OCCURANCE OF DROUGHT AND ITS IMPACT ON AGRICULTURE IN RAJASTHAN: A CASE STUDY OF AJMER DISTRICT

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CERTIFICATE

I, Samay Singh Meena, certify that the dissertation entitled **"OCCURANCE OF DROUGHT AND ITS IMPACT ON AGRICULTURE IN RAJASTHAN: A CASE STUDY OF AJMER DISTRICT"** submitted by me for the degree of **MASTER OF PHILOSOPHY** is my bonafide work and may be placed before the examiners for evaluation.

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DEDICATED TO

MY PARENTS

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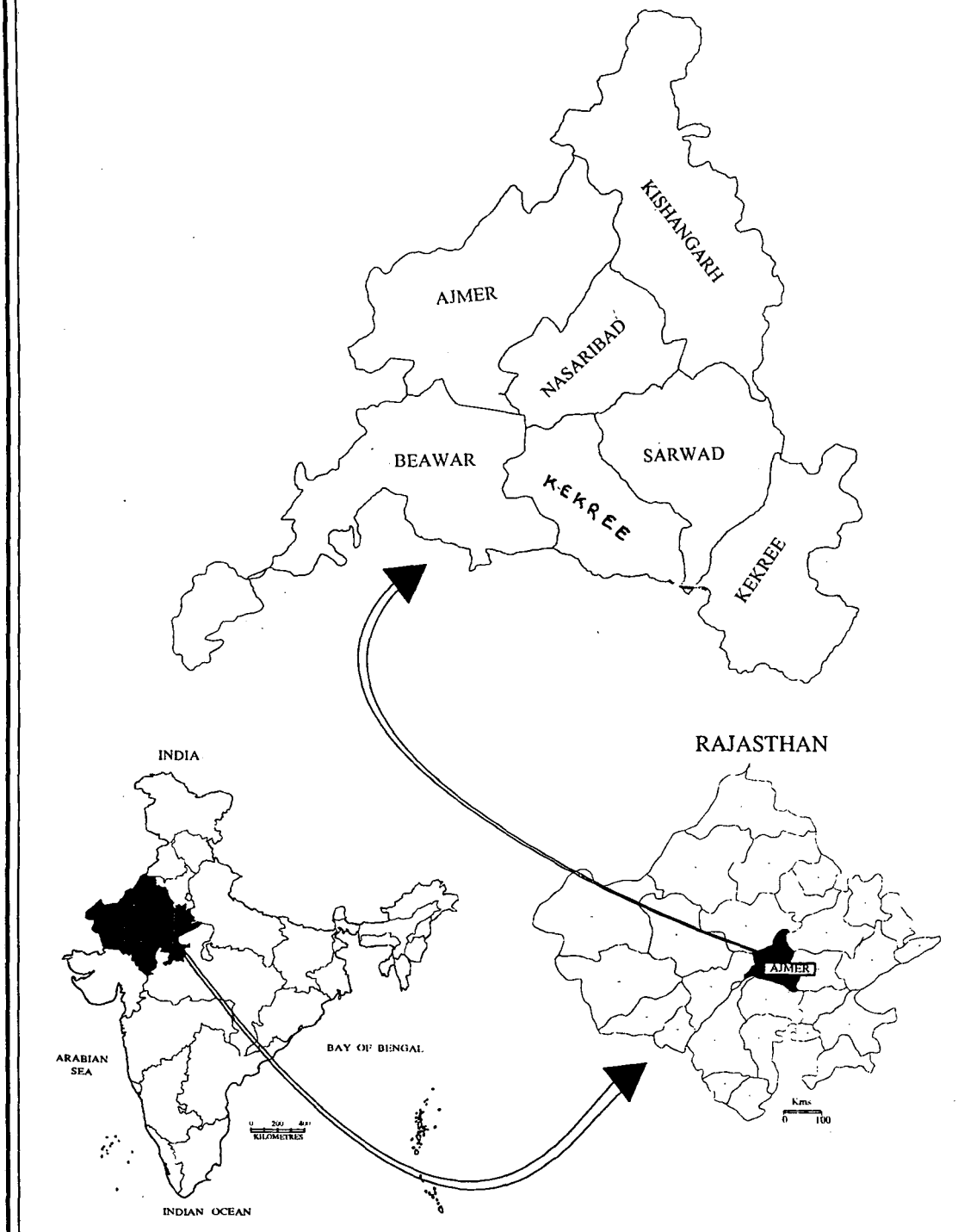


CHAPTER - I

INTRODUCTION

1.0 Introduction

The Director of Common Wealth Bureau of methodology in 1966 suggested a broad definition of Brought as "Sever water shortage". It means shortage of water in comparison to the need of drinking water for the inhabitants and animals in a particular area.

The negative impact on the production system due to shortage of water results in the severity of drought. The shortage of water mainly effects three main users of water (10 plants (2) animals (3) men. The intensity of water shortage is often reflected in the shortage of water for drinking purpose and it results in the migration of animals during severe drought year and also affects the production system, particularly the production of agricultural crops and partly the industrial production and livestock output. The shortage of water, grain and fodder all combined, is know as *'TRIKAL'*. The drought creates shortage of drinking water for human beings and animals which gives rise to migration. If drought kills plant which are used for grazing by livestock, is more likely to be identified than if it decimates inedible scarabs. The drought in the form of failure of crops and the death of livestock

leave a severe impact on the total economy of the rural area. The drought consequently results in the migration of levestock and dependence of villagers on urban population for labour as well as in search for drinking water sources.

If causes miseries for the rural people where as to the urban folk, insulated by the industrial production and supply of tap water, drought is something known through newspapers only. But for rural inhabitants, drought is personally identified and its effects are often practically experienced. In other words the community mostly depending on primary production system, face the consequence of drought which the community depending on secondary and tertiary occupations rarely confronts the impact of drought .

The definition of drought by *FOLEY* is worth mentioning. "A period of rainfall deficiency extending over months or years of such a nature that crops and pasturage for stock are seriously affected, if not completed burnt-up and destroyed,

Through the term drought is associated with scarcity of water it means different things to different people. Tannehill (1947) has underlined the uniqueness of drought among weather phenomena by painting out how it creeps on gradually almost mysteriously but its consequences are a terrible reality. Unlike

flood, drought do not makes their onset obvious nor is it all easy to say with creativity when does a drought withdraw. Drought has been defined in many ways including (a) a period of rainfall deficiency (b) a relative rate of forest flammation (c) occruing when a specific agricultural crop or pasture yields less than expected amounts. (d) denoting a critical level of soil moisture or groundwater depletion and (e) poetically as a valley of rain deficiency in the broad sweep of time and weather. In simple term drought is a period of acute water shortage arising from lack of rainfall or its improper distribution in time and space . Catastrophic drought events in a row may lead to famines' causing large scale migration loss of livestock and human lives due to use scarcity of water food and fodder.

1.1 Causes of Drought

Drought in the Indian sub continent is mainly due to failure of rainfall from southwest monsoon. The root cause for failure of monsoon rainfall is due to the widespread, persistent atmospheric subsidence, which results from the general circulation of the atmosphere. Recent studies on interaction between global circulation and drought showed that the *El-nino* phase of the southern oscillations (ENSO) also has an immense impact on India through drought. While ENSO events cause summer drought with

a reduction in food grain production during monsoon period, the winter rainfall usually enhanced consequently with an increase in the winter crop production (Sinha 1987, WHO-1994, Rao and Miyazaki, (1997). When the monsoon rainfall is not adequate to support the crop throughout, agricultural drought occurs. The frequency of drought are also influenced by climatic changes as a result of increased concentration of the atmospheric CO_2 methane (CH_4) and Nitrous-oxide, (NO_2). The indiscriminate use of gases like chlorofloro-carbon (CFC) and use of coke in thermal power plants have altered the radiation balance of the earth's atmosphere resulting in increased temperature due to Green House effect. The Inter-Governmental panel on climate change (IGPCC) of the World Meteorological Organisation. projected an increase of 01. To 03.^{0}C by 2010 and 0.4 – 2.0^{0}C by 2020 in South Asia. It was estimated that the implication of climate change might result in a decrease in cereal production in the South Asian region.

The studies conducted on secular changes in rainfall and air temperatures of northwest India showed that there was a marginal increase in the rainfall by 141 mm in the past 100 years (Pant and Hingane -1988) and more so in irrigated belts of Ganganagar region particularly during the past three decades (Rao. 1996). The studies on climatic changes over Jodhpur region showed that the

rainfall and air temperature were favorable, but the increase in human population (400%) and livestock (127%) during the twentieth century resulted in a major shift of land use pattern and tremendous pressure on surface and groundwater resources. This has been the main causative factor for drought and desertification conditions in the region. (Rao and Miyazaki 1997).

1.2 Kinds of Droughts

Drought means different things for different people and there are probably as many definitions as there are user of water. To start with for agricultural scientists it is the absence of soil moisture to support plant growth. To the meteorologist it is the absence of rain and to the hydrologist, it is the absence of water in the storage reservoirs and canal system for irrigation and power generation.

The National Commission of Agriculture (1976) defined drought in three categories: (a) Agricultural drought → It occurs when soil moisture and rainfall are inadequate during the growing season to support a healthy crop growth to maturity and cause crop stress and wilting. It may also cause decline in production from grazing land pastures and trees being used as top feed in arid regions. (b) Meteorological drought → It is a situation where there

is a significant (more than 25%) decrease in rainfall from the normal over the area.

Under this classification if drought occurs in 20% of the years in any area. It is classified as drought prove area and if the drought occurs in more than 40% of the years it is classified as chronically drought prone area. Indian arid zone falls in the category of chronically drought prove area.(c) Hydrological drought → meteorological drought when prolonged results in hydrological drought with a marked depletion of surface water and consequent drying up of reservoir, lakes, streams and rivers, cessation of spring flows and also fall in groundwater levels.

Many people have been trying to define 'DROUGHT' precisely. But so far no definition has unanimous acceptability. Many of the definitions are purely based on one climatic elements i.e. rainfall. All the definitions of drought centre around the 'want of rain' or 'want of soil moisture' the following definitions are given to understand drought as a concept.

According to Tannehill:→ "Drought belongs to the class of phenomena which is popularly known as spells of weather".

According to Bates:→ 'Drought occurs when annual precipitation value is 75% of the normal value or when the monthly precipitation is 60% of the normal value".

A Meteorologist, Hoyal, said that in humid and semi arid climates droughts do not occur until the annual precipitation is as low as 85% of the mean.

British Rainfall organization (BRO)- 1936 – Has given a term- "Absolute Drought" – i.e. A period of at least 15 consecutive days to none of which is credited a rainfall of 0.1 inch or more.

Henery (1906), Gibbs and Mahar (1967) Cocheme and Frequin (1967) etc. have also taken rainfall as the indicator of drought. In the U.S.A. absolute drought occurs when –" A year having a period at least 21 days when the precipitation is less than 30% of the normal".

Indian Meteorological Department – (I.M.D.) has defined drought as "A situation occurring in only area when the annual rainfall is less than 75% of the normal I.M.D differentiates the moderate and severe drought. It the rainfall deficit is 25% to 50% of the normal it is a moderate drought and if the rainfall deficit is more than 50% it is a severe drought.

L.A. Ramdas also attempted a definition of drought and observed that – "Drought is an occasion when the actual rainfall short of the normal by more than twice the mean deviation. This definition has more statistical base.

All the above definitions are based on one parameter which is negative departure of rainfall from the normal values. While rainfall and its availability in time and space is important many other factors such as temperature wind-velocity photoperiod, soil texture evaporation stage of crop growth and antecedent rainfall interact to produce drought situation. Therefore all these factors should be given the weightage.

Drought should be understood in relation to plants and the stage of their growth. If it is at the critical stage it causes more damage for this we have to see the phenological scale of the plant growth.

Landsberg (1958) observed that : → "Drought is a biological rather than climatic phenomena and that it should be defined separately for each plant species and soil environment".

Ramasastry observed that → "Drought begins when plants can no longer recoup water from the soil as quickly as it is lost by transpiration.

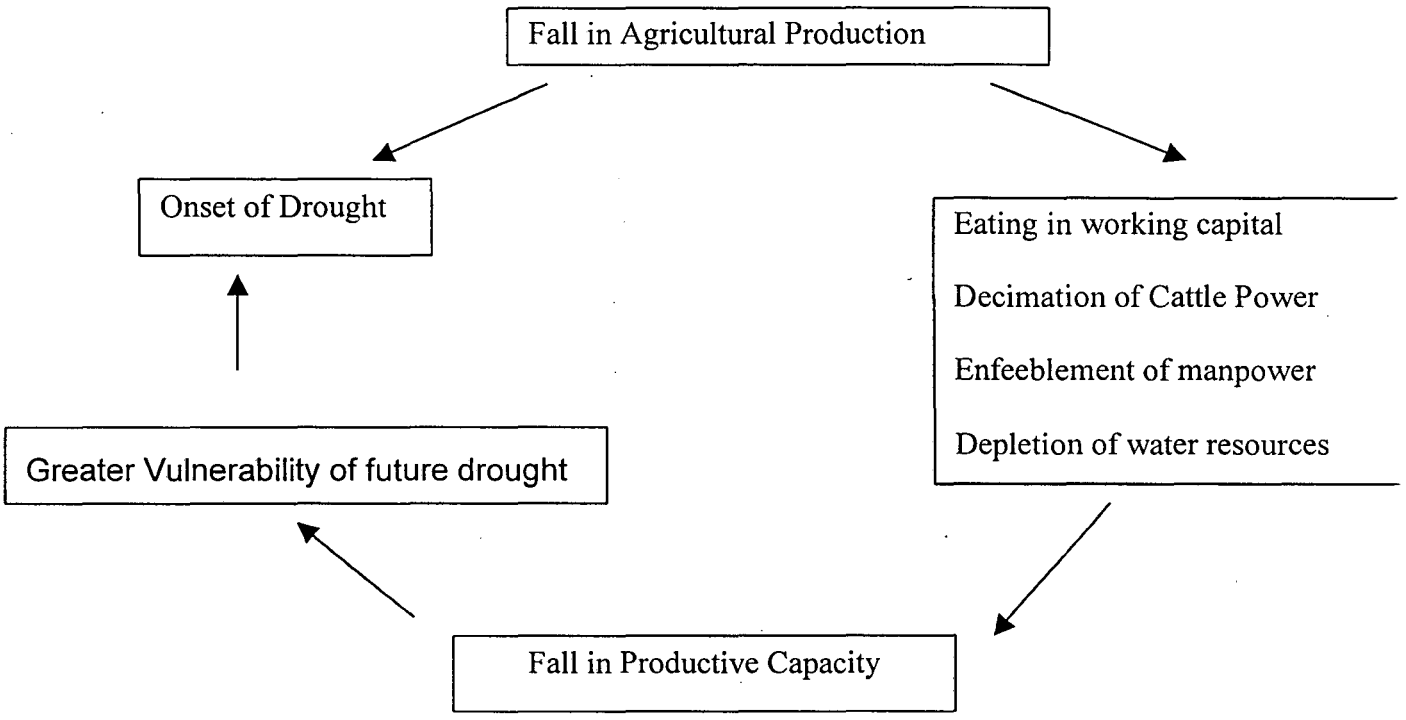
Thornthwaite → has also defined the drought as a period of dryness of weather which affects the earth or prevents the growth of plants.

American meteorological society → (A.M.S. 1959) has defined it as – A period of abnormally dry weather sufficiently prolongs for lack of water to cause serious hydrological imbalance which mean crop damage and water shortage in the affected areas. There are some people who think that it is a economic phenomena recognizable in crop failure.

P.R. Dubhashi – 1992:→ says that "A succession of bad harvests can plunges small and marginal farmers in a vicious circle of poverty dragging them down from the status of landowner to landless, penniless, powerless conditions" This is illustrated in the chart. The onset of drought creates a vicious circle and events go on repeating themselves unless large-scale amelioration is not brought about. Thus it is evident that drought cannot be defined as a shortage of rainfall alone.

The meteorological drought is a deficiency of rainfall in particular season during which some precipitation should have been normally received. The agricultural drought is a situation which ports stress and strain on plant growth and animal production. In the same way hydrological drought is depletion of

the surface and underground water level i.e. reduction of flow in rivers which leads to hydrological imbalance in the region.



Source : J.K. Komal (1995), Occurrence of Drought and Effect on Agricultural Productivity in Western India – A c ase study of Rajasthan Gujrat & Maharastra, 1961-1963 to 1985-87, Dissertation in JNU library.

The economic drought is caused by shortage of water which adversely affects the economy of the region and the biological phenomena resulting in adverse effects on biomass.

It is clear from the above that deficiency of water or departure of rainfall from the normal is the most important factors causing drought. Drought is a relative term and it has a limited

scope in respect to space. The climate and soil make it difficult tot apply the some precise definition to all the area.

Prof. Tapeshwar Singh → Explained if from the practical view point that – Drought may be regarded as a period of abnormal dry weather sufficiently prolonged lack of water to cause serious hydrological imbalance in the affected areas.

Hence, drought concerns with a particular state of an area when rainfall deficiency has reached to such an extent that the moisture available in the soil may not be found sufficient for the normal growth of plants and trees.

1.3 DROUGHTS IN INDIA

Failure of the monsoon rainfall is the most important cause for droughts/famines in India while occasionally floods and failure of crops due to epidemics of insects and pests are also responsible for famine like situations. Also extensive deforestation over centuries has altered hydrologic cycle and tended to increase the incidence of drought in pockets. A study of moderate and severe drought that occurred in India indicates that except for very small pockets in the North-Eastern India and Kerala, there were no areas which had not been affected by drought at one time or the other. While the entire country could thus be considered as

drought prone, there are certain areas which are chronically subjected to such condition and merit the application 'drought prone' Technical committee on Drought Prone Areas Programme (DPAP) and Desert Development Programe (DDP) identified about 120 million ha. of the country's area, covering 185 districts (1173 development blocks) in 13 states as drought prone (Anonymous 1994).

Scarcity of food, fodder and water resulting from rainfall has been a recurring feature in India. Based on historical records. *Jaiswal* and *Kolte* (1981) reported 120 droughts, famines in one or other part of the country between 1291 and 1979.

Das (1988) mentioned that from the 11th to the 17th century there were at lest 14 famines in different parts of India. Another 12 famines were recorded between 1769 and 1858 a ninety year period during the next 49 years between 1860 and 1908 there were 20 famine years of these the worst famines were in 1877, 1899 and 1908 when in each case more than 50% of the country had received less than 75% of normal rainfall ravaging more than 60% of the country. A study of slight intense and severe famines that occurred in India during the 19th century showed that with the exception of very small pockets there were no area which had not been affected by famine at one time or the other (Bhatia 1976).

He further reported that between 1800 and 1966 severe or wide spread droughts led to a sharp fall in food production in the country as a whole and gave rise to famine conditions. Much famines and near famine condition resulting from drought during the last 75 years, canal irrigation as well as other major and minor sources of irrigation reduced to a large extent the effects of droughts.

1.4 DROUGHT IN THE INDIAN ARID ZONE

Nearly two-third of the Indian arid zone is made up of dunes and sandy plains. The region has disorganized drainage network deep and often-saline ground water over a major part and high rates of evapo transpiration. Spatially the rainfall is erratic and merger ranging from 500 mm in the eastern margin of the region along the Aravallis to less than 100 mm in the west in Jaisalmer, 3 district. Added to this decreasing rainfall gradient the year-to-year annual rainfall variability increase from 40% in the east to 70% in the west. Therefore drought and disastrous famines are recurring features of the Indian arid zone. The main causes of droughts are geographic location not favouring the abundant monsoon rainfall, poor quality and excessive depth of groundwater absence of perennial river and forest, poor water holding capacity of soils and huge withdrawal from limited groundwater resources.

The region supports a high human and livestock population - the livestock outnumbering human by about 4 times in Jaisalmer 3 time in Barmer, 2 time in Bikaner and 1.5 time in Banaskantha, Jalor and Jodhpur districts as against only one half in rest of the country. As a result there is a perennial fodder shortage to the tune of 28.2 million tones/annum. Also in about 75% area the water table is declining at the rate of 0.20 to 0.40 meter annually due to over exploitation as a result of increasing demand. The agriculture is wholly dependent on rainfall.

In other words whenever drought or famine synchronized for the want of rainfall within the region the people were compelled to suffer severely. Popular saying in the Indian arid zone goes like this in the course of a decade one-year would be a bumper crop (100%) five years of average produce (60-75%) three years of famine (<25%). There is a defined and true impression that irregular and uncertain rainfall followed by drought and famine is an inevitable every three-year cycle in the region.

1.5 Identification of Drought Prone Area

The Agriculture in large parts of the country is rainfed and therefore agricultural productivity in these area is comparatively low. About 70 percent of the area in the country are still cultivated

under rainfed conditions and this area contributes about 42 percent of the total foodgrain production.

Fourth Five-year plan lists 128 districts of the country as drought prone. But of them 25 district of Rajasthan, Saurashtra, and rain shadow regions of Maharashtra and Karnatak suffer from aridity. These regions receive annual rainfall between 375 to 750 mm and above and less than 10 percent of cultivated area is under irrigation

Planning Commission's definition of dryland however cannot be considered as objective because annual rainfall cannot be considered as the only criteria to delimit dryland. Dryness or net loss of water is determined by soil moisture requirement or potential evopo-transpiration which depend on various climatic factors hence dry or wet land can be delimited keeping in view both sail moisture requirement and its supply.

Governments of various states identified drought prone area on the basis of rainfall and availability of irrigation facilities. The drought prone area were identified at tehsil, taluka or level. They adopted different criteria in absence of any concrete guideline and these criteria were not comparable. Therefore no uniformity could be observed by states in the identification of drought prone area.

In 1972, the irrigation commission had identified 67 districts as the core areas affected by drought, Taking mainly into account the meteorological data and level of irrigation development. Here the most important aspect is that it is not the amount of rainfall but its availability in right amount at the right time of crop growth is g significant

It is well know that the area receiving higher amount of rainfall has favorable water balance "The drought is the result of an imbalance between the soil moisture and evapotranspiration needs of an area over a fairly long period." All the identified drought prone districts fall unto the arid and semi arid parts of country.

1.6 Objective:

(1) To study the annual rainfall pattern over Rajasthan from 1875-2000 and Ajmer district from 1901-2000.

(2) To estimate the frequency of occurrence of severe or modrate drought over Rajasthan and Ajmer district.

(3) To study the irrigation development in Ajmer district.

(4) To study the cropping pattern in Ajmer district

(5) To study the impact of drought on agriculture in Ajmer district.

(6) To study the drought proofing and relief measures.

(7) To study the drought management techniques.

1.7 Methodology:

Simple mathematical techniques one hand, and appropriate statistical techniques on the other hand have been used in this work to reach at conclusions.

(1) To measure the variations in rainfall and identify the trend of occurrence of drought data for the last hundred years of state and meteorological subdivision average annual rainfall is taken into consideration mean standard deviations from the mean and coefficient of variation are calculated. Decadal fluctuations in rainfall, as well as fluctuations in past fifty years as well as hundred years as a whole have been analysed.

Also, the effects of El-nino years on the agriculture as well as occurrence of drought are analyzed.

(2) A section in this dissertation is devoted to find out productivity of various crops in Ajmer district for time period 1985 to 2000

Productivity was calculated the in rupees per hectare only weighing the production of each crop with its unit price summing up all values for all crops which is divided by area under all crops.

Regression analysis and correlation matrix between Productivity and Agricultural water use is prepared to identify the relationship between agricultural water use and productivity in Ajmer distinct.

Agricultural water use is calculated in Ajmer district by following formula, by using data on PE, effective rainfall and percentage gross cropped area irrigate .

Total water use = percent of irrigated area + % of unirrigated area

Appropriate, simple cartographic techniques bar area used in presenting graphically.

1.8 Database:

The data used in this dissertation work have been taken from following sources:

1. Annual Administrative and Progress Report, Flood and Relief Department, Jaipur, Rajasthan.

2. Annual District Statistical Abstract, Ajmer, Economic and Statistical Directorate, Jaipur, Rajasthan .

3. Annual Statistical Tablets, Revenue Department, District Ajmer, Rajasthan.

4. District Statistical Abstract, Statistical Department, Ajmer Rajasthan.

5. Block wise data for Ajmer district have been taken from Annual Report, Hydrological Department, 2000, Jaipur, Rajasthan..

6. Indian Agriculture Statistics – 1985-86 to 1999-2000.

7. Indian Journal of Meteorology and Geophysics –1967-82

8. Indian Journal of Meteorology, Geophysics and Hydrology.

9. Mausum. Journal (1985-2000)

1.9 Literature Review

Acharya A.S." Socio-Economic Impact of 1987 Drought in Rajasthan". Final Report of ICAR- Adhoc Research Project 1989.

The drought of 1987-88 was one of the most severe disaster which caused widespread shortages of food and footer leading to famine deaths. In this report attempts have been made to examine the impact of drought under the following leads-

(i) The impact of drought land use, cropping pattern, crop failure, adoption of new crop technology and irrigation.

(ii) The effect of drought on production and productivity of crops including fodder and livestock.

(iii) The effect of drought on price of inputs, fodder livestock and consumer goods and wage rates.

The report also examines the methods used by rural population to mitigate the effects of drought through borrowings and asset liquidation. If further explains how the life styles of the people changed during the period of drought. Lastly, attempts have been made to study the short term and long term benefits derived by rural families from the drought relief measures of government and voluntary organizations and the attitude of people towards these programmes.

Donald A. Wichita and Michael H. Glantz," Understanding the Drought Phenomenon: the Role of Definitions" PP 11-27

Planning for Drought toward a Reduction of societal vulnerability, Westview Press – Boulder and London UNEP.

This paper reviews numerous definitions of drought to determine those characteristics scientists considers most essential for a description and understanding of the phenomenon. It also discusses the far reaching impacts of drought on society. The final section suggests that definitions of drought are typically simplistic and, in that way, often lead to a rather poor understanding of the dimensions of the concept. It is suggested that definitions of drought should not be formulated in a narrow sense, but rather should incorporate both physical and social measures that have a local or regional significance.

Venkateswarlu. "Effect of Drought on Khari Foodgrains Production: A Retrospect and Prospect." Annual of Arid zone 32(1) 1-12 1993.

In this article the effect of drought on foodgrains production has been assessed on the national scale as well as for individual crops taking state as a unit. It should be noted that these are post-cropping analysis. An early warning system was developed by Slayers et. al. (1981) to assess the effect of drought on foodgrains production. The model evolved by Doovenbos and Kassam (1979) on " Yield response to water" can be used for assessing the

proportionate of the potential achievable based on the rainfall as it progresses in relation to the phenoeogy of the crop.

In the monsoon foodgrains production, the perceptible effect of drought is more visible with rice and coarse cerals grown under better endowments.

Some suggestions on tackling the high variability and almost faltering that is taking place in foodgrains production in Kharif season are made based on the responses available with the interventions (long and short term) at the government, farmer and village level.

(1) Singh, Tepeshwar, " Drought Disarter Management; An Indian Perspective", *National Geographical Journal of India*, Vol. 44 (1-4), Mar – Dec, 1998.

Paper studies different facets of drought management. From relief approach of pre-independence era to society approach of 1960s, In 1970s, Indian approach to drought has evolved to modern drought disaster management approach. Paper stresses the need for a durable national disaster management policy, dealing with all sort of natural disaster. Main components of disaster management are prevention of occurrence of a disaster; mitigation of the impact of disaster; preparedness to respond

rapidly & effectively to disaster situation; responses aimed at saving lives & material losses; recovery to normal life following a disruption, and the development & modernization of societies.

Drought disaster is a recurring phenomenon, the followings are required after the drought has started. First involves the humanitarian intervention phase in which lives are saved and human suffering are reduced through immediate relief measures Second phase involves rehabilitation after repairing damage. Third phase is the recondition which involves long term development activities.

Paper also discusses the magnitude, extent and impact of drought in the post-independence sever-drought years of 1965-67, 1972-73, 1979-80 and 1986-87. Drought induced losses continue to be significant dispute many drought mitigation effect and comistent agricultural growth. Impact indicators and decision indicators enable the comparison of different droughts. Although our country has significantly increased the potential and capacity to meet the threats posed by drought disaster but household or farm-level variability to drought in climatically unsafe areas still persists. The GIS, remote sensing and other scientific knowledge may be used for vulrierbility analysis, hazard evaluation, risk mapping and preparation of disaster reduction projects.

Bagchi, Kathakali s., in his book " Drought Prone India: Problems and Perspectives" deals with the problem of drought in Rajasthan also. After presenting general view of the physical, climatic and soil features, author gives the profile of drought prone districts. On the basis of the total available moisture, the drought prone districts have been divided into arid and semi-arid zones. Jhunjhunu is the only district in Eastern Rajasthan which comes under arid zone, rest other drought prone districts are in semi-arid zone. In western Rajasthan all drought prone districts except Pali are in arid zone.

For agriculturists, drought is a demand situation when inadequate moisture availability for the growing crops severely affects the total agricultural yield. In times of scant rainfall, spread of widespread hunger and famine is a regular nightmare for our peasant population.

Vohra, B.B., "Drought, Development and Desertification". This paper was presented as keynote address at a Seminar in 1986. Author sees inter-basin transfer of water as one solution to drought, but it is becoming very costly as is Narmada Project . Further there is a wide gap in potential created and the utilization one viable alternative is on the conservation of rainfall where it

falls and whenever it falls. For permanent solutions we must place as much land as possible under permanent vegetation.

Sinha B.P.C,." Potentials of Ground water Development in Droughts Prone District" GOI, Central Ground Water Board (1983)'

Drought is both a physical and socio-economic phenomenon. The most widely used interactive definition of drought is the Palmer Index, carefully developed as a general measure of water conditions in an area. It allows comparison of available water conditions between different areas and thus useful for scientific studies.

The book present general features, physiologial features, climatological, quality and ground water available in 75 drought prone districts of India on the basis of research carried out by govt. agencies including CGWB.

1.10 STUDY AREA - AJMER DISTRICT

The district derives its name from the headquarters town of Ajmer Before independence Ajmer. Merwara was an isolated province of British Indian in Rajputanu. The town, Ajmer take its name from Raja Ajay Raj, a Chauhan prince of the 12th century A.D. According to some scholars, it is derived from another chauhan

prince Jayapala of the early 7th century A..D. Ajmer remained under the central Government as part 'C' Centraly administered state till 31st October. 1956 when it was merged with Rajasthan according to the recommendation of the state Reorganization commission and become a separate district .

At the time of 1951 census the district comprised of three tehsils viz Ajmer Beawar and Kakri. As for urban areas there was one city alongwith six towns namely Beware, Nasirabad Kekri, Pushkar, Vijainagar and Deoli. During 1951-61, inter-census period four entire tehsils – Kishangarh Arain Sarwar and Rupnagar were transferred from Todarai Singh, tehsil of the tonk district. During this period one village three hamlets and one town Deoli was given to Deoli tehsil of Tonk district. During 1961-71 no inter district transfer took place in the district. However as inter-tehsil transfers former entire tehsils of Pupnagar and Arain were merged in Kishngarh tehsil and 34 villages were transferred from Kekri tehsil to Sarwar tehsil. During 1981-91. Nasirabad was formed as new tehsil constituting 69 villages of Ajmer tehsil and Nasirabad cantonment Board with an area of 656.12 sq. km. Similarly Alarmbo – a village of Sarwar tehsil, was transferred to Kekri Tehsil of the district.

At present the district is composed of four sub- division and five tehsils as under

Name of sub division	Name of Tehsil
1 AJMER	1 AJMER
2 BEAWAR	2 BEAWAR
3 KEKRI	3 KEKRI
4 KISHANGARH	4 KISHANGARH
	5 NASIRABAD
	6 SARWAR

PHYSIOGRAPHY:

The district is triangular in shape. It is generally a level plain interspersed with low hills, which run in the north-westerly direction in the upper part of Ajmer sub-division. The Beawar sub-division is an irregular terrain lying in the south-west of the district and is composed of two detached blocks. This track is generally hilly. The Kekri sub-division forms the South-Eastern portion of the district. It is a compact area composed of two blocks separated by the territory of Kishangarh sub-division. This tract is a level plain. The Kishangarh sub-division forms the eastern portion of the district and is sandy except for a few small isolated patches.

Aravali range which divides the plains of Marwar from the high table-land of Mewar passes through the district. The range comes into prominence near Ajmer city, where it appears in a parallel succession of hills. The highest point is about 870 meters above the sea level near Ajmer city on which Taragarh fort is situated. The 'Nagpahar' at a distance of about 5 Kms west of Ajmer city attains a scarcely interior elevation. The hills between Ajmer and Nasirabad marks the dividing watershed of the sub continent of India. The rain which falls on the Southern Nasirabad side, finds its way through the Chambal into the Bay of Bengal and that which fall on the other side is discharged by the Lani into the Gulf of Kutch. The range of hills on which Taragarh Forest stands passing through the district merges into the Vindhyan system near Abu. There are four well known passes in Beawar tehsil viz., Barr, Pakheria, Sheepuroghata and the Sarghata pass.

There were five rivers which flows through the district viz Banas, Khari, Sagarmati Sarawati and Rupnagar. All rivers are mere rivulets in hot weather but become torrents in the rains. The river Banas rises in the Aravali hills enters this district near village Jeetapura in Kekri Tehsil. The Khari river rises in the hills near the village Birjal and after forming the boundary between Udaipur and Ajmer district for a short distance falls into Banas. The river Sagarmati rises near the Besala tank in Ajmer and meets

river Saraswati at the extreme north of village Govindgarh (Ajmer Tehsil) Another river Rupnagar flows in the major part of Kishangarh Tehsil.

There are natural lakes viz. Pushkar and Budha Pushkar near Ajmer city and Karanatia near Beawar town. Among the important tanks in the district are Sagar, Phool Sagar, Bisala Ramsor Dilwar, Kalingar, Jawaja, Makreda etc. Besides several small reservoirs are also found in the district.

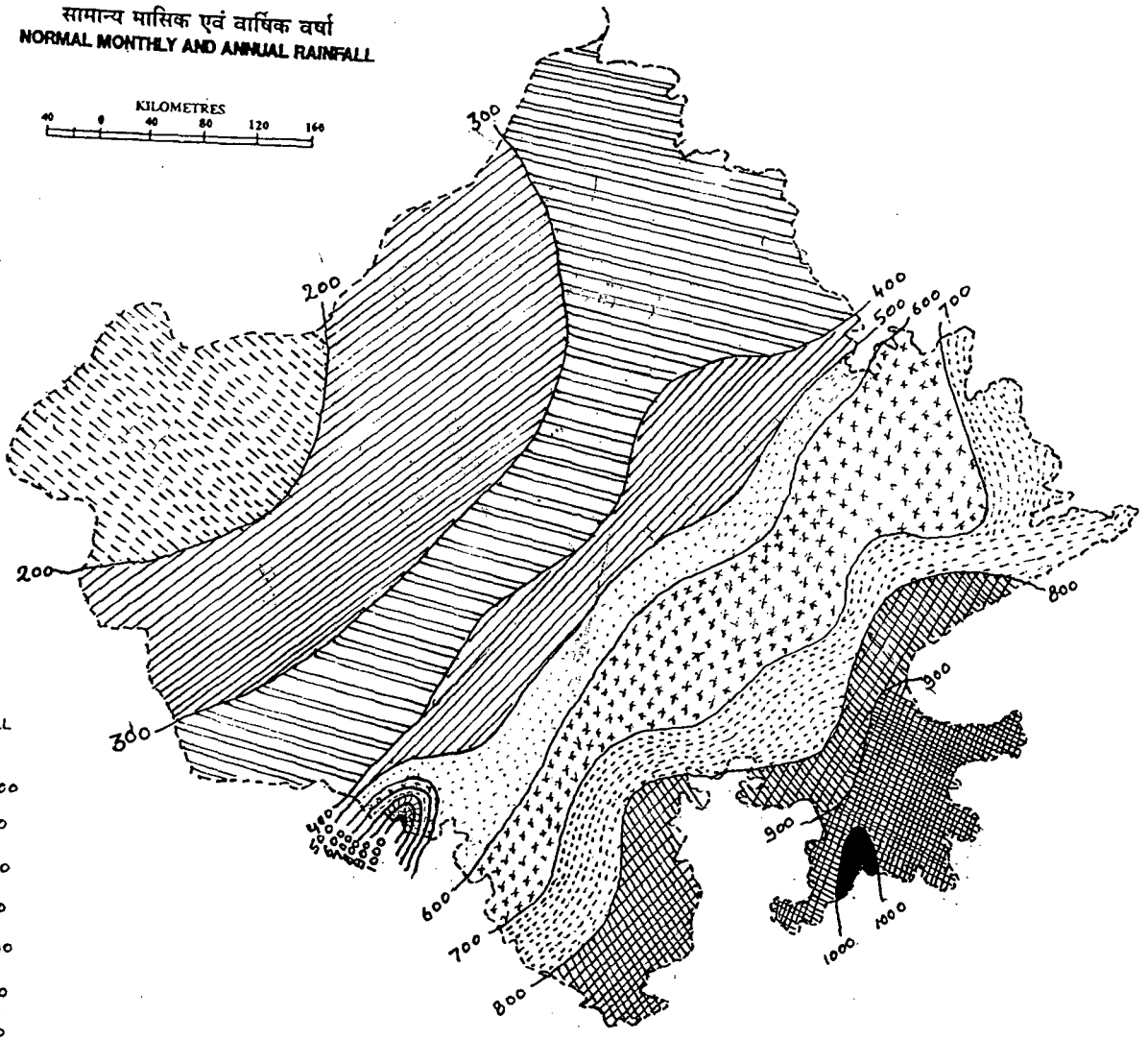
Climate

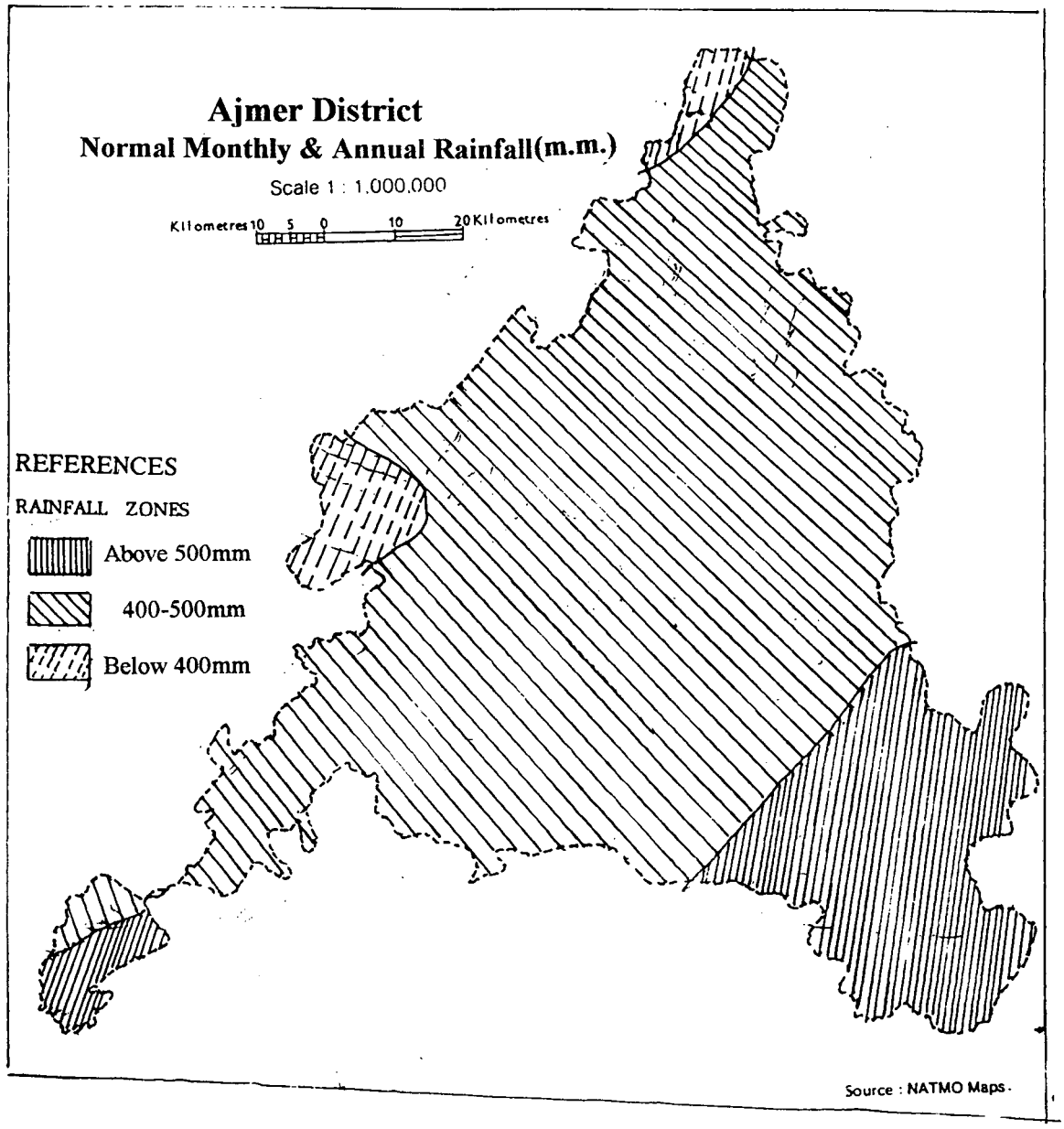
The district has a hot dry summer and cold bracing winter. The rainy season is comparatively short in this region and lasts only till mid September. The maximum temperature was 45 ^{0}C and the minimum was recorded 2^{0}C at Ajmer center during 1989. During the period the mean temperature remained 23.5^{0}C. The normal annual rainfall was recorded 52.73 cm while the actual rainfall was 42.33 cm in 1989. The rainfall generally increases from the north-west to the South-East. Kekri gets more rain than other parts of the district About 90 percent of the annual rainfall is received during the period June to September, July and August being the rainiest month. The variation in annual rainfall from year to year is very large. On an average there are 26 rainy days in a year. During the south-west monsoon season, the relative

RAJASTHAN

सामान्य मासिक एवं वार्षिक वर्षा

NORMAL MONTHLY AND ANNUAL RAINFALL




Ajmer District
Normal Monthly & Annual Rainfall(m.m.)
Scale 1 : 1,000,000
Kilometres 10 5 0 10 20 Kilometres
REFERENCES
RAINFALL ZONES
Above 500mm
400-500mm
Below 400mm
Source : NATMO Maps.

humidity is generally over 60 percent and during the rest of the year the air is dry.

Minerals

The district is endowed with a large number of non-metallic minerals which add several lakhs of rupees to the state's treasury. The main minerals found in the district are as under:

1) Asbestos → Chrysolite asbestos is found at Kanwalai (Ajmer Tehsil, and Hai Khurd (Beawar Tehsil) where as the amphibole variety occurs near Kotro (beawar Tehsil) Arjunpura (Ajmer Tehsil) and Kotri (Sarwar Tehsil) it is Chiefly used in the manufacture of leaf and fire resistant materials.

Beryl / Emerald: → Beryl is found in Pegmatites near Lohagarh and Makreda. Emerald of the gem variety is quarried from Rajgarh and Babani – Mahmimines where it occurs within the ultra-basic rocks.

Feldspar:→ It occurs in the pegmatite at Kadea (Kekri Tehsil) Baburgarh. Taragarh hills (Beawar Tehsil) Jeewan mines near Rajgarh, Makreda near Ajmer and Lohagarh. It is used in the China- ware and glass industries.

Garnet : → Lilac to pink coloured garnet is found within the mica schist near Sarwar it a used mostly as an abrasive and partly as a gem-stone.

Mica: → Muscavite mica associated in the pegmatite vains is mined near Dadiya (Kishangarh Tehsil) Basundni (Kekri Tehsil) mines near Sarwar and Arian.

Vermiculite:→ The mineral occurs near oxides within the ultra rocks. Since it swells up to 10 times on heating it finds use where extreme lightness and low heat conductivity are required.

Besides these calcite, China clay, kyanite limestone soapstone and building stone are also produced on a minor scale and occurrences of lead-zink copper are reported from Lohakhan Taragarh.

Forest Flora and Fauna

Around 5.56 percent of the total area is covered under forests Owing to its geographical position and limited rainfall the flora of the district is not rich. The forest crop is mainly xerophtic species common to the more arid tracts of India. The district is completely outside the timber line i.e. Teck Sal and Sisso Zone of the tropical and sub-tropical India. The main species found in the district are Dhokar (Anogeissas pendula) Kumpta (Acacia

rupestris) Salar (Baswellia Serrata), Khejri (Prosopis spicigera) Khair (Acacia catechu) Ber (Zizyphus Jujuba). Jinja (Bouhinia Recemoso), Kowulassi, Aranja, Gol (Lannea Gradis) Tembolia (Ehretia laevis) Sinjora, Thor, Grangan (Grewio popalifolia) Jharbar (Zizyphus numulario) Dessen Rhus Mesorensis), Ferangan (Grewiapillosa) salepan (Securinega abovata) Arni (Derodendron phlomoides) Heem (Azaderachta Indica) Semal (Salmalia Malabaricum) Pipal (Ficus religiosa) Kar (sterculia urens) etc.

The most common grasses found in the district are conchrus cillaris Schima marvosas Duchanthium, annulatum, chloris barbata, chrysopason, montanus and eremonopogon fovealatas etc.

The forests play a very important role in the economy of the district. They meet the requirements of villagers in respect of agricultural implements and timber for their hutments and provide grazing. The wood is used as used in town and vilages.

Among the wild animals block buck (antelope bezortica) rivine deer (Gazella bemettii) and nilgai (Portax pictus) are commonly found while tigers are occasionally seen in the forests of Beawar, Leopards and hyneas are found Leopard and hyneas are found in the hills of Hagpahar. Besides wild ply and sambhar (rura aristateli) are also found. Among small games geesa etc are

found around the lake in cold weather. Hares and grey partridges are seen in every season. Small sand grouse is found in abundance while Indian bustard is occasionally seen.

Land use

The Geographical area of the district is reported as 850410 hectare while the area recorded for the land utilisation purpose was 842388 hectares in 1988-89. The area classified under land use pattern during the year was as under:

Classification of the land use	Area in Hectares	Percentage to total area
Forests	46,853	5.56
Land put to non agricultural use	89154	10.59
Barren and uncultivated land	53074	6.30
Other uncultivated land excluding fallow land	81375	9.66
Culturable waste	77339	9.18
Fallow land	117449	13.94
Net area sown	377144	44.77
Total	842388	100

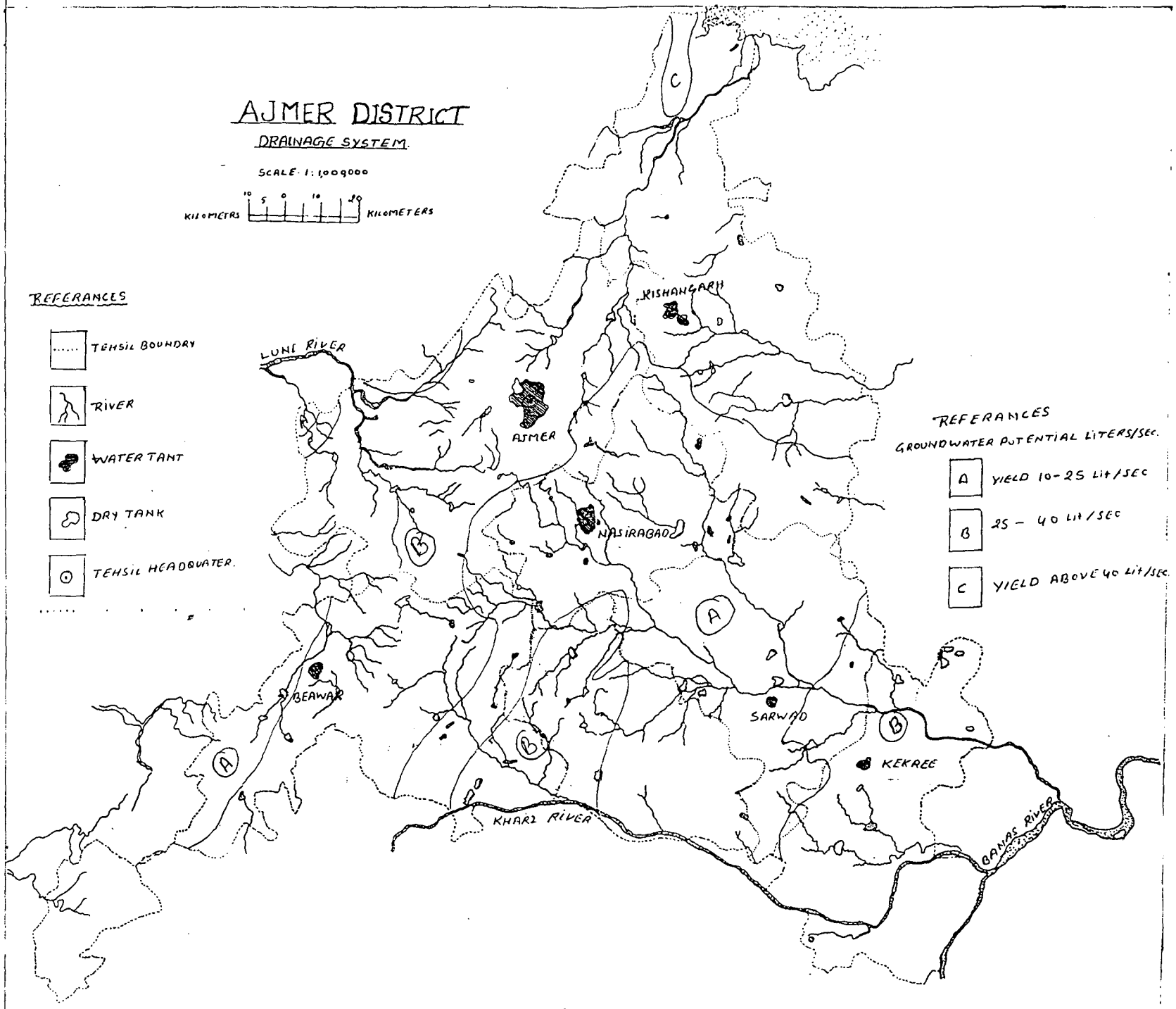
Agricultural implements and machinery: →

Most of the agricultural implements in the district are of old type but attemps are being made to introduce improved types of implements the main implements are ploughs harrows levellers, cloderushers, seed drills and hoes. There were 56889 ploughs 3414 thousand carts 7851 electric pumps 5622 oil engines 343 Ghanies 1189 tractors and 7 sugarcane crushers in the district according to the livestock census 1988.

Irrigation

The farmers of the district mainly depend on rainfall for their agricultural operation as this district is not rich in irrigation facilities as compared to many other districts of the state and the wells are the single most important sources of irrigation. Out of the net irrigated area during 1988-89, 86.98 percent was irrigated by well and tubewells 11.06 percent by tanks and the remaining 1.96 percent by other sources. During this period the gross irrigated area by crops was as under:

Name of Crops	Area irrigated in Hectares	Percentage of Total irrigated area
Food Crops (Other than sugarcane)	51202	75.04


AJMER DISTRICT
DRAINAGE SYSTEM
SCALE 1:1,000000
KILOMETERS
KILOMETERS
REFERANCES
TEHSIL BOUNDRY
RIVER
WATER TANT
DRY TANK
TEHSIL HEADQUATER
LUNI RIVER
AJMER
KISHANGARH
NASIRABAD
BEAWAR
SARWAD
KEKREE
KHARI RIVER
BANAS RIVER
REFERANCES
GROUNDWATER PUTENTIAL LITERS/SEC.
A YIELD 10-25 Lit/SEC
B 25 - 40 Lit/SEC
C YIELD ABOVE 40 Lit/SEC

Sugarcane	4	0.01
Cotton	5,425	8.05
Others	10708	15.9
Total	67339	100.00

Five minor irrigation project were under taken by 1988-89 in the district and an expenditure of Rs. 33.46 lakhs was incurred on them under state plane Besides Rs. 96.69 lakhs under NREP Scheme and Rs. 7.83 lakhs under RLEGP were spent on these minor irrigation schemes.

Animal Husbandry

In 1988 the district had a livestock population as shown in the follow in the following table:

Animals	Number	Percentage of Total
Cattles	372817	23.83
Buffaloes	148177	9.47
Sheep	566958	36.24
Goats	433990	29.02
Donkeys & Mules	4364	0.28
Horses & Ponies	499	0.03
Camels	5191	0.33
Pigs	12438	0.80
Total	1564434	100.00

The total poultry in the district was about 6.51 lakhs in 1988 in 1988.89 there were 26 veterinary hospitals, 19 veterinary dispensaries Seven sheep extension centres, 15 artifical inscemination centres and two mobile veterinary units in the district. The most common breed of cattle found almost in every part of the district is the 'Gir' which has been given a local name of 'Renda' or 'Ajmera" in some portion of Kekri tehsil the Haryana breed is also found while Hgori breed is available mainly in Rupnagar Tehsil.

Population

Ajmer district has 14.40 lakh inhabitants; out of them, 2.42 lakh are cultivators, 36954 are agricultural labourers and 43,516 are marginal workers; 90 percent of them are females.

The dissertation is arranged in six chapters in the first chapter, the definition of drought selection of the study area, data base, methodology and salient features of the study area in gives. Chapter II discusses the frequency of occurrence of drought. Chapter III describes the irrigation development in Ajmer district. Chapter IV discusses the cropping pattern, the impact of drought on cropping patterns, the relationship between agricultural productivity and agricultural water use. Chapter V evaluates drought management strategy and implementation Chapter VI gives the conclusion.

NOTES

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CHAPTER - II

RAINFALL CHARACTERISTICS IN RAJASTHAN

2.0 Introduction

In a country where 70% population is directly dependent on agriculture, timely and adequate rainfall is essential for the sustenance of the population. In a situation where agriculture is primarily dependent on rainfall, any failure or inadequacy of the monsoon rains which amounts to 80% of the annual rainfall can play havoc with the economy.

Although the annual precipitation in India is 96 cm, it may show a deficit of 20 cm (1899) and a surplus of 30 cm (as in 1907). Spatial distribution of rainfall in India is marked with a high degree of variation. The Kerala coast and the North-Eastern hills receive more than 400 cm of rainfall while the rainfall is even less than 20 cm in parts of Rajasthan. This variation can be explained through the existing mountain barriers, existence of monsoon trough, amount of moisture carried by the air and so on.

2.1 Spatial distribution of Rainfall over Rajasthan:

Mean annual rainfall in the state varies from 14 cms over the extreme north western part, to 95 cm over the South-Eastern parts. The South-West monsoon is the principal rainy season, when the state receive 75% to 85% of its annual rainfall. Rainfall in the

winter season (November-March) is about 1% to 8% of the annual total. In the hot weather season (April – June) it is about 8% to 13% and in the post monsoon season (mid-September-October) about 2 to 3%.

South and South Eastern district, adjacent to Madhya Pradesh constitute, the area of maximum rainfall in the state. Mean annual rainfall in East-Rajasthan is 68.3 cms and Western part of the Rajasthan 3.18 cms.. Pali and Jaisalmer district receives the lowest mean annual rainfall (8.78 cm) in India. This district and the adjoining areas constitute the driest zone of the state. These areas are also characterized by highly erratic and seasonal variation in rainfall. The rainfall decreases from East to West and from South-West to North-East in the state.

The rainfall mostly occurs in the South-West monsoon in the state. It sets in over the Eastern part of the state by about the last week of June and extends over the entire state by the first week of July. July and August are the rainiest months each accounting to 30% of the annual rainfall. In each of these months there are 2-7 rainy days (with daily rainfall of at least 2.5 mm) in West Rajasthan and 7 to 14 rainy days in East Rajasthan. A few air current from the main Arabian sea branch are diverted north wards and causes rain in western parts of Rajasthan. The monsoon currents leading towards Rajasthan are rather shallow and are superimposed by

stable anti-cyclonic air. The withdrawal of the southwest monsoon begins from the northwestern part of the state around 1st September and by 15th September monsoon withdraws from the entire state. During winter (November – March) East and West Rajasthan receive 2.6 and 1.7 cms of rainfall respectively, which although small in amount is of great significance for agriculture. This rainfall occurs in association with western disturbances which move from west to east across northern part of the country.

2.3 Rainfall Variation

Co-efficient of variation (C.V) of annual rainfall is more than 40% over same portion of eastern districts viz. Jaipur, Tonk, Bundi, Sawai-Madhopur, Bharatpur and Alwar. While it is more than 80% for western district viz. Jaisalmer, Bikaner, Ganganagar and Barmer.

Table (1.A.B.C.) Reveals that the mean annual rainfall for Rajasthan has been recorded as 551.43 mm over a period of hundred years (1901-02 to 1999-2000). While minimum rainfall in a year has been as low as 233.5 mm in 1905-06 the maximum amount of rainfall received in a calender year has been recorded as 999 mm during 1917-18. This year (1917-18) shows a deviation of 73% from the mean annual rainfall while the year which is marked

by minimum rainfall has shown a deviation of 59.4% (1905-06) from the mean.

TABLE 2.1

(a) DECADAL AVERAGE . STDEV. & C.V,)

RAJASTHAN				AJMER			
YEAR	MEAN	STDEV.	C.V	YEAR	MEAN	STDEV.	C.V
1901-11	492.14	165.56	33.64	1901-11	480.04	209.81	43.7
1911-21	534.74	235.55	44.05	1911-21	482.25	274.14	56.84
1921-31	549.63	87.39	15.9	1921-31	545.98	202.12	37.02
1931-41	549.63	109.37	20.16	1931-41	552.27	174.86	31.66
1941-51	632.74	115.23	18.21	1941-51	524.38	150.65	28.73
1951-61	511.24	130.96	25.61	1951-61	487.9	129.87	26.62
1961-71	515.95	95.13	18.43	1961-71	433.96	108.45	24.99
1971-81	632.42	155.19	24.54	1971-81	665.68	264.94	39.8
1981-91	521.14	104.149	19.98	1981-91	535.93	213.85	39.9
1991-2000	582.12	91.85	15.78	1991-2000	543.18	113.64	20.92

(b) FIFTY YEAR, AVERAGE,. STDEV,.& C.V,

RAJASTHAN				AJMER			
YEAR	MEAN	STDEV.	C.V	YEAR	MEAN	STDEV.	C.V
1901-1950	550.32	158.9	28.87	1901-1950	516.98	208.81	40.39
1950-2000	551.97	127.71	23.13	1950-2000	533.13	190	35.64

(c) HUNDRED YEAR AVERAGE. STDEV. &C.V,

RAJASTHAN				AJMER			
YEAR	MEAN	STDEV.	C.V	YEAR	MEAN	STDEV.	C.V
1901-02 to 1999-2000	551.13	144.32	26.19	1901-02 to 1999-2000	524.97	200.86	38.26

Source: Rajasthan Stastical Aabstract, Youjna Bhavan ,Jaipur
Hydrometerological Department, Irrigation Department, Jaipur

Very little variation in noticed in the average annual rainfall values for the 50 year period 1901-1950 and 1951-2000.

It was 550.32 mm for (1901-50) and 551.97 mm for (1951-2000). However the value of Standard deviation (S.D) and Co-efficient of variation (C.V) favoured the argument that first fifty year period is marked with greater variability as Co-efficient of variation (C.V). for 1901-50 is 28.87% and for 1951-2000 is only 23.13%.

The picture becomes more clear when the decadal mean and variance is analyzed. The lowest mean annual rainfall was received in the first decade of the century when the state received on an average 492.14 mm rain during 1901-11. It has already been noted that minimum occurrence of rainfall (233.5 mm) was marked in this decade during 1905-6. Where as maximum rainfall in a decade was marked during 1941-51 (632.74 mm). Closely followed by 1971-81 (632.42 mm). The two consecutive decades of 1921-31 and 1931-41, has shown least variation from the century mean of 551.13 mm. Apart from the earlier mentioned two decades of higher rainfall the decade of 1991-2000 has recorded higher amount of rainfall (582.12 mm) than the mean value during last of the decade. Rajasthan has received lower than the average amount of rainfall. S.D. has a tendency to get multiplied if a numerical series is

multiplied by any constant for this purpose. C.V. has been calculated which is free from this error.

The C.V. is minimum for the last decade of the century with a value of 15.78, lowest amount of rainfall received during this decade is 429.7 1911-21 and the highest is 1138.7 mm in 1917-18.

On the other hand, incidence of rainfall has shown maximum variation during 1911-21 with a value of 44.05%, maximum rainfall was received during 1917-18 (999 mm) which is highest for the century as well. While minimum rainfall received during this decade is 306.6 mm (1911-12). This is the second lowest amount of rainfall during a year after the lowest amount 233.5 mm of (1905-06). This can be noticed from the Table 'c' that after 1950 decadal variation from mean value is comparatively lower than the first fifty year.

Ajmer has its location on the Western margin of Eastern Rajasthan and marked with a higher variability than the state as a whole. The average amount of rainfall in Ajmer (524.97 mm) is lower than the mean annual rainfall of the state (551.13 mm) over the period of hundred year. Not surprisingly, C.V. for Ajmer district is quite high than the state. It is 38.26% for Ajmer district as against a value of 26.19% for Rajasthan state as a whole. Minimum amount of rainfall (159.8 mm) was recorded during 1987-88 as against the state average of 314.5 mm in the same year. On the

other hand Ajmer district has received its maximum amount of rainfall (1203.7 mm) in one calender year during 1975-76. During this year the state has also received a higher rainfall than average though this is not the highest. Ajmer has recorded a deviation of 100% from the mean when it experienced highest rainfall while the lowest incidence of rainfall was marked with a deviation of 73% from the average. The fifty year mean shows that distribution of rainfall in Ajmer has a similarity with that of Rajasthan. First fifty year show lower amount of rainfall (516.98 mm) than the latter half of the century 1533.13-mm. The C.V of the latter half is lower by 5% inspite of the fact that Ajmer has recorded maximum as well as minimum amount of rainfall during this half. In brief it can be said that the variability of rainfall has gone down after 1950 when compared to first half of the century.

The decadal average shows that during 1961-71 the district of Ajmer received lowest amount of rainfall 433.96 mm. It is noted that during this decade Rajasthan did not experience the lowest amount of rainfall while during 1941-51 Rajasthan recorded highest amount of rainfall 632.74 mm. Ajmer during this decade has recorded just lower 524.38 mm than the average amount of rainfall 524.97 mm. In the decade 1971-81 Ajmer recorded highest amount of average rainfall. This year Rajasthan also experienced higher amount of rainfall. The maximum amount of Ajmer 665.68

mm is much higher than the states maximum 632.74 mm. While average annual rainfall for Ajmer is lower 524.97 mm than the state average of 551.13 mm.

The C.V is maximum for the decade of 1911-21 during which minimum rainfall during a year is (182.1 mm in 1918-19) and the maximum amount of rainfall received over calender year is 1203.7 mm (1975-76). Minimum decadal variation is recorded during the last decade of the century when the C.V. is just 20.92% as against the maximum C.V. of 56.84% (1911-21). This feature is similar for Ajmer.

Rainfall variability seems to be independent of the amount of rainfall received during a year in Ajmer as well. The decade is which Ajmer experienced highest rainfall C.V. is also as high as 40% on the other hand higher variation is also associated with lower average rainfall during a decade. Like 43.7% during 1901-11 when mean annual rainfall is just 480.04 mm. Notably maximum variation has been seen during 1911-21 when average rainfall is 482 mm and C.V is 56.84% while the during 1951.61 amount of rainfall is similar (487.9 mm) to the decade of 1911-21 but value of C.V is as low as 27%.

2.4 Frequency of Occurrence of Drought in East Rajasthan, West Rajasthan and Ajmer District

Because of the inherent variable character of rainfall there are often occassions when the actual rainfall falls appreciably below the normal expected on a long term basis. This phenomena, which can be frequently experienced in the arid region causes drought. This is manifested in terms of crop failure non replenished ground and surface water resources and drying of lakes and reservoirs.

Droughts have been defined in many ways including:

(a) A period of rainfall deficiency

(b) A relative state of forest flammation.

(c) Occuring when a specific agricultural crop or pasture yields are less than expected amounts.

(d) Denoting a critical level of soil moisture or ground water depletion and.

(e) Potentially as a value of rain deficiency in the broad sweep of time and weather (Encyclopedia of Climatology)

Drought means different things to different people and therefore, there can be as many definitions as there are users of water. To the agriculturalist, it is the absence of soil moisture; to

the meterologist, it is absence of rainfall and to the hydrologist, it is absence of water in storage reservoirs, in canal systems for irrigation and power generation.

National Commission of Agriculture (1976) defined drought in 3 categories:

(1) **Agricultural Drought:** It occurs when rainfall and soil moisture are inadequate during the growing season to support a healthy crop growth to maturity and cause crop stress and wilting. It may also cause decline in production from grazing lands, pastures and trees being used as top feed in arid region.

(2) **Meteorological Drought:** It is a situation when there is a significant (more than 25%) decrease in rainfall from the normal value over the area.

(3) **Hydrological Drought:** Meteorological drought, when prolonged results in hydrological drought with a marked depletion of surface water and consequent drying up of reservoirs, lakes, steams and rivers, cessation of spring flows and also fall in underground water levels.

As far as meteorological drought is considered it is further classified as moderate drought if rainfall deficit is between 25-50% and severe drought when it is more than 50%. Areas where

frequency of drought (when meteorologically defined) is 20% of the year's examined are classified as 'Drought areas' and areas having drought condition for more than 40% of the years under consideration represent chronically drought affected areas.

Meteorgologically the state of Rajasthan has been divided into two subdivisions.

West Rajasthan: Consisting of the districts Barmer, Bikaner, Churu, Ganganagar, Jalore, Jaisalmer, Jodhpur, Hanumangarh Nagaur and Pali.

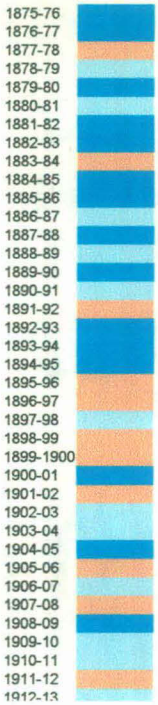
East Rajasthan: Ajmer, Alwar, Banswara, Bundi, Bharatpur, Bhilwara, Chittorgarh, Dungarpur, Jaipur, Jhalawar, Jhunjhunu, Kota, Sikar, Sirohi, Sawai-Madhopur, Tonk, Udaipur, Kuraly and Dholpur.

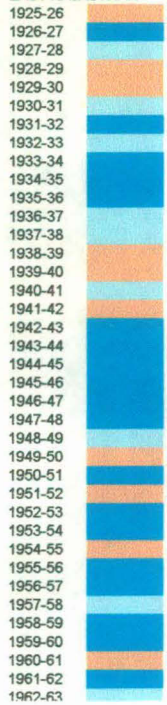
With the annual rainfall variation of 40% in Eastern Rajasthan and 80% in Western Rajasthan it is not uncommon to experience frequent occurance of droughts in different parts of the state. During the last 100 years (1901-2000) the state has 55 years of normal rainfall and rest are marked either with drought or with floods (26 years drought; 18 years of floods).

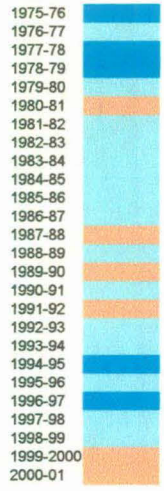
During the last 126 years (1875-2001). The Eastern Part has witnessed 45 years of normal rainfall and floods each while,

126 YEAR , DROUGHT FLOOD & NORMAL SITUATION IN RAJASTHAN STATE.

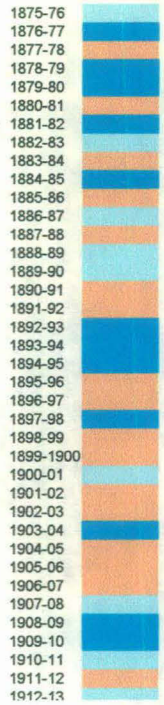
EAST RAJASTHAN

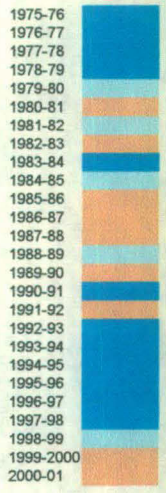






WEST RAJASTHAN





Thus, in the post independence period the variations in rainfall and its deficit has been not as harsh (25% deficit) as it was in the early years of the twentieth century. Floods for two consecutive years were witnessed for three times (1916-18, 1944-46, 1975-79). The Table -'2b' therefore indicates increase in the total amount of rainfall in the state in the later half of the century.

Table 2.2

(A) FREQUENCY OF OCCURANCE OF DROUGHT ,FLOOD & NORMAL YEAR IN EAST RAJASTHAN AND WEST RAJASTHAN IN 1875-76 TO 2000-01

EAST RAJASTHAN					WEST RAJASTHAN				
YEAR	DROUGHT	FLOOD	NORMAL	TOTAL	YEAR	DROUGHT	FLOOD	NORMAL	TOTAL
1875-76 TO 2000-01	36	45	45	126	1875-76 TO 2000-01	53	31	42	126

(B) CONSECUTIVE TWO YEAR OF OCCURANCE OF DROUGHT ,FLOOD &NORMAL YEAR IN EAST RAJASTHAN AND WEST RAJASTHAN IN 1875-76 TO 2000-01

EAST RAJASTHAN					WEST RAJASTHAN				
YEAR	DROUGHT	FLOOD	NORMAL	TOTAL	YEAR	DROUGHT	FLOOD	NORMAL	TOTAL
1875-76 TO 2000-01	7	9	5	21	1875-76 TO 2000-01	10	5	2	17

(C) CONSECUTIVE THREE OR MORE OF OCCURANCE OF DROUGHT ,FLOOD &NORMAL YEAR IN EAST RAJASTHAN AND WEST RAJASTHAN IN 1875-76 TO 2000-01

EAST RAJASTHAN					WEST RAJASTHAN				
YEAR	DROUGHT	FLOOD	NORMAL	TOTAL	YEAR	DROUGHT	FLOOD	NORMAL	TOTAL
1875-76 TO 2000-01	0	3	3	6	1875-76 TO 2000-01	3	4	1	8

SOURCE - → YOUJNA, JUNE -1989, (P.P. 16-31) , VOLUME -33, NO .11

→ MOUSUM JOURNAL (1985 – 2000) J.N.U. LIBRARY NEW DELHI,

drought conditions were prevailing for 36 years. On the contrary over the same period of time, Western part of the state has experienced 53 years of deficit of rainfall which resulted in drought where as flood occured 31 times in the observed period and 42 year had normal course of rain. This depicts that Western Rajasthan is more conducive to droughts.

The data reveals 55 years of normal rainfall in the state, this can be well explained through the information (Table '2a') on floods and drought, Floods denote excess rainfall and droughts are phenomena of deficit rainfall. In the Eastern region there have been 36 years of drought and 45 years of floods while in the Western part the number is 53 and 31 respectively this denotes 17 years differences in drought condition and 14 year difference in flood occurrence and this difference explain the 55 years of normal rainfall in Rajasthan.

Occasion of occurrence of drought condition in successive year were not very frequent in the state. Only at four periods of time droughts occurred for two consecutive years while floods have also occurred twice. The normal rainfall has been experienced for 12 continuous years.

This explains that for four time periods the state was under the umbrella of droughts conditions for two or more simultaneous years. These periods are 1901-03, 1904-06, 1920-22 and 1938-40.

For the observed period of time the state has been on safer side as it has never experienced and witnessed drought condition for three or more consecutive years. Although floods did sweep the state for three years simultaneously (1975-76 to 1978-79).

Table No. 'C' shows that in the state droughts have not occurred for 3 or more consecutive years whereas flood did occur for four continuous year from 1975-79. Normal rainfall was experienced for nine times (3 or more consecutive years). Therefore, one can interpret that severity of droughts not only depends upon the order of rainfall deficiency in a single year but also upon continued occurrence of deficient rain in successive years. Although the deficiency in each such successive year may not be as high as in the single year.

Table 2-'A' depicts that occurrence of drought condition in successive years were quite frequent in the case of Eastern Rajasthan (i.e. the region has rainfall < 75% of annual normal in each year). In the years– 1895-96, 1898-99, 1920-21, 1928-29, 1938-39, 1965-66 and 1999-2000 the entire area was affected by drought. While floods were witnessed for 12 time periods for two or more consecutive year –1875-76, 1881-82, 1884-85, 1892-94, 1916-17, 1923-24, 1933-35, 1942-47, 1952-53, 1955-56, 1958-59 and 1977-78. This indicates that this part had rainfall sufficiently

in excess of the normal for these years which became a predominant factor for occurance of floods (annual rainfall of 125% or more of the normal is considered as excessive rain). The sub-division therefore recorded excessive rainfall in 30 years, in which rainfall in three or more consecutive years occurred thrice viz 1892-94, 1933-35 and 1942-47. In Western Rajasthan almost all the districts became the victims of drought and as this region experienced this phenomena for more than 20% of the years under consideration it may therefore be classified as 'drought area'.

Occasions of drought in two or more successive years were very frequent in this case. The Table 1 'A' gives the years of successive drought, (i.e. the rainfall less than 75% of annual normal in each year). These are (1890-91, 1985-96, 1898-99, 1901-02, 1904-06, 1920-23, 1925-26, 1938-39, 1948-49, 1968-69, 1971-72, 1985-87, 1999-2000). The decade of 90s in the nineteenth century and that of 20's in the last century has been very harsh as in these decades the sub-division has experienced 6 years of drought conditions each. Thus it can be said that this area has been simultaneously affected by drought conditions.

Floods are the result of excessive rainfall, when the annual rainfall is as high as 125% or more of the normal. Table 2 'B' shows that during the period under consideration, the sub division recorded excessive rainfall in 27 years, successive years of excessive

rainfall are (1878-79, 1908-09, 1916-17, 1892-94, 1933-34, 1942-45, 1955-56, 1975-78, 1992-95 and 1996-97, so far as vagaries of rainfall are concerned. The periods 1901-05 and 1906-10 stand unique as both fairly deficient and excessive rainfall occurred in these five years alternately. The period 1901-06 has five years of drought (except 1903) and in 1906-10 there were two consecutive years of floods with no drought conditions in the sub-division. Similar was the case in the 70s when there was drought for two successive years in 1971-72, and floods for continuous four years (1975-78). 1973 also experienced excessive rainfall while 1974 was a drought year.

Most of the drought years in East Rajasthan (10 out of 14 years when drought occurred for 2 consecutive years 7 times) were also drought years for western part. These years are 1895, 1896, 1898, 1899, 1920, 1921, 1938, 1939, 1999 and 2000. This indicates that the frequency of occurrence of drought as well as its severity is more in this part. As drought for consecutive year (2 or more) have occurred for 13 time periods in contrast to 7 time periods for the Eastern sub-division.

Ajmer is situated in the Eastern part of the state, generally a level plain interspersed with low hills. It experiences hot dry summer and cold bracing winter. It has been classified as a 'drought prone area' as it has experienced drought conditions for at

Drought ,Flood & Normal Situation in Rajasthan State 1901-02 to 1999-2000

YEAR	ANNUAL RAINFALL
normal	575.1
1901-02	261.4
1902-03	410
1903-04	536.2
1904-05	435.5
1905-06	233.5
1906-07	537.6
1907-08	451.5
1908-09	814.4
1909-10	647.9
1910-11	593.4
1911-12	306.6
1912-13	585.1
1913-14	395.7
1914-15	628.1
1915-16	277.8
1916-17	811.8
1917-18	999
1918-19	239.1
1919-20	665.9
1920-21	438.3
1921-22	438
1922-23	500.3
1923-24	573.6
1924-25	680.7
1925-26	412.1
1926-27	688.9
1927-28	613.3
1928-29	540.5
1929-30	525.7
1930-31	523.2
1931-32	626.3
1932-33	485.7
1933-34	739.3
1934-35	681.8
1935-36	546.3
1936-37	450.6
1937-38	585.4
1938-39	451
1939-40	371
1940-41	486.3
1941-42	458
1942-43	777.9
1943-44	606.8
1944-45	777.1
1945-46	749.7
1946-47	698.3
1947-48	621.3
1948-49	492.5
1949-50	487.1
1950-51	658.7
1951-52	312.6
1952-53	572.3
1953-54	477.2
1954-55	465.3
1955-56	641.5
1956-57	703.7
1957-58	462.5
1958-59	332.9
1959-60	693.5
1960-61	450.9
1961-62	689.7
1962-63	522
1963-64	480.2
1964-65	573.7
1965-66	363
1966-67	486
1967-68	570.6
1968-69	391.4
1969-70	465.4
1970-71	617.5
1971-72	638.5
1972-73	411.5
1973-74	780.6
1974-75	471.3
1975-76	834.3
1976-77	756.4
1977-78	766
1978-79	735.7
1979-80	506
1980-81	423.9
1981-82	562.1
1982-83	557.8
1983-84	620.3
1984-85	473.5
1985-86	502.8
1986-87	464
1987-88	314.5
1988-89	534.1
1989-90	455
1990-91	727.3
1991-92	492.7
1992-93	649.5
1993-94	536.7
1994-95	688.2
1995-96	749
1996-97	562
1997-98	594
1998-99	517
1999-2000	450

Indicates Normal Year
Indicates Flood Year
Indicates Drought Year

Source; Govt of Rajasthan
Directorate of Agriculture , Pant Krishi Bhavan ,Jaipur,Rajasthan

Drought ,Flood & Normal Situation in Ajmer District 1901-02 to 1999-2000

YEAR	ANNUAL RAINFALL
normal	601.8
1901-02	332.1
1902-03	410.6
1903-04	515.2
1904-05	383.7
1905-06	192.7
1906-07	536.1
1907-08	316.2
1908-09	973.1
1909-10	694.9
1910-11	445.8
1911-12	211.2
1912-13	392.9
1913-14	352.8
1914-15	517.2
1915-16	308.6
1916-17	787.7
1917-18	1138.7
1918-19	182.1
1919-20	406.1
1920-21	525.2
1921-22	293.6
1922-23	346.3
1923-24	364.2
1924-25	905.2
1925-26	342.4
1926-27	607.3
1927-28	701.6
1928-29	617.8
1929-30	799.4
1930-31	482
1931-32	538.2
1932-33	399.9
1933-34	803.1
1934-35	758.7
1935-36	662
1936-37	506
1937-38	604.9
1938-39	271.8
1939-40	297.7
1940-41	680.4
1941-42	353.5
1942-43	735.1
1943-44	623.5
1944-45	531.8
1945-46	427.9
1946-47	621.9
1947-48	587.1
1948-49	266
1949-50	386
1950-51	711
1951-52	..... N.A.
1952-53	516.1
1953-54	481.8
1954-55	545.6
1955-56	491.5
1956-57	626.9
1957-58	394.9
1958-59	739
1959-60	738.2
1960-61	345
1961-62	..... N.A.
1962-63	589.9
1963-64	446.5
1964-65	553.7
1965-66	348.2
1966-67	499.2
1967-68	485.9
1968-69	447.2
1969-70	299.6
1970-71	669.4
1971-72	725.1
1972-73	307.1
1973-74	570.4
1974-75	431
1975-76	1203.7
1976-77	1060.7
1977-78	555
1978-79	659.8
1979-80	695.2
1980-81	448.8
1981-82	525.9
1982-83	532
1983-84	934.5
1984-85	679.8
1985-86	454.2
1986-87	347
1987-88	159.8
1988-89	449.5
1989-90	457.5
1990-91	819.1
1991-92	468.4
1992-93	650.8
1993-94	573.1
1994-95	521.2
1995-96	507.2
1996-97	743
1997-98	615
1998-99	415
1999-2000	395

Indicates Normal Year
Indicates Flood Year
Indicates Drought Year

Source; Govt of Rajasthan
Directorate of Agriculture , Pant Krishi Bhavan ,Jaipur,Rajasthan

least 20% of the years under consideration (40 years of 99 year from 1901-02 to 1999-2000) in contrast to 26 years of the whole state).

Table 2.3.

(A) FREQUENCY OF OCCURANCE OF DROUGHT ,FLOOD & NORMAL YEAR IN RAJASTHAN AND AJMER DISTRICT IN 1901-02 TO 1999-2000

RAJASTHAN					AJMER				
YEAR	DROUGHT	FLOOD	NORMAL	TOTAL	YEAR	DROUGHT	FLOOD	NORMAL	TOTAL
1901-02 TO 99-2000	26	18	55	99	1901-02 TO 1999-2000	40	17	40	99*

* NOTE→ TWO YEAR DATA(1951-52&1961-62) ARE NOT AVAILABLE

(B) CONSECUTIVE TWO YEAR OF OCCURANCE OF DROUGHT ,FLOOD & NORMAL YEAR IN RAJASTHAN AND AJMER DISTRICT IN 1901-02 TO 1999-2000

RAJASTHAN					AJMER				
YEAR	DROUGHT	FLOOD	NORMAL	TOTAL	YEAR	DROUGHT	FLOOD	NORMAL	TOTAL
1901-02 TO 1999-2000	4	2	3	9	1901-02 TO 1999-2000	7	5	5	17

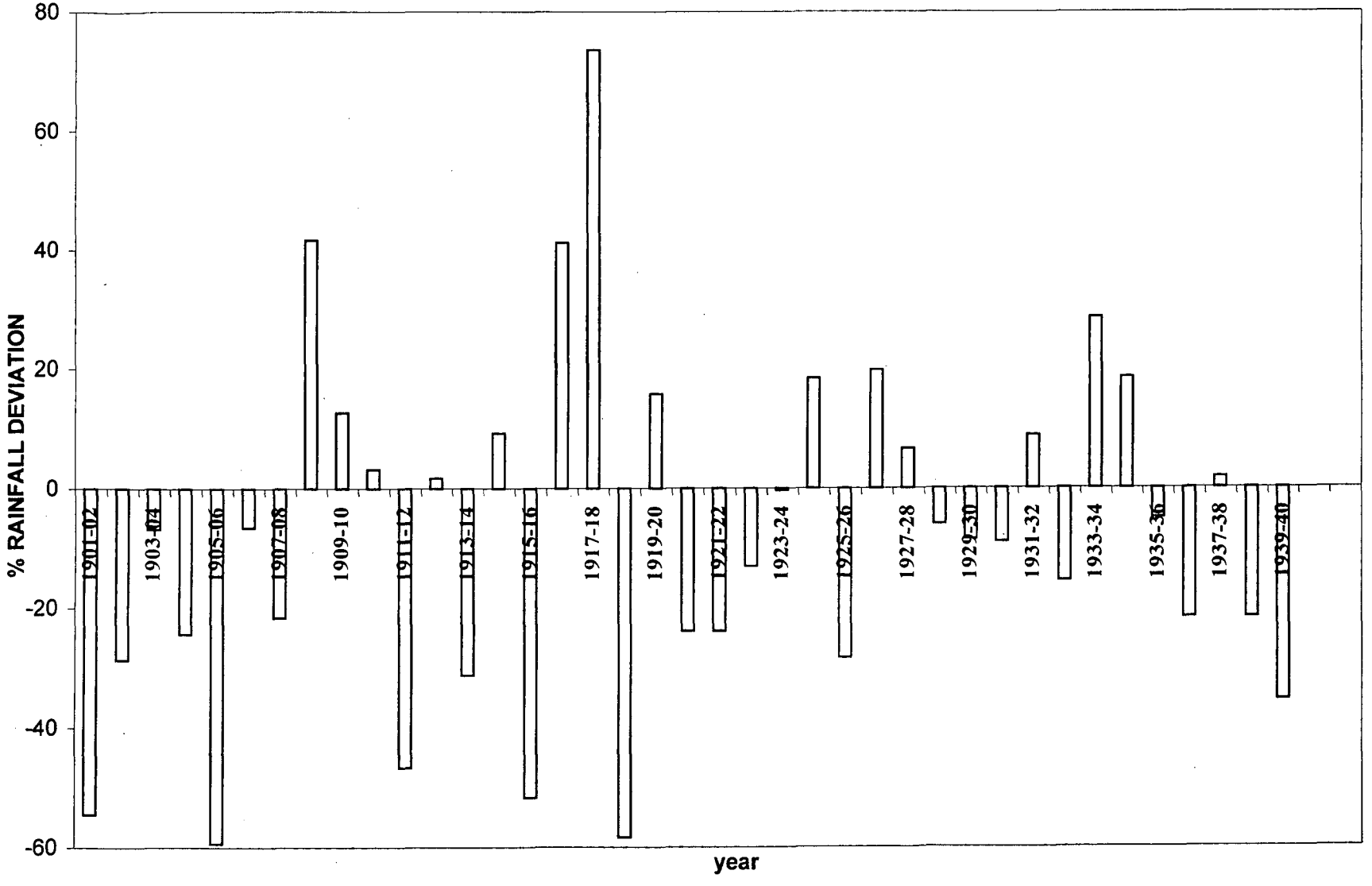
(C) CONSECUTIVE THREE YEARS OR MORE OCCURANCE OF DROUGHT ,FLOOD & NORMAL YEAR IN RAJASTHAN AND AJMER DISTRICT IN 1901-02 TO 1999-2000

RAJASTHAN					AJMER				
YEAR	DROUGHT	FLOOD	NORMAL	TOTAL	YEAR	DROUGHT	FLOOD	NORMAL	TOTAL
1901-02 TO 1999-2000	0	1	9	10	1875-76 TO 2000-01	3	0	5	8

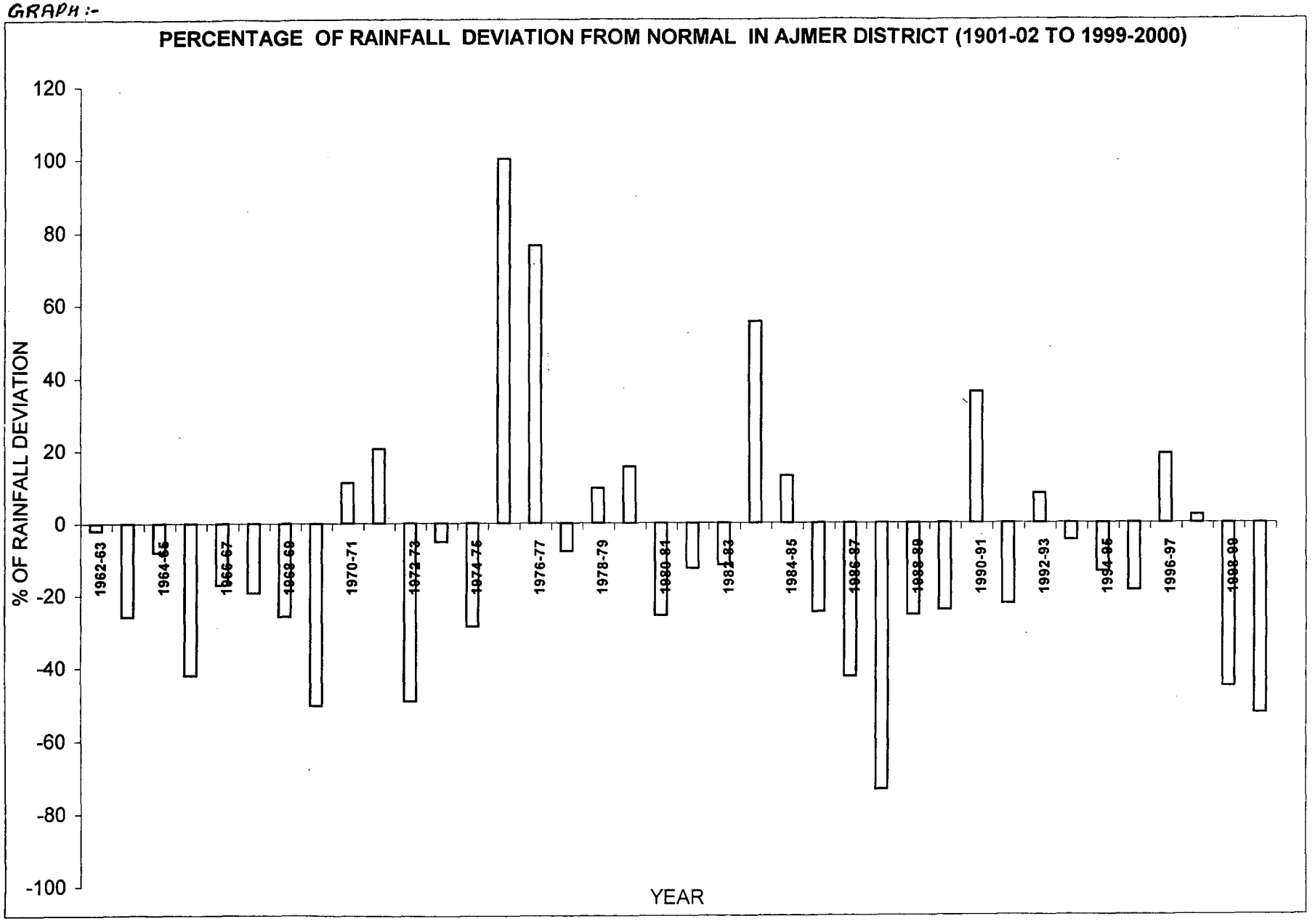
SOURCE -→ MOUSUM JOURNAL (1985 – 2000), J.N.U. LIBRARY NEW DELHI
-→ RAINFALL STATISTICAL ABSTRACT YOUJANA BHAVAN JAIPUR (RAJ.)
-→ IRRIGATION DEPARTMENT JAIPUR (RAJ.)

GRAPH:-

PERCENTAGE RAINFALL DEVIATION FROM NORMAL IN RAJASTHAN (1901-02 TO 1999-2000)



GRAPH :-


PERCENTAGE OF RAINFALL DEVIATION FROM NORMAL IN AJMER DISTRICT (1901-02 TO 1999-2000)
% OF RAINFALL DEVIATION
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
1962-63
1964-65
1966-67
1968-69
1970-71
1972-73
1974-75
1976-77
1978-79
1980-81
1982-83
1984-85
1986-87
1988-89
1990-91
1992-93
1994-95
1996-97
1998-99
YEAR

The frequency of successive drought year (2 or more) has been very frequent. The district has experienced ten such time periods when drought conditions prevailed for two or more years. These years were 1901-03, 1904-06, 1910-14, 1918-20, 1921-24, 1938-40, 1948-50, 1968-70, 1985-90 and 1998-2000. The decades of tens, twenties and eighties has been affected at large as 6.8 and 6 drought years respectively. Here successive drought in considered in terms of district rainfall being less than 75% of the annual normal in each years. In this aspect also the district is adversely affected when compared to the whole region which has experienced only four such successive occasions and in all these four occassions the drought period existed for two years only and was not as long as 6-8 years as witnessed by district. Table No. 3'A' therefore, clearly brings out that the district has been simultaneously affected by the drought phenomena. In some years the drought conditions were severe when the rainfall was even less than 50% of the annual normal – 1905: 35%, 1918: 27%.

During the period under consideration the district recorded excessive rainfall in 17 years, which became a predominating factor for the occurrence of floods. The extent of floods is similar to the state as whole which witnessed 18 years of floods in the considered period. Successive years of excessive rainfall for Ajmer were 1908-10, 1916-18, 1933-35, 1958-60, and 1975-77. Among these floods,

the floods of 1916-18 and 1975-77 were common with the floods of the state which experienced three periods of consecutive floods as against five of the district. Therefore from Table 3'B' it can be concluded that the district of Ajmer is more to prone to the vagaries of rainfall be it excessive or deficit in comparison to the state as a whole (Rajasthan state gazetteer).

This becomes more evident as drought for three or more consecutive years have been experienced by the district (1910-14, 1921-24 and 1985-90) while the state has not witnessed any such occurences.

2.5 El-Nino Effect

The term El-Nino refers to describe a warm seasonal ocean current that arrives along the coastline of Ecuador and Peru. Though the term is generally used as a description of a dual phenomenon that has a closely linked oceanic and atmospheric element. Hence most Scientists describe El-Nino as –

(1) Remarkable increase in sea surface temperature Pacific in the region and colder waters in the Western Pacific and

(2) Associated period of heavy rainfall in the central Pacific, Western South America and California with corresponding droughts in Australia and Indonesia (Philander 1989).

An-El-Nino is only on combined element (warm period) of a dual-phase ascillating ocean atmospheric system (NOAA, 1998) when the system switches to a cold phase. Pacific water returns to a cool state with cold water of the coast of Ecuador and Peru and warmer water in the western pacific in the vicinity of Indonesia and Eastern Australia. As a result dry conditions return to the central and Eastern Pacific (Peru and Ecuador) with wet conditions in the western Pacific (Indonesia and Australia). Sometimes in an El-Nino's wake eastern pacific waters not only return to a cool state but become unusually cold. When this happens a 'La-Nino' occurs which causes, among other climate effects, extreme drought in coastal Peru and Ecuador and very heavy rain in the Western Pacific. The entire ocean atmospheric system so described in corporating warmer-phase El-Nino and colder phase events often with 'La-Linas' is called the El-Nino-Southern oscillation or ENSO.

It was originally described as a Southern oscillation because most countries in the pacific basin where it effects are immediately felt are in the Southern Hemisphere.

El-Nino is said to be the factor behind drought condition in various parts of the country. But it has not been proved on all empirical situation. Rajasthan a dominant drought prone area has also shown a mix effect as here for 12 years there has been no

instance of drought in any parts of the state despite the prevailing El-Nino effect over the country. On the other hand 15 years out of 65 drought years (when either western, eastern or Ajmer has witnessed drought) have been associated with the El-Nino effect. Table No. 4. shows that for these years 1877-78, 1899-1900, 1905-06, 1913-14, 1915-16, 1925-26, 1941-42, 1972-73, 1987-88 and 1991-92 the entire state has been under the grip of drought condition and also is marked with the occurrence of El-Nino in the Indian Ocean.

The district of Ajmer has witnessed this association in the years 1904-05, 1905-06, 1913-14, 1915-16, 1925-26, 1941-42, 1972-73, 1986-87, 1987-88, 1991-92, the entire state has been under the grip a drought condition and also is marked with the occurrence of El-Nino in the Indian Ocean.

The district of Ajmer has witnessed this association in the year of 1904-05, 1905-06, 1913-14, 1915-16, 1925-26, 1941-42, 1972-73, 1986-87, 1987-88, 1991-92 and 1997-99. Where Ajmer district has experienced 41 years of drought only 11 were associated with this effect this can be noticed through the fact that such a global phenomena has limited effect on a small unit of study.

Table No 2.4

DROUGHT SITUATION IN E.RAJ, W.RAJ, AJMER, &EL-NINO, IN 1875-76 TO 2000-01

YEAR	1875-76	1876-77	1877-78	1878-79	1879-80	1880-81	1881-82	1882-83	1883-84	1884-85
E.RAJ			O						O	
W.RAJ			O			O			O	
AJMER										
EL.NINO		*	*	*						

YEAR	1885-86	1886-87	1887-88	1888-89	1889-90	1890-91	1991-92	1892-93	1893-94	1894-95
E.RAJ							O			
W.RAJ	O		O			O	O			
AJMER										
EL.NINO										

YEAR	1895-96	1896-97	1897-98	1898-99	1899-1900	1900-01	1901-02	1902-03	1903-04	1904 -05
E.RAJ	O	O		O	O		O			
W.RAJ	O	O		O	O		O	O		O
AJMER							O	O		O
EL.NINO					*	*				*

YEAR	1905-06	1906-07	1907-08	1908-09	1909-10	1910-11	1911-12	1912-13	1913-14	1914-15
E.RAJ	O		O				O		O	
W.RAJ	O	O					O		O	
AJMER	O		O			O	O	O	O	
EL.NINO	*								*	*

YEAR	1915-16	1916-17	1917-18	1918-19	1919-20	1920-21	1921-22	1922-23	1923-24	1924-25
E.RAJ	O			O		O	O			
W.RAJ	O			O		O	O	O	O	
AJMER	O			O	O		O	O	O	
EL.NINO	*									

YEAR	1925-26	1926-27	1927-28	1928-29	1929-30	1930-31	1931-32	1932-33	1933-34	1934-35
E.RAJ	O			O	O					
W.RAJ	O	O				O				
AJMER	O							O		
EL.NINO	*	*								

YEAR	1935-36	1936-37	1937-38	1938-39	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45
E.RAJ				O	O		O			
W.RAJ				O	O		O			
AJMER				O	O		O			
EL.NINO						*	*			

YEAR	1945-46	1946-47	1947-48	1948-49	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55
E.RAJ					O		O			O
W.RAJ		O		O	O		O		O	
AJMER	O			O	O					
EL.NINO										

YEAR	1955-56	1956-57	1957-58	1958-59	1959-60	1960-61	1961-62	1962-63	1963-64	1964-65
E.RAJ						O				
W.RAJ			O			O			O	
AJMER			O			O			O	
EL.NINO										

YEAR	1965-66	1966-67	1967-68	1968-69	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75
E.RAJ	O	O		O				O		
W.RAJ	O			O	O		O	O		O
AJMER	O			O	O			O		O
EL.NINO								*	*	

YEAR	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
E.RAJ						O				
W.RAJ						O		O		
AJMER						O				
EL.NINO								*	*	

YEAR	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95
E.RAJ			O		O		O			
W.RAJ	O	O	O		O		O			
AJMER	O	O	O	O	O		O			
EL.NINO		*	*	*			*	*	*	*

YEAR	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-00
E.RAJ					O	O
W.RAJ					O	O
AJMER				O	O	O
EL.NINO	*		*	*		

2.6 Consecutive years of Abnormal Rainfall Situation in East-Rajasthan, West-Rajasthan and Ajmer district

In East-Rajasthan, West-Rajasthan and as well as Ajmer district there were consecutive years of abnormal rainfall situation characterised by two or more consecutive years of drought. With one year of either normal or flood situation, when drought occured for two years or more, one year of good rainfall may not offset the adverse consive of drought. Such year are also considered abnormal years and similar situation occured in Rajasthan in the years.

The duration of abnormal year has been two to seven years and such occurance where noticed after a some of many years of good rainfall. Since East Rajasthan, West Rajasthan and Ajmer district experience good rainfall from 1991-1998 there is a high probability of occurance of frequent and consecutive years of drought in the coming decade. Thus, abnormal weather period may last for some more years in near future. There fore, this makes the necessity of comprehensive drought mitigation strategies to be formulated for a longer period ranging from five to ten years (Table No.5).

Table 2.5

Consecutive Years of Abnormal Rainfall situation in East Rajasthan, West Rajasthan & Ajmer District

East Rajasthan	West Rajasthan	Ajmer District
1895-1901	1895-1906	1901-1907
1920-1929	1920-1926	1910-1916
1938-1941	1938-1941	1917-1926
1965-1968	1948-1953	1938-1941
1987-1991	1968-1974	1985-1989
	1985-1991	

Source: Rainfall statistical abstract, Youjna Bhavan, Jaipur (Rajasthan) Hydrometerological Department, Irrigation Department, Jaipur

NOTES

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CHAPTER - III

DEVELOPMENT OF IRRIGATION IN AJMER DISTRICT

3.0 Introduction

Irrigation in simplest form can be defined as artificial application of water to the land in order to grow crops or to improve crop yields. Water, no doubt, is the most important single requirement for the growth of plants. Crops can be raised successfully only if adequate quantity of water is available.

3.1 Sources of Irrigation:

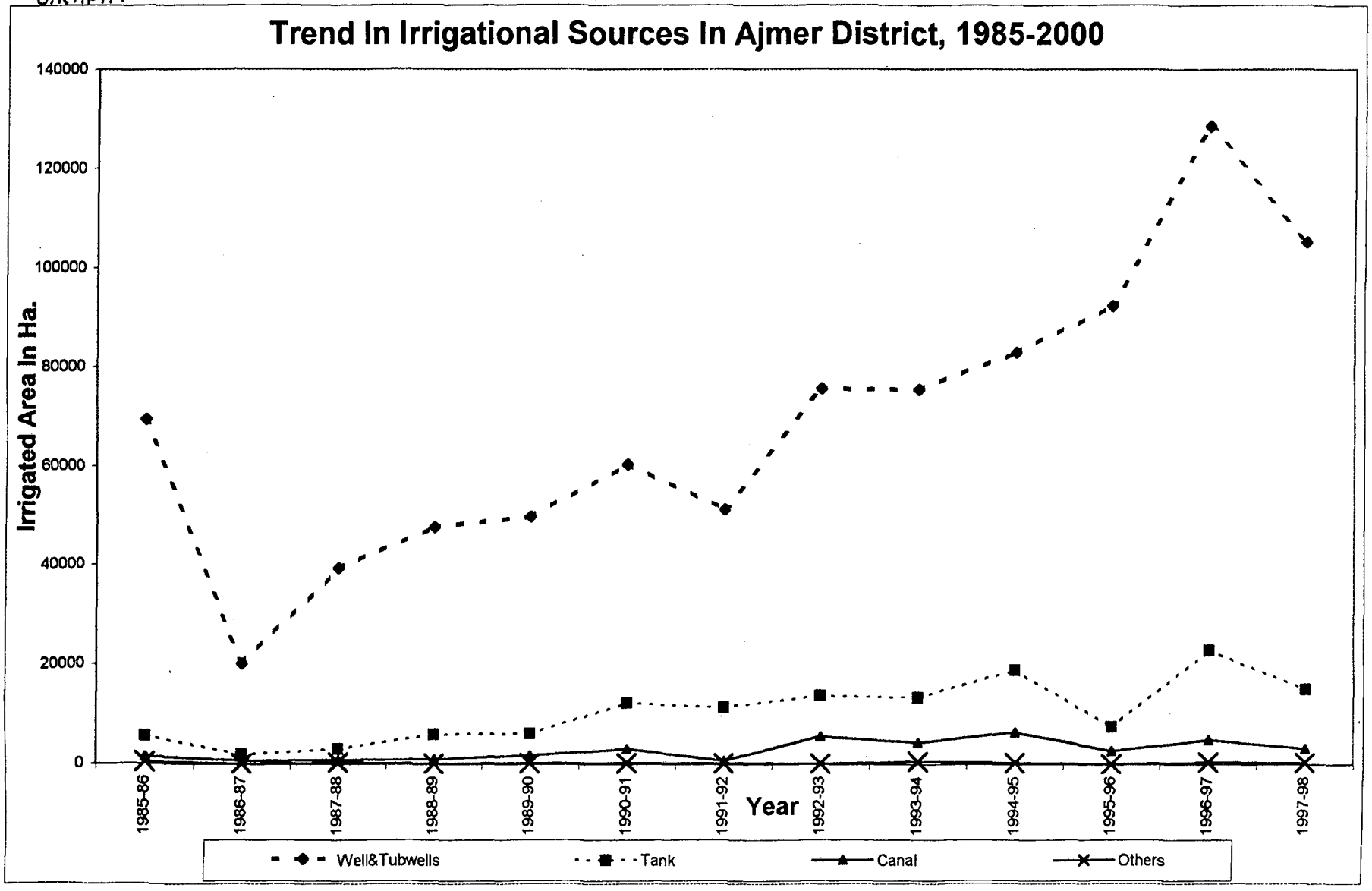
Situated in the eastern part of Aravalis, without any major river passing through it, Ajmer district depends mainly on the well and tubewell for irrigation. In 1997-98 well and tube well irrigation accounted for 85% of the irrigated area. Tanks irrigated 12.18% of the net irrigated area. Area irrigated from canal was only 2.53% of the net irrigated area.

Table 3.1:Sources of Irrigation in Ajmer District Percentage Area Irrigated.

Year	Well & Tube	Tank	Canal	Others
1987-88	90.50	7.04	1.71	0.75
1992-93	79.58	14.42	5.91	0.09
1997-98	85.09	123.18	2.53	0.22

Source: District Statistical Outline, 1985-2000, Economic & Statistical Directorate, Rajasthan, Jaipur.

GRAPH :-


Trend In Irrigational Sources In Ajmer District, 1985-2000
Irrigated Area In Ha.
140000
120000
100000
80000
60000
40000
20000
0
1985-86
1986-87
1987-88
1988-89
1989-90
1990-91
1991-92
1992-93
1993-94
1994-95
1995-96
1996-97
1997-98
Year
Well&Tubwells
Tank
Canal
Others

During the period 1985-1998 a small decrease is noticed in the proportion of irrigated area by well and tubewels. It was 90.55 in 1985-86 and it came down to 85.09% in 1997-98. The Percentage of area irrigated by tank has increased from 7.36% in 1985-86 to 12.18% in 1997-98. The percentage area irrigated by canal fluctuated.1.9.1% in 1985-86 4.05% in 1990-91 and a maximum of 5.97% in 1994-95.

3.2 Trends in Irrigation

Table 3.2, shows an increase in the proportion of irrigated area in Ajmer tehsil in terms of Gross Cropped Area as well as Net shown area over a period of 15 years. (1985-86 to 1999-2000). Though the increase is not continuous and a decline has been noticed after 1996-97. Gross irrigated area has gone down from 29.79 percent to 26.16 percent in 1997-98 while net irrigated area went done from 31.7 percent to 29.4 percent in the same year gross irrigated area has declined further and it was only 24.12 per cent in 1999-2000. A sharp decline was increased in Net irrigated area and it went down from 29.3 percent in 1997-98 to 23.1 percent in 1999-2000.

Table 3.2 :

TOTAL AREA, GROSS AND NET CROPPED AREA,GROSS AND NET IRRIGATED AREA IN AJMER TEHSIL (in Ha.)							
YEAR	TOTAL AREA	G.C.A	N.C.A	G.I.A	N.I.A	%OF G.I.A	%OF N.I.A
1987-88	155175	62597	51203	14779	10792	23.61	21.07
1992-93	155175	80544	64881	24018	18568	29.82	28.61
1997-98	155175	94168	66625	36201	26056	38.44	39.1
1999-2000	155175	73567	56645	28408	21038	38.62	37.14

Ajmer Tehsil is most irrigated among the six tehsil in Ajmer district. It is the only tehsil that has more than 30 percent of gross cropped area and net shown area under irrigation. This scenario over the period has under gone change.In 1985-86, 31.2, percent area was under irrigation that increased up to 40.4 percent in 1986-87. But next five years shows a sharp decline in proportion of gross irrigated area and remained at an average of 22 percent. After 1990-90 again an increasing trend is noticed and in 1996-97 40.3 percent of Gross Cropped Area was under irrigation. After this there was a slight decline and in 1999-2000 gross irrigated area was 38.6 percent.

Nashirabad Tehsil showed maximum increase in irrigation potential. Table shows that only 12.2 percent of gross cropped area was irrigated in 1987-98 which went up to 28.9 per cent in

1996-97. After wares the decline is also sharp and in 1999-2000 only 19.5 percent of gross-cropped area was irrigated. In case of net-shown area increase is much more. Table reveals that only 10 percent net-sown area was found under irrigation.in 1987-88 and it was 28.05% in 1997-98.At decreased to 17.97 in 1999-2000.

Table – 3.3

TOTAL AREA, GROSS AND NET CROPPED AREA,GROSS AND NET IRRIGATED AREA IN NASHERABAD TEHSIL(in Ha.)

Year	Total area	G.C.A	N.C.A	G.I.A	N.I.A	%of G.I.A	%of N.I.A
1987-88	73632	26238	24472	3221	2648	12.28	10.82
1992-93	73632	41933	34571	9578	7772	22.84	22.48
1997-98	73632	49942	34982	12552	9815	25.13	28.05
1999-2000	73632	32259	29946	6878	5384	19.51	17.97

Bhewar tehsil irrigated percentage of GCA was as low as 7.2 percent in 1987-98. After this an increasing trend has been noticed and the table shows that in 1997-98 maximum 34.7 percent gross-cropped area was under irrigation. It may be noted that in other tehsil maximum irrigated area has been recorded in 1996-97. In terms of net-sown area increase is unpredictable. Only 6.5 percent net-sown area was irrigated which went up to 37 per cent in 1997-98 but again went down to 21 percent in 1999-2000.

Table – 3.4

TOTAL AREA, GROSS AND NET CROPPED AREA,GROSS AND NET IRRIGATED AREA IN BHEWARE TEHSIL(IN HA.)							
Year	Total area	G.C.A	N.C.A	G.I.A	N.I.A	%of G.I.A	%of N.I.A
1987-88	155927	39840	38458	2894	2530	7.26	6.57
1992-93	155927	70910	55923	19190	15236	27.06	27.24
1997-98	155927	78788	57241	27368	21275	34.74	37.16
1999-2000	155927	57507	49334	13233	10388	23.01	21.05

Source: District Statistical Outline, 1985-2000, Economic & Statistical Directorate, Rajasthan, Jaipur

Kekree and Sarwad showed a similar situation. Table 5 & 6 shows that both the tehsil have more increase in terms of net irrigated area. In Kekree only 5 percent was irrigated which went up to 35.6 percent in 19896-96 while for Sarwad it is a 4 percent to 30 percent in same year respectively. After this both the Tehsil have shown, a decline in terms of Irrigation potential of Gross-cropped area increase is some what moderate Kekree was having 19.3 percent gross-cropped area under irrigation in 1985-86 which went up to 31.5 percent in 1996-97 and again came down to 24 percent in 19990-2000.

Table 3.5

Tehsil->Kekree							
Total area, gross and net cropped area,gross and net irrigated area in (in Ha.)							
Year	Total area	G.C.A	N.C.A	G.I.A	N.I.A	%of G.I.A	%of N.I.A
1987-88	181312	112740	95024	17061	13274	15.13	13.96
1992-93	181312	117201	99731	29278	26301	24.98	26.37
1997-98	181312	137109	102842	37078	32041	27.04	31.15
1999-2000	181312	103683	90753	25023	21000	24.13	23.13
Tehsil-- Sarwad							
Total area, gross and net cropped area,gross and net irrigated area in Ajmer district(in Ha.)							
Year	Total area	G.C.A	N.C.A	G.I.A	N.I.A	%of G.I.A	%of N.I.A
1987-88	103448	57108	50933	8093	6676	14.17	13.1
1992-93	103448	67999	57718	14243	12401	20.95	21.48
1997-98	103448	84492	59427	17654	14050	20.89	23.64
1999-2000	103448	65415	53450	14616	11622	22.34	21.74

Kishangharh is the only Tehsil which show a decline in the percentage of gross-cropped irrigated area. 18.7 percent gross-cropped area was irrigated in 1985-86 but only 17.4 percent gross-cropped area was under irrigation in 1999-2000.

Table 3.6

Total area, gross and net cropped area,gross and net irrigated area in Ajmer district(in Ha.)							
Year	Total area	G.C.A	N.C.A	G.I.A	N.I.A	%of G.I.A	%of N.I.A
1987-88	172894	73514	65867	8512	7381	11.58	11.2
1992-93	172894	106758	92327	17865	4746	16.73	5.14
1997-98	172894	152606	99153	25341	20272	16.61	20.44
1999-2000	172894	108415	84496	18889	15037	17.42	17.79

Source: District Statistical Outline, 1985-2000, Economic & Statistical Directorate, Rajasthan, Jaipur

In terms of net-sown area only 3 percent was under irrigation in 1985-86 that went up to 13 percent in 1988-89 but again went to a low of 5 percent in 1992-93. After this there was an increasing trend till 1996-97 when 22 percent net-sown area was under irrigation. But in 1999-2000 only 17.5 percent net-sown area was under irrigation.

3.3 Number of wells and tubewels

Number of wells in Ajmer District has increased over a period of time. In 1997-98, the total number of 74491 while in 1979-80 the total number was 69033 only. Nevertheless, it has been noticed the number of wells that are not in use has gone up during this period (from 18591 in 1985-86 to 26812 in 1997-98. In other words, percentage of wells that is in use has not remained consistent over this period in Ajmer district. Table shows that in 1985-86 about 74 percent of total wells were in use. While in consequent years the percentage has gone done to 64 percent in 1996-97 and 1997-98. In between the percentage of useful wells remain around 65 percent.

When we examine the scenario at tehsil level a mixed picture is be emerging. While tehsil to Nashirabad and Kishangharh has shown an increase in the percentage of used well, other tehsil shown a negative trend. Table shows that in Ajmer Tehsil in 1986-87 68.5

Table 3.7: Number of wealth in Ajmer District

Tehsil. Ajmer				
Year	Wells in use	Wells not in use	Total Wells	% of Wells in use
1986-87	10935	5008	15943	68.588095
1990-91	9744	6541	16285	59.834203
1997-98	8914	6258	15172	58.752966

Tehsil. Nashirabad				
Year	Wells in use	Wells not in use	Total Wells	% of Wells in use
1986-87	3727	1886	5613	66.39943
1990-91	4117	1637	5754	71.550226
1997-98	5683	2406	8089	70.255903

Tehsil. Bhewar				
Year	Wells in use	Wells not in use	Total Wells	% of Wells in use
1986-87	9100	7617	16717	54.435604
1990-91	8381	8640	17021	49.239175
1997-98	7532	9074	16606	45.3571

Tehsil. Kekree				
Year	Wells in use	Wells not in use	Total Wells	% of Wells in use
1986-87	10604	3768	14372	73.782355
1990-91	10442	4215	14657	71.24241
1997-98	10697	4180	14877	71.902937

Tehsil. Sarwad				
Year	Wells in use	Wells not in use	Total Wells	% of Wells in use
1986-87	5092	1730	6822	74.640868
1990-91	5154	2025	7179	71.792729
1997-98	5323	2103	7426	71.680582

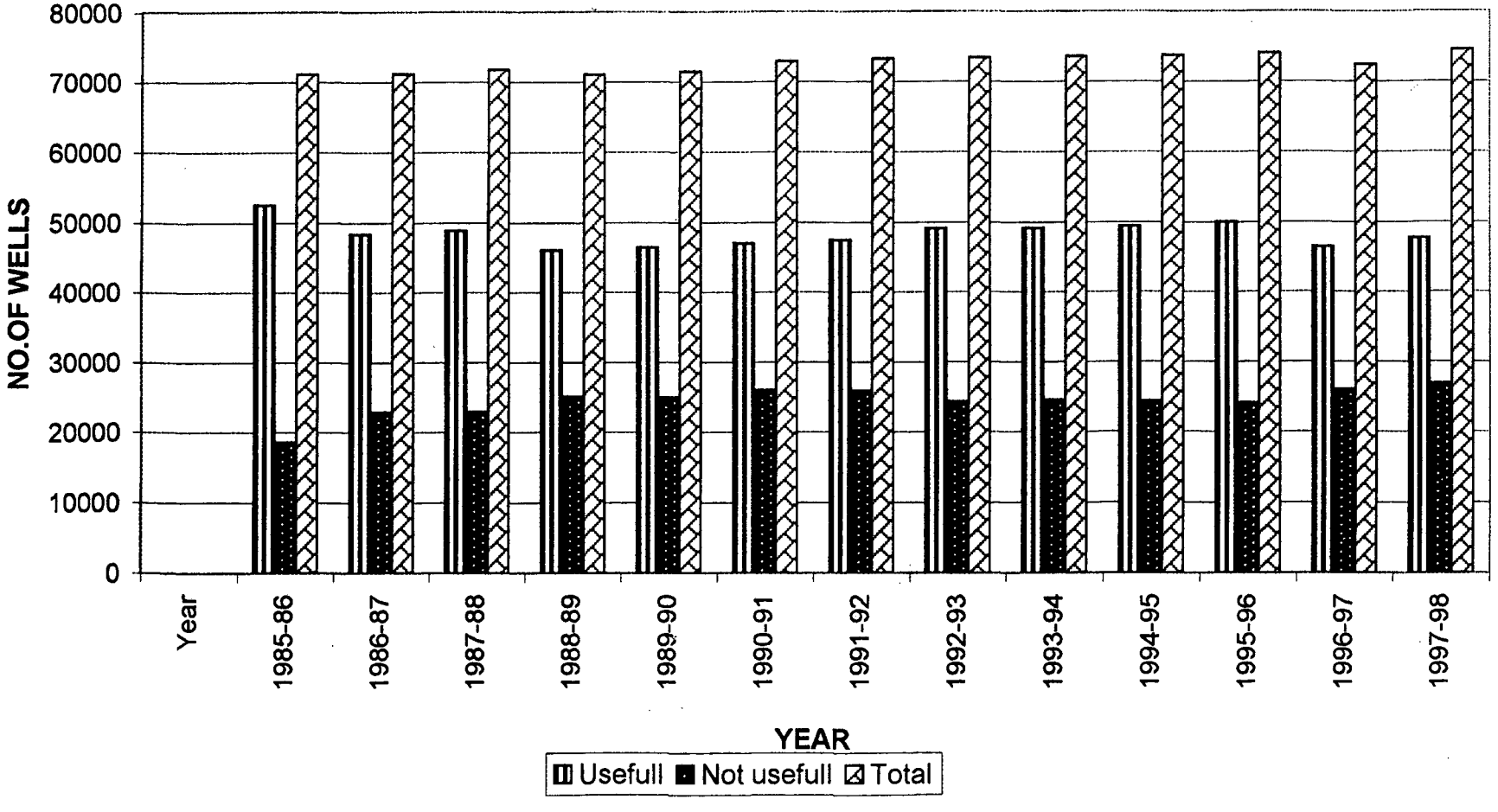
Tehsil. Kishanghar				
Year	Wells in use	Wells not in use	Total Wells	% of Wells in use
1986-87	8850	2805	11655	75.933076
1990-91	9158	2908	12061	75.930686
1997-98	9530	2791	12321	77.347618

District Ajmer				
Year	Wells in use	Wells not in use	Total Wells	% of Wells in use
1985-86	52526	18591	71117	73.86
1986-87	48308	22814	71122	67.92
1987-88	48892	22861	71753	68.14
1988-89	46038	24982	71020	64.82
1989-90	46461	24930	71391	65.08
1990-91	46996	25961	72957	64.42
1991-92	47475	25792	73267	64.80
1992-93	49102	24322	73424	66.87
1993-94	49092	24441	73533	66.76
1994-95	49413	24311	73724	67.02
1995-96	50014	24070	74084	67.51
1996-97	46438	25953	72391	64.15
1997-98	47679	26812	74491	64.01

Source: District Statistical Outline, 1985-2000, Economic & Statistical Directorate, Rajasthan, Jaipur

GRAPH :-

WELL & TUBWELL IRRIGATION IN AJMER DISTRICT.



percent of wells in and 58.7 percent in 1997-98. Notably the absolute number of wells remained at a same level (in 1986-87, 15,943 well existed and in 1997-98, it was 15,172.

Bhewar tehsil has also shown a similar trend a total number of well are at same level (about 16,500). Percentage of useful well in this tehsil has also gone down from 54 to 45 over same period. Tehsil of Kekree and Sarwad are placed at a higher level with similar trend. In these Tehsil more than 70 percent wells are put under use. Though in Kerkree percentage has lowered by 2% (from 73.7 to 71.9) and in Sarwad it has gone down by 3 percent (from 74.6 in 1986-87 to 71.61 in 1997-98).

As mentioned earlier tehsil of Nashirabad and Kishangarh have shown an increase in Nashirabad during 1997-98, 70 percent wells were used while in 1986-87 the percentage was as low as 66 percent wells were being used in 1997-98 as against 75.9 percent in 1986-97.

Area irrigated by wells and tubewells has increased from 39187 hectares in 1986-87 to 1,05, 100 hectares in 1998-98 in the year 1991-92 the area irrigated by wells and tubewells decrease by to 86 hectares were the year 1990-91.

The date on sources and irrigation for the years 1999 and 2000 are not available. Considering the decrease in the net irrigated area from 130673 faces in 1996-97 to 84 by 78 hectares in 1997-2000 and the decrease in number of wells in use, it can be said that well tubewell irrigation shows a increasing trend in recent years. If the decrease is due to over exploitation of groundwater resources, then the future scenario and irrigation appears disturbing.

It is imperative therefore to take measures to conserve ground water and to ensure that over exploitation ground water for irritation should not late the water available for drinking purpose.

3.4 Trends in Tank Irrigation

Total number of tanks in the district of Ajmer has remained more or less static except in 1997-98 when a decrease of about 600 tanks has been noticed. While in 1997-98 it is only 2908. As far as the number of useful tanks is concern it is near about 3300 except in 1988-89 (3063) and in 1997-98 (2685). The percentage of useful tanks is more than 90. It was 94.6 percent in first three years then it decreased slightly to 93 percent in 1988-89., After thus till 1996-97 the percentage of used tanks remained near about 94 percent which again went down in 92 percent in 1997-98.

Table No. 3.8: Number of Tanks in Ajmer District

Tehsil. Ajmer				
Year	Tank in use	Tank not in use	Total Tank	% of Tank in use
1986-87	351	16	367	95.64
1990-91	349	10	359	97.21
1997-98	174	14	188	92.55

Tehsil. Nashirabad				
Year	Tank in use	Tank not in use	Total Tank	% of Tank in use
1986-87	322	68	390	82.56
1990-91	325	71	396	82.07
1997-98	135	47	182	74.18

Tehsil. Bhewar				
YEAR	Tank in use	Tank not in use	Total Tank	% of Tank in use
1986-87	336	55	391	85.93
1990-91	333	57	390	85.38
1997-98	334	53	387	86.30

Tehsil. Kekree				
Year	Tank in use	Tank not in use	Total Tank	% of Tank in use
1986-87	616	37	653	94.33
1990-91	616	48	664	92.77
1997-98	319	33	402	79.35

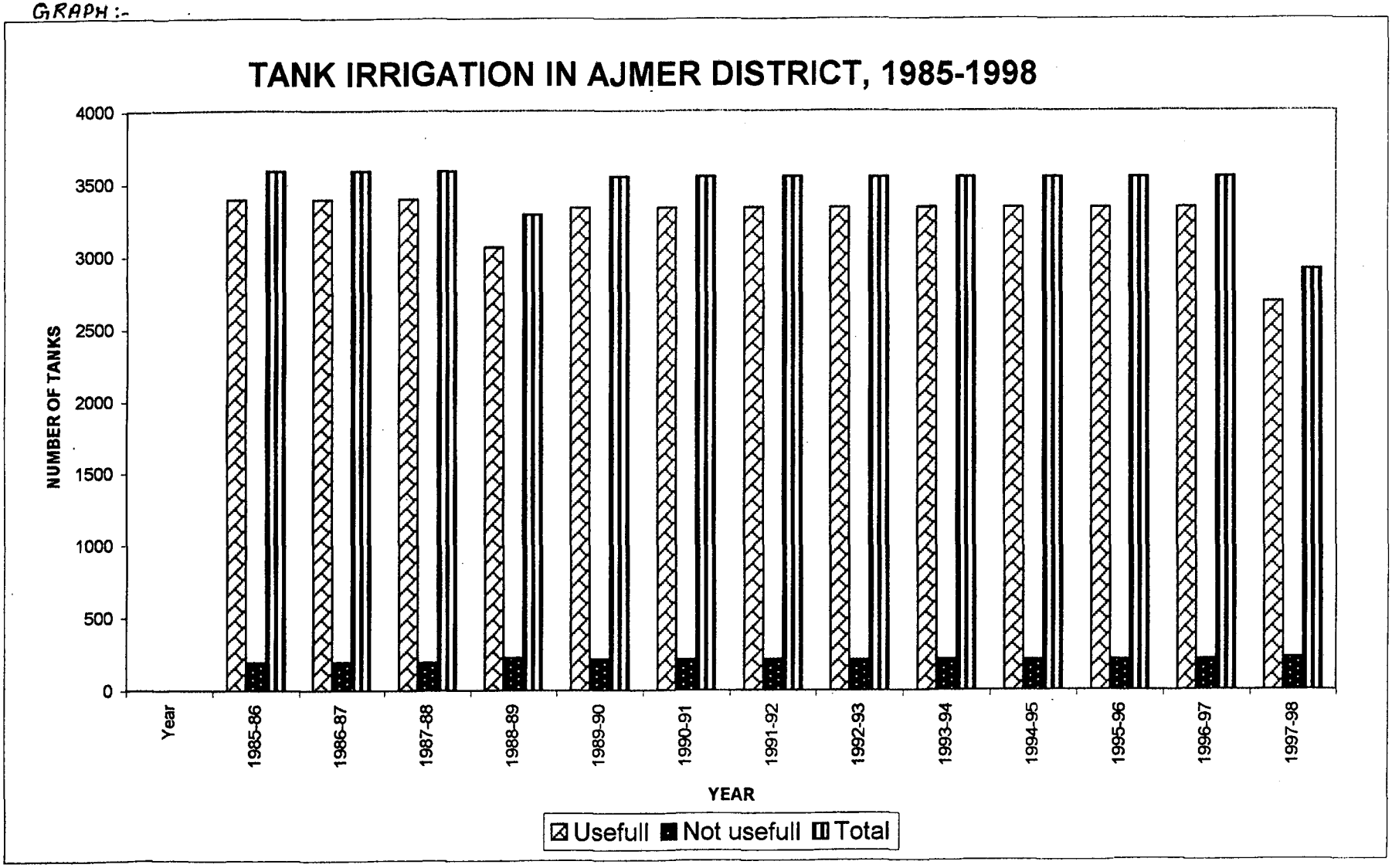
Tehsil. Sarwad				
Year	Tank in use	Tank not in use	Total Tank	% of Tank in use
1986-87	392	1	393	99.75
1990-91	338	11	349	96.85
1997-98	338	11	349	96.85

Tehsil. Kishanghar				
YEAR	Tank in use	Tank not in use	Total Tank	% of Tank in use
1986-87	1375	15	1390	98.92
1990-91	1375	15	1390	98.92
1997-98	1375	15	1390	98.92

DISTRICT AJMER				
YEAR	Tank in use	Tank not in use	Total Tank	% of Tank in use
1985-86				
1986-87	3392	192	3584	94.64
1987-88	3393	192	3585	94.64
1988-89	3063	224	3287	93.19
1989-90	3336	212	3548	94.02
1990-91	3336	212	3548	94.02
1991-92	3336	212	3548	94.02
1992-93	3336	209	3545	94.10
1993-94	3336	209	3545	94.10
1994-95	3336	209	3545	94.10
1995-96	3336	209	3545	94.10
1996-97	3336	209	3545	94.10
1997-98	2685	223	2908	92.33

Source: District Statistical Outline, 1985-2000, Economic & Statistical Directorate, Rajasthan, Jaipur

GRAPH :-


TANK IRRIGATION IN AJMER DISTRICT, 1985-1998
NUMBER OF TANKS
4000
3500
3000
2500
2000
1500
1000
500
0
Year
1985-86
1986-87
1987-88
1988-89
1989-90
1990-91
1991-92
1992-93
1993-94
1994-95
1995-96
1996-97
1997-98
YEAR
Usefull
Not usefull
Total

Tehsil level data shows a mixed trend where three Tehsil (Nashirabad, Kekree and Sarwad) showed a decreasing trend while one showed an increasing trend. The rest two presented a different picture. Kishanganh has maintained the same level/while in Ajmer Tehsil the percentage has gone up in 1990-91 and again came down in 1997-98.

Table shows that 95.6 percent of tanks were in use in 1986-87 that went up to 97.2% during 1990-91. But the percent age of useful tanks went down to 92.5% in 1997-98. It has been pointed out that percentage of used tanks has also gone down in this tehsil. Nashirbad recorded minimum percentage of used tanks in 1997-98 when it is 74 (about 20% lower than the state average). Though in 1985-86 also it was lowest among various Tehsil (833.5 percent).

Bhewar is another tehsil that was shown a lower percentage of used tanks but it has an increasing trend. Table shown that in 1986-87, 85.9% tanks were useful while in 1997-98 has slightly gone up to 86.3 percent.

Kekree has recorded maximum decline in percentage of incase tanks. Table shown that in 1986-97, 94 percent of tanks were

used that went down to 92.7 percent in 1990-91. This has gone down to 79.3 percent in year 1997-98, the latest for which data is available. Sarwad Tehsil has also shown a slight decline of 3 percent but still 98.8 percent of tanks are being used.

Area irrigated by tanks increased significant as during proved under study. It was 3049 hectares in 1987-87 and it increased to 18741 hectares in the year 1994-95. But it decreased to 15041 hectares in 1977-98 (Appendix).

3.5 Canal Irrigation

There is no major irrigation scheme in Ajmer district. The only one medium irrigation project is (give to name and details of the project CWc report)

The area irrigated by canal has been fluxing in the study period it was as low as 711 hectares in 1987-88 as maximum area of 6472 hectares was irrigates in the year 1994-95. It has decreased to 3126 hectares in 1997-98.

These year 1992-93, to 1993-94, 1994-95 irrigated more area.

3.6 Net irrigated area

During the period 1986-87 there is an 2-3-fold increase in through 1999-2000, net irrigated area (NTA) in Ajmer district. In 1986-97

NIA was 43,301 ha and it increased to 130, 672 ha in 1996-97. After 1996-97 there had been a sharp decrease in NIA and in 1999-2000 it was only 84,472 ha. This decrease may be due to drought situation and decrease in number of wells in use. In the earlier drought year, 1987-88, 13% net shown area was irrigated, while in a good monsoon year as in 1996-97 it was 31.7%.

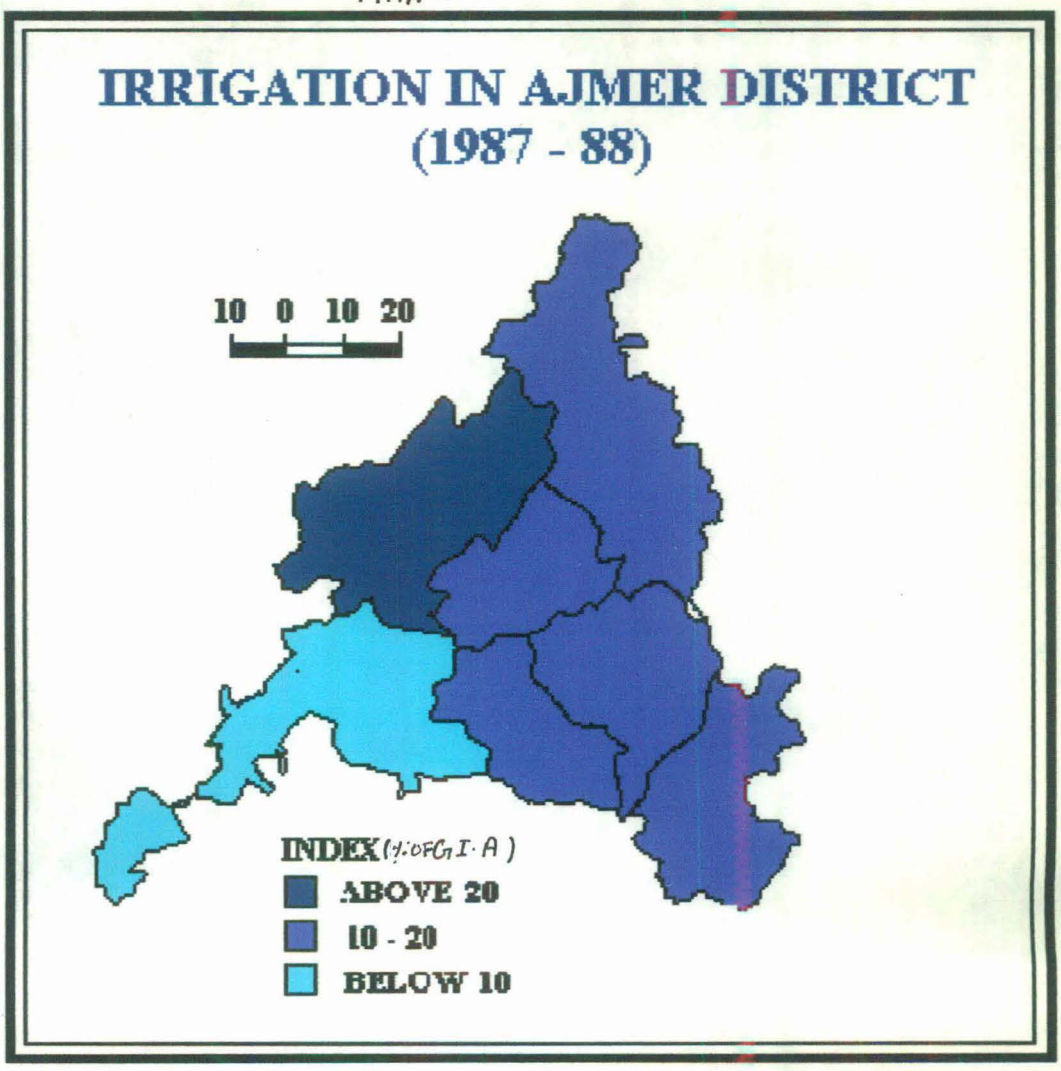
Table shown an over all increase in the percentage of net cultivated area irrigated in all thus his m 1987-88 the percentage of net cultivated area irrigated varied from 6.5.71 in Bhawaer tehsil to 21.07% in Ajmer tehsil Where as in 1999-2000 37.14% of net cultivated area was irrigated in Ajmer thanil and 371.16% in Bhavani Thasil. Kishangarh tehsil has the lowest percentage of net cultivated area irrigated.

3.7 Gross irrigated area

The percentage of gross cultivated area irrigated (GCAI) has increased from 14.67% in 1986-97 to 24.12% in 1999-2000. Although there was a steady increase, in years of high rainfall the percentage increased to 29.79 in 1996-97.

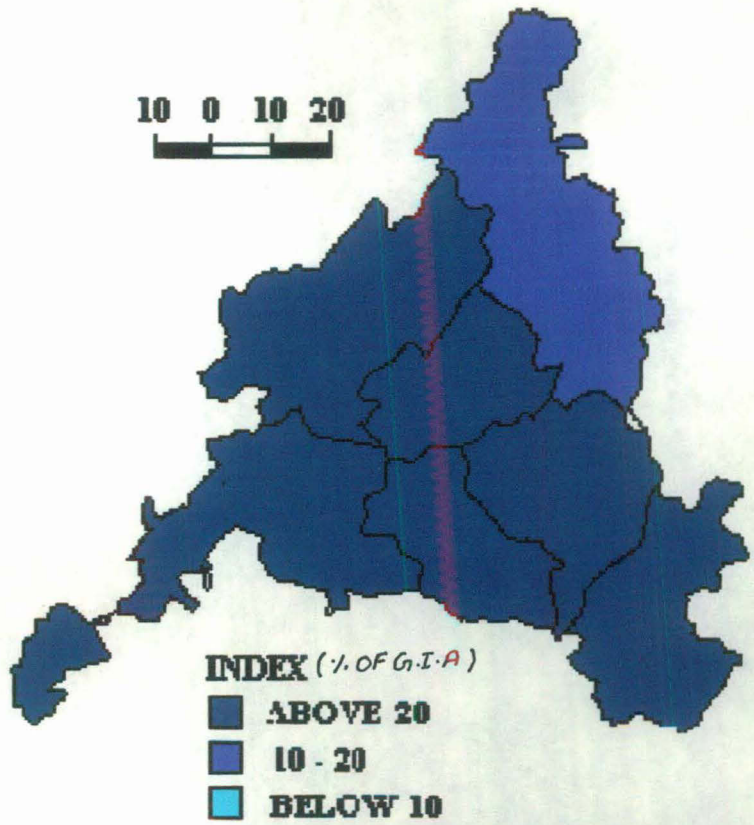
There was been a steady increase in the grass irrigated area. In the year 1987-88 the GCAI was 54560 ha and it reached a maximum of 1,56577 in the year 1996-97. In 1997-90 also the

MAP -


IRRIGATION IN AJMER DISTRICT
(1987 - 88)
10 0 10 20
INDEX (% OF GIA)
ABOVE 20
10 - 20
BELOW 10

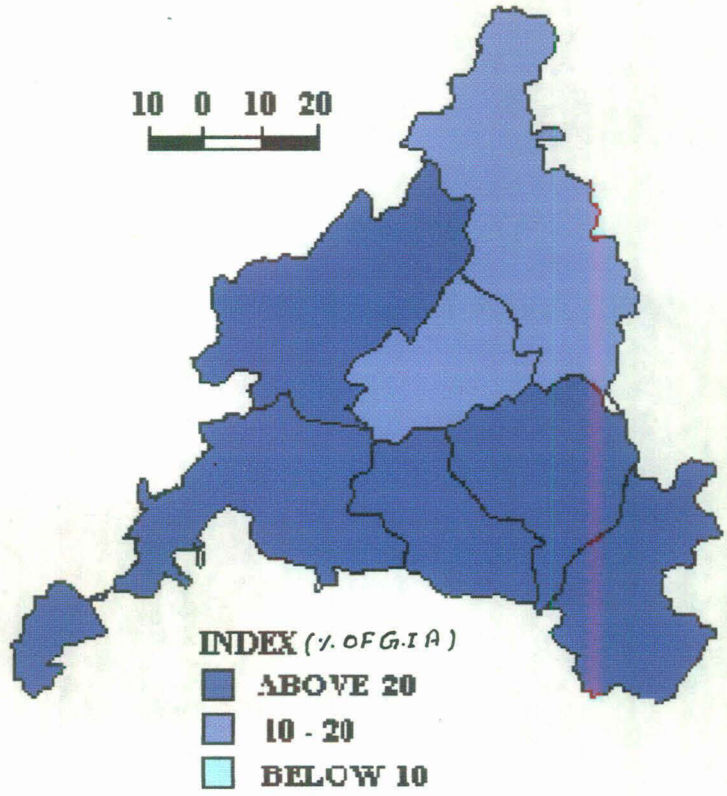
MAP-

IRRIGATION IN AJMER DISTRICT
(1992 - 93)



MAP-

IRRIGATION IN AJMER DISTRICT
(1999 - 2000)



gross area irrigated remained the same at 156221. After wards it decreased and in the year 1999-2000 it was 1,07047 ha, a decrease of 46967 a decrease 737, 338.

Among the tehsils Ajmer has 38.62% of the gross cultivated area irrigated in the year 1999-2000. Kishangarh tehsil has to lowest percentage, 17.79% of gross cultivated area irrigated. In all tehsils the percentage values increased from 10-13% to around 25% significant increase in noticed in Bhawer tehsil. Where the gross irrigated area increased from a more 2894 ha in 1987-87 ha to 13,233 ha 1999-2000. In 1997-98 GIA was 2736 & ha. Which accounts for 37.16% of the gross cropped area.

The trend in irrigated area and percentage of cultivated and irrigated shows a fluctuation in response to rainfall. This means irrigation is not that effective as a drought proofing measure. It is emphatic therefore to maximize the protecting in years of good monsoon which might provide resources for use in drought year. In this a judicious miss of institutional support and use of weather forest medium and long range can be of great help.

CHAPTER - IV
CROPPING PATTERN AND IMPACT OF DROUGHT ON AGRICULTURE

Ajmer district is situated in semi-arid tract and, thus, the rainfall and irrigation conditions have important bearings on the agriculture of the area. In this chapter attempts have been made first to explain the cropping pattern and then the area, production and yield of different crops with the help of the rainfall and irrigation facilities.

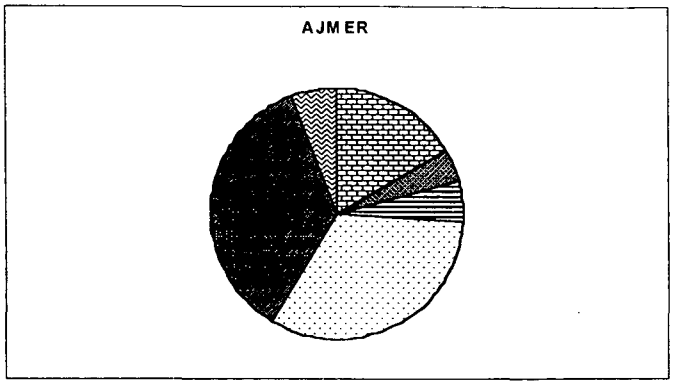
4.1 Cropping pattern

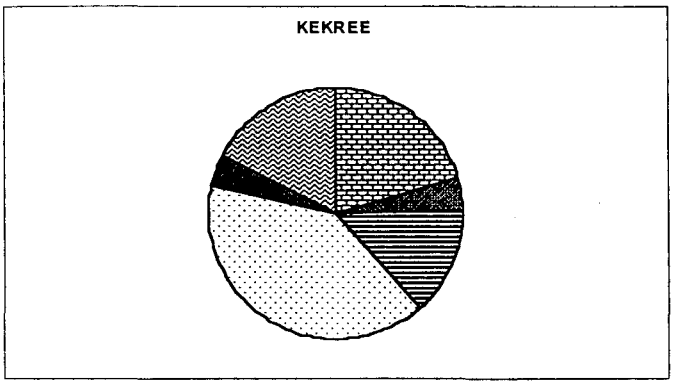
The cropping pattern of a region shows the area & extent of a particular crop with respect to the gross cropped area of that region. There may be a number of factors, which determine the cropping pattern of a region such as physical, technological and institutional. In Ajmer district, where agriculture is not well developed, the physical factors play a dominant role on the cropping pattern. The studies of Indian agriculture show that in subsistence type of agriculture, large number of crops are grown where as it shifts towards specialization with the development of agriculture in general and the growth of irrigation facilities in particular.

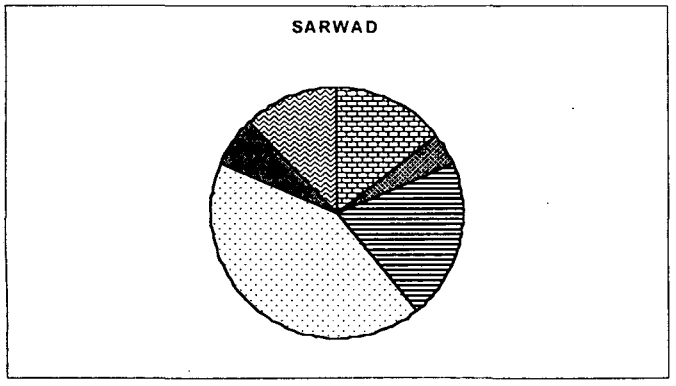
The agro-climatic conditions of Ajmer district are not very conducive for agricultural development. The area is located in semi-arid climatic conditions and has very low level of irrigation

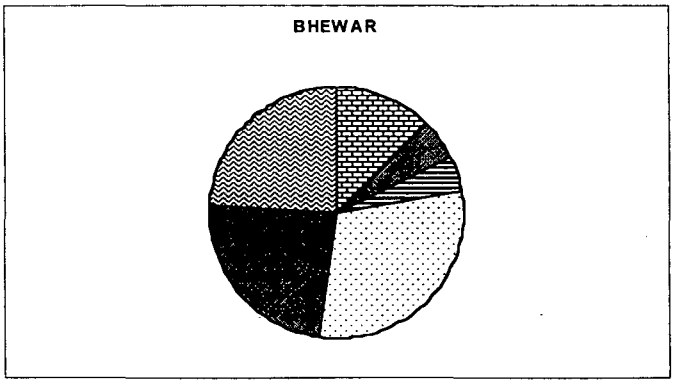
DIAGRAM.

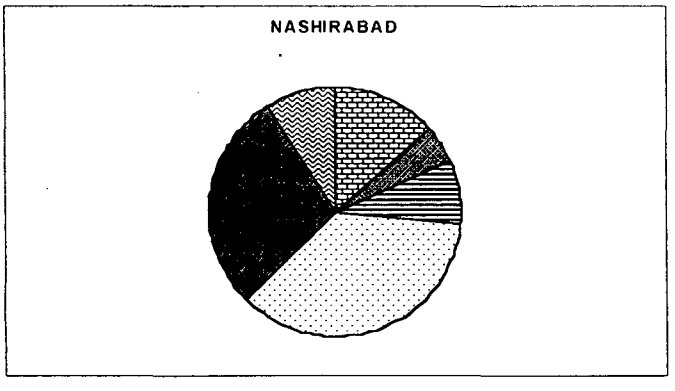
Cropping Pattern In Ajmer District & Its Tehsil(s), 1985-2000

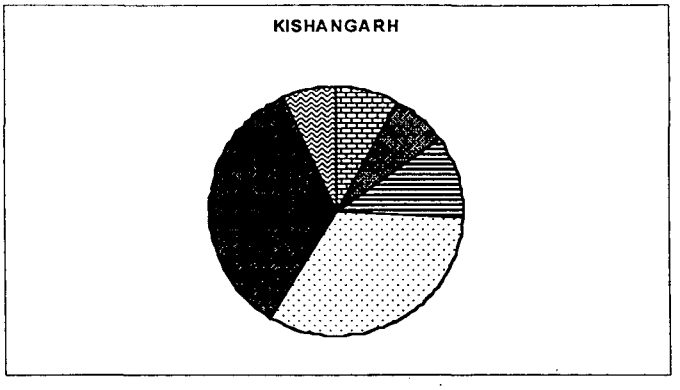


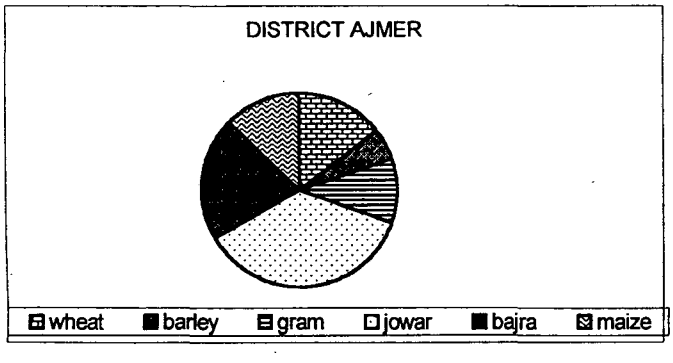












development. The area also has sandy, soils and, thus cannot support high value crops in the absence of assured irrigation facilities. More or less jowar, bajra, maize, wheat, barely and gram are important crops in all the six tehsils of the district. Jowar, bajra and maize are the major kharif crops which are grown in rainfed conditions whereas wheat, barely and gram, the important rabi crops, depend on irrigation. In Ajmer district winters are dry, soil are deficient of moisture.

4.1.1 Ajmer Tehsil: -

The cropping pattern of Ajmer tehsil shows the dominance of coarse grains (jowar, bajra and maize), which together occupy about 2/3 rd of the GCA. The average proportion of area under jowar is 23.5%, which declined from about 31% in 1985-88 to 18% in 1997. Again the decline is irrespective of the drought, normal or a good monsoon year. Less than 1% of the area under jowar is irrigated.

TABLE 4.1

AJMER TESHIL (See –Appendix No 4.85(A)

CROPPING PATTERN

	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-88	10	3.31	3.14	30.77	31.09	6.20
1991-94	11	2.96	2.29	22	25	4
1997-00	16	3.62	9.57	18	16	4
Total avg.	12.43	3.13	4.33357	23.51	25.54	4.24

1985-88	10.36	3.30	3.14	30.77	31.09	6.19	Drought Year
1992-95	11.94	2.99	2.72	23.38	24.68	4.04	Normal Year

LEVEL OF CROP IRRIGATION (try. Average)

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	95.01	89.19	16.70	0.86	3.86	46.99	
1991-94	96.64	87	9	0.09	1	43	
1997-2000	99.00	90	2	0.11	2	41	
Average	94	89	9.74	0	2	41.10	
Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	96.20	91.85	15.77	0.72	3.84	45.16	Drought Year.
1992-95	96.82	86.98	12.21	0.12	1.19	39.37	Normal Year

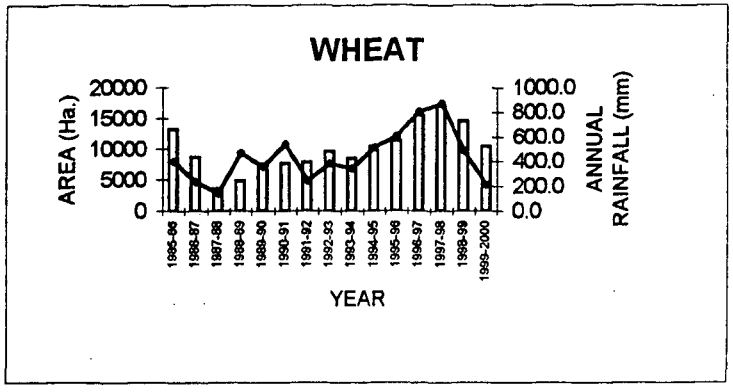
Source: District Statistical Outline,1985-2000, Economic & Statistical Directorate, Rajasthan, Jaipur.

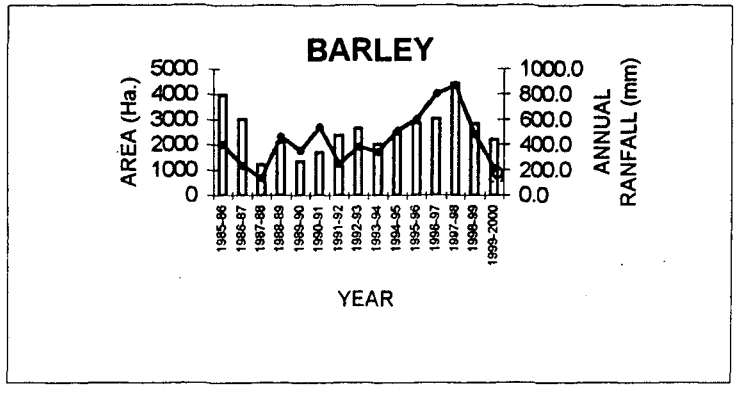
The area devoted to bajra is almost similar to that of the jowar. Bajra is grown on an average on 25.5% of the G.C.A. The proportion was about 31% in 1985-88 but declined to only 16% in 1997-2000. Though the bajra grown under irrigated conditions is more than that of the jowar but it is quite insignificant as only about 2% of its area is irrigated. Even the good rainfall years failed to reverse the declining trend in the area under bajra.

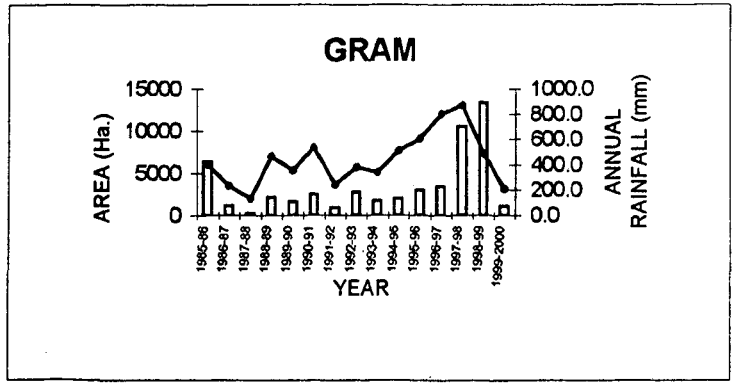
The area under maize was 6.2% of the G.C.A in 1985-88, which declined to 4% in 1991-94 and remained stagnant at this level during 1997-2000. The proportion of irrigated area under maize is quite high i.e. about 41%, thus, maize is both the rainfed and irrigated crop. Wheat occupies about 12% of the GCA and thus it is the most important rabi crop of the tehsil. The area under wheat was only 10% in 1985-88, which increased to 16% in 1997-2000. Wheat is totally grown under irrigated conditions. The proportion of irrigated area to

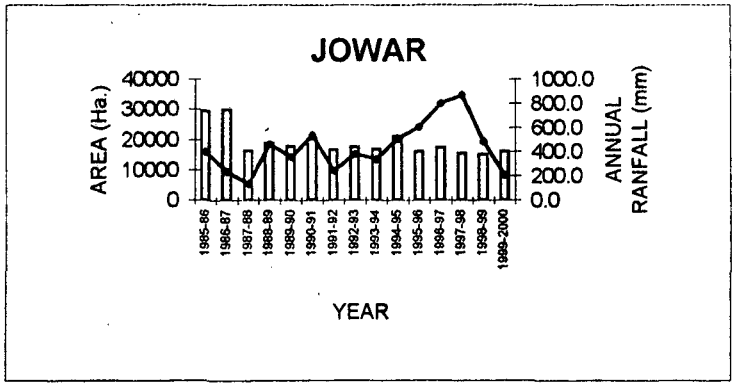
GRAPH :-

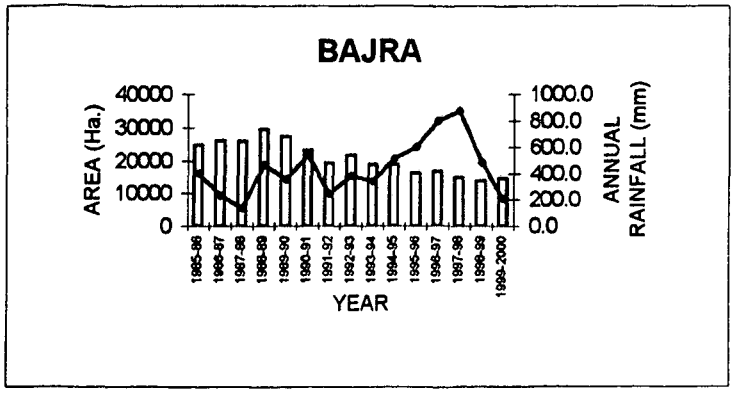
AJMER TEHSIL

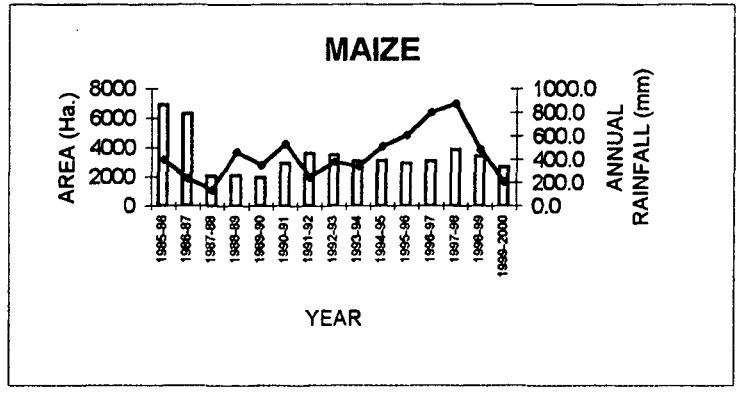












total area under was 95% in 1985-88, which increased to as high as 99.0% in 1997-2000. It shows that almost the entire area under wheat was irrigated.

The average area devoted to gram is 4.3% of GCA. It is a dry crop but supplemented by irrigation. The proportion of irrigated gram is about 10%. The area under gram increased from 3.1% in 1985-88 to 9.6% in 1997-2000.

Barely is another rabi crop of the tehsil that is grown mostly under the irrigated conditions. The proportion of GCA devoted to barely is only about 3.5%, which also remained almost stagnant; but the proportion of area grown under irrigated conditions is about 90%.

The cropping pattern of Ajmer tehsil shows that the share of coarse cereals declined continuously irrespective of the rainfall conditions whereas the proportion of area under wheat increased supported by increase in irrigation conditions.

4.1.2 Nasirabad Tehsil:-

The cropping pattern of Nasirabad tehsil is dominated by jowar and bajra, which together occupy about 48% of the GCA. Jowar, is the most dominant crop which occupied about 27% of the GCA. The area under jowar was 38% in 1985-88, which declined to 26% in 1991-94 and further to 21.8% in 1997-2000. The decline was continuous

irrespective of a good or bad rainfall years. In all the years the proportion of irrigated area was less than one percent.

Bajra is the second ranking crop that occupied about 22% of the GCA. Though the area under bajra also declined from about 29% of the GCA in 1985-88 to 18% in 1997-2000, the decline was not as high as that of the jowar. In the first period (i.e. between 1985-88 to 1991-94) the decline was more as compared to the later period i.e. between 1991-94 and 1997-2000. Similar to jowar, the area under bajra kept on declining irrespective of the rainfall and irrigation conditions.

Table 4.2

TEHSIL.NASHIRABAD (See –Appendix No ५.६९(A)

Cropping pattern

	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	4.73	2.96	3.09	38.02	29.41	7.82	
1991-94	13.62	4.28	4.88	26.02	21.84	7.51	
1997-00	11.01	3.26	13.15	21.85	18.27	5.94	
Total avg.	11.17	3.83	7.21	27.04	21.79	6.81	
1985-88	4.73	2.96	3.09	38.02	29.41	7.82	Drought Year.
1992-95	14.96	4.29	5.56	26.52	22.27	7.18	Normal Year

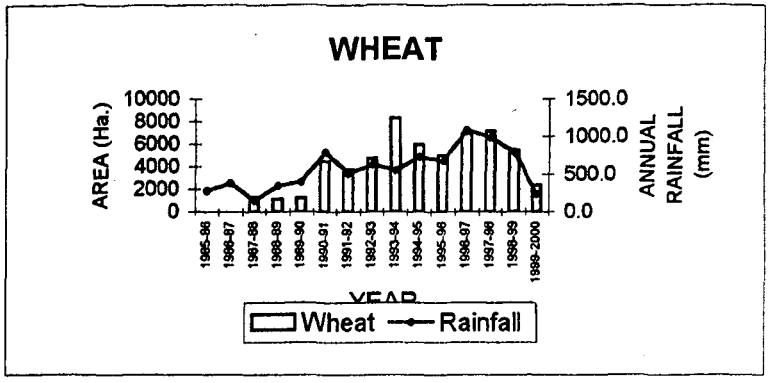
LEVEL OF CROPIRRIGATION

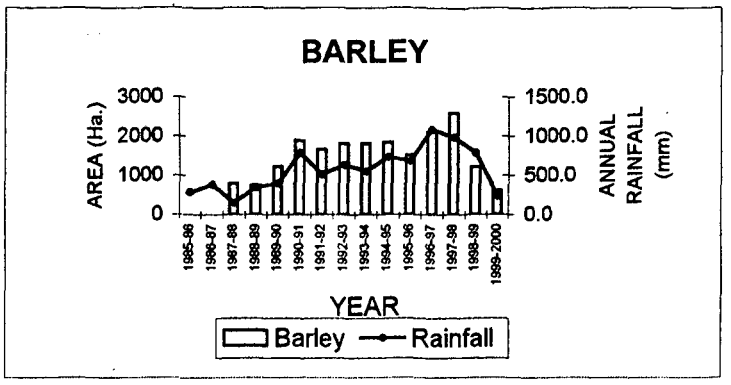
Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	24.29	25.12	1.72	0.09	0.23	4.15	
1991-94	26.43	25.16	5.47	0.16	0.56	10.79	
1997-2000	31.06	26.31	0.77	0.04	0.07	4.29	
Average	75.13	67.11	8.92	0.27	0.72	14.56	
Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	24.29	25.12	1.72	0.09	0.23	4.15	Drought Year.
1992-95	26.99	26.12	4.68	0.10	0.35	7.49	Normal Year

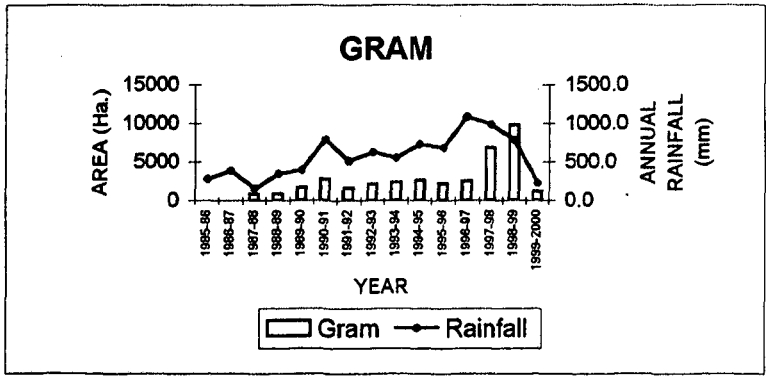
Source: District Statistical Outline,1985-2000, Economic & Statistical Directorate, Rajasthan, Jaipur.

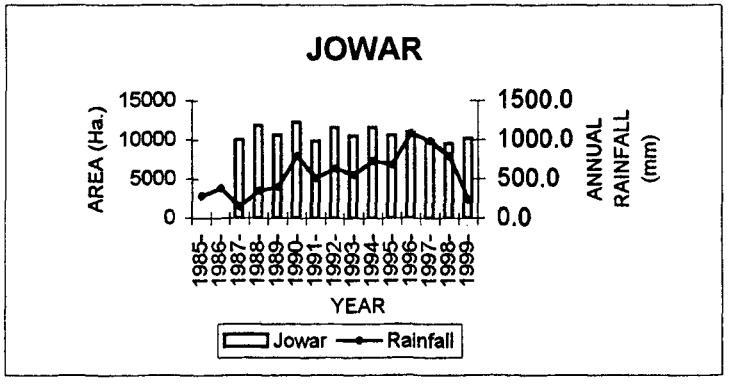
GRAPH :-

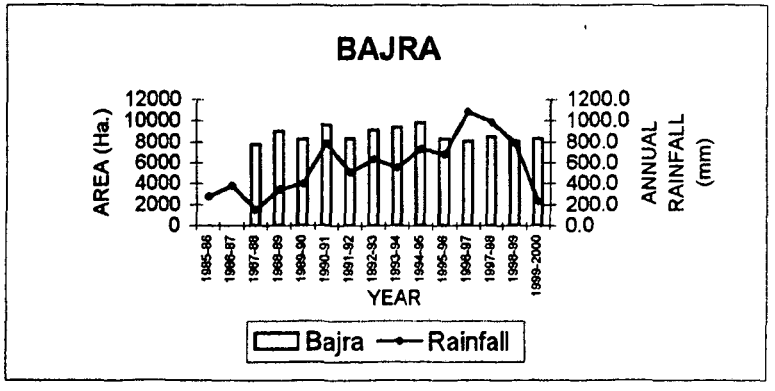
TEHSIL NASHIRABAD











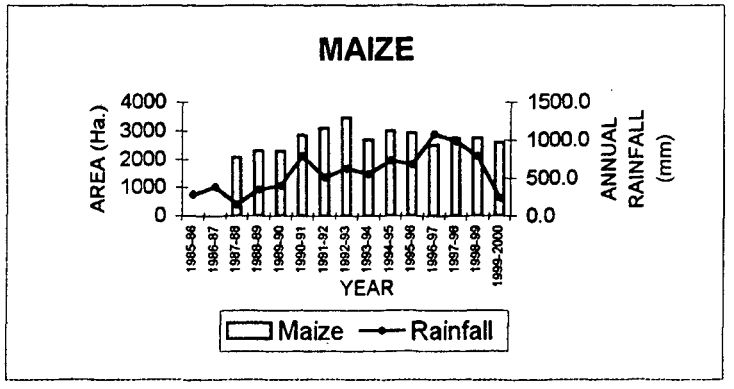


Table:-

TEHSIL AJMER

Year	Area (hect.) Wheat	Area (hect.) Barley	Area (hect.) Gram	Area (hect.) Jowar	Area (hect.) Bajra	Area (hect.) Maize	Total Annual Rainfall
1985-86	13252	3955	6365	29493	24533	6880	396.9
1986-87	8655	2996	1153	29923	26066	6329	230.8
1987-88	3585	1182	205	16264	25862	2032	133.8
1988-89	4815	2071	2108	18865	29411	2071	462.2
1989-90	7464	1326	1570	17718	27224	1948	352.4
1990-91	7564	1679	2500	20212	22961	2919	536.1
1991-92	7826	2362	923	16805	19126	3579	241.9
1992-93	9562	2632	2726	17608	21391	3492	379.3
1993-94	8464	1998	1768	16979	18759	3058	339.4
1994-95	10431	2515	1996	21128	18663	3096	510.0
1995-96	11392	2846	2921	16149	16113	2942	603.3
1996-97	15564	3018	3391	17313	16633	3077	800.0
1997-98	17097	4406	10549	15402	14820	3882	870.0
1998-99	14561	2820	13327	15064	13703	3428	482.4
1999-200(	10415	2194	1035	16103	14331	2657	206.5

TEHSIL NASHIRABAD

Year	Area (hect.) Wheat	Area (hect.) Barley	Area (hect.) Gram	Area (hect.) Jowar	Area (hect.) Bajra	Area (hect.) Maize	Total Annual Rainfall
1985-86	N.A	N.A	N.A	N.A	N.A	N.A	275.0
1986-87	N.A	N.A	N.A	N.A	N.A	N.A	380.0
1987-88	1242	779	812	9977	7718	2054	147.0
1988-89	1109	745	807	11816	8997	2290	341.0
1989-90	1212	1206	1699	10598	8236	2271	395.0
1990-91	4465	1891	2751	12219	9592	2824	788.0
1991-92	3687	1653	1554	9865	8315	3091	507.0
1992-93	4722	1796	2070	11526	9094	3441	628.0
1993-94	8294	1804	2364	10509	9369	2677	550.0
1994-95	5935	1842	2620	11555	9745	2986	727.0
1995-96	4998	1506	2174	10567	8313	2923	681.0
1996-97	6936	2105	2483	10973	8053	2481	1082.0
1997-98	7130	2595	6815	9889	8459	2736	982.0
1998-99	5432	1210	9789	9521	8014	2736	787.0
1999-200(	2352	612	1207	10180	8275	2583	229.0

Maize, the third important kharif crop of the tehsil remained almost stagnant at about 7% of the GCA. The proportion of maize area enjoying irrigation facilities remained about 6%.

Wheat is the most important rabi crop of the tehsil, occupying about 11 %of the GCA. The proportion of area under wheat increased from 4.7% in 1985-88 to as high as 13.6% in 1991-94 but declined slightly to 11.2% in 1997-2000. As compared to other tehsils, the proportion of irrigated wheat in Nashriabad is very low i.e. only about 26%. Thus, wheat cultivation is more of a rainfed type. The increase in wheat in 1991-94 and its decline in 1997-2000 can be attributed to good and bad monsoon year respectively.

The area under barley was only about 3% of the GCA, which increased phenomenally to about 13% in 1997-2000. The area under barley remained almost stagnant at about 4% of the GCA. the irrigation conditions enjoyed by barley are almost equal to that of the wheat.

4.1.3 Beawar Tehsil

The cropping pattern of Beawar tehsil also witnessed the dominance of the Kharif crops of jowar, bajra and maize. All the three crops are rainfed. The rabi crops have not developed well because of the lack in irrigation facilities.

On an average jowar occupied about 25% of the GCA. Which declined from 30.3% during 1985-88 to 24.0% in 1991-94 and further to 21.7% in 1997-00 less than 1-% area of jowar is grown under irrigated conditions.

The area under bajra was 14.1% in 1985-88 that declined to 8.0% in 1997-2000. The area under bajra is very low in Beawar telhsil as compared to other tehsil. It is totally a rainfed crops as less than one percent of bajra is grown under irrigated conditions.

Table 4.3

TEHSIL.BHEWAR (See –Appendix No) 4.8.5(A).

Cropping pattern							
Year	**Wheat**	**Barley**	**Gram**	**Jowar**	**Bajra**	**Maize**	
1985-88	3.98	4.17	1.65	30.31	14.15	23.79	
1991-94	11.14	4.37	3.03	24.07	46.86	20.85	
1997-00	15.42	3.21	6.70	21.78	8.30	18.18	
total avg	11.76	4.60	4.38	24.64	19.67	19.97	
	Wheat	**Barley**	**Gram**	**Jowar**	**Bajra**	**Maize**	
1985-88	3.988882	4.179532	1.651656	30.31974	14.15559	23.79592	Drought year.
1992-95	13.92778	5.263558	4.281008	24.80332	44.123	20.36973	Normal year

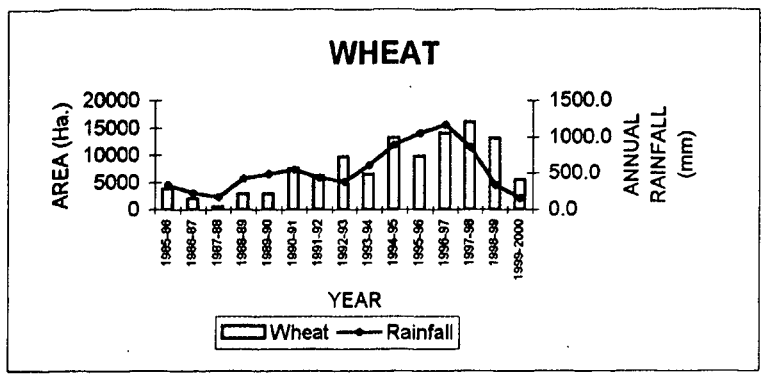
LEVEL OF CROPIRRIGATION

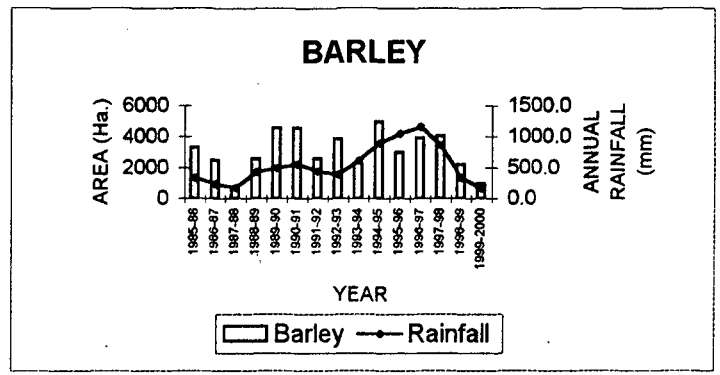
Year	Wheat	Barley	Gram	Jowar	bajra	Maize	
1985-88	89.71	80.55	5.914	0.21	0.60	10.10	
1991-94	85.57	78.65	11.20	0.13	0.11	7.10	
1997-00	98.29	81.06	6.017	0.09	0.17	4.12	
Average	92.00	76.52	8.819	0.12	0.19	5.35	
Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	89.72	80.56	5.91	0.21	0.60	10.11	Drought year.
1992-95	85.55	78.04	12.65	0.08	0.06	2.95	Normal year

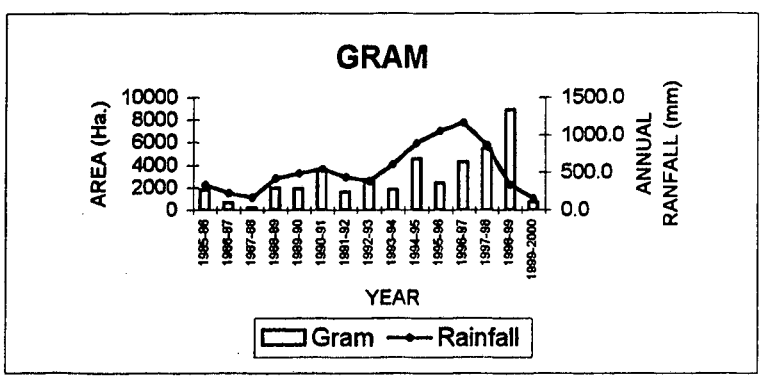
Source: District Statistical Outline,1985-2000, Economic & Statistical Directorate, Rajasthan, Jaipur.

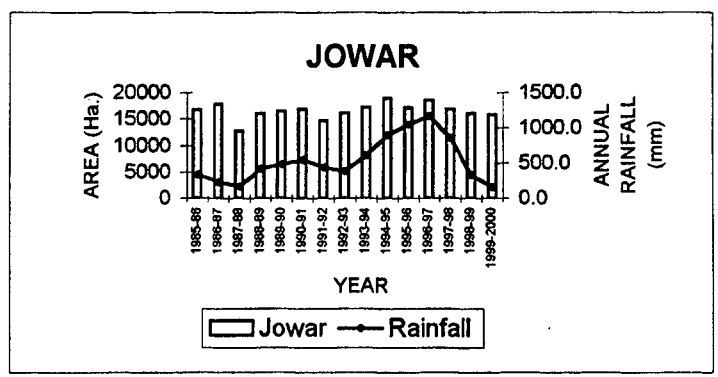
GRAPH :-

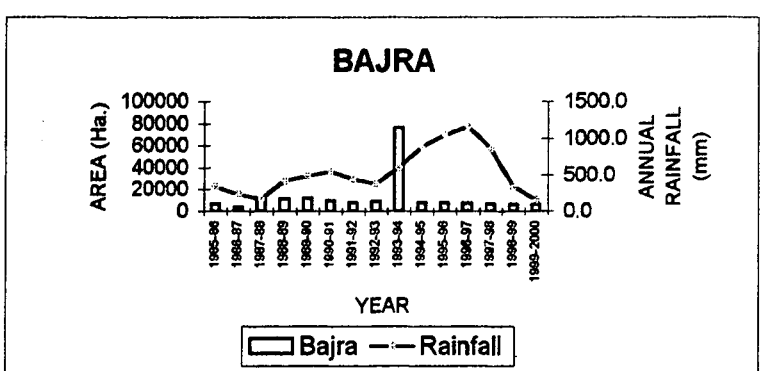
TEHSIL BHEWAR

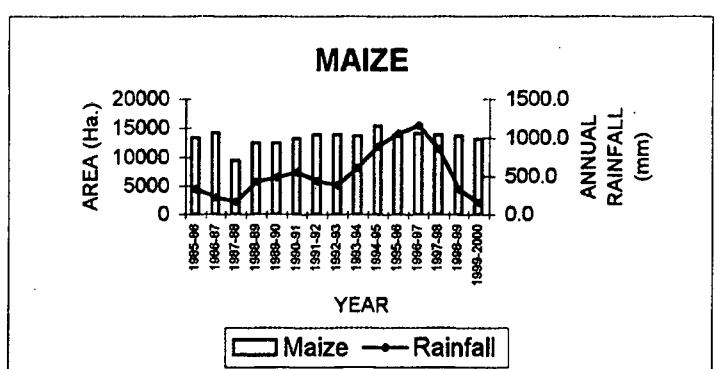












Maize is an important crop of the tehsil as it was grown at about 20% of the GCA. The area under maize was as high as 24.0% in 1985-88 but it declined to 18.2% in 1997-2000. About 5% of the maize is grown with assured irrigation facilities.

Wheat is the most important rabi crop of Beawar. The area under wheat was only about 4% in 1985-88 but it increased phenomenally to about 12% in 1997-2000. It was during this period that the proportion of wheat cultivated areas with irrigation facilities increased to 89% in 1997-2000. Thus, the shift in the cropping pattern towards wheat can be explained with agricultural development in general, and improvement in irrigation facilities in particular.

The area under barely was about 4% in 1985-88, which declined to 3% in 1997-2000. About 80% of the barely cultivated area are under irrigated condition. Thus, like wheat barely is also an irrigated crop.

The area under gram cultivation was only 1.6% in 1985-88 but increased to 6.7% in 1997-2000. Gram is a rainfed crop in this tehsil as only about 10% of gram is cultivated under irrigated conditions.

4.1.4 Kekree Tehsil

In Kekree, the most important crop is jowar that on an average occupied about 26% of the GCA. However, the proportion came down

from 30.4% in 1985-88 to 22.2% in 1997-00. Jowar is a rainfed crop and grown under rained conditions.

Table 4.4

Kekery (See –Appendix No 4.&5.(A) **)**

Cropping Pattern							
Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	14.40	3.77	9.13	30.41	3.25	12.35	
1991-94	14.06	2.46	6.08	24.64	2.36	12.15	
1997-00	12.28	1.78	15.09	22.17	1.80	10.04	
Total Avg.	13.53	2.51	9.52	25.89	2.61	11.27	
	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	14.40	3.77	9.13	30.41	3.25	12.35	Drought year.
1992-95	15.28	2.42	7.84	25.70	2.27	11.94	Normal year

LEVEL OF CROP IRRIGATION

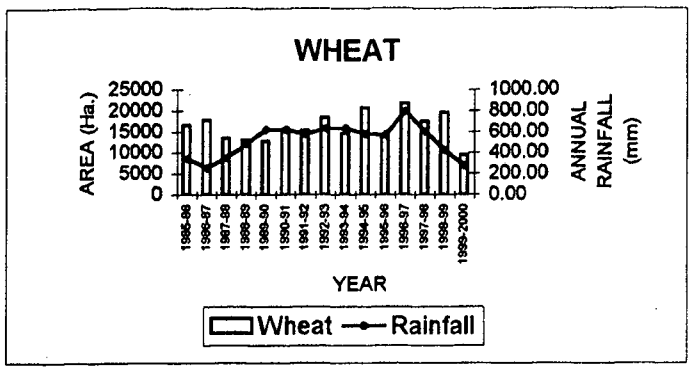
Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	47.32	76.03	3.19	0.58	1.89	24.59	
1991-94	58.21	75.52	9.28	0.18	0.92	18.70	
1997-00	80.07	78.78	2.70	0.04	1.26	9.63	
Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	47.32	76.03	3.19	0.58	1.89	24.59	Drought year.
1992-95	62.96	74.77	9.43	0.12	0.32	12.18	Normal year

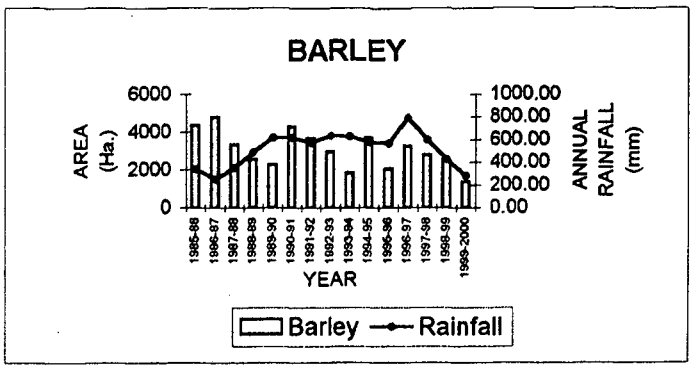
Source: District Statistical Outline,1985-2000, Economic & Statistical Directorate, Rajasthan, Jaipur

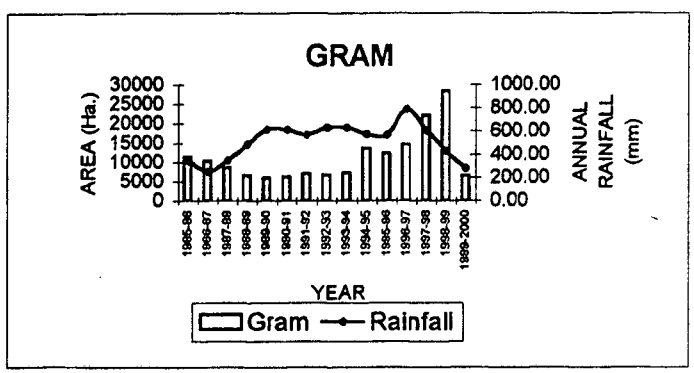
Wheat, a rabi crop figures as a second important crop in the cropping pattern of Kekree which accounted for about 11% of the GCA. The proportion of area under maize declined slightly from 12% in 1985-88 to 10% in 1997-2000.

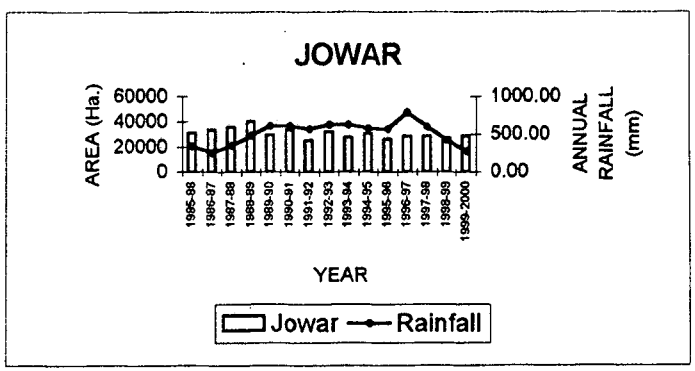
GRAPH :-

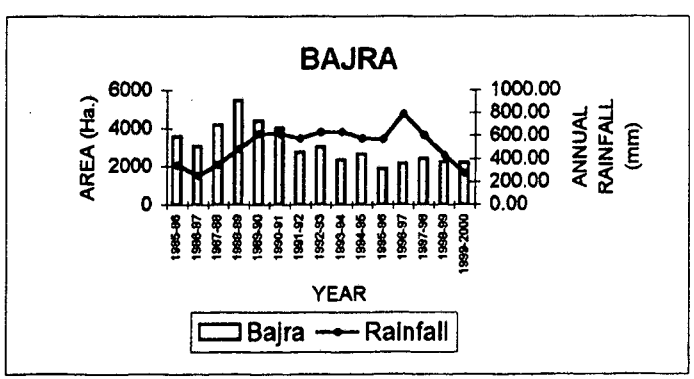
TEHSIL KEKREE











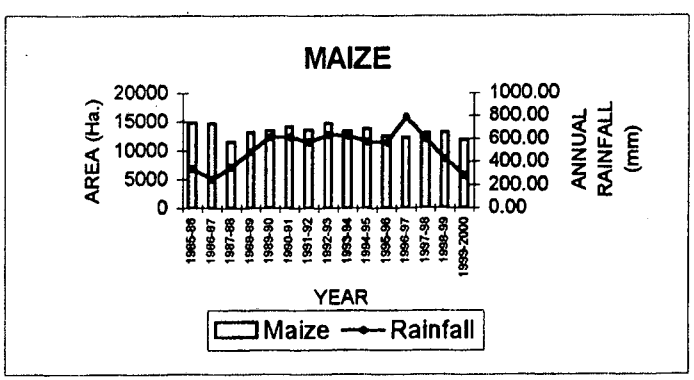


Table:-

TEHSIL BHEWAR

Year	Area (hect.) Wheat	Area (hect.) Barley	Area (hect.) Gram	Area (hect.) Jowar	Area (hect.) Bajra	Area (hect.) Maize	Total Annual Rainfall
1985-86	3752	3302	1774	16695	6396	13363	331.9
1986-87	2040	2468	604	17774	3800	14275	224.0
1987-88	422	741	195	12764	11856	9432	165.3
1988-89	2803	2577	1906	16056	11435	12472	420.5
1989-90	2793	4534	1903	16440	11654	12469	484.5
1990-91	7517	4539	3566	16845	9806	13191	548.5
1991-92	6097	2574	1566	14608	7908	13930	433.9
1992-93	9641	3845	2667	16088	8801	13920	379.4
1993-94	6424	2276	1801	17178	76484	13619	608.3
1994-95	13235	4952	4538	18913	7537	15313	887.5
1995-96	9799	2972	2414	17151	7779	13935	1047.5
1996-97	13952	3934	4260	18522	7097	14070	1161.0
1997-98	16020	4052	5415	16879	6681	13843	856.8
1998-99	13057	2178	8884	16011	6150	13669	331.5
1999-200(	5377	961	682	15763	5726	13106	151.0

TEHSIL KEKREE

Year	Area (hect.) Wheat	Area (hect.) Barley	Area (hect.) Gram	Area (hect.) Jowar	Area (hect.) Bajra	Area (hect.) Maize	Kekri tehsil Total Annual Rainfall
1985-86	16469	4355	11311	31057	3532	14829	340.00
1986-87	17732	4795	10270	33704	3049	14636	251.30
1987-88	13417	3314	8615	35804	4174	11365	349.00
1988-89	12971	2545	6506	40313	5445	13071	484.75
1989-90	12653	2259	5731	29463	4362	13494	613.50
1990-91	15298	4268	6179	33698	4003	14131	614.00
1991-92	15189	3647	7015	24832	2731	13614	571.50
1992-93	18319	2939	6632	31882	3008	14635	630.00
1993-94	14532	1826	7120	27472	2321	13284	629.75
1994-95	20514	3679	13637	30365	2614	13759	574.00
1995-96	13707	2032	12218	25917	1870	12433	567.00
1996-97	21601	3246	14565	28436	2139	12254	789.90
1997-98	17349	2789	22076	28241	2391	12975	599.85
1998-99	19443	2555	28335	26731	2221	13067	423.50
1999-200(	9527	1369	6496	28621	2167	11807	274.50

Gram is the second most important rabi crop, which is grown on about 9% of GCA. The area under gram declined from about 9% in 1985-88 to 6% in 1991-94 but again increased significantly to about 15% in 1997-2000. Gram is grown mostly under rainfed conditions. The trend in the area under gram shows that more area has been devoted to gram during the years of moisture stress.

Surprisingly the proportions of area under bajra to gross copped are is very low in Kekree. The proportion was only 3.2% in 1985-88 which again declined to less than 2% in 1997-2000.

Barely, which grown mostly under irrigation occupy about 2.5% of the GCA. The proportion of area under barley to GCA has declined continuously from 3.8%in 1985-88 to 1.8% in 1997-2000.

4.1.5 Sarwad Tehsil

Jowar is the most important crop of Sarwad tehsil. On an average, it occupied about 28% of the GCA. The area under jowar declined from 35% in 1985-88 to 22% in 1997-2000. In the absence of irrigation, people depend heavily on rainfed crops like jowar.

Table 4.5

TEHSIL.SARWAD (See –Appendix No(425-B)

Cropping Pattern						
Year	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-88	9.60	4.20	17.36	35.02	4.42	9.86
1991-94	10.03	3.05	6.39	27.86	4.84	9.46
1997-00	10.51	1.83	24.52	22.11	3.67	6.19

Total Avg.	10.19	2.80	14.71	28.27	4.48	8.16	
Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	9.60	4.20	17.36	35.02	4.42	9.86	Drought year.
1992-95	11.70	3.18	10.04	28.52	4.65	8.90	Normal year

LEVEL OF CROP IRRIGATION

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	62.25	75.35	3.43	1.14	6.42	29.94	
1991-94	70.15	75.61	8.38	0.69	4.82	13.70	
1997-00	82.06	74.16	3.74	0.08	0.57	10.12	
Average	70.08	73.69	5.81	0.42	2.89	15.00	
Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	62.25	75.35	3.43	1.14	6.42	29.94	Drought year.
1992-95	77.79	77.15	9.91	0.48	3.69	5.67	Normal year

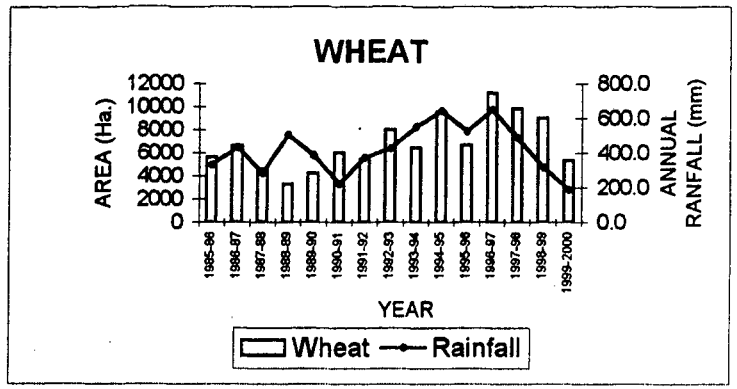
Source: District Statistical Outline,1985-2000, Economic & Statistical Directorae, Rajasthan, Jaipur.

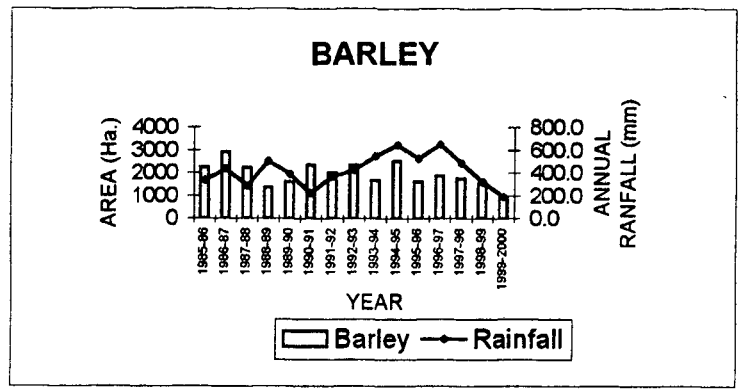
Gram, though a rabi crop, figures out as the second most important crop in the cropping pattern of Sarwad tehsil. The area under gram was 17% in 1985-88, which declined to 6.4% in 1991-94 but increased to 24.5% in 1997-2000. The first and the last period, when the proportion of grain cultivated area was high, are also the years of moisture stress. Since gram is a drought resistant crop people prefer it during the years of relatively low rainfall.

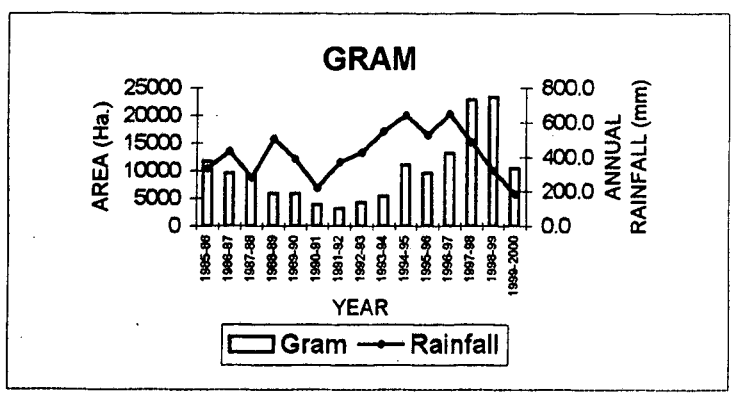
Wheat occupies the third place in terms of the area under this crop. The proportion was 9.6% in 1985-88, which increased marginally to 10.2% in 1997-00. Most of the wheat is grown under irrigated conditions, as the proportion of irrigated wheat area was as high as 82% in 1997-2000.

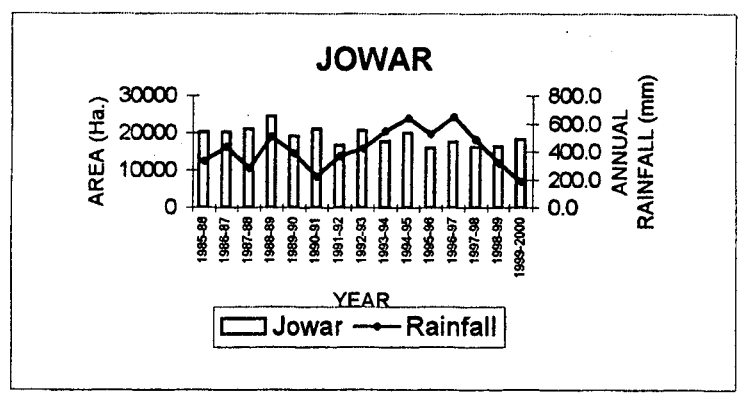
GRAPH:-

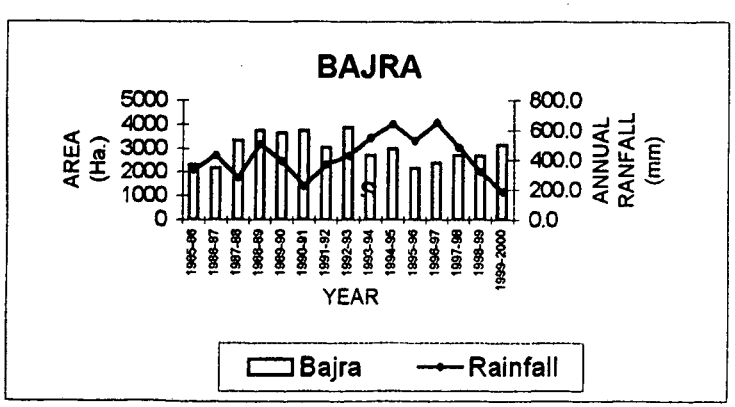
TEHSIL SARWAD

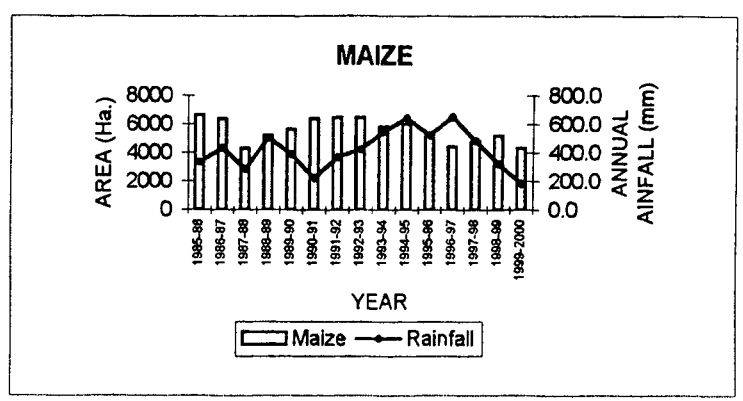












The area under maize was 9.8% in 1985-88, which declined to 8.2% in 1997-2000. About 15% of the area under maize enjoy irrigation facilities.

Like Kekree, the area under bajra is also very low in Sarwad tehsil. Bajra occupies only about 4% of the total cropped area. Another important thing to be noted is that the proportion remained stagnant.

The area under barley is also only about 2% of the GCA. It is a rabi crop and is grown mostly under irrigation.

4.1.6 Kishangarh Tehsil

Bajra is the most important crop, which covers about 23.04% of the area. The highest acreage under this crop was found during 1988-89 (34.81%), while the lowest was found in 1998-99 (14.07%). During 1987-88, the drought year, its average was 31.15%.

The next crop in importance is Jowar with an acreage of 21.52% of GCA. It showed initial increase till 1987-88, then declined to 12.63% during 1997-98, but then increased to 12.97% (98-99) and then finally to 18.56% during 1999-2000 the only exception to this general trend were 1989-90 and 1994-95, when acreage instead of declining, increased marginally.

Table 4.6

TEHSIL.KISHANGHAR (See –Appendix No 4&5B)

Cropping pattern							
Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	4.64	4.22	3.16	30.89	30.04	6.71	
1991-94	5.42	4.66	3.96	21.05	24.92	4.47	
1997-00	6.79	4.95	19.70	14.35	15.51	3.61	
Total avg.	5.98	4.86	9.06	21.53	23.04	4.32	
Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	4.64	4.22	3.16	30.89	30.04	6.71	Drought year.
1992-95	6.35	5.82	5.63	20.78	23.78	4.35	normal year

LEVEL OF CROP IRRIGATION

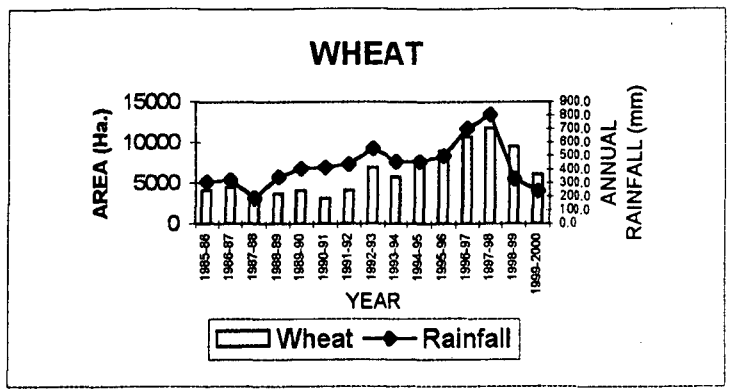
Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	92.78	93.27	8.98	1.03	3.92	35.50	
1991-94	89.63	76.32	11.27	0.67	0.91	19.84	
1997-00	95.27	83.78	0.94	0.18	1.62	12.96	
Average	91.66	84.55	7.82	0.47	1.72	19.48	
1985-88	92.78	93.27	8.98	1.03	3.92	35.50	Drought year.
1992-95	90.95	83.30	10.28	0.60	0.36	10.52	normal year

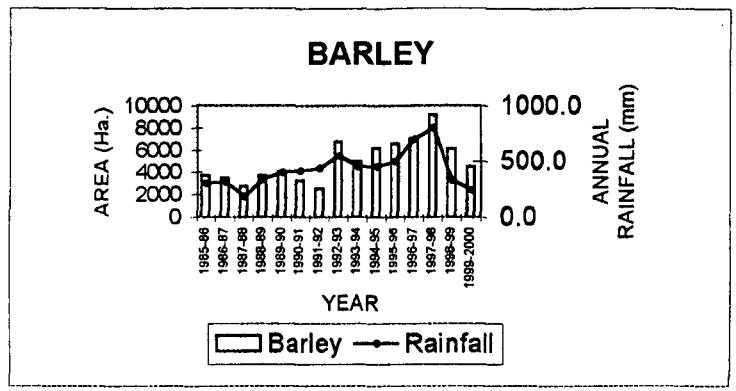
Source: District Statistical Outline,1985-2000, Economic & Statistical Directorate, Rajasthan, Jaipur.

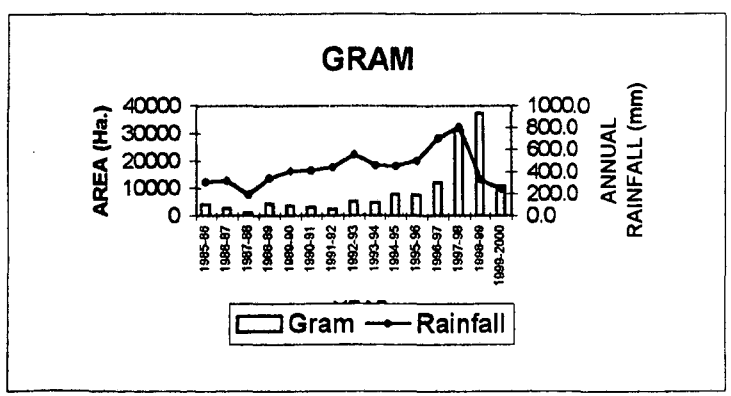
Wheat has low proportion of 6.34% to GCA. The crop shows fluctuating trend till 1993-94, showing increase and decrease alternately, but then it increased to 9.11% during 96-97, which has been the highest for this crop. After that, the crop shows declines again till 1999-00 5.53%).

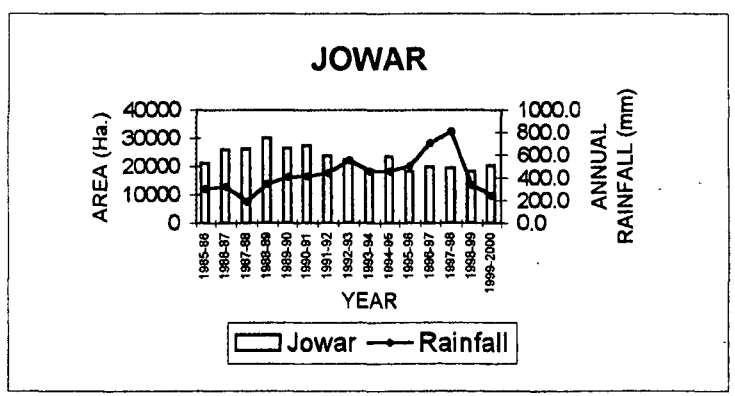
TEHSIL KISHANGHAR

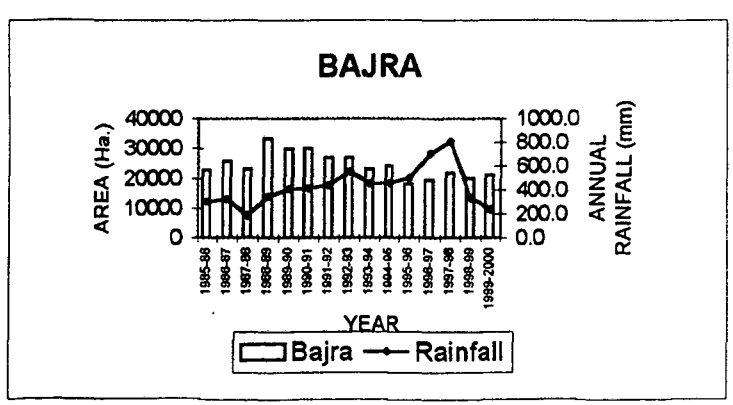
GRAPH :-











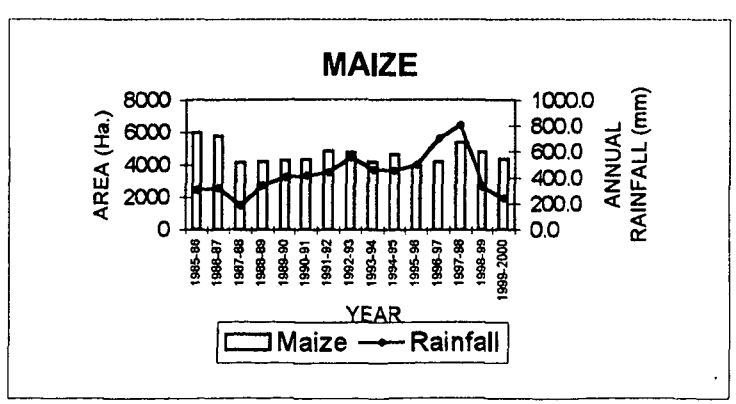


Table:-

TEHSIL SARWAD

Year	Area (hect.) Wheat	Area (hect.) Barley	Area (hect.) Gram	Area (hect.) Jowar	Area (hect.) Bajra	Area (hect.) Maize	Total Annual Rainfall
1985-86	5633	2234	11620	20135	2283	6621	331.0
1986-87	6612	2913	9581	20145	2157	6348	431.0
1987-88	4567	2213	9183	21015	3305	4289	279.8
1988-89	3292	1344	5820	24518	3711	5229	504.1
1989-90	4201	1604	5843	19104	3627	5646	387.0
1990-91	6022	2349	3850	21067	3718	6367	220.0
1991-92	5420	2014	3135	16666	3013	6462	369.0
1992-93	7987	2345	4201	20741	3870	6441	424.5
1993-94	6462	1676	5315	17761	2699	5827	547.0
1994-95	9538	2498	11079	19981	2975	5985	639.5
1995-96	6690	1610	9581	15967	2137	5285	524.0
1996-97	11183	1867	13132	17645	2353	4427	648.0
1997-98	9822	1760	22833	16194	2689	4758	483.9
1998-99	9020	1529	23260	16434	2653	5161	316.5
1999-200(	5353	921	10339	18265	3112	4330	183.5

TEHSIL KISHANGHAR

Year	Area (hect.) Wheat	Area (hect.) Barley	Area (hect.) Gram	Area (hect.) Jowar	Area (hect.) Bajra	Area (hect.) Maize	Total Annual Rainfall
1985-86	4014	3722	3962	21101	22655	5977	302.0
1986-87	4396	3514	2549	25804	25468	5763	318.3
1987-88	2571	2743	955	26128	22897	4120	184.7
1988-89	3649	3734	4177	30051	32973	4184	339.3
1989-90	4029	4074	3600	26275	29576	4249	404.5
1990-91	3079	3251	3084	27369	29860	4306	411.2
1991-92	4063	2502	2360	23702	26854	4831	437.6
1992-93	6869	6794	5110	22306	26797	4730	553.7
1993-94	5696	5014	4680	18609	22832	4154	456.7
1994-95	7117	6234	7654	23515	24088	4606	453.0
1995-96	8905	6617	7432	18149	17911	3923	497.3
1996-97	10630	7097	11984	19810	19139	4166	703.2
1997-98	11786	9180	31119	19270	21566	5392	805.3
1998-99	9500	6156	37270	18237	19784	4762	328.1
1999-200(	5995	4563	10727	20127	20945	4340	238.7

Barely is the other crop which covers 5.81% of GCA. The crop has shown highest acreage of 6.36% during 1992-93, while the lowest has been observed during 1991-92 (2.49%).

Gram and maize are the last two crops cultivated in Kishangarh Tehsil which cover 5.62% and 4.35% of their GCA respectively. Gram has shown continous declining trend in terms of acreage till 1993-94 with exception of 1988-89, 1992-93; on the other hand after 1993-94 the crop has shown increasing trend and rose upto maximum of 26.50% during 1998-99 However, during 1999-2000, it declined to 9.89%.

Maize has remained within the range of 6% to 3% of GCA throughout the study period, except during 1985-86, when it occupied 7.57% of cross cropped area. However, it gradually declined after that reaching the lowest during 1998-99, (3.39%), though there were exception to this rule. During 1999-2000, maize occupied 4% of the gross cropped area.

4.1.7 Ajmer District

Wheat is the most important rabi crop of Ajmer district. During 1985-88 the proportion of area deveoted to wheat was about 9.0% which increased to 10.2% in 1991-94 and further to 11.9% in 1997-2000. Though marginally, the area under wheat increased continuously. It was during these years the proportions of area

irrigated to total area under wheat cultivation also increased significantly. The proportion was 63.8% in 1985-88 in 1992.95, thus it can be said that the increase of irrigation conditions under wheat helped in the marginal increase in the area under wheat. Gram is another important rabi crop of the district which occupied 8.3% of the G.C.A. The area under gram shows very high fluctuations. The proportion of area under grain was 6.6% in 1985-88 that declined to 4.5% in 1991-94 but again increased to 15.6% in 1997-2000. It should be noted that irrigation conditions for gram increased from 3.2% in 1985-88 to 10.7% in 1992-95. The decline of area in 1985-88 was probably due to the severe drought conditions during these years.

Table 4.7

AJMER DISTRICT (See –Appendix No 4&5(B)

Cropping pattern							
Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	9.05	3.78	6.61	30.71	16.73	10.71	
1991-94	10.22	3.82	4.49	23.86	14.62	9.60	
1997-00	11.94	3.60	15.58	20.47	10.42	7.69	
Total avg.	10.65	3.73	8.33	25.19	14.31	9.08	
Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	9.05	3.78	6.61	30.71	16.73	10.71	Drought year.
1992-95	11.67	3.94	6.11	24.60	14.11	9.38	normal year

LEVEL OF CROP IRRIGATION

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-86	63.82	82.74	3.23	0.79	3.83	27.75
1986-87	78.64	80.48	10.43	0.42	1.74	20.63
1987-88	88.45	75.31	2.45	0.09	1.15	10.97
Average	76.60	79.57	6.51	0.33	1.70	18.72

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize	
1985-88	63.82	82.74	3.23	0.79	3.83	27.75	drought year.
1992-95	82.03	80.20	10.72	0.34	1.32	28.06	normal year

Source: District Statistical Outline,1985-2000, Economic & Statistical Directorate, Rajasthan, Jaipur.

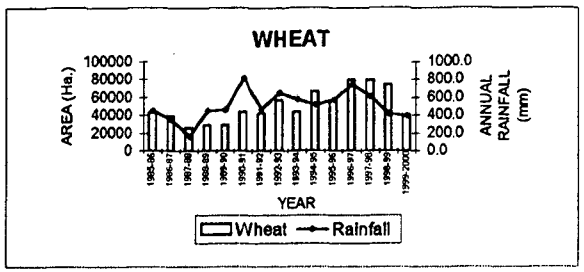
The area under barely is only 3.7% of the G.C.A., which is almost stagnant over the years. The variation is only of 0.2% between 1985-88 and 1997-2000. The irrigation conditions under barely showed a slight decline from 82.7% in 1985-88, 80 2% in 1992-95.

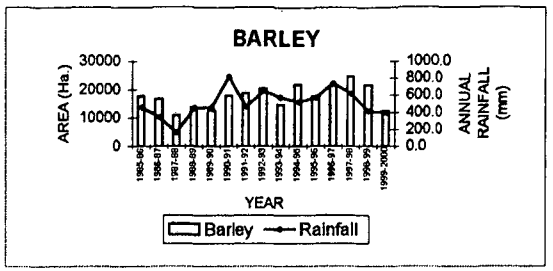
The cropping pattern shows that Jowar is the most important crop of the district. The proportion of GCA devoted to Jowar is about 25.0%. It should be noted that the proportion of area under Jowar declined continuously from about 30% in 1985-88 to 20% in 1997-2000. It is in conformity with the general trends observed that there has been a perceptible and continuous decline in the area under coarse cereals. The irrigation data shows that less than 1% of area under Jowar is irrigated. The area under Jowar declined continuously irrespective of a normal monsoon year or a drought year.

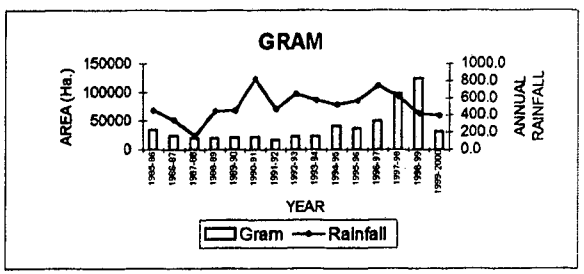
After Jowar, bajra is the second important kharif crop of Ajmer district. It occupied about 14% of G.C.A. Like jowar, the area under bajra also declined continuously from about 16.7% in 1985-88 to 10.4% in 1997-00 the irrigation condition under bajra is about 2%

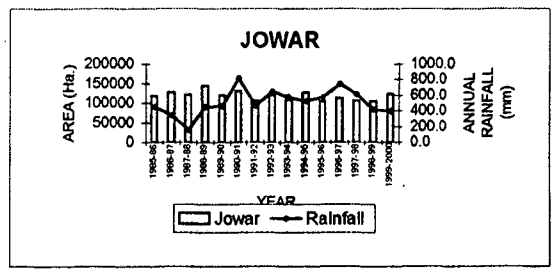
GRAPH:-

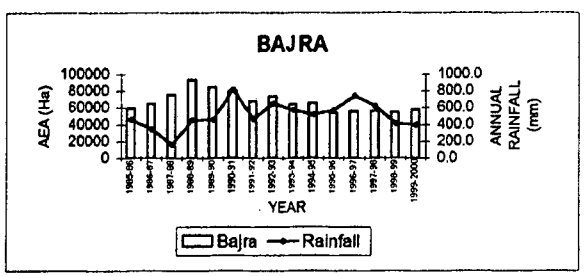
DISTRICT AJMER

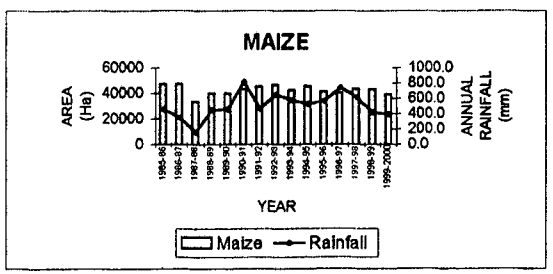












DISTRICT AJMER

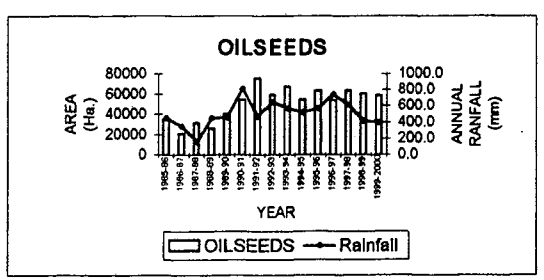


Table :-

DISTRICT AJMER

Year	Area (hect.) Wheat	Area (hect.) Barley	Area (hect.) Gram	Area (hect.) Jowar	Area (hect.) Bajra	Area (hect.) Maize	Area (hect.) OILSEEDS	Total Annual Rainfall
1985-86	43126	17568	35032	118481	59398	47670	35218	454.2
1986-87	39434	16687	24157	127350	65120	47351	20639	347.0
1987-88	25804	10978	19965	121952	75819	33292	31095	159.8
1988-89	28922	13760	20665	145013	93461	39925	25926	449.5
1989-90	29333	12706	20872	119598	84679	40080	40782	457.5
1990-91	43945	17972	21930	131410	79940	43738	54736	819.1
1991-92	42282	18752	16552	106478	67947	45507	75303	468.4
1992-93	57100	20351	23406	120151	72961	46659	59039	650.8
1993-94	44112	14595	23048	108508	64463	42619	67015	573.1
1994-95	66770	21720	41524	125457	65622	45745	54603	521.2
1995-96	55491	17583	36740	104500	54123	41441	63248	570.2
1996-97	79866	21267	49815	112699	55414	40475	54031	743.0
1997-98	79204	24782	98807	105875	56606	43586	63619	615.0
1998-99	74805	21534	123824	105177	55089	42823	60337	415.0
1999-200(	40412	12259	30961	122136	57959	38823	58329	395.0

which is more than that of the Jowar. The proportion of bajra irrigated declined from about 4% in 1985-88 to 1.2% in 1992-95.

Thus, it can be said that both jowar and bajra are rainfed crops. Even the good monsoon years failed to increase the area under these two crops.

Maize is another important kharif crop of the district. The average area occupied by maize is about 9% of the G.C.A. It is a crop that is both rainfed and irrigated. The proportion of irrigated area under maize is about 28%. The area under maize remained almost stagnant.

4.2 Impact of Drought on Agriculture in Ajmer District

Ajmer district frequently experiences drought, causing a sharp fall in gross cropped area, net shown area, production and yield of various crops in drought years. In this study three drought years viz. 1986-87, 1987-88 and 1999-2000 are considered. The decrease in area, yield and production in drought years over the proceeding years in discussed in this section. The crops chosen for the study are wheat, barley, gram, jowar, bajra and maize.

Gross Cropped Area (GCA) : The gross cropped area in the district fluctuated during to period of study. In the drought year of 1987-88, it was very low, 3,72037 ha andin 1998-99, a good rainfall

year, it was 5,86,925 ha. In general there was a sharp fall in G.C.A in the drought year 1999-2000 compared to the earlier drought year 1987-88. In 1999-2000 the GCA decreased by on an average over the district by 24.4% over 1998-99. Where as in 1987-88 it was – 8.07. When thesils are considered. The decrease in G.C.A. in 1999-2000 were 1998-99 varied from 18.5% in Sarwed thesil to 34% in Bhewar thesil. The second largest decreased –29.8% was noticed in Nashirabad thesil. Other thesils increased around – 23%. In 1987-88 the decrease in gross cropped area was less than in 1999-2000. Rather Kekree showed a marginal increase of 4.6% in 1987-88 over 1999-2000. There was no change in sawad – 29.6% occurred in Bhewar. Kishangarh thesil it was – 12.4%.

Table No. 4.8
DISTRICT AJMER District – Gross and net cropped area and gross and net irrigated area

	Total area	G.c.a	N.c.a	G.I.a	N.I.a
Year	Hect.	Hect.	Hect.	Hect.	Hect.
1985-86	842388	421374	363609	99303	76886
1986-87	842388	404345	355758	100650	77972
1987-88	842388	372037	329957	54560	43301
1998-99	842388	586925	411594	144405	115077
1999-2000	842388	443846	364627	107047	84478

Percentage change in area yield & production in Ajmer district.

	total area	g.c.a	n.c.a	g.I.a	n.I.a
year	hect.	hect.	hect.	hect.	hect.
A	0	-4.0	-2.2	1.4	1.4
B	0	-8.0	-7.3	-45.8	-44.5
C	0	-24.4	-11.4	-25.9	-26.6

Where A= % change in 1986-87 over 1985-86 G.C.A=gross cropped area
B=% change in 1987-88 over 1986-87 N .C.A=net cultivated area
C=% change in 1999-2000 over 1998-99

Net cropped area (NCA) The decrease in net cropped area was similar to gross cropped area. In the district as whole NCA deceased by – 11.4% in 1999-2000 over 1998-99 and by –8% in 1987-88 over 1986-87 and by –4% in 1986-87 over 1985-86. There was not much variation in the decrease in NCA in the thesil. It was around 10% in 1999-2000. But in 1987-88. Beware had a large decrease – 26% in NCA over 1986-87. The thesils Lekree, Sarwad did not have any significant change in NCA.

Considering the two drought periods, in recent years the declined in cultivated area had increased which might cause more instability in agriculture when viewed against increasing population pressure on land.

Wheat is an important Rabi crop. In Ajmer district. The area and production in wheat have steadily increased over the years. It was 43126 ha in 1985-86 and increased to 74805 ha in 1998-99 an increase of 73.5% but in drought years the area considerably decreased. (Table 4.10) The decrease in 1986-87 was 8.6% over 1985-86 and as high has 44.2% in 1987-88 over 1986-87. In 1999-2000 the percentage decrease from the previous year was –26.6. Considering 1986, and 1987 were two consecutive drought years the decrease was considerable. The corresponding decrease in production were – 9.6%, -46.4% and –69.3% respectively. The decrease in yield was negligible in 1985-86, -18% in 1987-88 and –43.2% in 1999-2000.

TABLE 4.9a: Area, Production and yield of selected crops

		Wheat				Barley				gram	
	Area	Produ.	Yield		Area	Produ.	Yield		area	produ.	Yield
Year	Hect.	Met.tone	Kg/hect.	Year	Hect.	Met.tone	Kg/hect.	Year	Hect.	met.tone	kg/hect.
1985-86	43126	44162	1024.023	1985-86	17568	16527	940.7445	1985-86	35032	14258	406.9993
1986-87	39434	39881	1011.335	1986-87	16687	15446	925.6307	1986-87	24157	11295	467.5663
1987-88	25804	21384	828.7087	1987-88	10978	9208	838.7684	1987-88	19965	5570	278.9882
1998-99	74805	134057	1792.086	1998-99	21534	40167	1865.283	1998-99	123824	67301	543.5214
1999-2000	40412	41161	1018.534	1999-2000	12259	17580	1434.048	1999-2000	30961	12014	388.0366

Percentage change in area yield & production in Ajmer district.

		Wheat				Barley				Gram	
	Area	Produ.	Yield		Area	Produ.	Yield		Area	Produ.	Yield
Year	Hect.	Met.tone	Kg/hect.	Year	Hect.	Met.tone	Kg/hect.	Year	Hect.	Met.tone	Kg/hect.
A	-8.6	-9.7	-1.2	A	-5.0	-6.5	-1.6	A	-31.0	-20.8	14.9
B	-34.6	-46.4	-18.1	B	-34.2	-40.4	-9.4	B	-17.4	-50.7	-40.3
C	-46.0	-69.3	-43.2	C	-43.1	-56.2	-23.1	C	-75.0	-82.1	-28.6

Where A= % change in 1986-87 over 1985-86
B=% change in 1987-88 over 1986-87
C=% change in 1999-2000 over 1998-99
G.C.A=gross cropped area
N .C.A=net cultivated area

Barley is another important crop. Although area under barley increased from 17568 ha in 1985-86 to 21534 ha in 1998-99, in drought year is the decline in area was considerable. In the drought years of 1985-86, it was –24% in 1987-88 it was –34% in 1999-2000, it was –43.7%. The corresponding reduction in yield were –1.7%, 9.4% and 2.3%.

The area under gram has been greatly fluctuating. In 1985-86 it was 35032 ha. And 1998-99 it went upto 1,23,824. Naturally in drought years considerable decline in noticed in area, production and yield. (Table 4.9) The decline in area and production was considerable in the years 1985-86 and in 1999-2000. It was –31.03% and 75.0% respectively. The production declined by 50% in 1985-86 and by 82.1% in 1999-2000. The yield in gram did not decline much as production. The decline in the year 1999-2000 were 1998-1999 was only – 28.6%.

The Kharif crop jowar and bajra showed decline in area over the years. But in drought years 1987-88 the area under jowar cased marginally by – 41% over 1986-87 unlike other way of cross sending the data.

Summing up crop production in Ajmer district is very vulnerable to drought. In recent drought year 1999-2000 the decline in area production and yield in rabi crops was much more than in

TABLE 4.9b

	Jowar				Bajra				Maize		
	Area	Produ.	Yield		Area	Produ.	Yield		Area	Produ.	Yield
Year	Hect.	Met.tone	Kg/he.	Year	Hect.	Met.tone	Kg/hect.	Year	Hect.	Met.tone	Kg/hect.
1985-86	118481	1777	14.99	1985-86	59398	1441	24.26	1985-86	47670	21791	457.12
1986-87	127350	3479	27.31	1986-87	65120	2021	31.03	1986-87	47351	13871	292.94
1987-88	121952	1596	13.08	1987-88	75819	1871	24.67	1987-88	33292	1746	52.44
1998-99	105177	6080	57.80	1998-99	55089	6045	109.73	1998-99	42823	6998	163.41
1999-2000	122136	21196	173.54	1999-2000	57959	5922	102.17	1999-2000	38823	27474	707.67

Percentage change in area yield & production in Ajmer district.

		Jowar				Bajra				Maize	
	Area	Produ.	Yield		Area	Produ.	Yield		Area	Produ.	Yield
Year	Hect.	Met.tone	Kg/hect	Year	Hect.	Met.tone	Kg/hect.	Year	Hect.	Met.tone	Kg/hect.
A	7.5	95.8	82.1	A	9.6	40.2	27.9	A	-0.7	-36.3	-35.9
B	-4.2	-54.1	-52.1	B	16.4	-7.4	-20.5	B	-29.7	-87.4	-82.1
C	16.1	248.6	200.2	C	5.2	-2.0	-6.9	C	-9.3	292.6	333.0

Wheare A= % change in 1986-87 over 1985-86
B=% change in 1987-88 over 1986-87
C=% change in 1999-2000 over 1998-99

G.C.A=gross cropped area
N .C.A=net cultivated area

earlier drought year. Kharif crops like jowar, bajra, maize have performed better in the drought year 1999-2000. However the instability in agricultural production persits. Judicious management of land and water in drought years, increasing productivity in normal and good rainfall years are to be adopted to minimize the adverse consequences of drought on the agricultural economy, Ajmer district gross cropped area has increased in 1999-2000, over 1998-99 by 16% while the production declined by –54% in 1987-88, it increased by 24.8% in 1999-2000. The yield increased by 200%.

The area under bajra increased in all the drought years. But the production and yield were marginally declined.

There in considerable decreased in area under maize (-30%) in 1987-88, it was – 9.3% in 1999-2000. The production of maize fell down by 87% in 1987-88. But in 1999-2000 it increased by 292% due to increase in yield by 300%.

One wonders whether the phenomenal increase in yield in bajra, jowar and maize in due to better agricultural production or there is error in data.

Table shows the number drought stained affected villages in Ajmer district during the science 1981-82 1995-2000. The villager

TABLE 4.10.

POSITION OF DROUGHT SINCE 1981-82

YEAR	SAMVAT	NO.OF VILLAGE AFCTD.	DATE OF NOTIFI-CATION	MONTH OF RELIEF WORKS STARTED	LABOUR CEILING	LABOUR ENGAGED	EXPENDITURE ON RELIEF OPERATION	REMARKS
					----------IN LACS----------			
1981-82	2038	23246	27.10.81	DEC..81	7.39	6.62	10915.03	
1982-83	2039	22606	11.12.82	DEC..82	6.92	6.25	10116.83	
1983-84	2040	282	13.03.84	-	-	-	6807.00	EXP.PERTAINS 203
1984-85	2041	10276	15.01.85	MAR..85	2.94	1.93	628.91	
1985-86	2042	26859	15.10.85	OCT..85	11.00	10.44	9133.07	
1986-87	2043	31936	07.11.86	JAN..87	17.35	15.97	16259.34	
1987-88	2044	36252	26.10.87	JAN..88	20.43	19.92	62231.32	
1988-89	2045	4497	04.04.89	APR..89	*	*	32276.45	
1989-90	2046	14024	18.01.90	MAY. 90	4.40	4.14	3065.68	
1990-91	2047	-	-	-	-	-	3842.71	EXP.PERTAINS 204
1991-92	2048	30041	22.02.92	FEB.,92	7.90	5.40	574.61	
1992-93	2049	4376	02.04.93	APR.,93	1.15	0.71	13116.65	
1993-94	2050	22586	31.01.94	FEB.,94	8.85	7.92	3421.39	
1994-95	2051	-	-	-	-	-	16658.96	EXP.PERTAINS 205
1995-96	2052	25478	30.11.95	DEC.,95	8.07	7.28	4568.86	
1996-97	2053	5905	12.03.97	APR..97	0.55	0.37	20364.56	EXP.PERTAINS 205
1997-98	2054	4633	04.04.98	MAY,98	1.33	0.83	521.42	
1998-99	2055	20069	30.09.98	OCT..98	6.39	6.12	18653.34	EXP.PERTAINS 2054 & 2055
1999-2000	2056	23406	09.01.2K	FEB.,2K	15.97	15.16	27861.89	EXP.PERTAINS 205

Source : Relief\Computer\lab\dr812K

* Indicates affected people were benefitted by employment generation programme through Khadi Gramudyog, Raj. Handloom board and Raj.Laghuudyog nigam hence figure of labour engaged is not available

affected by drought ranges from 282 to 36252. In recent years more number of villages are affected by drought.

4.3.1 Agricultural water use and productivity in Ajmer Districts

The economy of Ajmer districts is primarily dependent on agriculture. Low rainfall with high variability stresses the need for irrigation. Absence of major or rivers, uneven topography put a limit to the development of irrigation. Never the less there has been a steady increase in irrigation during the period of study. However the availability irrigation is very much dependent on rainfall. So it is imperative to increase the productivity per unit of water particularly in good monsoon year to provide a cushion for the fall in productivity in a drought year. In this section an attempt is made to determine the relationship between agriculture water use and productivity.

Considering the importance of irrigation in increasing the agricultural productivity, suitable methods are needed for setting realistic goals for increasing productivity with available and potential irrigation facilities in a region. At present there is no well defined yard stick by which goals are set for increasing agricultural productivity. National commission on Agriculture observed (1976) that "the yard stick used for estimating the agricultural targets were not correct indicators of the actual input response under field condition. For this reason the production target

for different agricultural commodities, particularly food grains fixed for different plan periods, was not realistic. We would emphasis here the need for realistic assessment of the production potential in the country". Further it adds "We consider the specific targets of production should be indicated down to the districts/ project level". A meaningful relationship between the amount of water made availabile to district and the productivity in the district could serve this purchase.

Most of the analyses on the input of irrigation on agricultural production relate agricultural production to the percentage of cultivated area irrigated, taking generally district as a unit of study. Some are those relate the weather parameters during the critical stage of crop growth with its production. Such approaches consider only one among the two source of water for crop. Its is either rainfall or irrigation. These two sources of water need to be integrated into a common unit, so that the actual amount of water utilized in agriculture over a region in related with the agricultural productivity.

The relationship between agricultural and productivity is calculated for Ajmer district the period 1984-85 to 1999-2000.

The data were obtained from the following sources.

1. Rainfall (Rainfall statistics abstract, IMD jaipur.)

2. Production and price.

4.3.2. Methodology

In the present study an attempt has been made to develop a methodology for estimating agricultural water use and relating it to productivity.

The agricultural water use (AWU) can be defined as the amount of water used by the plants in a given area from natural as well as from artificial sources (i.e irrigation). This amount is expressed as an average depth of water in mm.

In developing the method for estimating the agricultural water use in a district are used concepts of potential evapotranspiration, effective rainfall and water requirements of crops.

Potential- Evapotranpiration (PE) defined by Penman as "evaporation from an extended surface of short green crop, actively growing, completely shading the ground, of uniform height and not short of water. For the optimal growth, the plant needs water equivalent to potential evapotranspiration. It is presumed in the irrigated area the water utilized by the plant is equal to PE. Since irrigation in Ajmer is negligible in rainy season the PE for the rabi

season from November to March is considered, for the study Average monthly values of PE for Ajmer districts as given by Rao, K.N. is used in this exercise It is assumed PE value for Ajmer observatory is representative for the district.

In irrigated area plant uses that part of rainfall retained by the soil. This is defined as effective rainfall. In this study the effective rainfall (ER) for the khaif and rabi seasons from June to March. are taken in the account. In which ever month the rainfall is less than the normal PE, The entire rainfall is taken as ER. In other months where the rainfall is more than PE, The PE values are considered as effective rainfall, Then the average effective rainfall and the normal PE are weighted by the proportionate area un-irrigated and irrigated respectively for all the years. The proposed formula for the calculation of agricultural water use (AWU) is as follows.

AWU = (UIA x ER) + GIA x PE.

Where –AWU - is agricultural water use in mm

UIA - is the area un-irrigated as percentage to gross cropped area.

ER- is effected rainfall in mm.

GIA is the gross irrigated area as percentage to gross cropped area and

PE is potential evapotranspiration in mm.

4.3.3 Agricultural Productivity

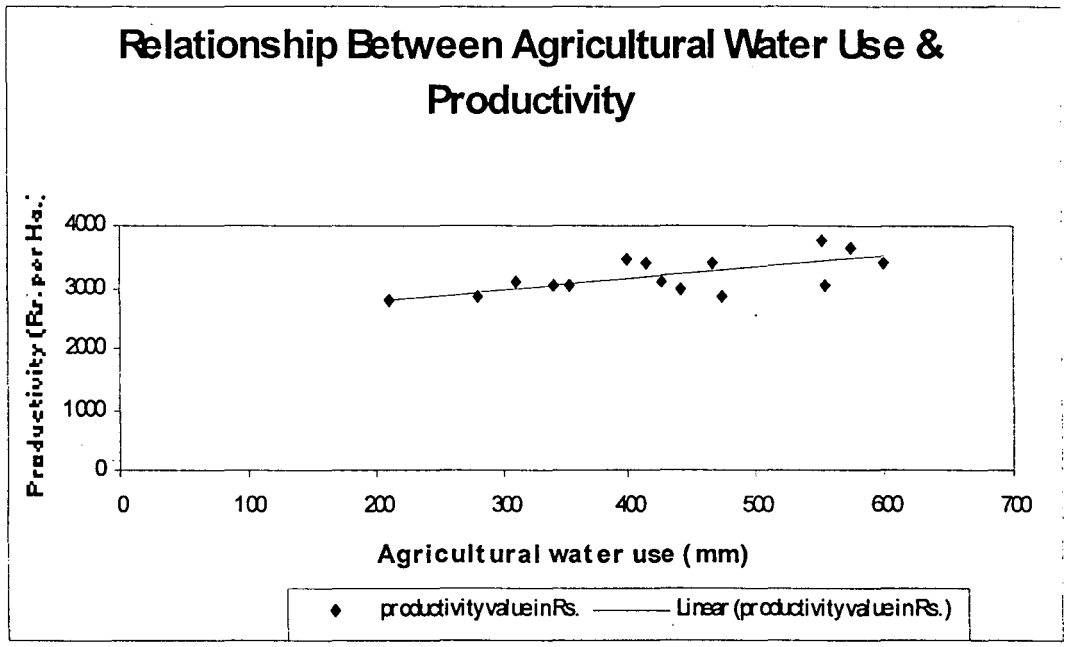
Agricultural productivity in value terms is computed for nine crops viz. wheat , barley , gram, jowar, bajra, seasum rape seed & mustard, groundnut. The estimate is done using the fix prices for 1991-93 as arbitrary weight year for different crops for each year. The production of each of the nine crops in each year is multiplied by its respective fix price. The values thus arrived from nine crops are added together and then divided by the total area under these crops to obtain productivity per hectare in rupees. The productivity for all the years has thus been computed.

4.3.4 Relationship between Agricultural water use and productivity.

Table – 1 and Fig.2Shows the relationship between agricultural water use and Productivity. There is a linear relationship between the two. The regression equation is y = 2440.58 + 1.75 x where y is productivity in rupees per hectare and x is agricultural water use in mm. It shows that for every 100 mm additional availability of water there is an in average of Rs. 175 per hectare in productivity (R^2 =0.43). The lowest productivity was Rs. 2775 in 1987-88, a drought year and the highest productivity of Rs. 3653 per Ha. was in the year 1999-2000. Agricultural of productivity in recent years shows that high value crops are grown, Table also shows moderate

variability in productivity. This means that productivity is unstable. With no more prospects of increasing the area under irrigation, attention should be paid to maximize the returns per unit of water by using better water management practices.

Figure 4



(APPENDIX - 3 (A,B,C)

Table 4.11
Productivity and Agricultural Water use in Ajmer District (1985 to 2000)

Year	Productivity value in Rs.	Agr.Water use (mm)
1985-86	3016	354
1986-87	3000	342
1987-88	2776	212
1988-89	3424	399
1989-90	3121	311
1990-91	3419	600
1991-92	3103	425
1992-93	3376	415
1993-94	2999	442
1994-95	3392	468
1995-96	2834	474
1996-97	3052	554
1997-98	3653	575
1998-99	3781	552
1999-2000	2861	281

$y = 2440.58+1.75x$
$R^2 = 0.43$

CHAPTER – V

"DROUGHT MANAGEMENT STRATEGY AND ITS IMPLEMENTATION

5.1 Introduction

The Arid Zone extends to about 12% of the Geographical Area of the country is highly prone to droughts and famines. During the twentieth century the region experienced agricultural drought once in three years to every alternate year in one or the other parts. Failure of monsoon leaves the Arid region totally dependent for food and fodder on buffer-stocks to sustain its 19.8 million human and about 28 million livestock population.

Inspite of repeated occurrence of droughts providing relief to the people after the drought has occurred is the only major option adopted by the government in managing the drought. This may reduce the hardship of the people for the time but it is not a lasting solution. The strategy of drought management should shift from fire fighting operation before to drought proofing operation strategies. The advances in weather forecasting, information technology and communication and the vast experience of handling drought situation is the states of India do point to the possibility of managing the drought in a more rational manner. The drought management work should commence at the very initial stage of the on set of drought

rather than after the drought has devastated the economy and the people.

Development of water resources rainwater harvesting water conservation , integrated watershed management, ground water recharge alternate land use planning breeding drought tolerant varieties and drought warning and monitoring would go a long way to combat drought in the region.

5.2 EARLY WARNING AND DROUGHT MONITORING:

Drought in the arid zone of India can be monitored from the on set progress and withdrawal of the southwest monsoon. Weather forecasts broadly can be classified into three categories viz.

1. Short range forecast : validity for less than 3 days.

2. Medium range forecast : Validity for 3-10 days.

3. Long range forecast : Validity for 10-30 days.

These forecasts are issued by the Indian Meteorological Department and National Centre for Medium Range Weather Forecast. (N.C.M.R.W.F) and broadcasted through all India Radio and Doordashan and reported in newspapers.

Central Arid zone Research Institute (CAZRI) Jodhpur (Raj) has started issuing Agro-meteorological advisory service to farmers of Jodhpur and surrounding area with effect from July 1988. This Agro-Meteorological bulletin is issued every Tuesday and Friday based on the medium range weather forecast received from the same day. It includes different agricultural operations to be performed under the anticipated weather conditions. This medium range weather forecast is given for eight meteorological parameters i.e. (1) cloud cover, (2) Precipitation (3) wind spread (4) wind direction (5) maximum and minimum temperatures and (6) maximum relative humidity. Validation of forecast is also done for weather of next 24 to 72 hours from the time of issue. These forecasts are given for the benefit of farmers for planning their agricultural operations and for planners for advance planning in case of an anticipated flood or drought.

5.2 (a) Long-Range Forecast:-

It is in purview of I.M.D besides data of onset and withdrawal of monsoon accurate forecast of amount and distribution of rainfall in ensuring KHARIF season would be of great value for planners as well as farmers to develop contingent plans for the season, Weather report for drought as well as flood management. Rainfall data are available for more than hundred years. Estimates of the probability of occurrence of droughts and probability of occurrence of rainfall of specific amount in standard values have already been made for

several rain gage states in India. Judicious case of these estimates the long range forecast continued in with the local wisdom of the people can facilitate formulation of appropriate strategy for cultivation in the beginning of the growing season and how to manage adverse situation in the monsoon progress.

5.3 Contingency crop planning for drought profing:-

Several technologies were developed and tested by Central Arid Zone Research Institute (CAZRI)-Jodhpur (Raj.) to increase crop-production under erratic weather conditions in the Indian Arid Region. Often variability in the Indian monsoon influence the risk in crop production and therefore the cropping strategies should be based on the availability of monsoon rainfall from year to year.

To avoid risk from erratic weather conditions mixed, inter cropping is advisable so that if the rainfall pattern is not suitable to one crop, it may be suitable to other crop and hence farmers can get a crop insurance against the weather adversaries. Some of the recommended mixtures are perl-millet cluster bean pearl milet, mung bean and pean millet combination.

5.4 Integrated watershed management:-

So for development programmers were planned and implemented by taking the revenue district as a unit. However this

unit was often to be unwieldy and also to a large extent heterogeneous in its resource endowments. The strategy under the DPAP, therefore, envisaged a significant departure from this practice by adopting watershed as the unit for integrated planning and implementation. The watershed is claimed to be the most scientific unit for efficient management of land and water resources as it is basically an agro-climatic unit with relatively more homogeneity of land and other resources as compared to the revenue district. A suitable size of watershed can be selected for making concentrated efforts and for easy management. A land capability survey is undertaken to prepare a soil use map. Other basic information should also be collected through hydrological vegetation, socio-economic and site specific surveys to fully assess the status of land and water resources of a watershed and the human and livestock pressure on them. Accordingly measures like afforestation, pasture development, livestock management, field crops, water storage etc. are undertaken in the areas identified as suitable for such measures. Suitable soil and moisture conservation measures like contour vegetative barriers, tillage mulching and shelter belts and wind strip cropping along with cropping strategies will minimize the risk due to drought. Rainwater harvesting techniques are also to be employed for successful crop production. Runoff storage and recharging ground water by adopting the latest technologies are also recommended for the same.

An approach of Index catchment was recommended by Central Arid Zone Research Institute(CAZRI) Jodhpur (Raj). Integrated watershed management plays a key role in fighting the drought on the basis of the total available water resources, conjunctive use of surface and ground water, allocating priority for rational use of water and also the preparation of a coordinated plan. Thus watershed management holds the promise of conservation of land and water resources and their optimal utilization in reality.

5.5 Rain-water Harvesting:-

Rainwater harvesting is traditional way of life in arid region and semi-arid regions in the Western Rajasthan. It is an age old practice in the form of harvesting meager runoff in different forms like rooftop rainwater harvesting. 'NADIS" (village Pond) and 'TANKAS' (Underground cistern). These systems of rainwater harvesting have helped in mitigating the drinking water problem in regions where low and erratic rainfall and saline ground water are the realities and simultaneously complementing the ground water recharge.

A) Roof-Top Rainwater Harvesting:-

Roof top rainwater harvesting comprises of the roof-top of the building area connected by gutters and pipes to a storage tank. Rooftop rainwater harvesting used traditionally in most part of the Indian Arid zone. This system provides an on site source of water

supply next to home or public buildings. However, with the advent of piped water supply, the rooftop rainwater harvesting technique has been neglected. It should be made mandatory by the town planner to harvest rainwater for drinking and household use of a family. Rooftop rainwater harvesting system requires good periodic management and maintenance to ensure that the quality and reliability of water supply is high. The system could also be utilized for groundwater recharging through abandoned wells and injecting in abandoned hand pumps.

B) NADIS

These are small excavated/embanked rainwater harvesting structures to mitigate the scarcity of drinking water. Water from NADIS is available from two months to an year depending on the catchment characteristics, the amount of rainfall received and its distribution.

The recommendations of Central Arid Zone research institute(CAZRI)- Jodhpur (Raj) for development of NADI and optimum utilization of stored water are as follows:-

1. Sediment input to Nadi can be reduced-appreciably by constructing silt trap at the inlet.

2. Optimizing the depth in relation to impermeable soil layer and surface area could minimize the evaporative and seepage losses.

3. To minimize the pollution of water the entry of animals and human beings into the NADIS must be restricted. Use of catchment areas for the purpose of defecation by the villagers and movement of livestock must also be checked.

4. To prevent the seepage losses lining in beds of Nadi may be done if expenditure permits.

C) TANKAS:-

The underground 'tanks' are traditional water sources in the Indian desert up to 300 mm rainfall zone and the water from the traditional tank are temporary structures and are subjected to leakage from bed and sides.

The important constructional features are follows:-

1) Circular in shape

2) Diameter equal to depth

3) Construction with stone masonry in cement motor.

4) Stone slab roofing

5) Cemented portion around the tank with 8% in ward slop

6) Silt collecting gutter

7) Three inlets and one outlet

8) Inside surface fully plastered.

These are used for drinking. These tanks are constructed on individual household basis or on community basis since ancient time.

D) In-situ utilization of rainwater:-

In situ moisture conservation and inter-plot rainwater harvesting for crop production have been in vogue in arid regions. Studies on in situ rainwater harvesting at Central Arid Zone Research Institute (CAZRI) Jodhpur revealed that ridge forrow system (60:40 cm) and micro-catchments of 4% slope resulted in 210 and 120 percent higher yield of pearl-millet respectively than the regular flat planting.

(E) KHADIN:-

Nearly 8% area in the western Rajasthan is rocky/gravelly generating runoff in response to intense rainfall. This in-situ rainwater harvesting practices is known as KHADIN cultivation in local parlance. It is somewhat similar to Haveli cultivation in the Bihar.

This practice dates back to several centuries and is being followed in 100-200 mm rainfall zone in the contiguous farm lands by constructing earthen bunds across the gentle slope of the land in the valley bottom to facilitate spreading and standing of harvested water on the farm soil. Water is thus made to accumulate to a depth of 60 to 80 cm. This water seeps into ground and recharge the adjoining wells as well as ground water.

5.6 Utilizing flash floods for artificial recharge of groundwater

On an average in a five years period there is an excess rainfall year when at localized places the annual rainfall exceeds 200% of the normal long-term average rainfall. Since 1917 there have been 15 flash floods of moderate to severe intensity in various parts of the region, each generating about 3500 million m^3 of runoff in a short span of 5-7 days. This out flows as flood water to the ephemeral river system and finally to the Ran of Kachchh. If harvested this is adequate to meet the water demand of entire human population (19.81 million) in this region for about 13 years.

By all possible means it is advisable to harvest nearly one third i.e. about 1200 million m m^3 of flash flood for the human consumption.

This water could be used as follows:-

1. Ground water recharge – 12 million m^3

2. Human/Livestock drinking – 509 million m^3

3. Evaporative lessees - 153 million m^3

4. Irrigation – 90,000 ha.

Greater emphasis should be placed on multiplying the recharge structures such as anicuts, check dams, diaphragm across the stream flow percolation tank injection wells, ponds and surface storage strictures to enhance the artificial recharge of ground water

5.7 Water conservation measures:-

1) Contour Bundting:-

In order to secure uniform soaking of the rainwater and to prevent the loss of rainwater by surface runoff – Kanitkar – 1944 proposed universal contour bunding to be constructed by means of cattle drawn implements. Bunds of 0.3 to 0.6 meters height were found to be sufficient for sandy soils. The bunds must be placed in a series from ridge to the bottom of a valley, one below the other to form torched slopes. However the natural surface drainage should be maintained and used for occasional overflow of water along bunds.

2) Contour-furrowing:-

Contour furrows have been extensively used in the Indian arid zone as a measure of moisture conservation as well as economical and quick alternative for soil preparation for better establishment and growth of grasses. Vermaet at 1977 recorded the highest soil moisture at the center of the furrow throughout the season. The mean soil moisture storage at the middle of the ridge top of the mound and at center line of the horizontal spacing followed a similar pattern.

3) Contour vegetative barriers:-

Biological measures such as contour vegetative barriers of suitable grasses shurbs and trees offer cheap productive cum objective measures in place of earthen structures (NARAIN sat – 1998) for conservation of runoff and sediment in situ (sharma sat 1997). Designed contour vegetative barriers (D.V.B) to replace the traditional soil and water conservation measures such as contour – bund in arid regions.

4) Reducing deep percolation losses:-

To minimize loss of rainwater or irrigation water through deep percolation in sandy soil an array of technologies have been developed and some of these are.

a) Use of sub-surface barriers of asphalt bentonite and pond silt clay at 60 cm depth in the profile.

b) Use of amendments such as pond silt vermiculite etc. for increasing soil moisture storage.

c) Use of organic or inorganic mulches.

5.8 Management of groundwater resources:

1) Construction of recharge facilities:-

The recharge to groundwater around the well and in the area as a whole shall need to be augmented by constructing suitable types of recharge structures like a jacket well around the drinking water supply well. Infiltration tanks, check dams, injection well etc.

Revival of the village pond concept:-

The traditional village ponds, which have been filled up in most of the village used to act as storage tank for the cattle drinking water and were the natural measures for augmenting recharge to ground water. These ponds must be rehabilitated and made usable for storage and recharge of ground water.

Protection from pollution:-

The main cause of pollution in the village and the cities is the fecal disposal. The haphazard disposal of the wastes has led to an

increase in the nitrate content in ground water in the rural areas. This is a cause of concern. The location of latrines vis a vis hand pumps must be suitably decided keeping in view the ground water gradient in the area.

5.9 Groundwater recharge in urban areas:

It is essential that construction of ground water recharge structures for tapping and recharging the roof top runoff should be mandatory by amending the urban laws.

1. It should be the responsibility of the urban municipal bodies to recharge the storm run off from the city drainage system

2. The urban liquid wastes after the required treatment must be recharged underground for re-circulation through the aquifer. During the passage of the wastewater through the aquifers, the pathogens are automatically killed. Such a practice therefore does away with the normal procedures of water treatment and purification and thus results in cost saving.

5.10 Supply of water of lower specifications:

In many areas particularly in the western Rajasthan waters of higher salinity are available in some areas However since these do not meet the prescribed standards these are not for use. Such water may be used after blending with better quality water.

5.11 Creation of groundwater sanctuaries/protection zone:

In many areas in the state though the present sources are adequate to meet the requirement of drinking and domestic uses, they may not sustain the pressure of population after ten or fifteen years. In such a case it will be desirable to locate alternate aquifers either in other area or depth range and declare these as reserves for drinking and domestic uses. These could be termed as groundwater sanctuaries.

5.12 Setting up village hand pump/water source maintenance:

Even through the initial investment for the creation of the resource may be made from public sources, the responsibility for the maintenance, repair and future replacement should vest with the users. The users should be encouraged or rather it should be a pre-requisite that the villagers constitute a users group and set up a maintenance fund in a local financial institute. The users should also maintain these resources as common property resources.

5.13 Adoption of water saving devices:

Large-scale adoption of water saving device like sprinkler and drip irrigation system may be propagated. Liberal subsidies to the users may be provided in suitable situation. Losses on account of

subsidy shall be compensated by the gains from the additional production from water saved by adopting these devices.

5.14 Community irrigation wells-setting up of water cooperatives:

The small sized and fragmented land holdings do not qualify for assistance from the institutional resources because of the lack of economic feasibility. The alternative therefore is to persuade farmers to form cooperatives and share the water from the well. The approach shall lead to economy in water use and reduce over exploitation.

5.15 Improved agronomic practices:

The crop yield in arid region are low compared to the humid and sub-humid regions. The major cause of low yield is the deficiency of water. Availability of surface and ground water for irrigation is meager and crop production is mainly dependent on low and erratic rainfall. Hence the most obvious priority is to achieve maximum production of an economic yield per unit of available water.

5.16 Maximization production per unit rainfall:

Because of the limited water resources in the region there is no escape from increasing the efficiency of rainwater use – KANWAR –. Suggested five steps to improve rainwater use efficiency:

1. To retain precipitation in situ and minimize the runoff.

2. To reduce evaporation in relation to transpiration

3. To use drought tolerant crops that fit in to the rainfall pattern.

4. To recycle the runoff water after rainwater harvesting and drainage.

5. To use integrated watershed approach for maximizing rainwater use.

5.17 Choice of crops and their varieties:

The existing cropping systems of a region are not necessarily the most suitable ones. Farmers grow certain crops for convenience or by conviction. This is because first priority of a farmer continues to be the production of food for his family and feed for his livestock. On the other hand selection of crops suitable to the environment leads to increased and stabilized production and efficient utilization of natural resources.

5.18 Onset of rainfall and length of growing season:

Analysis of rainfall dates of the Indian arid-zone has shown that the length of growing season is positively correlated with onset of rainfall i.e. the growing season is longer if the onset of rainfall is early. Hence long duration crops/cultivation should be selected to fully

utilize the benefits of long growing season when onset of rainfall is early. If on set of rainfall is late the choice will cultivators obviously i.e. short duration crops. The relationship between onset of rainfall and growing season length can be used to guide farmers for selecting crop taking into consideration the:

1. length of growing season of crop / cultivate.

2. Soil depth and water holding capacity

3. Crop coefficient for estimation of water requirement.

4. Evaporation rate through the season.

There are the crop/cultivators that will reach maturity within the rainy period or within a time period following the final rainfall. But before the extractable soil water is depleted crops should be selected. The choice will also depend on soil type. Thus a shallow sandy soil should be put under short term crops / cultivators even at an earlier onset date while a deeper soil with loamy or clayey texture should be put under longer duration crops.

5.19 Weed Management:

Crop weed competition is one of the most important constraints to crop production in dry-lands. Weeds compete with crops for soil moisture and nutrients which are the most limiting factors for growth.

5.20 Judicious use of limited irrigation water:

Availability of water for irrigation is much below the desired level in Ajmer/Rajasthan Irrigation is using 90% of the groundwater obstructed which compounds the problems of fragile arid ecosystem- (Mohice – 2000). Water table is falling at an alarming rate as a result of over exploitation of groundwater in several parts of this region. While the excessive use of canal water in I.G.N.P. command area has created the problems of water logging and salinity. Considering the fragile nature of arid agro-eco. Judicious use of irrigation water is essential. In intensively irrigated areas where the land is the most limiting factor. The objective is to get maximum production per unit of land. But in arid region where water is the most limiting factor, the objective should be to obtain maximum yield per unit of water rather than per unit of land.

5.21 Extensive irrigation approach:

This approach aims at obtaining maximum production per unit of irrigation water. The limited amount of water is used to give irrigation in relatively large area so that maximum water use efficiency is achieved

5.22 Improved irrigation methods:

As the soils in the Indian arid zone are mostly light textured and topography is undulating. The conventional methods of irrigation are inefficient. Sprinkler and drip irrigation methods are most suitable for arid conditions although these methods need relatively high initial investment.

A) Sprinkler system;-

Sprinkler system is the most suitable for narrow-spacing crops (wheat, mustard etc) grown on undulating light textured soils. This technique has gained popularity among the farmers of the region. The conveyance losses of water are practically negligible and risk of soil erosion is low as the application rate is low. This system helps in saving sufficient amount of water at least 20%.

B) Drip irrigation system:-

The drip irrigation system is not affected by high wind velocity as it applies water directly in the root zone. Though the initial cost of drip irrigation is high it is quite pertinent to our region where availability of irrigation water is scarce soils are light textured, topography is undulating, wind velocity is high and evaporation demand is high.

This method of irrigation is more suitable for wider spacing crops and orchards.

5.23 Land-Use Planning:

With the increased pressure on land marginal lands are now brought under cultivation. Small and marginal farmers mostly cultivate these lands. Another dimension to the problem is overgrowing and deforestation of the community lands (C.P.R.). Further good lands are sometimes going under tree farming either due to labour problems or obsentee land tenurial system.

Taking an overview of the problem and the need for fuel fodder, fruit and timber at the village level, a concerted effort has to be made to adopt suitable land use system keeping in consideration the rainfall soil types and need of the people in the region.

5.24 Agro-Forestry system:-

Agro- forestry including livestock components is a way of life in the Indian arid zone. Agro-forestry is a collective name for land use systems and technologies in which woody perennials, trees shrubs etc. are deliberately combined on the same land unit with herbaceous crops and animals in some form of spatial or temporal sequence. In such systems, there are both ecological and economic interactions amongst the different components of the system.

5.25 Silvi- Pastoral system:-

Agricultural farming in low rainfall zone with sandy sails results in frequent crop failures and accelerated wind erosion. In such areas the most ideal system is Silvi Pasture. It may not be practical to adopt pure silvi pastoral system in these areas and therefore agro-forestry system may be adopted in relatively heavy textured soils, preferably with a source of supplemental irrigation to save the crops from vagaries of weather.

5.26 Agri-Pastoral system:-

In low rainfall areas with light textured soils agri pastoral system is more sustainable than crop production. Crops can be grown in between the strips of permanently planted grass strips. This system also checks the soil erosion.

5.27 Farming System involving Horticultural components:-

In relatively high rainfall areas of the arid zone there is high potential for agri-horti silviculture systems depending upon the soil climate and other economic factors 'BER' is the most suitable fruit crop for this region.

A) Agri-Horti System:-

In this system the inter spaces between two rows of horticultural crop is utilized for the cultivation of a suitable rainy season crop. The crop

can be legume or non-legume but the thumb rule for selecting an intercrop is that the height of the intercrop should not be more than the height of the fruit plant.

B) *Horti – Pastoral System:-*

This system provides fodder for animals and fruits for additional income. 'BER' with grass can form on ideal combination.

C) *Horti-Silva System:-*

In this system both fruit and forest trees are planted together to act as complementary to each other. For this region drought hardy species of both components are selected.

5.28 Pasture Development:-

The flora of the Indian desert consists of a large number of grass and legume species. Of these the perennial grass species like cenchrus ciliaris, cenchrus setigerus, dichanthium annulatum, laisurus sindicus and panicum antidotale are highly productive and suitable for pasture development in this region. The soil and climate of the Arid region are well adopted to grassland, husbandry. The measures to be adopted for improvement of animal husbandry largely depend on the improvement of native pastures which are over-exploited. In order to sustain livestock industry, the carrying capacity of the native pasture should be increased and its quality improved.

5.29 Feed and Fodder Resources:-

During drought severe shortage of animal feed especially of roughage is encountered. The major feed and fodder resources, for livestock are natural vegetation on common grazing lands, industrial by products and crop residues. Decrease in biomass production in drought years and shifting of priorities result in scarcity of feed and fodder. Concrete efforts are needed in this direction to cope up with the problem.

5.30 Socio-Economic Aspects:-

The frequent occurrence of droughts for a longer period lead to famines i.e. scarcity of food and feed in the region and price raise.

A two pronged strategy i.e. curative and preventive can be adopted to cope up with droughts.

A. Immediate curative measures

B. long-term preventive measures

A). Immediate curative measures:-

To alert drought effects some of the curative measures should be undertaken by state and central governments on priority basis. These can be.

1. Assuring the availability of drinking water and food grains.

2. Fodder depots

3. Food for work

4. Contingency plan

5. Cattle camps

6. Relief works

B). Long-term Preventive measures:-

Despite above preventive measures to tackle the drought problem, on small, long-term basis and to minimize the adverse effects of drought some preventive measures are also needed. These measures can be:-

1. Early long-term forecast of monsoon to enable planners to plan accordingly
2. Timely availability of resources such as credit fertilizers pesticide and power should be ensured for increasing crop production.
3. Improvement in communication and transport system
4. Introduction of cottage industries and other alternatives for employment generation
5. Crop and livestock insurance

6. Remunerative price for produce in good years.

7. Reasonable buffer stock of foodgrain and fodder.

8. Rational utilization of common property resources such as water and grazing lands.

9. Afforestation/pasture development on wastelands

10. Disposal of unproductive livestock.

11. Motivation for the adoption of proper technologies at the required time by governmental agencies.

12. Education and training to combat drought situation.

Low and erratic rainfall and fragile land resources govern intricate cycle of water biomass production livestock and human sustenance in arid region. Severe scarcity of surface and groundwater, failure of crops and decreased production from grasses and tree fodder are hitting the cattle and people below poverty line the most. Many socio-economic issues such as drudgery of women for water work and family care due to shift in occupation crop up during drought years.

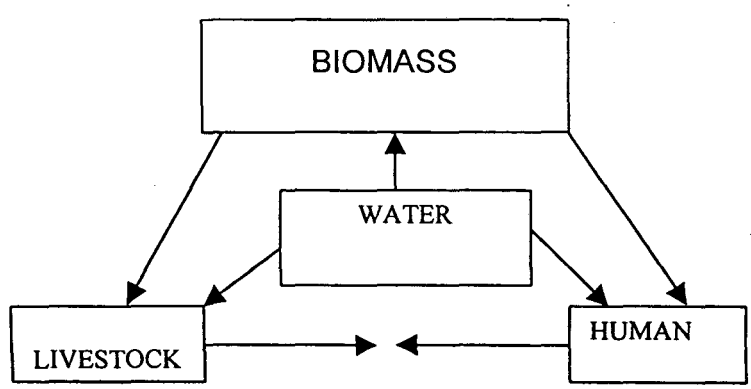


Fig →

Rainwater harvesting both the in-situ and through traditional water harvesting system water conservation, groundwater recharging and alternative grass and fodder based land use systems discouraging water intensive crops would be long-term answers to sustainable development of the arid and drought prone regions.

CONCLUSION

Drought is regular phenomena in India. No part of India is free from drought .Only the frequency of occurrence of drought varies from one region to another. In per- humid, humid, moist-humid areas the frequency in less, while in dry sub-humid semi-arid and arid regions it occurs more frequently. Since in arid regions its is s recurrent phenomena, the people over the years developed mechanisms to cope- up with the drought whereas dry sub-humid and semi and areas the effect of drought is very severe. In Rajashthan arid regions is in its western part and eastern part comes under semi-arid region.

Ajmer is generally a level plain interspersed with low hills. No major river flows through the district. The climate is semi-arid. It has good mineral resources. Around 5.50% of the area is covered by forest. Irrigation development is low. Major crops are rainfed. Jawar, Bajra and Maize is important crops in Kharif season, Wheat and Barley are the crops of the rabi season.

The mean annual rainfall in the state varies from 14 cms in the North-western part to 95 cms over South eastern part. The co-efficient variation of annual rainfall in more than 40% in Eastern Rajasthan and over 80% in Western Rajasthan. The mean annual rainfall for the period 1901-2000 is 551.43mm with C.V. of 26.19%.

The mean annual rainfall in the later half of this century was slightly higher than the earlier one. The decade 1901-11 had the lowest mean of 492.14mm for Rajasthan and the highest mean for the decade occurred in 1941-51. Ajmer district also had a higher mean annual rainfall, 533.1mm in 1950-2000 and the mean for 1901-50 was 517mm.

The definition of drought as given by 1MD is adopted in this study. Any year which receive less than 75% of the normal rainfall in considered as drought. If the rainfall deficit is 25-50%, it is classified as moderate drought and if the deficit is more than 50% it is considered as severe drought. In Eastern Rajasthan drought conditions occurred in 36 years in the last 126 years, whereas the Western Rajasthan experienced drought in 53 years. Fortunately the occurrence of drought in consecutive years had been less frequent. While Rajasthan as a whole had an occasion when droughts occurred in consecutive years, Ajmer district experienced 7 times drought for two consecutive year and 3 times drought for three consecutive years. This shows the severity of drought occurrence in Ajmer district. The worst drought occurred in the years 1910-11 to 1913-14.

Availability of irrigation facilities moderates the severity of drought. Ajmer district unfortunately is not well endowed with irrigation facilities . Absence of major rivers, undulating

topography, hard rock terrain do not permit development of irrigation on a large scale. Well and tubewels are the major sources of irrigation. More than 90% the irrigated areas is from well and tubewell.

Proportion of irrigated area by tanks has increased in recent years. The percentage of gross cultivated area irrigated increased from 14.67% in 1986-87 to 24.12% in 1999-2000. The gross cultivated area irrigated increased from 54560 ha in 1987-88 to 1,56,577 ha. 1996-97. However the gross irrigated area fluctuates very much. In drought years there is significant drop in irrigated area. The decrease in number of wells in use and fluctuation of irrigated area in response to rainfall show that irrigation is not effective as a drought proofing measure.

Ajmer district has this predominately rainfed agriculture. Jowar, Bajra. Maize, Wheat, Barley and Gram are the important crops. In the period under study, 1985-2000, the area under wheat increased continuously. The area under course grain has decreased. Although there is as steady increase in area, yield and production in drought years they decrease considerably. The percentage decrease in drought year 1987-88 was less when compared to the decrease witnessed in 1999-2000, surprisingly in the drought year 1999-2000 Jowar Bajra and Maize performed better.

The productivity of Ajmer district is around Rs 3000 per hectare . The relationship between productivity and agricultural water use shows that for every addition of 100mm water availability there is an increase of Rs.175/- productivity per hectare.

These findings point out that Ajmer is very vulnerable to drought. With no more possibility of increasing the area under irrigation and decreasing trend in ground water availability it is necessary adopt appropriate drought management strategies to minimize the adverse impart of drought on economy and people. Early warning, proper drought monitoring, judicious use of weather forecast, adoption of appropriate cropping pattern, conservation of water resources and efforts to increase the productivity in good years and developed a well co-odinated relief measures alone will ameliorate the severity of drought in Ajmer district in the coming decades.

APPENDIX 1

YEAR WISE SEASONAL RAIN FALL IN RAJASTHAN - 1901-02 to 1999-2000.(Rainfall in m.m.

AR	ANNUAL	%DEVIATION		YEAR	ANNUAL	%DEVIATION
NORMAL	575.1	.....				
1901-02	261.4	-54.5		1951-52	312.6	-45.6
1902-03	410	-28.7		1952-53	572.3	-0.5
1903-04	536.2	-6.8		1953-54	477.2	-17
1904-05	435.5	-24.3		1954-55	465.3	-19.1
1905-06	233.5	-59.4		1955-56	641.5	11.5
1906-07	537.6	-6.5		1956-57	703.7	22.4
1907-08	451.5	-21.5		1957-58	462.5	-19.6
1908-09	814.4	41		1958-59	332.9	-42.1
1909-10	647.9	12.7		1959-60	693.5	20.6
1910-11	593.4	3.2		1960-61	450.9	-21.6
1911-12	306.6	-46.7		1961-62	689.7	19.9
1912-13	585.1	1.7		1962-63	522	-9.2
1913-14	395.7	-31.2		1963-64	480.2	-16.5
1914-15	628.1	9.2		1964-65	573.7	-0.2
1915-16	277.8	-51.7		1965-66	363	-36.9
1916-17	811.8	41.2		1966-67	486	-15.5
1917-18	999	73.7		1967-68	570.6	-0.8
1918-19	239.1	-58.4		1968-69	391.4	-31.9
1919-20	665.9	15.8		1969-70	465.4	-19.1
1920-21	438.3	-23.8		1970-71	617.5	7.4
1921-22	438	-23.8		1971-72	638.5	11
1922-23	500.3	-13		1972-73	411.5	-28.4
1923-24	573.6	-0.3		1973-74	780.6	35.7
1924-25	680.7	18.4		1974-75	471.3	-18
1925-26	412.1	-28.3		1975-76	834.5	45.1
1926-27	688.9	19.8		1976-77	756.5	31.5
1927-28	613.3	6.6		1977-78	766	33.2
1928-29	540.5	-6		1978-79	735.7	27.9
1929-30	525.7	-8.6		1979-80	506	-12
1930-31	523.2	-9		1980-81	423.9	-26.3
1931-32	626.3	8.9		1981-82	562.1	-2.3
1932-33	485.7	-15.5		1982-83	557.8	-3
1933-34	739.3	28.6		1983-84	620.3	7.9
1934-35	681.8	18.6		1984-85	473.5	-17.7
1935-36	546.3	-5		1985-86	502.8	-12.6
1936-37	450.6	-21.6		1986-87	464	-19.3
1937-38	585.4	1.8		1987-88	314.5	-45.3
1938-39	451	-21.6		1988-89	534.1	-7.1
1939-40	371	-35.5		1989-90	455	-20.9
1940-41	486.3	-15.4		1990-91	727.3	26.5
1941-42	458	-20.4		1991-92	492.7	-14.3
1942-43	777.9	35.3		1992-93	649.5	12.9
1943-44	606.8	5.5		1993-94	53607	-6.7
1944-45	777.1	35.1		1994-95	688.2	19.7
1945-46	749.7	30.4		1995-96	492.1	-12
1946-47	698.3	21.4		1996-97	562.3	-10
1947-48	621.3	8		1997-98	594	12
1948-49	492.5	-14.4		1998-99	517	-3
1949-50	487.1	-15.3		1999-200	450	-16
1950-51	658.7	14.5				

APPENDIX 2

% of Deviation From Normal in AJMER District (1901-02 to 1999-2000)

Year	% Deviation
1901-02	-44.8
1902-03	-31.8
1903-04	-14.4
1904-05	-36.2
1905-06	-68
1906-07	-10.9
1907-08	-47.5
1908-09	61.7
1909-10	15.5
1910-11	-25.9
1911-12	-64.9
1912-13	-34.7
1913-14	-41.4
1914-15	-5.1
1915-16	-48.7
1916-17	30.9
1917-18	89.2
1918-19	-69.7
1919-20	-32.5
1920-21	-12.7
1921-22	-51.2
1922-23	-42.5
1923-24	-39.5
1924-25	50.4
1925-26	-43.1
1926-27	0.9
1927-28	16.6
1928-29	2.7
1929-30	32.8
1930-31	-19.9
1931-32	-3.1
1932-33	-33.5
1933-34	33.4
1934-35	26.1
1935-36	10
1936-37	-15.9
1937-38	0.5
1938-39	-54.8
1939-40	-50.5
1940-41	13.1
1941-42	-41.3
1942-43	22.2
1943-44	3.6
1944-45	-11.6
1945-46	-28.9
1946-47	3.3
1947-48	-204
1948-49	-55.8
1949-50	-55.9
1950-51	18.1
1951-52	.....

Year	% Deviation
1952-53	-14.2
1953-54	-19.9
1954-55	-9.3
1955-56	-18.3
1956-57	4.2
1957-58	-34.4
1958-59	22.8
1959-60	22.7
1960-61	-42.7
1961-62	.....
1962-63	-2
1963-64	-25.8
1964-65	-8
1965-66	-42.1
1966-67	-17
1967-68	-19.3
1968-69	-25.7
1969-70	-50.2
1970-71	11.2
1971-72	20.5
1972-73	-49
1973-74	-5.2
1974-75	-28.4
1975-76	100
1976-77	76.3
1977-78	-7.8
1978-79	9.6
1979-80	15.5
1980-81	-25.4
1981-82	-12.6
1982-83	-11.6
1983-84	55.3
1984-85	13
1985-86	-24.5
1986-87	-42.3
1987-88	-73.4
1988-89	-25.3
1989-90	-24
1990-91	36.1
1991-92	-22.2
1992-93	8.1
1993-94	-4.8
1994-95	-13.4
1995-96	-18.65
1996-97	19
1997-98	2.14
1998-99	-45.01
1999-2000	-52.35

APPENDIX 3(A)

DISTRICT <-----> AJMER

year	total area hect.	g.c.a hect.	n.c.a hect.	g.l.a hect.	n.l.a hect.
1985-86	833960	421374	363609	99303	76886
1986-87	837628	404345	355758	100650	77972
1987-88	842388	372037	329957	54560	43301
1988-89	842388	426664	377144	67339	54691
1989-90	842388	426911	382004	70074	57819
1990-91	842388	484460	409324	90259	75603
1991-92	842388	459180	393386	107726	63467
1992-93	842388	485345	405151	114172	95024
1993-94	842388	459932	390566	118429	95214
1994-95	842388	494206	405413	126237	108411
1995-96	842388	459081	388425	124780	102683
1996-97	842388	525379	412392	156517	130673
1997-98	842388	597105	420270	156221	123510
1998-99	842388	586925	411594	144405	115077
1999-200	842388	443846	364627	107047	84478

"Calculation of agriculture wateuse for Ajmer distric".
P.E=47506 (in rabi season-oct. to march)

year	Per.of G.I.A		Agri.water use in irri area. =(o/o of G.I.A.*P.E)	Per.of unirri.area (=100- Per.of G.I.A.		E.R*%of unirri.area	Total Water use (Per.of irri.area.+ Per.of unirri area)
1985-86	23.57	0.236	112.08	76.43	0.764	242.29	354.38
1986-87	24.89	0.249	118.39	75.11	0.751	223.07	341.46
1987-88	14.67	0.147	69.75	85.33	0.853	141.91	211.66
1988-89	15.78	0.158	75.06	84.22	0.842	324.24	399.30
1989-90	16.41	0.164	78.07	83.59	0.836	233.29	311.36
1990-91	18.63	0.186	88.61	81.37	0.814	511.32	599.93
1991-92	23.46	0.235	111.58	76.54	0.765	313.81	425.39
1992-93	23.52	0.235	111.88	76.48	0.765	302.62	414.50
1993-94	25.75	0.257	122.47	74.25	0.743	319.13	441.60
1994-95	25.54	0.255	121.49	74.46	0.745	346.30	467.78
1995-96	27.18	0.272	129.27	72.82	0.728	345.09	474.36
1996-97	29.79	0.298	141.69	70.21	0.702	411.84	553.53
1997-98	26.16	0.262	124.43	73.84	0.738	450.85	575.28
1998-99	24.60	0.246	117.02	75.40	0.754	434.89	551.90
1999-200	24.12	0.241	114.71	75.88	0.759	166.64	281.34

SEASONAL RAINFALL

year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	Eqtual rainfall in karif season.
1985-86	0	0	0	1.2	27	10.8	155.8	128.3	7.9	0	0	14.2	345.2	317
1986-87	0	18.4	0	0	17.1	50.4	151.8	72	4.4	0	0	0	314.1	297
1987-88	17.5	0	0	0	39	29.8	51.9	67.1	0	0	0	0	205.3	166.3
1988-89	1.8	0	5.6	0	3.6	39.5	155.8	54.7	127.6	0	0	0	388.6	385
1989-90	29.4	0	0	2	0	17.8	78.6	128.3	22	0	0	3	281.1	279.1
1990-91	0	47.6	0	0	8.2	154.6	155.8	128.3	142.1	0	0	0	636.6	628.4
1991-92	0	4.2	2	28	0	6.4	147.8	128.3	107.2	0	2.1	12	438	410
1992-93	16.4	4	2.2	0	11.2	6	155.8	128.3	83	0	0	0	406.9	395.7
1993-94	0	2	0.5	8	17.6	149.5	155.8	48	74	0	0	0	455.4	429.8
1994-95	39	0	0	0	0	74	155.8	128.3	68	0	0	0	465.1	465.1
1995-96	7.2	0	2	0	0	78.6	155.8	128.3	102	0	0	0	473.9	473.9
1996-97	11	2.5	0	2.5	9.4	174	155.8	128.3	115	0	0	0	598.5	586.6
1997-98	0	0	24	14	79	77.4	155.8	128.3	100	108.3	8.4	8.4	703.6	610.6
1998-99	18.4	6	0	17.2	0	58.3	155.8	128.3	141.5	68.5	0	0	594	576.8
1999-00	0	0	0	0	0	12.1	42.8	91.2	73.5	0	0	0	219.6	219.6
P.E--->	55.2	76.5	113	174.5	243	229.3	155.8	128.3	142.1	113.9	66.4	50.6	1566.3	1131.1

APPENDIX 3(B)

DISTRICT <-----> AJMER

year	wheat area hect.	barley area hect.	gram area hect.	jowar area hect.	bajra area hect.	maize area hect.	Summum area hect.	Rape&Musta area hect.	Groundn area hect.	Cotton area hect.
1985-86	43126	17568	35032	118481	59398	47670	11408	4018	6387	18423
1986-87	39434	16687	24157	127350	65120	47351	8600	3084	4419	12389
1987-88	25804	10978	19965	121952	75819	33292	5986	5477	3042	7917
1988-89	28922	13760	20665	145013	93461	39925	7060	8725	2597	7662
1989-90	29333	12706	20872	119598	84679	40080	14527	9900	5690	11119
1990-91	43945	17972	21930	131410	79940	43738	25395	12479	5177	9949
1991-92	42282	18752	16552	106478	67947	45507	38829	21791	5469	9229
1992-93	57100	20351	23406	120151	72961	46659	28740	18112	4631	6155
1993-94	44112	14595	23048	108508	64463	42619	28640	16851	8429	7672
1994-95	66770	21720	41524	125457	65622	45745	16222	25351	4966	7599
1995-96	55491	17583	36740	104500	54123	41441	12098	36149	5334	11380
1996-97	79866	21267	49815	112699	55414	40475	9810	30030	4952	10682
1997-98	79204	24782	98807	105875	56606	43586	7954	25474	7760	16002
1998-99	74805	21534	123824	105177	55089	42823	7521	25109	6782	15206
1999-2000	40412	12259	30961	122136	57959	38823	6982	24875	5980	14802

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.65783
R Square	0.43274
Adjusted R Squa	0.3891
Standard Error	236.933
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	1	556718	556718	9.9170735	0.00768437
Residual	13	729785	56137.3		
Total	14	1286503			

	Column	*olumn 2*
Column	1	
Column	0.65783	1

	Coefficien	*ndard E*	*t Stat*	*P-value*	*Lower 95%*	*pper 95%*
Intercept	2440.58	244.829	9.96852	1.866E-07	1911.66181	2969.5
X Variable 1	1.74865	0.55528	3.14914	0.0076844	0.54904199	2.94825

APPENDIX 3(c)

PRODUCTION

year	wheat produ. met.tone	produ. quental.	Rs./Quinta	value in Rs.	barley produ. met.tone	produ. quental.	Rs./Quinta	value in R	gram produ. met.tone	produ. quental.	Rs./Quintal.	value in R	jowar produ. met.tone	produ. quental.	Rs./Quinta	value in Rs.	bajra produ. met.tone	produ. quental.	Rs./Quintal.	value in Rs
1985-86	44162	441620	419	185038780	16527	165270	406	67099620	14258	142580	1052	1.5E+08	1777	17770	315	5597550	1441	14410	331	4769710
1986-87	39881	398810	419	167101390	15446	154460	406	62710760	11295	112950	1052	1.19E+08	3479	34790	315	10958850	2021	20210	331	6689510
1987-88	21384	213840	419	89598960	9208	92080	406	37384480	5570	55700	1052	58596400	1596	15960	315	5027400	1871	18710	331	6193010
1988-89	35221	352210	419	147575990	15990	159900	406	64919400	9140	91400	1052	96152800	26104	261040	315	82227600	35343	353430	331	1.17E+08
1989-90	36738	367380	419	153932220	13859	138590	406	56267540	9463	94630	1052	99550760	15661	156610	315	49332150	17531	175310	331	58027610
1990-91	61233	612330	419	256566270	19221	192210	406	78037260	10475	104750	1052	1.1E+08	42911	429110	315	135169650	40649	406490	331	1.35E+08
1991-92	69908	699080	419	292914520	26753	267530	406	1.09E+08	10034	100340	1052	1.06E+08	3011	30110	315	9484650	2900	29000	331	9599000
1992-93	114009	1140090	419	477697710	28678	286780	406	1.16E+08	18429	184290	1052	1.94E+08	34840	348400	315	109746000	41110	411100	331	1.36E+08
1993-94	78332	783320	419	328211080	19257	192570	406	78183420	14506	145060	1052	1.53E+08	3022	30220	315	9519300	2285	22850	331	7563350
1994-95	113832	1138320	419	476956080	30658	306580	406	1.24E+08	29879	298790	1052	3.14E+08	42773	427730	315	134734950	33207	332070	331	1.1E+08
1995-96	83868	838680	419	351406920	21580	215800	406	87614800	27303	273030	1052	2.87E+08	3045	30450	315	9591750	1011	10110	331	3346410
1996-97	15162	151620	419	63528780	21730	217300	406	88223800	30663	306630	1052	3.23E+08	54136	541360	315	170528400	39758	397580	331	1.32E+08
1997-98	166074	1660740	419	695850060	26614	266140	406	1.08E+08	80749	807490	1052	8.49E+08	59226	592260	315	186561900	27194	271940	331	90012140
1998-99	134057	1340570	419	561698830	40167	401670	406	1.63E+08	67301	673010	1052	7.08E+08	6080	60800	315	19152000	6045	60450	331	20008950
1999-2000	41161	411610	419	172464590	17580	175800	406	71374800	12014	120140	1052	1.26E+08	21196	211960	315	66767400	5922	59220	331	19601820

PRODUCTION

maize produ. met.tone	produ. quental.	Rs./Quinta	value in R	Summum produ. met.tone	produ. quental.	Rs./Quinta	value in R	Rape&Mustard produ. met.tone	produ. quental.	Rs./Quinta	value in Rs.	Groundnut produ. met.tone	produ. quental.	Rs./Quinta	value in Rs.	productivity	productivity value in Rs.	Agr.Water use
21791	217910	279	60796890	228	2280	1404	3201120	2956	29560	1012	29914720	1463	14630	975	14264250	301630.385	3016	354.4
13871	138710	279	38700090	169	1690	1404	2372760	1270	12700	1012	12852400	358	3580	975	3490500	300009.527	3000	341.5
1746	17460	279	4871340	115	1150	1404	1614600	4244	42440	1012	42949280	119	1190	975	1160250	277579.495	2776	211.7
15422	154220	279	43027380	1780	17800	1404	24991200	6683	66830	1012	67631960	865	8650	975	8433750	342425.505	3424	399.3
12028	120280	279	33558120	2777	27770	1404	38989080	7100	71000	1012	71852000	1385	13850	975	13503750	312064.947	3121	311.4
22161	221610	279	61829190	6015	60150	1404	84450600	6337	63370	1012	64130440	2017	20170	975	19665750	341879.922	3419	599.9
12934	129340	279	36085860	1201	12010	1404	16862040	9539	95390	1012	96534680	1318	13180	975	12850500	310348.669	3103	425.4
39577	395770	279	1.1E+08	9951	99510	1404	1.4E+08	14163	141630	1012	143329560	1737	17370	975	16935750	337560.833	3376	414.5
8164	81640	279	22777560	689	6890	1404	9673560	17817	178170	1012	180308040	568	5680	975	5538000	299881.193	2999	441.6
35611	356110	279	99354690	5997	59970	1404	84197880	15751	157510	1012	159400120	2733	27330	975	26646750	339204.545	3392	467.8
6113	61130	279	17055270	304	3040	1404	4268160	17278	172780	1012	174853360	432	4320	975	4212000	283417.047	2834	474.4
24637	246370	279	68737230	4328	43280	1404	60765120	31999	319990	1012	323829880	2263	22630	975	22064250	305154.395	3052	553.5
34954	349540	279	97521660	2658	26580	1404	37318320	8522	85220	1012	86242640	4348	43480	975	42393000	365303.45	3653	575.3
6998	69980	279	19524420	2593	25930	1404	36405720	8483	84830	1012	85847960	4281	42810	975	41739750	378098.368	3781	551.9
27474	274740	279	76652460	2423	24230	1404	34018920	7992	79920	1012	80879040	4032	40320	975	39312000	286131.242	2861	281.3

y=2440.58+1.75x

R2=0.43

APPENDIX 4 (A)

CROPPING PATTERN

TABLE-1 TEHSIL. AJMER

AREA UNder crops as percentage to gross cropped area

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-86	11.78	3.51	5.66	26.21	21.80	6.11
1986-87	12.22	4.23	1.63	42.26	36.82	8.94
1987-88	5.73	1.89	0.33	25.98	41.32	3.25
1988-89	6.41	2.76	2.80	25.10	39.13	2.76
1989-90	10.05	1.79	2.11	23.86	36.66	2.62
1990-91	9.30	2.07	3.08	24.86	28.25	3.59
1991-92	10.02	3.02	1.18	21.51	24.48	4.58
1992-93	11.87	3.27	3.38	21.86	26.56	4.34
1993-94	10.90	2.57	2.28	21.86	24.15	3.94
1994-95	13.04	3.14	2.50	26.41	23.33	3.87
1995-96	15.03	3.76	3.85	21.31	21.26	3.88
1996-97	18.67	3.62	4.07	20.77	19.95	3.69
1997-98	18.16	4.68	11.20	16.36	15.74	4.12
1998-99	15.75	3.05	14.41	16.29	14.82	3.71
1999-2000	14.16	2.98	1.41	21.89	19.48	3.61

TABLE-2 TEHSIL. N ASHIRABAD

Area under crops as percentage to gross cropped area

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-86	N.A	N.A	N.A	N.A	N.A	N.A
1986-87	N.A	N.A	N.A	N.A	N.A	N.A
1987-88	4.73	2.97	3.09	38.03	29.42	7.83
1988-89	3.71	2.49	2.70	39.52	30.09	7.66
1989-90	3.81	3.79	5.34	33.31	25.89	7.14
1990-91	10.45	4.43	6.44	28.61	22.46	6.61
1991-92	9.55	4.28	4.02	25.54	21.53	8.00
1992-93	11.26	4.28	4.94	27.49	21.69	8.21
1993-94	19.73	4.29	5.62	25.00	22.29	6.37
1994-95	13.91	4.32	6.14	27.07	22.83	7.00
1995-96	12.57	3.79	5.47	26.59	20.92	7.35
1996-97	15.93	4.83	5.70	25.20	18.50	5.70
1997-98	14.28	5.20	13.65	19.80	16.94	5.48
1998-99	10.82	2.41	19.50	18.96	15.96	5.45
1999-2000	6.67	1.74	3.42	28.87	23.47	7.33

TABLE-3 TEHSIL. BHEWAR

AREA UNDER crops as percentage to gross cropped area

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-86	6.32	5.56	2.99	28.13	10.78	22.51
1986-87	3.61	4.36	1.07	31.41	6.72	25.23
1987-88	1.06	1.86	0.49	32.04	29.76	23.67
1988-89	4.62	4.25	3.14	26.45	18.84	20.55
1989-90	4.66	7.56	3.17	27.40	19.43	20.78
1990-91	10.53	6.36	4.99	23.59	13.73	18.47
1991-92	9.30	3.93	2.39	22.28	12.06	21.24
1992-93	13.60	5.42	3.76	22.69	12.41	19.63
1993-94	10.30	3.65	2.89	27.55	122.66	21.84
1994-95	17.16	6.42	5.89	24.53	9.77	19.86
1995-96	14.15	4.29	3.49	24.76	11.23	20.12
1996-97	18.21	5.13	5.56	24.18	9.26	18.36
1997-98	20.33	5.14	6.87	21.42	8.48	17.57
1998-99	15.00	2.50	10.20	18.39	7.06	15.70
1999-2000	9.35	1.67	1.19	27.41	9.96	22.79

TABLE-4 TEHSIL. KEKREE

Area under crops as percentage to gross cropped area

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-86	14.95	3.95	10.27	28.20	3.21	13.47
1986-87	16.45	4.45	9.53	31.26	2.83	13.58
1987-88	11.90	2.94	7.64	31.76	3.70	10.08
1988-89	11.78	2.31	5.91	36.60	4.94	11.87
1989-90	11.84	2.11	5.36	27.56	4.08	12.62
1990-91	12.26	3.42	4.95	27.00	3.21	11.32
1991-92	13.42	3.22	6.20	21.94	2.41	12.03
1992-93	15.63	2.51	5.66	27.20	2.57	12.49
1993-94	13.05	1.64	6.39	24.67	2.08	11.93
1994-95	17.01	3.05	11.31	25.18	2.17	11.41
1995-96	12.79	1.90	11.40	24.18	1.74	11.60
1996-97	16.89	2.54	11.39	22.24	1.67	9.58
1997-98	12.65	2.03	16.10	20.60	1.74	9.46
1998-99	14.27	1.87	20.79	19.61	1.63	9.59
1999-2000	9.19	1.32	6.27	27.60	2.09	11.39

APENDIX 4 (B)

CROPPING PATTERN

TABLE-5 TEHSIL. SARWAD

Area under crops as percentage to gross cropped area

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-86	9.33	3.70	19.25	33.36	3.78	10.97
1986-87	11.48	5.06	16.64	34.99	3.75	11.02
1987-88	8.00	3.88	16.08	36.80	5.79	7.51
1988-89	5.87	2.40	10.38	43.73	6.62	9.33
1989-90	7.01	2.68	9.75	31.88	6.05	9.42
1990-91	8.87	3.46	5.67	31.04	5.48	9.38
1991-92	8.58	3.19	4.96	26.39	4.77	10.23
1992-93	11.75	3.45	6.18	30.50	5.69	9.47
1993-94	9.66	2.51	7.95	26.55	4.04	8.71
1994-95	13.59	3.56	15.78	28.46	4.24	8.53
1995-96	10.51	2.53	15.05	25.08	3.36	8.30
1996-97	14.47	2.42	16.99	22.83	3.04	5.73
1997-98	11.62	2.08	27.02	19.17	3.18	5.63
1998-99	11.24	1.91	28.98	20.48	3.31	6.43
1999-2000	8.18	1.41	15.81	27.92	4.76	6.62

TABLE-6 TEHSIL. ISHANGHAR

Area under crops as percentage to gross cropped area

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-86	5.08	4.71	5.01	26.71	28.68	7.57
1986-87	5.24	4.19	3.04	30.74	30.34	6.87
1987-88	3.50	3.73	1.30	35.54	31.15	5.60
1988-89	3.85	3.94	4.41	31.73	34.81	4.42
1989-90	4.28	4.33	3.83	27.94	31.45	4.52
1990-91	3.20	3.37	3.20	28.41	30.99	4.47
1991-92	4.04	2.49	2.35	23.58	26.71	4.81
1992-93	6.43	6.36	4.79	20.89	25.10	4.43
1993-94	5.72	5.03	4.70	18.68	22.92	4.17
1994-95	6.87	6.01	7.38	22.69	23.24	4.44
1995-96	8.61	6.40	7.19	17.55	17.32	3.79
1996-97	9.11	6.08	10.27	16.98	16.41	3.57
1997-98	7.72	6.02	20.39	12.63	14.13	3.53
1998-99	6.75	4.38	26.50	12.97	14.07	3.39
1999-2000	5.53	4.21	9.89	18.56	19.32	4.00

TABLE-7 DISTRICT <-----> AJMER

Area under crops as percentage to gross cropped area

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-86	10.23	4.17	8.31	28.12	14.10	11.32
1986-87	9.75	4.13	5.97	31.50	16.11	11.71
1987-88	6.94	2.95	5.37	32.78	20.38	8.95
1988-89	6.78	3.23	4.84	33.99	21.91	9.36
1989-90	6.87	2.98	4.89	28.01	19.84	9.39
1990-91	9.07	3.71	4.53	27.13	16.50	9.03
1991-92	9.21	4.08	3.60	23.19	14.80	9.91
1992-93	11.76	4.19	4.82	24.76	15.03	9.61
1993-94	9.59	3.17	5.01	23.59	14.02	9.27
1994-95	13.51	4.39	8.40	25.39	13.28	9.26
1995-96	12.09	3.83	8.00	22.76	11.79	9.03
1996-97	15.20	4.05	9.48	21.45	10.55	7.70
1997-98	13.26	4.15	16.55	17.73	9.48	7.30
1998-99	12.75	3.67	21.10	17.92	9.39	7.30
1999-2000	9.10	2.76	6.98	27.52	13.06	8.75

APPENDIX 5 (A)

TABLE-1 TEHSIL. AJMER

LEVEL OF CROP IRRIGATION

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-86	94.87	92.06	6.35	0.39	2.22	42.57
1986-87	94.78	86.28	11.71	1.03	5.53	57.34
1987-88	98.97	97.21	29.27	0.74	3.77	35.58
1988-89	91.28	84.07	9.11	0.82	2.30	48.04
1989-90	60.88	81.67	7.77	0.20	1.52	43.79
1990-91	95.32	85.35	11.48	0.05	1.85	25.01
1991-92	96.72	90.22	3.47	0.11	1.25	42.27
1992-93	96.80	85.22	17.06	0.06	1.08	37.43
1993-94	96.41	86.89	6.00	0.11	1.79	47.97
1994-95	97.25	88.83	13.58	0.18	0.70	32.72
1995-96	96.85	90.58	11.74	0.11	1.46	46.16
1996-97	98.24	92.61	13.59	0.06	0.68	33.96
1997-98	98.60	79.23	0.84	0.05	1.03	38.64
1998-99	99.01	93.83	0.50	0.12	1.51	40.46
1999-2000	99.39	97.58	3.57	0.17	2.71	44.49

TABLE-2 TEHSIL. NASHIRABAD

LEVEL OF CROP IRRIGATION

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-86	N.A	N.A	N.A	N.A	N.A	N.A
1986-87	N.A	N.A	N.A	N.A	N.A	N.A
1987-88	72.87	75.35	5.17	0.27	0.69	12.46
1988-89	78.63	69.40	11.15	0.96	2.06	23.01
1989-90	79.95	69.57	9.77	0.78	1.94	22.72
1990-91	94.87	83.29	18.10	0.02	0.08	7.51
1991-92	91.54	78.64	22.46	0.53	2.00	35.75
1992-93	95.89	78.17	16.86	0.04	0.29	15.43
1993-94	50.42	69.62	9.90	0.83	2.79	45.91
1994-95	96.61	87.30	15.34	0.06	0.11	6.10
1995-96	89.68	77.03	4.09	0.18	0.14	3.04
1996-97	96.93	81.43	14.02	0.02	0.02	7.86
1997-98	90.43	67.21	4.40	0.02	0.09	11.88
1998-99	92.36	82.98	0.66	0.02	0.05	7.09
1999-200	96.77	86.60	1.91	0.28	0.47	19.63

TABLE-3 TEHSIL. BHEWAR

LEVEL OF CROP IRRIGATION

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-86	93.60	84.86	9.47	0.02	0.06	8.75
1986-87	88.58	82.46	3.15	0.57	1.68	19.52
1987-88	86.97	74.36	5.13	0.04	0.07	2.06
1988-89	88.23	76.48	2.20	0.06	0.03	2.79
1989-90	88.65	43.52	2.89	0.21	0.09	3.08
1990-91	93.53	75.52	16.24	0.02	0.06	2.59
1991-92	95.44	78.83	13.79	0.16	0.15	12.93
1992-93	96.54	77.74	14.66	0.14	0.12	4.55
1993-94	64.76	79.39	5.16	0.10	0.06	3.85
1994-95	95.38	77.00	18.14	0.02	0.00	0.47
1995-96	96.66	80.18	9.98	0.10	0.00	6.03
1996-97	96.80	74.28	13.43	0.07	0.00	1.34
1997-98	97.17	67.42	13.81	0.00	0.00	1.46
1998-99	98.64	83.79	0.87	0.03	0.31	5.41
1999-2000	99.07	91.99	3.37	0.27	0.23	5.50

TABLE-4 TEHSIL. KEKREE

LEVEL OF CROP IRRIGATION

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-86	53.91	66.80	2.75	0.08	0.57	14.68
1986-87	49.76	81.31	4.72	1.56	4.66	46.19
1987-88	38.30	79.99	2.09	0.10	0.46	12.91
1988-89	36.97	123.54	2.00	0.03	0.22	9.98
1989-90	34.00	70.56	2.04	0.12	0.32	12.56
1990-91	53.10	79.31	12.07	0.01	0.12	2.51
1991-92	52.34	78.86	9.78	0.19	2.01	21.82
1992-93	62.31	72.88	9.79	0.01	0.13	6.39
1993-94	59.98	74.81	8.29	0.33	0.60	27.88
1994-95	66.59	76.62	10.21	0.01	0.23	2.27
1995-96	60.04	71.60	4.43	0.05	0.21	11.45
1996-97	78.97	77.85	9.07	0.00	0.00	1.05
1997-98	77.63	74.76	2.84	0.00	0.25	4.76
1998-99	79.64	79.41	2.77	0.07	3.11	9.76
1999-200	82.93	82.18	2.49	0.04	0.42	14.36

APPENDIX 5 (B)

TABLE-5 TEHSIL. SARWAD

LEVEL OF CROP IRRIGATION

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-86	74.40	80.93	2.68	0.23	1.49	16.78
1986-87	57.88	68.38	4.68	2.75	14.88	57.89
1987-88	54.48	76.73	2.93	0.44	2.87	15.16
1988-89	50.46	64.43	2.08	0.23	2.86	15.39
1989-90	47.77	65.27	2.91	0.21	2.98	24.12
1990-91	69.50	76.71	9.19	0.01	0.08	3.64
1991-92	58.78	73.88	4.56	0.73	4.02	28.74
1992-93	73.61	75.27	10.88	0.03	0.28	6.80
1993-94	78.06	77.68	9.71	1.31	10.15	5.56
1994-95	81.70	78.50	9.14	0.10	0.64	4.64
1995-96	72.44	69.63	7.10	0.09	1.17	14.76
1996-97	86.00	75.42	10.13	0.00	0.17	1.17
1997-98	81.36	69.55	2.65	0.01	0.33	3.91
1998-99	78.17	71.94	2.81	0.03	0.30	7.60
1999-2000	86.66	81.00	5.76	0.19	1.06	18.87

TABLE-6 TEHSIL. KISHANGHAR

LEVEL OF CROP IRRIGATION

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-86	95.71	94.55	7.24	0.88	3.02	39.33
1986-87	91.38	93.40	7.14	1.66	6.33	56.01
1987-88	91.25	91.87	12.57	0.55	2.40	11.17
1988-89	84.95	79.91	9.15	1.01	3.94	22.68
1989-90	87.47	84.51	11.19	0.31	1.86	29.21
1990-91	90.87	85.60	5.87	0.03	0.31	11.05
1991-92	87.03	62.87	15.21	0.24	1.71	34.03
1992-93	88.53	81.35	12.05	0.05	0.54	12.79
1993-94	93.33	84.74	6.54	1.72	0.48	12.71
1994-95	91.01	83.81	12.24	0.03	0.05	6.06
1995-96	93.97	87.79	10.98	0.04	0.25	13.08
1996-97	93.57	86.53	4.26	0.00	0.06	5.18
1997-98	91.46	74.01	1.02	0.01	0.13	7.60
1998-99	95.75	84.37	1.15	0.14	2.15	15.58
1999-200	98.62	92.97	0.65	0.40	2.57	15.69

TABLE-7 DISTRICT <-----> AJMER

LEVEL OF CROP IRRIGATION

Year	Wheat	Barley	Gram	Jowar	Bajra	Maize
1985-86	66.47	82.12	1.94	0.44	3.71	29.58
1986-87	67.65	82.66	5.25	1.51	5.50	42.40
1987-88	57.33	83.46	2.50	0.41	2.29	11.26
1988-89	61.87	76.45	4.30	0.60	2.57	17.58
1989-90	59.50	75.21	4.85	0.26	1.48	16.00
1990-91	76.42	80.16	12.06	0.03	0.22	5.36
1991-92	74.33	82.16	10.78	0.32	1.55	23.93
1992-93	81.38	78.96	12.51	0.06	0.53	9.54
1993-94	80.20	80.32	8.01	0.89	3.15	28.43
1994-95	84.52	81.31	11.65	0.06	0.28	46.21
1995-96	83.67	82.50	7.38	0.08	0.59	13.03
1996-97	90.32	82.28	9.12	0.02	0.24	4.51
1997-98	89.78	72.92	2.72	0.01	0.36	7.43
1998-99	85.48	64.08	1.71	0.07	1.33	11.05
1999-2000	90.09	88.94	2.92	0.18	1.76	14.43

APPENDIX 6

CROPPING INTENSITY AND IRRIGATION INTENSITY IN AJMER DISTRICT

	TEHSIL. AJMER			TEHSIL. NASHIRABAD			TEHSIL. BHEWAR			TEHSIL. KEKREE	
	CROPPIN	IRRIGATION		CROPPING	IRRIGATION		CROPPING	IRRIGATION		CROPPING	IRRIGATION
Year	INTENSIT	INTENSITY	Year	INTENSITY	INTENSITY	Year	INTENSITY	INTENSITY	Year	INTENSITY	INTENSITY
1985-86	121.35	133.55	1985-86	N.A	N.A	1985-86	115.01	471.24	1985-86	117.78	408.65
1986-87	117.29	133.26	1986-87	N.A	N.A	1986-87	109.12	482.56	1986-87	115.98	408.97
1987-88	122.25	136.94	1987-88	107.22	121.64	1987-88	103.59	114.39	1987-88	118.64	128.53
1988-89	120.53	134.46	1988-89	111.55	120.73	1988-89	113.68	124.14	1988-89	112.60	117.91
1989-90	116.78	131.51	1989-90	110.27	122.12	1989-90	113.86	124.01	1989-90	110.89	116.84
1990-91	122.78	131.07	1990-91	122.90	122.02	1990-91	126.45	124.21	1990-91	121.24	111.13
1991-92	122.04	134.47	1991-92	116.93	124.25	1991-92	122.98	131.03	1991-92	116.36	117.09
1992-93	124.14	129.35	1992-93	121.30	123.24	1992-93	126.80	125.95	1992-93	117.52	111.32
1993-94	124.21	131.39	1993-94	124.75	130.85	1993-94	116.43	126.95	1993-94	116.49	118.89
1994-95	122.10	127.16	1994-95	128.07	120.85	1994-95	134.25	119.06	1994-95	121.19	108.77
1995-96	109.51	127.85	1995-96	122.86	124.06	1995-96	126.14	129.76	1995-96	114.07	117.95
1996-97	127.95	130.36	1996-97	127.79	123.92	1996-97	134.88	129.27	1996-97	125.93	111.32
1997-98	141.34	138.94	1997-98	142.76	127.89	1997-98	137.64	128.64	1997-98	133.32	115.72
1998-99	142.35	133.56	1998-99	147.70	119.76	1998-99	157.71	130.52	1998-99	133.94	118.82
1999-2000	129.87	135.03	1999-2000	117.74	127.75	1999-2000	116.57	127.39	1999-2000	114.25	119.16

	TEHSIL. SARWAD			TEHSIL. KISHANGHAR			DISTRICT <-> AJMER	
	CROPPIN	IRRIGATION		CROPPING	IRRIGATION		CROPPING	IRRIGATION
Year	INTENSIT	INTENSITY	Year	INTENSITY	INTENSITY	Year	INTENSITY	INTENSITY
1985-86	112.76	494.81	1985-86	109.36	596.09	1985-86	115.89	129.16
1986-87	114.54	527.94	1986-87	111.13	520.66	1986-87	113.66	129.08
1987-88	112.12	121.23	1987-88	111.61	115.32	1987-88	112.75	126.00
1988-89	108.06	118.90	1988-89	111.57	120.11	1988-89	113.13	123.13
1989-90	110.55	18.36	1989-90	108.99	114.08	1989-90	111.76	121.20
1990-91	116.01	116.87	1990-91	106.55	112.50	1990-91	118.36	119.39
1991-92	115.79	122.28	1991-92	110.20	120.44	1991-92	116.73	169.74
1992-93	117.81	114.85	1992-93	115.63	376.42	1992-93	119.79	120.15
1993-94	117.70	127.23	1993-94	112.74	118.33	1993-94	117.76	124.38
1994-95	118.31	109.52	1994-95	114.78	119.26	1994-95	121.90	116.44
1995-96	115.00	113.33	1995-96	115.40	115.98	1995-96	118.19	121.52
1996-97	128.69	111.49	1996-97	123.12	117.68	1996-97	127.40	119.78
1997-98	142.18	125.65	1997-98	153.91	125.00	1997-98	142.08	126.48
1998-99	136.07	122.41	1998-99	145.44	125.13	1998-99	142.60	125.49
1999-2000	122.39	125.76	1999-2000	128.31	125.62	1999-2000	121.73	126.72

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