated Rural Water Supply Programme that was introduced all over the country in 1972-73 for providing safe drinking water to villagers, but by the unrestricted irrigation using groundwater. The Public Health Engineering Department (PHED), which is responsible for providing drinking water in the state, has done commendable service by ensuring pipe water supply to almost all villages in western Rajasthan, and installing hand pumps at suitable locations, although problems of maintenance and falling groundwater level render several water supply schemes non-functional. Despite the drawback, many villages are now assured of drinking water through pipe supply, and the village women do not have to undergo the drudgery of bringing water from long distances. During the 2002-03 drought many sample villages in Jodhpur, Nagaur, Churu and Jhunjhunun districts reported sufficiency in drinking water supply.

As the dependence on pipe water supply increased, the traditional systems of water harvesting in nadis and tankas began to be neglected, creating a potentially dangerous situation during mild to moderate droughts, especially where groundwater is depleting fast. During 2002-03 drought, however, there was very little scope for rain water harvesting in tankas and nadis, as run-off generating precipitation was almost negligible in most parts. Except during such extreme situations, nadis and tankas still serve as dependable sources of drinking water, and need to be constructed in large numbers, as has been done under the Rajiv Gandhi Drinking Water Mission. Augmenting the water supply in tanka through roof water harvesting is another way of minimising the water crisis.

Since irrigation of crops is the single-most reason for fast fall in the groundwater level, a constructive dialogue is necessary between the departments of Irrigation, Agriculture, PHED and Rajasthan Ground Water Board for developing a comprehensive and executable water policy in the state. Crops that demand less irrigation water need to be promoted, as also water use efficiency through drips and sprinklers. A strong irrigation monitoring mechanism, ban on sinking tube wells in the critical and over-exploited zones, and a water cess for irrigation may help to minimise the water loss.

It is also time to take up state-sponsored activities on groundwater recharge in favourable locations.

Employment guarantee

One of the major casualties during drought in the region is rural employment, because rural workers are still overwhelmingly dependent on crop cultivation, or working as agricultural labours. So much dependence on agriculture makes the people more vulnerable. It is, therefore, suggested that non-farm employment opportunities may be increased through encouraging the development of agri-horticulture based food processing units, as well as strengthening of sectors complimentary and subsidiary to agriculture, like dairy, agro-processing, etc. Simultaneous generation of market opportunities for the products will ensure that employment is self-generated and sustained over a longer period of time. Encouragement to agri-tourism in the vicinity of popular tourist locations may also generate some employment, while the expanding infrastructure sector will also be able to generate some employment. In the farm sector, sustainable land management programme for long-term drought management has the potential to generate employment in various related activities, including soil and water conservation, wasteland development, oran and gochar development, etc.

Need for a separate drought policy for arid region

At present India has a single procedure for drought impact assessment and assistance in the whole of the country, irrespective of the climatic zone in which the drought occurs. Thus, the criteria for assessing the severity of drought impact, and quantum and kind of assistance to given to say the sub-humid zone or the arid zone, are the same. This puts the arid zone in a disadvantageous position. It overlooks the fragility of the natural resource base of arid region, its high human and livestock populations vis-à-vis the scarce resources, as well as delayed resilience of the arid eco-system due to its inherent low capacity. The region does not receive proper weightage for its inherent poor capacity to recoop when the quantum and kind of assistance are planned. As a result, the state often finds it difficult to bring the system back to the pre-drought stage.

Summing up

Short-term contingency plans for water, food, fodder, crops and alternate employment will always be needed during droughts despite technological development. If a robust drought monitoring and early warning system is developed that can forewarn the farmers about the kind and severity of drought, especially crops likely to be damaged because of agricultural drought, then farmers can utilize the information to plan for the season. This will also help the state to prepare appropriate crop contingency plan well in advance, and arrange for seeds of crops that would be suitable for the remaining crop growth periods.

At the same time medium and long term management practices, especially for sustainable land management practices, and employment generation through such practices, would be able to create durable natural resources capitals that would ultimately replace the concept of "resource transfer from distant places with resource generation and conservation measure within affected zones" (Anon., 2004 b, p.187). Called the climate variability management, it will lead to capacity building in the affected zone for combating drought with *in situ* resource generation, rather than *ex citu* assistance.

CAZRI TECHNOLOGIES FOR COMBATING DROUGHT

Central Arid Zone Research Institute has developed a number of alternate strategies for combating drought and desertification. Some of these can be highlighted here.

Water Conservation

Water is the most precious resource that is necessary for survival and development activity, and is the most limiting resource in arid regions. Although the inhabitants of western Rajasthan developed traditional water harvesting structures like tanka, nadi and khadin, many of these became dysfunctional due to various reasons. Realising the need for improvement of these traditional structures, CAZRI improved upon the designs of tankas for storing 10000 to 630000 L water for household and community purposes, and nadis with LDPE lining for arresting seepage loss. At least 12000 tankas of improved design have been constructed by the state under the Rajiv Gandhi Drinking Water Mission. Design has also been made for integrating tankas with roof-water harvesting structure. Similarly, designs of khadins have been improved upon with inlet structures for efficient water intake and spill way systems for draining the excess water to the khadins downslope.

Apart from improving upon the methods of such *ex-situ* water conservation, CAZRI is also providing research interventions for *in-situ* water conservation through inter-plot and inter-row water harvesting, especially for soil moisture availability. Micro-catchments having a catchment to cropped area ratio of 0.5 resulted in high soil moisture availability in profile. CAZRI also provides research support to the state on integrated watershed management technologies, where arresting runoff and soil loss, rainwater harvesting and recycling of water for irrigation, conservation forestry, agronomic treatments, groundwater recharge and management, etc., are executed and demonstrated to the stakeholders for adoption.

Improved Practices of Agroforestry

Agroforestry is a way of life in arid regions. Soil conservation on degraded land could be better addressed through an integrated programme of erosion control, nutrient management and sustainable yield from different components of annual and perennial productions. Adoption of different alternative land use systems, based on land capability as well as on farmers' choice, is perhaps the best for land management in arid regions. Many traditional agroforestry systems are in vogue in the arid region. However, considering the socio-economic problems of subsistence farming, poor economic base and uncontrolled animal grazing, different packages of alternate land use systems have been prepared for the region by CAZRI. Net economic return from agri-pastoral system has been found to be the highest (B:C ratio 1.87), followed by that from agroforestry (1.69), silvi-pasture (1.66), agri-horticulture (1.46) and sole production of crops (1.24). The higher returns from agri-pastoral system are especially because of the importance of livestock component in the farming systems prevailing in the region. It also safeguards the vulnerable terrain from drought and desertification, although all the other agroforestry systems prevailing in the arid region since time immemorial are also economically viable for sustainable production and protection of the fragile ecosystem.

P. cineraria is the most dominant tree over large parts of western Rajasthan, is common in many crop fields, and is considered the lifeline of the desert as it provides dry leaves for fodder as well as twigs and fuel wood that are lopped every year. Studies on crop performance under *P. cineraria* revealed that the shade effect of a full-grown tree on crop performance remains only up to a distance of 3-4 m from the tree trunk. Pearl millet and cowpea performed better than mung bean and moth bean under the shade of the tree. Apart from *P. cineraria*, *Tecomella undulata*, *Hardwickia binnata* and *Holoptelea integrifolia* are also important trees for agro-forestry in the region. A tree density of 100 to 200 plants ha^{-1} has been found optimum for minimum interference with the yield of various dryland crops.

Agri-horticulture

Some horticultural plants like jujube (Ber; *Ziziphus mauritiana*) provide assured and high returns, and have been recommended for growing with kharif crops. Jujube density of 200 plants ha^{-1} has been found optimum for growing with crops in the inter-space. In the >300 mm rainfall zone clusterbean (*Cymopsis tetragonoloba*) performs better during drought years, while mung bean during good rainfall years, but cowpea provides stability in yield in most years. In the drier sandy undulating terrain, *Citrullus lanatus* (water melon) and *C. clolcynthis* (Tumba) grow well with pearl millet and other kharif crops, and fetches remunerative prices. The creepers also act as good sand binders.

Agri-silvi-pastoral System

Inter-cropping of trees, grasses and legumes with crops not only provide some assured returns during bad years, but also help to improve the soil health. Growing of pearl millet and clusterbean with grasses *L. sindicus* and *C. ciliaris* between rows of *A. tortilis* and *Z. rotundifolia* were found to be highly compatible and remunerative in terms of grain and fodder yield. A strip cropping of grasses and kharif legumes in 1:2 ratio has been recommended by CAZRI, with a strip width of 5 m.

Silvi-pastoral System

Silvi-pastoral system is best suited for areas receiving <200 mm rainfall, or for degraded rocky-gravelly areas. The following tree species have been found to be highly compatible with grasses: *Acacia senegal, A. tortilis, Albizzia lebbek, Tecomella undulata, Colophospermum mopane, Dychrostasis nutans, Hardwickia binnata, Z. nummularia and Z. rotundifolia.* Among the pasture legumes *Clitoria ternatea* and *Lablab purpureus* showed good compatibility with *L. sindicus* and *C. ciliaris*. Production from a silvipastoral system with *A. tortilis* and *C. ciliaris* was higher than that from a pure pasture. The carrying capacity of a pure pasture was found to be 3.9 sheep ha^{-1} after 9 years of establishment, while that from a silvi-pastoral system was 8.5 sheep after 7 years.

Under goat grazing, *Z. nummularia* with grass strips in 1:2 ratio led to higher economic returns due to weight gain of the animals and higher wool production.

Diversified Agriculture

It has been found that a better cropping strategy during a normal kharif season could be to reduce the pearl millet area from 60% of an individual farmland to 40%, and crop diversification in the rest 60% land in the following proportions: legume 30%, oilseeds 20% and forage 10%.

A number of crop varieties, developed by CAZRI are not only drought-resistant and pest-resistant, but also good yielders. These include pearl millet varieties CZP-9802 and CZP-IC-923, moth bean varieties CAZRI-Moth-1 and CAZRI-Moth-2 (also called Maru-Moth-1 and Maru-Moth-2), clusterbean variety Maru Guar and horsegram variety Maru Kulthi-1. Pearl millet variety CZP-9802, released during 2002, has better capabilities to withstand drought, and a potential to produce 13 q ha^{-1} grain (i.e., 14% higher than Pusa-266) and 33 q ha^{-1} dry stover (i.e., 28% higher than HHB-67). The variety matures in 72-75 days, and thus is able to escape terminal drought. It is also resistant to downy mildew, smut and ergot diseases. Drought-resistant moth bean variety CAZRI-Moth-2, which was released during 2003, matures in 62-70 days, with a potential to produce 570 kg grains ha^{-1}.

Grazing Management

Scientific management of pastures and their proper utilization are as important as development of the pasturelands, or new varieties of grasses. Uncontrolled grazing in the developed pastures can result in very serious degradation, offsetting the benefits from elaborate research and development activities. This happened in the case of 52 degraded range areas across western Rajasthan, which were taken up by CAZRI developed through research interventions to their full potentials in a phased manner, with 10 to 40-fold increase in production in each of the range areas, and then handed back to the state during the 70s and the 80s. To avoid degradation of the rangelands, CAZRI has recommended a rotational and staggered system of grazing. The success of such a plan, however, depends on the whole-hearted community participation. Special work plan is also necessary to integrate the results of scientific research on pasture development with a system of management practices of the orans and gochars at the level of the elected village bodies like the Panchayats, as well as by the temple trusts, NGOs, etc.

Forage Improvement

Considering that animal husbandry is an important component of the farming systems in arid western part of Rajasthan, where production potentials of the growing animal population depend partly on the availability of good quality forage, CAZRI is continuously striving to develop improved rangeland management practices. A number of new varieties of grasses and legumes with higher dry matter and seed yields have been developed and supplied to stakeholders. These include Marwar Anjan (CAZRI-75), CAZRI-357 and CAZRI-358 of *Cenchrus ciliaris*, Marwar Dhaman (CAZRI-76), CAZRI-1 and CAZRI-296 of *C. setigerus*, CAZRI-318, 319; 30-5 of *Lasiurus* *sindicus*, and CAZRI-347 of *Panicum antidotale*. Additionally, technology for bulk grass seed production and its pelleting has been developed. It has been shown that the improvements in range conditions can increase the carrying capacity of an average grazing land from 2.5 sheep ha^{-1} to as much as 4.5-6.9 ha^{-1} sheep in sandy soils and 9.0-13.8 ha^{-1} sheep in loamy sand soils.

Production from an Improved Khadin during 2002: A Success Story from Jaisalmer

During 2002 CAZRI employed some of its technologies for improving the production in a small Khadin named the Darbari Khadin, which is located 15 kms away from Jaisalmer town, and has a catchment area of ~4 km^2. The total rainfall during the year at Jaisalmer was 63 mm (i.e., only 33% of the normal), while the monsoon rainfall was 25 mm.

In the lower reach of the Khadin, pearl millet (HHB-67 and Pioneer 87-M.41), requiring 70 days to mature, were sown. In the middle reach short duration mung bean (var. K851) and clusterbean (var. RGC936) were grown, whereas the upper reach was kept under arid horticulture, i.e., a block of Ber (*Ziziphus mauritiana*) cv. gola at 6 x 6 m spacing. A line of Gonda (*Cordia myxa*) was planted at 6 m spacing along beyond.

Soil moisture in the upper reaches of the Khadin was lost within 15 days of the rain, while in the middle reaches it was lost within a month. Lower reaches could store runoff and conserve moisture throughout the crop-growing season (Table 38), producing a bumper harvest of grain (15-17 q ha^{-1}), even though the kharif rainfall during this extreme drought year was 30-40 mm. In the lower part soil moisture during sowing time was 155 to 204 mm m^{-1} soil for pearl millet var. HHB67, and 153 to 190 mm m^{-1} soil for var. 87-M.41. The values during crop harvest were 61 to 97 and 51 to 65 mm m^{-1}, respectively. Thus, short-duration varieties of pearl millet could be grown in the lower part of the Khadin, even with a rainfall of 30 to 40 mm, and soil profile moisture of 200 mm m^{-1} soil.

Table 38. Soil moisture dynamics in different parts of Darbari Khadin in Jaisalmer

Part of khadin	Soil depth (cm)	Soil moisture content (%) over time			
		After 7 days of rain at sowing	After 25 days of rain	After 45 days of rain	After 75 days of rain/ at harvest
Upper	0-30	3.51-3.59	0.49-1.80	1.61-3.19	0.32-0.51
	30-60	1.57-3.22	3.19-3.80	3.33-5.19	1.57-3.31
	60-90	--	--	--	--
	90-120	--	---	--	--
Middle	0-30	4.2-7.23	3.91-6.68	3.50-4.20	0.43-2.99
	30-60	3.36-8.78	3.31-8.8	1.90-4.73	1.90-3.71
	60-90	3.98-11.10	3.25-7.11	2.64-3.98	1.83-3.33
	90-120	--	--	--	--
Lower	0-30	8.93-9.47	5.34-7.49	6.51-8.07	4.47-5.0
	30-60	10.64-11.78	6.77-9.71	5.70-6.80	4.85-5.28
	60-90	11.42-11.64	6.47-12.98	5.84-8.46	4.15-5.54
	90-120	11.28-16.69	5.59-11.64	7.34-9.61	4.33-2.99

Growth and yield attributes of the crops grown are shown in Table 39. It was found that in the lower part of the Khadin both the varieties of pearl millet survived on harvested runoff and conserved soil moisture. The crops were harvested 70 days after sowings. Clusterbean and mung bean failed in the middle part due to drought, while survival percentage of Ber was 52% and Gonda 80% in the upper reaches and near the peripheries of the Khadin.

Table 39. Land use and cropping pattern in Darbari Khadin

Land use	Crop	Sowing date	Fertilizer dose	Harvest date	Plant height (cm)	Branches or tillers/ plant	Grain yield (q ha^{-1})	Dry fodder (q ha^{-1})
Upper reach: horticulture	Ber, Gonda	Block of 100 ber plants at 6 x 6 m spacing; along the bund 70 plants at a distance of 6 m						
Middle reach: legume cropping	Guar (RGC-936)	6.9.02	Nil	--	31.5	6.3		
	Mung bean (K851)	6.9.02			13.9	--		
Lower reach: cereal cropping	Pearl millet (HHB-67)	10.9.02	N @ 12.5 kg ha^{-1} as basal	19.11.02	125.5	5.1	17.03	24.5
	(Pioneer-87-M.41)	10.9.02		19.11.02	137.9	3.6	15.05	21.1

Due to extreme paucity of rains, there was very little success in rainfed cropping in the region, even with improved varieties or technologies, except in the Khadins. Kharif crops did not survive in any of the sampled adopted villages of CAZRI due to non-availability of moisture in the root zone of crops.

CONCLUSIONS

The present assessment of drought impact brings out the following points clearly:

- A number of successful traditional coping strategies were available earlier to the rural communities in the region, but most of these are becoming defunct due to changing demands of the time and changes in technologies.
- The most useful traditional coping strategy that needs a vigorous implementation is construction and maintenance of rainwater harvesting and storage structures. Old structures and their catchment areas are in a degraded state, and have a reduced capacity.
- Presently coping strategies of the farmers depend on the resources available to them. In the absence of income from cropland, sale of livestock and de-stocking are the major income generation strategies for small farmers, but the medium farmers tend to generate income through sale of milk and other animal by-products. The strategy succeeded during the drought of 2002-03 due to a number of dairy plants and a better transport network than before.
- Livestock farming is a more secured economic activity in the region than rain-fed cropping, especially during drought, but needs to be better organised. Despite its potentials, livestock-based economy is still not properly developed. Dairy industry needs a strong support, and should be developed. Animal migration, especially of small ruminants, is an integral part of the livestock economy, but is facing acute problems.
- Cropping strategies need to have agro-forestry component so that availability of top-feed resources is ensured during the drought years. Also, growing fodder-yielding crops/grasses, and keeping a part of the land fallow, needs to be a part of the cropping strategy.
- Improvement of the large number of grazing lands, that are also known as common property resources, including orans, gochars and other kinds of sacred open forests, is vital for fodder security, but these are now in a very severely degraded state. A policy for their appropriate utilization through people's participation will go a long way to meet the fodder demands of the large livestock population of the region. At the same time fodder banks need to be established in adequate numbers with proper storage facilities and distribution mechanism.
- Too much dependence on groundwater for drinking and use of this water for growing high water demanding crops (e.g. chillies) have led to fast depletion of the aquifer, and will create serious problems of water availability in near-future. Appropriate policy decisions will be required for sustainable use of water. Replenishing the near-empty aquifers through groundwater recharge needs to be given proper attention.
- In order to cope better with drought it is necessary to find alternate sources of rural income that are sustainable on a long term. Small-scale processing of arid horticultural crops has a high potential in the region, especially in view of the current demands for fruit drinks and other fruit products.
- Too much dependence on cropland is leading to a serious livelihood problem during drought. Therefore, potentials of the village artisans and rural handicrafts need also to be cultivated

and such skills need to be groomed for marketing. Agri-tourism in the vicinity of popular tourist destinations could be another means of income supplementation.

- Too much dependence on drought relief programme of the government is also a major factor of weakening the coping mechanism of the rural society. Drought relief programme is an ad-hoc contingency plan. It cannot address long-term drought-coping strategies. It is necessary to prepare a drought preparedness strategy that provides the rural community with enough resources to cope with drought.
- It is essential to strengthen research for a robust drought forecasting and early warning system, as also for monitoring and near-real-time assessment of drought impact through remote sensing and other tools, identification of drought-vulnerable areas, as well as post-drought evaluation of the socio-economic and environmental consequences, for satisfactory drought preparedness and mitigation strategies on the basis of lessons learnt.
- A policy framework is urgently needed for long-term drought management. Concurrently, it is necessary to ensure minimum employment guarantee for the rural unemployed in the weaker segments of the society, and use their potentials for sustainable development of land.
- It is hoped that the medium-term and long-term management practices, especially the sustainable land management practices with employment guarantees, will create durable natural resources capitals to fight drought more efficiently with internal resources than to look for outside assistance.

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Appendix 1

Rainfall distribution in western Rajasthan during 2001 and 2002

Station	Normal (mm)	Annual (mm) 2001	Monsoon (mm) 2001	Annual (mm) 2002	Monsoon (mm) 2002	Percentage of normal annual (%)	
						2001	2002
Barmer	271	264	234	126	105	97	46
Ramsar	343	480	452	56	50	140	16
Baytu	220	238	145	56	43	108	25
Shiv	223	325	249	81	66	146	36
Guda Malani	289	272	245	12	12	94	4
Chohatan	302	482	357	72	69	160	24
Siwana	349	270	264	107	101	77	31
Pachpadra	250	236	196	167	159	94	67
Bikaner	264	206	158	32	9	78	12
Lunkaransar	280	263	157	64	10	94	23
Nokha	334	270	237	83	43	81	25
Kolayat	299	459	432	61	19	154	20
Pugal	175	274	196	34	11	157	19
Khajuwala	144	164	109	89	77	114	62
Chattargarh	219	284	195	63	42	130	29
Churu	385	413	331	288	198	107	75
Sardarshahr	348	336	273	110	39	97	32
Ratangarh	362	297	195	78	41	82	22
Sujangarh	419	276	236	130	77	66	31
Rajgarh	420	480	389	210	140	114	50
Taranagar	379	439	353	157	99	116	41
Dungargarh	337	231	151	93	67	69	28
Jaisalmer	192	321	314	63	25	167	33
Ramgarh	142	126	110	9	9	89	6
Sam	194	79	76	51	32	41	26
Fatehgarh	145	373	350	45	32	257	31
Pokaran	189	263	227	43	18	139	23
Naukh	187	152	123	48	31	81	26
Pali	421	500	470	90	74	119	21
Bali	569	536	514	268	248	94	47
Desuri	636	686	649	350	327	108	55
Marwar Jn	532	577	540	192	165	108	36
Sojat	409	440	423	77	61	108	19
Raipur	501	619	568	143	86	124	29
Jaitaran	447	563	527	224	176	126	50

Rohat	281	511	478	63	63	182	22
Sumerpur	454	737	665	167	160	162	37
Ganganagar	283	305	231	98	52	108	35
Karanpur	244	248	180	73	50	102	30
Padampur	262	245	145	50	35	94	19
Raisinghnagar	227	185	133	86	64	81	38
Anupgarh	218	250	180	115	73	115	53
Gharsana	189	278	204	100	47	147	53
Vijaynagar	148	301	219	71	50	203	48
Suratgarh	243	331	250	68	26	136	28
Sadulshahr	308	438	345	140	78	142	45
Hanumangarh	225	264	172	117	67	117	52
Pilibangan	273	285	153	67	27	104	25
Sangariya	297	456	338	90	24	154	30
Tibi	296	456	320	150	16	154	51
Rawatsar	276	245	122	109	46	89	39
Nohar	359	310	230	165	77	86	46
Bhadra	361	412	314	249	119	114	69
Sikar	548	657	577	152	109	120	28
Rampur	325	343	281	205	138	106	63
Fatehpur	397	609	452	324	249	153	82
Laxmangarh	428	298	219	123	102	70	29
Danta Ramgarh	490	554	418	248	189	113	51
Sri Madhopur	522	401	341	125	47	77	24
Neem ka Thana	499	350	272	207	158	70	41
Jalor	443	340	318	171	167	77	39
Ahor	400	334	292	126	126	84	32
Bhinmal	407	300	279	142	142	74	35
Jaswantpur	492	602	576	347	347	122	71
Raniwara	321	503	476	187	171	157	58
Sanchor	396	238	235	60	60	60	15
Jodhpur	392	497	431	91	77	127	23
Luni	302	653	617	39	36	216	13
Bilara	444	395	336	149	113	89	34
Bhoplagarh	343	397	317	98	74	116	29
Shergarh	271	350	265	85	70	129	31
Phalodi	237	251	228	56	50	106	24
Osian	313	324	267	94	84	104	30
Jhunjhunun	373	397	326	117	60	106	31
Chirawa	423	475	421	165	73	112	39
Khetri	546	621	524	233	166	114	43

Navalgarh	376	462	367	131	76	123	35
Udaipurwati	527	369	295	211	145	70	40
Buhana	356	565	473	133	77	159	37
Malsisar	334	521	417	188	108	156	56
Nagaur	429	305	252	110	87	71	26
Khimsar	249	268	217	82	51	108	33
Jayal	379	390	330	97	73	103	26
Merta City	386	292	276	157	116	76	41
Degana	464	347	262	194	131	75	42
Didwana	348	329	227	98	86	95	28
Ladnun	404	318	261	77	63	79	19
Parbatsar	430	460	305	157	128	107	37
Makrana	304	481	349	259	203	158	85
Nawa	480	443	260	212	147	92	44
Average	**343**	**377**	**310**	**127**	**90**	**113**	**36**

Source: Government of Rajasthan.

Appendix 2

List of villages selected for primary village-level survey in different districts

	District	Tehsil	Village
1.	Barmer	Ramsar	Derasar
2.	Barmer	Chohtan	Goniya
3.	Barmer	Shiv	Naya Nimbla
4.	Barmer	Shiv	Dholkiya
5.	Barmer	Baytu	Ahoniya Beniwalo ki Dhani
6.	Barmer	Baytu	Madasar
7.	Barmer	Pachpadra	Sarvadi
8.	Barmer	Pachpadra	Karmawas
9.	Barmer	Guda Malani	Guda Malani
10.	Bikaner	Pugal	Lakhusar
11.	Bikaner	Pugal	Amarpura
12.	Bikaner	Pugal	5 PB
13.	Bikaner	Kolayat	Jhajju
14.	Bikaner	Kolayat	Siyana
15.	Bikaner	Kolayat	Ranjitpura
16.	Bikaner	Kolayat	Beethnok
17.	Bikaner	Kolayat	Bhikampur
18.	Bikaner	Bikaner	Gosainsar
19.	Bikaner	Bikaner	Moondsar
20.	Bikaner	Nokha	Kakku
21.	Bikaner	Nokha	Utmamdesar
22.	Bikaner	Lunkaransar	Rojhan
23.	Bikaner	Lunkaransar	Kallu
24.	Bikaner	Chatargarh	Sattasar
25.	Churu	Sujangarh	Magrasar
26.	Churu	Sujangarh	Chadwas
27.	Churu	Ratangarh	Sikarli
28.	Churu	Ratangarh	Gorisar
29.	Churu	Sardarshahr	Dalman
30.	Churu	Sardarshahr	Bhadasar
31.	Churu	Taranagar	Jigsana Tal
32.	Churu	Taranagar	Panderu Tal
33.	Churu	Churu	Doodhwa Mitha
34.	Churu	Churu	Aslu-Lakhau
35.	Ganganagar	Ganganagar	Ladhduwala
36.	Ganganagar	Sadulsahahr	Morjhad Khari
37.	Ganganagar	Karanpur	60 A
38.	Ganganagar	Raisinghnagar	Kikarwali

39.	Ganganagar	Suratgarh	Silwari
40.	Ganganagar	Vijaynagar	41 GB
41.	Ganganagar	Anupgarh	Patroda
42.	Ganganagar	Gharsana	Rojri
43.	Hanumangarh	Tibbi	Peerkamadai
44.	Hanumangarh	Tibbi	Mehrwala
45.	Hanumangarh	Sangariya	Bolanwala
46.	Hanumangarh	Hanumangarh	Dholipal
47.	Hanumangarh	Hanumangarh	Fatehgarh
48.	Hanumangarh	Rawatsar	Gandheli
49.	Hanumangarh	Pilibangan	Baropal
50.	Hanumangarh	Bhadra	Bhirani
51.	Hanumangarh	Bhadra	Bhojasar
52.	Hanumangarh	Bhadra	Malsisar
53.	Hanumangarh	Nohar	Parlika
54.	Hanumangarh	Nohar	Meghana
55.	Hanumangarh	Rawatsar	Bharamsar
56.	Jaisalmer	Jaisalmer	Bhaiyon ki Dhani
57.	Jaisalmer	Jaisalmer	Murad Khan ki Dhani
58.	Jaisalmer	Jaisalmer	Daw
59.	Jaisalmer	Jaisalmer	Barsiyala
60.	Jaisalmer	Jaisalmer	Chah Tibba
61.	Jaisalmer	Jaisalmer	Ghantiyali
62.	Jaisalmer	Jaisalmer	Changaniyon ki Basti
63.	Jaisalmer	Jaisalmer	Bharamsar
64.	Jaisalmer	Jaisalmer	Khuyala
65.	Jaisalmer	Jaisalmer	Damodara
66.	Jaisalmer	Jaisalmer	Sam
67.	Jaisalmer	Jaisalmer	Meghwalon ki Basti
68.	Jaisalmer	Jaisalmer	Mandai
69.	Jaisalmer	Jaisalmer	Rewadi
70.	Jaisalmer	Jaisalmer	Sanwata
71.	Jaisalmer	Jaisalmer	Barora Gaon
72.	Jaisalmer	Pokaran	Nachna
73.	Jaisalmer	Pokaran	Nokh
74.	Jaisalmer	Pokaran	Chinnu
75.	Jaisalmer	Pokaran	Lawan
76.	Jaisalmer	Pokaran	Dhursar
77.	Jaisalmer	Pokaran	Madopura
78.	Jaisalmer	Pokaran	Mitthu ki Dhani
79.	Jalor	Sanchor	Hadetar
80.	Jalor	Sanchor	Dhamana

81.	Jalor	Raniwara	Akhrod
82.	Jalor	Raniwara	Malwara
83.	Jalor	Ahore	Bhadrajun
84.	Jalor	Ahore	Kamba
85.	Jalor	Jalor	Bhaglisinghlan
86.	Jalor	Jalor	Leta
87.	Jalor	Bagoda	Raha
88.	Jalor	Bagoda	Sewari
89.	Jalor	Sayla	Tilora
90.	Jalor	Sayla	Choraun
91.	Jalor	Bhinmal	Ramsin
92.	Jalor	Bhinmal	Jhunjhani
93.	Jhunjhunun	Jhunjhunun	Abusar
94.	Jhunjhunun	Jhunjhunun	Luna
95.	Jhunjhunun	Nawalgarh	Dabri Baloda
96.	Jhunjhunun	Chirawa	Pichanwa
97.	Jhunjhunun	Buhana	Moe Bharu
98.	Jhunjhunun	Udaipur Wati	Khinvsar
99.	Jhunjhunun	Khetri	Madhogarh
100.	Jodhpur	Shergarh	Shergarh
101.	Jodhpur	Osian	Malunga
102.	Jodhpur	Osian	Parasla
103.	Jodhpur	Phalodi	Lordiyan
104.	Jodhpur	Bilara	Khariya Mithapur
105.			
106.	Nagaur	Khimsar	Bhojash
107.	Nagaur	Khimsar	Pabusar
108.	Nagaur	Merta	Bhaggar
109.	Nagaur	Nagaur	Gajju
110.	Pali	Sumerpur	Basant
111.	Pali	Jaitaran	Banjakudi
112.	Pali	Pali	Manihari
113.	Pali	Bali	Bagol
114.	Pali	Desuri	Bhatund
115.	Pali	Marwar Jn.	Dudod
116.	Sikar	Fatehpur	Hudera
117.	Sikar	Fatehpur	Shekhisar
118.	Sikar	Lachmangarh	Basani
119.	Sikar	Lachmangarh	Singodhara
120.	Sikar	Ramgarh	Karamsura
121.	Sikar	Sikar	Kasali

122.	CAZRI's technology village	Doli
123.	CAZRI's technology village	Lunawas
124.	CAZRI's technology village	Bhawad
125.	CAZRI's technology village	Manai
126.	CAZRI's technology village	Kharda
127.	CAZRI's technology village	Pabusar
128.	CAZRI's technology village	Nathu Khan ki Dhani
129.	CAZRI's technology village	Dhundara