Geomorphology and Landuse Pattern & It's Impact on Agricultural Development.
(A Case Study of Bharatpur District (Rajasthan)

A Thesis

Submitted for the award of the Ph.D. Degree
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To the
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By
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2019

(Certificate to be given by the Supervisor)

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I feel great pleasure in certifying that the thesis entitled ***Geomorphology and Landuse Pattern & It's Impact on Agricultural Development. A Case Study of Bharatpur District.*** by ***Ms. Nishtha Sharma*** under my guidance. She has completed the following requiremts as per Ph. D. regulations of the University.

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Abstract

The present study in the thesis deals with geomorphology and landuse pattern of Bharatpur district for better landuse planning with the growing population and limited resources, it is imperative to take into account proper planning of land and its resources to meet the needs of future generations. An investigation has been made through previous datas and studies, the basic geomorphological problems of Bharatpur district and how they make an impact on the landuse planning of the district, with the help of quantitative and crop combination techniques. The objectives of sustained production can only be achieved through the analysis of morphological character of the region.

The study area is chosen as Bharatpur district because of its unique location with schist and quartzite of Aravalli and Delhi system in North, sandstone of upper Vindhyan range in south east and Vindhyan rock types in last. This study encompasses the range of climate, types of soil fluvial morphology relief morfomovetry existing land utilization, extent of agricultural crops and forests and based upon these investigations, suggestions are proposed for agriculture development in the district.

Candidate's Declaration

I hereby, certify that the work, which is being presented in the thesis entitled ***Geomorphology and Landuse Pattern & It's Impact on Agricultural Development. A Case Study of Bharatpur District.*** by ***Ms. Nishtha Sharma*** in partial fulfillment of the requirement for the award of the Degree of Doctor of Philosophy, carried under the supervision of Associate Professor Dr. L.C. Agrawal and submitted to the the University of Kota, Kota represent my ideas in my own words and where others ideas or words have been included. I have adequately cited and referenced the original sources. The work presented in this thesis has not been submitted elsewhere for the award of any other degree or diploma from any Institutions. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented of fabricated or falsified and ideas/data/fact/source in my submission. I understand that any violation of the above will cause for disciplinary action by the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed

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All the data collection, theories, specimens would have failed to serve their purpose for me of blessing of God would not have joined hand with my efforts.

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(Nishtha Sharma)

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ABBREVIATIONS

AOAP – Alligarh Older Alluvial Plan

CA - Cultivated Area

CI – Cropping Intensity

Cl - Chloride

CP – Cropping Pattern

CGWB – Central Ground Water Board

CSO – Central Stastistical Organisation

DES – Data Encryption Standard

DSA – District Stastistical Abstract

EC – Electric Conductivity

FAO – Food and Agriculture Organisation

Fl – Flouride

GCA – Gross Cropped Area

GDP – Gross Domestic Product

GIS – Geographical Information

GoR – Government of Rajasthan

GW – Ground Water

GWP – Ground Water Potential

IMD – Indian Meteorological Department

Kg/hec – Kilogram per hectare

Kms – Kilometrs

LUP – Landuse Planning

mm – Mili metre

MT – Metric tones

MSL – Mean sea level

NSA – Net Sown Area

NCR – National Capital Region

RIICO – Rajasthan Industrial and Investment Corporation Ltd.

Sc – Scheduled Caste

SGWD – State Ground Water Development

ST – Scheduled Tribe

TE – Triennium Ending

TGA – Total Geographical Area

UN – United Nation

CHAPTER-1

INTRODUCTION

Geomorphology is a significant branch of physical geography. In its strictest sense, the science of geomorphology is the study of terrestrial denudation and of the forms and features that result from it (Peel, 1967). The interpretation of these forms through processes is a complicating task and has been undergoing vast changes with the time and space. In recent years considerable conceptual change has taken place in geomorphology and techniques have envolved to analyse the dynamic nature of earth's form. Various morphometric techniques through statistics are becoming more and more useful for geomorphologist to analyse the land as an open system and even more important are the new scientific questions centered on comparative planetary geomorphology, the interaction of tectonism with landscape, the dynamics of late Cenozoic climate changes, the influence of cataclysmic processes, the recognition of extremely ancient landforms and the history of the world's hydrologic systems. The catalysts for this development include technological advances in Global Remote Sensing System, Mathematical Modelling and the Dating of the Geomorphic Surfaces and Processes.

The significance of geomorphological research is indicated by the fact that an international organization of geomophologists has been formed and India has taken a big stride in the field of geomorphology in the past two decades at various universities, central and state government organizations such as The Geological Survey of India, Survey of India, National Atlas Organization, Soil and Land Use Survey, Central and State Ground Water Departments, Space Application Centre. Ahmedabad and National Remote Sensing Agency, Hyderabad, initiated serious geomorphological research according to their needs and requirements.

Geomorphologists have undertaken the study of very large scale landforms, such as planation surfaces of continent wide extent, but for the most part their attention has been focused on the smaller scale phenomena of the earth's surface, such as drainage basins, area of uniform rock type, individual river valley or the hill side slopes of small region. The reason for this is no doubt partly a practical one:

geomorphology at research level is essentially a field study, and only comparatively restricted parts of the landscape can be adequately investigated by one worker or a small group of workers.

Geomorphology has adopted from geology the basic thesis of the uniformitarian creed that ‘the present is the key to the past, or in other words that landforms can be explained only in terms of processes that are observable today in some parts of the earth. There is no real alternative to this assumption, yet great difficulties arise because of the recent climatic changes that most areas have experienced.

On the other hand natural scientists from various parts of the world have realized the significance of geomorphic research in various fields. As a matter of fact an increasing use of this research is being made in forestry, mining, hydrology, civil engineering, urban planning, military science, agriculture and irrigation. Therefore, the studies of this aspect of research in geomorphology have been initiated by Chorley (1957, 65 and 72), Doornkamp and King (1971), Gardiner (1977), Horton (1945), Melton (1957-68), Morisawa (1959), Mather and Doornkamp (1970), Strahler (1950, 52, 54, 56, 58, 60, 64 and 76), Schumn (1956), Smith (1958) and a number of others have contributed a great deal in quantification in geomorphology. In comparison with American and European countries, the progress of research in geomorphology in India remained a bit slow but the studies of Agrawal (1972), Ahmed (1968), Asthana (1967), Bandhopadhyay (1957), Bose (1961), Chandra (1970), Chatterjee (1957), Chaubey (1965), Desai (1968), Gupta and Kaith (1977), Kharkwal (1970 and 71), Murkherjee (1963 and 75), Pradhan and Sinha (1973), Sharma and Padmaja (1976-80), Sindhu and Pandey (1974), Singh and Srivastava (1977), Singh (1960), Singh and Ghose (1967), Sen (1965), Subramanyam (1976), Tandon (1997), Vaidyanadhan (1967), Verma (1957) and West (1962) are very remarkable and authentic and thus worth mentioning.

A modest attempt has also been made to synthesis geomorphology land system. Land use is the surface utilization of all developed and vacant land on a specific point at the given time and space. “These leads are back to the village farm and the farmer, to the fields, gardens, pastures, fallow land, forests and to the isolated farmstead” (Freeman 1968) as geography deals with the spatial relationship between these aspects and planning. Whether it is latitudinal location or stage of economic development including technological inputs the geomorphology influences the entire agricultural structure. So the study of land utilization is of immense value in tracing out the past use of land and its future trend. Keeping these facts in view, the present study confines itself to Bharatpur District as a case study for studying the application of geomorphology in land use pattern.

Land use planning has been carried out in different parts of our country. Pioneer studies in this regard have been made by Ghose and Singh (1965), Cooke (1974), Iyer and Srinivasan (1977), Subramanyam (1978), H.S. Sharma (1979), Vats and Singh (1982), Rai (1984) and similar studies were carried out by Klimoszenski (1985).

Therefore a coherent account of geomorphological and hydrological features of the region would help in showing the relationship between landforms and agricultural development.

CHOICE OF THE STUDY AREA

The conspicuous location of Bharatpur district itself is of great geomorphic significance. The district takes it name from the town of Bharatpur, the state local tradition claims that the place is named after Bharat.

This is the eastern most district of Rajasthan. It forms boundaries with Gurgaon district in the north; Mathura and Agra district in the east; Morena district of Madhya Pradesh in the south; and Sawai Madhopur and Alwar district of Rajasthan in the west.

The northern portion of the district is covered with alluvium from which rise a few isolated hills of schist and quartzite belonging to the Aravalli and Delhi system respectively. The quartzite’s are well exposed in the Bayana Hills, where they have been divided into five groups mainly Weir, Damdama, Bayana, Badalgarh and Nithahar, to the south-east, sandstone of upper Vindhyan age is faulted down against the quartzites and form a horizontal plateau over looking the alluvium of the Chambal River.

The formation of Bharatpur district is almost entirely of the sedimentary class. There are no granite rock, and the amount of either metamorphic or volcanic rock is very small, the igneous rocks occurring only in small amounts and isolated and detached. The exposed rocks may be divided into three classes (i) Alluvial (ii) the series called Vindhyan (iii) the series called Alwar quartzite.

Bharatpur forms part of the alluvial basin of the Ganga and Yamuna. The great majority of the exposed rocks are alluvial consisting of modern under alluvial deposits with blown sand which the wind carries from the desert of Rajasthan and occasionally forms into mounds on the leeward of some natural inequality in the surface. Portions of the Dholpur and Rajakhera tehsils are covered by the alluvium of the Chambal valley and extensive plateau formed of nearly horizontal upper Vindhyan sandstone.

Vindhyan occurs in the range which runs from Fatehpur Sikri towards Hindaun. The range belongs to the upper Vindhyan division and two of its sub-division, the Bhander and Rewa are represented, the former extensively. The main range representing upper Bhander, consists almost entirely of sandstone of various texture and colour, varying from a very fine rock to almost conglomerate. The prevailing colour is brick red with white spots or streaks sometimes green and yellowish white, occurring sometimes in alternative beds of considerable thickness. The ridge which runs parallel to the west of the above range in tehsil Roopbas is probably formed of Rewa.

The hills west of Bayana and divided from the sidgit Pahar by the catchment basin of the Gambhir River are formed of quartzite sandstone interstratified with trap and shale. All the hills in the north and west are of the same character with trap and shale.

The rocky and rugged region of Bharatpur district is occupied by Vindhyan sandstone hills in the north–eastern part while in the western part of quartzite hills continue to a length of about 64 km in the north-east direction and thus form the hilly region of the Dholpur unit. They enter the district at Bichoran and Bund Baretha hills are prominent. These hills include the typical sandstone formation of the Vindhyan system. The hills in the western side of the district represent the geological formation of the Delhi system.

The next formation is the Vindhyan sandstone. The typical Bhander sandstone is red and at places with white streaks scattered all over it.

AIM OF THE STUDY

In general notion that geomorphology is the science of landforms but the studies of A.N. Strahler (1952) and R.J. Small (1970) demonstrate that it is the study of quantification in the present time and giving rise to the branch of modern geomorphology known as Morphometery. The studies of H.S. Sharma (1979, 1982) also show the geomorphic factors combine together have played very important role in the processes and social systems of agricultural activities in shaping their taxonomic characteristics in one side, and the agricultural enterprise system including cropping pattern associated with the natural factors on the other, which have conditioned the definite enterprise systems in a much more complex way. Considering this hypothesis the efforts were made during the study that upto what extent geomorphic parameters affect the distribution of agriculture in the Bharatpur district.

Thus agriculture is seen with a complex phenomena and function of their closely but widely associated geographic control in different parts of the district. It would be quite in sequence to see the different levels of agricultural setup in contrast to the physiography, soil and water resources embodying geomorphic control in the district. This has great relevance for an agricultural area such as present study area where cultivation has been carried out since times immemorial and in which a high portion of rural population is dependent on primary vocation. The objectives of sustained production can only be achieved through an analysis of morphological character of the region. As geomorphological analysis or approach attempts to express the integration of all elements of the land complex, recognized the casual links between them through an understanding of the genesis of landform themselves.

At last agriculture in geomorphic terms and also the aim of the study can be defined as the replacement of the natural vegetation by an artificial plant over consisting of cultivated plants. (Tricard and Cailleux, P. 206).

REVIEW OF LITERATURE

The present status of geomorphology is the result of the gradual but successive development of the geomorphic thoughts postulated in different periods by innumerable philosophers, experts and geoscientists in the subject and outside the subject.

In comparision with American and European countries the progress of the research in geomorphology in India is as follows:

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OBJECTIVE OF THE RESEARCH WORK

1. To study the geomorphology and landuse patterns and its impact on agricultural development in Bharatpur district.
2. To study genesis and development of surface features of Bharatpur district.
3. To identify and delineate land systems, land units on the basis of land use planning.
4. To examine the relationship between fluvial morphology and landuse.
5. To study the changing picture of landuse and suggesting measures for improving the quality of landuse with reference to the Geomorphology of the region.
6. To examine the spatial distribution of crops, and other landuse activities.
7. To ascertain the spatial concentration of landuse phenomena.
8. The reasons why certain area are lagging behind in agricultural productivity.
9. To diagnose at the micro level the causes of existing agricultural backwardness and then to suggest suitable strategies to enchance productivity.

HYPOTHESIS

1. Stream frequency and drainage density determines the landuse patterns in the study area.
2. Slope suitability of the area determines the agricultural landuse.
3. Soil of the area determines the agricultural cropping pattern.
4. Climatic conditions of the area determine the agricultural activities.

METHODOLOGY

(i) Data Base

The present research study is based on the primary as well as the secondary data relating to geographical and agricultural indicators. The secondary data have been collected from various agencies listed below:-

1. The Directorate of Agriculture, GOR, Jaipur.
2. Office of the Joint Director, Agriculture Department, Bharatpur.
3. District Statistical Department, Bharatpur.
4. Eco and Statistics Department, GOR, Jaipur.

Name of Data		Name of Agencies (Source)	
A.	Land Utilization and Crop Wise Statistics	(i)	The Revenue Board, Ajmer
		(ii)	Land Record (Revenue), Collectorate, Bharatpur
		(iii)	The Directorate of Agriculture, Government of Rajasthan, Jaipur
		(iv)	Department of Economics and Statistics Government of Rajasthan, Jaipur
		(v)	Office of Joint Director, Agriculture Department, Bharatpur.
		(vi)	Finance Department, Government of Rajasthan, Jaipur.
		(vii)	District Statistical Department, Bharatpur.
		(viii)	Tehsil and Patwar Offices, District, Bharatpur.
B.	Population Data		The Census Department, Government of India, Jaipur.
C.	Climatic Data	(i)	Indian Meteorological Department, Jaipur.
		(ii)	Irrigation Department, Government of Rajasthan, Jaipur and Bharatpur

It was aimed to study the relationship between geomorphology and landuse through the application of various statistical techniques. Basic and preliminary information about different landforms has been collected from the topographical maps on 1:50,000 viz. $45\frac{0}{13}$, $45\frac{0}{14}$, $45\frac{0}{12}$, $45\frac{0}{15}$, $45\frac{0}{7}$, $54\frac{C}{2}$, $45\frac{0}{6}$, $45\frac{0}{8}$, $54\frac{C}{3}$, $45\frac{0}{10}$, $45\frac{0}{16}$, $54\frac{C}{6}$, $54\frac{C}{T}$, $45\frac{0}{11}$. Climatic data was collected from Meterological Department, Bharatpur; District Census Handbook, Bharatpur, 2012. The land use data has been collected from Land Record Department Collectrate, Bharatpur and Statistical Census Handbooks of Bharatpur District. Some of the Agriculture Data has been collected from Yojana Bhawan, Jaipur. Data related to population and geology have been collected from Census Department, Jaipur. Stream Frequency Method, Drainage Density Method and Wentworth. Method have been used to elaborate geomorphology of the district, while Weaver's Method, Doi Method and Raffiullah Method have been used to study the Crop Combination Regions of the district and also to do landuse planning. The analysis of soil samples were done at the Soil Research Institute, Durgapura, Jaipur and other information regarding soils of Bharatpur District has been collected from Soil Conservation Department, Bharatpur.

1. STREAM FREQUENCY

Stream frequency is an index for denoting the evolutionary process for a fluvial erosion system. It is controlled by factors like the climate, underlying rock and vegetation. The formula for calculating stream frequency is as follows:

$$S_f = \frac{\Sigma N}{A}$$

Where,

S_f = Stream frequency,
$\sum N$= Total number of streams in the unit area, and
A= Area of unit.

2. DRAINAGE DENSITY

Drainage Density is defined as a measure of the texture of the drainage system, expressed as the ratio of the total length of all stream channel within unit area. It is influenced by underlying lithology, climates and character of the terrain. The formula for calculating drainage density is :

$$Dd=\frac{\Sigma L}{A}$$

Where,

Dd= Drainage density

∑L= Total length of stream channels in a unit area

A = Area of the unit

3. WENTWORTH'S METHOD OF AVERAGE DETERMINATION FOR PREPARATION OF SLOPE ZONE MAP

Wentworth Method is the widely used and convenient method of average determination for the preparation of slope zone map. The formula for calculating slope is as follows:

$$\text{Tan } \Phi = \frac{N}{L} \times \frac{V.I.}{3361}$$

Where,

Tan Φ = Slope angle in tangent values

N = Number of Contour crossing in a grid

V.l. = Vertical contour interval

L = Length of grid in km, and

3361 = constant value of sin Φ

The study of crop combination regions done by Weaver, Doi and Rafiullah Method provides a good basis for agricultural regionalization. In recent years the concept of crop combination has engaged the attention of geographers and agricultural landuse planners.

4. WEAVER'S METHOD

Weaver Method is used for determining combination having minimum deviation. Weaver calculated deviation of real percentages for all the possible combinations in the unit considered against a theoretical standard which was obtained by dividing 100 percent in one crop, 50 percent in each of two crop association, 33.3 percent in each of three crop association regions. Weaver formula is as such :

$$\delta = \sqrt{\frac{d^2}{N}}$$

Where

δ= value of crop combination

d= difference between actual crop percentage in a given unit and appropriate percentage in the theoretical curve, and

N = Number of crops in a given combination

5. RAFILULLAH METHOD

Rafiullah Method was new deviation formulae for crop combination. The formulae by Rafiullah for calculating Crop–Combination regions is as follows:-

$$\delta = \sqrt{\frac{D^2p - dn^2}{N^2}}$$

Where

δ= Deviation

D_p= Positive difference

D_n = Negative difference from the medial value of the theoretical curve value of the combination, and

N = Number of functions in the combination

6. DOI'S METHOD

Doi's technique is considered to be the easiest for combination analysis. The doi's formulae may be expressed as:

$$\delta = \sum d^2$$

Where

d = sum of the squared differences

7. CROP DIVERSIFICATION METHOD

Bhatia (1965) developed a formula based on the gross cropped area. It involve intense competition among various activities for space the keener the competition, the higher the degree of diversification and lesser the competition and greater will be the degree of specialization or monoculture. The formula has been expressed as:

Index of crop diversification = $\frac{Percent\ of\ sown\ area\ under\ x\ crop}{Number\ of\ x\ crops}$

Where,

x = The crops that individually occupy 10% or more of the gross cropped area in the area under study.

8. CROP CONCENTRATION METHOD

This method is used for the percentage share of a crop in the total cropped area. The Department of Agriculture, Government of India has adopted the following technique for the determination of crop concentration at the local, regional and national levels.

Cropping intensity = $\frac{\sum aij}{\sum \text{ajo}} / \frac{Ni}{No} \times 100$

Where,

a_{ij} = area under ith crop in the jth year

a_{jo} = area under the ith crop in the base year

N_i = Net sown area in the jth year and

N_o = Net area sown in the base year

CHAPTERISATION SCHEME

The study has been divided into 12 chapters. The chapter 1 deals with introduction, choice of the study area, aim of the study, review of literature, objectives, hypothesis, methodology : Wentworth's Method of average determination for the preparation of slope zone map, Weaver's Method, Rafiullah Method, Crop Diversification Method, Crop Concentration Method and Cropping Pattern Method.

Chapter 2 deals with the geographical background of the Bharatpur District. It includes geographical location, type of topography, population characteristics.

Chapter 3 is denoted to a detail geographical description, climatic base and soil characteristics. The first section deals with geological history and rock formation in chronologicl order. The structural features like the Great Boundary Fault, joints, have been dealt with. The second section of this chapter represents the study of climatic conditions of the district. The area has extremes of temperature and variability of rainfall is much. Different seasons of the district, namely, pre-monsoon, monsoon, post-monsoon and winter have been discussed thoroughly. Rainfall intensity and distribution have also been included. The third section includes the properties of soil. A detail account of soil types, texture, chemical analysis and soil fertility status have been taken in the view. The factors affecting soil genesis have been also fully elucidated.

Chapter 4 touches the vital aspect of fluvial morphology of the Chambal, the Gambhir, the Banganga and Kakund and their distributaries. The long and cross profiles of all main rivers have been analysed; various drainage patterns, drainage frequency and drainage density are also analysed in relation to their controlling factors.

Chapter 5 encompasses the study of morphometry of the district. Various types of landforms have been analysed and studied by different morphometric techniques. The analysis of slopes have been made under two heads: regional slope and hill side slope development. Regional slope deals with slope analysis and slope histogram. The slope forming processes have also been elaborated in the text. An attempt has been made to delimit geographic regions of Bharatpur District. Geomorphic properties of each region and the dominating landforms and features within these units have been described.

Chapter 6 presents the existing landuse pattern of three different intervals. The changing picture of landuse has been depicted. Landuse tables has been discussed under the heads of forest, land not available for cultivation, other uncultivated land, fallow land, net area sown, double cropped area, cultivable wasteland and area sown more than once.

Chapter 7 deals with raising the productivity of land through agricultural methods and techniques like land holdings, agricultural implements, manures and fertilitzers, improved crops, research programmes, soil conservation works and water resource development and its effects.

In chapter 8 cropping pattern, techniques and major crops have been dealt with. The cropping pattern in ravine lands has been taken in concern.

An attempt is being made in chapter 9 to bring out morpho-agricultural regions of the district on the territorial differenciation of geomorphic features and crop pattern and evaluate them according to their land capability.

Chapter 10 presents the influence of geomorphic features on agricultural land use in Bharatpur district. The first section describes about the direct effect of slope on agricultural land use. Second section deals with enumeration of aerial distribution of the slope. Third section discusses the recommendations for better landuse planning in the district.

Chapter 11 deals with geomorphology and landuse pattern and its impact on agricultural development and planning, geomorphological factors; slope, relief and drainage. It also deals with landuse pattern and cropping patterns and its impact on agricultural development.

This chapter also deals with village survey of the district. It provides account of cropping pattern, crop combination type, nature of topography, farming techniques, population and area of the sample villages in different geomorphic regions of the district.

Chapter 12 belongs to conclusion. This concluding chapter draws attention to the study of geomorphic application for landuse planning in the district and suggests plans as well as programmes for the use of resources abundantly available in the district to farmers and all the concerns.

In the end bibliography has been given.

CHAPTER-2

GEOGRAPHICAL BACKGROUND OF THE STUDY AREA

LOCATION

Bharatpur District is situated at the eastern most part of Rajasthan. It forms boundaries with Gurgaon District in the north, Mathura and Agra District in the east, Morena District of Madhya Pradesh in the south; and Sawai Madhopur and Alwar Districts of Rajasthan in the west. The River Chambal forms the southern boundary with Madhya Pradesh. The Bharatpur District presents a complex record of landscape evolution. The rocks of Delhi and Vindhyan Super Groups underwent polycyclic planation. Banganga represents anomalous drainage which causes large scale inundation during rainy season. The strain post-collision Himalayan tectonics resulted in slope mutation in Bharatpur District which changed slope from westerly to easterly.

It is located between north latitude $26^0 50'$ and $27^0 50'$east longitude $76^0 53'$ and $77^0 45'$ and is covered in the survey of Indian degree sheet Nos. 54A, 54E and 54F. It covers an area of 5066 sq. Km. and is bounded on north by Haryana, in the east by Uttar Pradesh and towards south and west by Dholpur, Karauli and Alwar. Bharatpur District forms only about 1.46 percent of the total area of state and ranks 24^{th} in the state, in respect of size. In slope, the district is a flat bottomed and irregularly skewed, bizarre figure. Administraively, the district is sub-divided into three sub-divisions which are Bayana, Bharatpur and Deeg. These are further sub-divided into ten tehsils namely- Bharatpur, Kumher, Nadbai, Deeg, Nagar, Kaman, Pahari, Bayana, Weir and Roopwas (Fig. 2.1).

Bharatpur District is located in the eastern plains of Rajasthan Sate. The Gambhiri, Banganga and Ruparel rivers drain in the district. The district area is underlain by schists, gneisees, quartizite and phyllites sandstone and slopes, which are overlain by quarternary alluvium of varying thckiness. More than 85 percent of the area is covered by alluvium. Thickness of alluvium is more in the central part as compared to the southern and northern parts.

The marked fertile land contributes towards rendering the revenues of the district superior to those of many districts of equal and even greater area in Rajasthan. But this is also brought about by means of the large number of Jats inhabiting it who are born cultivators and utilize every available square yard of the land for the purpose of cultivation. A great part of the excellent system of irrigation prevails throughout the district, and which of late has been so materially improved and added. As per census 2011, total population of the district was 25,48,462, whereas it was 20,98,323 during 2001 census, thus registering 27.05 percent growth in population between 2001 and 2011, with urban and rural population is 495,099 and 20,53,363 respectively (Fig.2.2). It ranked third in this aspect of Rajasthan. The density of population was 142 persons per sq. Km. as compared to 60 for the whole of Rajasthan. In all there are 13,55,726 males and 11,92,736 females (Fig. 2.3 & 2.4).

The socio-economic and geographical features of the district are presented in the next chapter. In short, tehsilwise geographical area and population area given table 2.1.

Table 2.1

Tehsil Profile

Tehsils	Total Geographical Area (Sq. Km.)	Population (2011)
Bharatpur	509.52 (10.06)	372506 (17.75)
Kumher	454.5 (8.97)	174112 (8.3)
Nadbai	446.70 (8.82)	182585 (8.7)
Deeg	492.85 (9.73)	195483 (9.32)
Nagar	465.30 (9.18)	195464 (9.31)
Kaman	337.15 (6.66)	157694 (7.54)
Pahari	383.85 (7.58)	147180 (7.01)
Bayana	808.69	225038

	(15.96)	(10.72)
Weir	606.53 (11.97)	237206 (11.30)
Roopwas	539.01 (10.64)	211059 (10.06)
District as a whole	5066.00 (100)	25,48,462

Source: Census of India, 2011. (Figures shown in brackets are in percentage)

It is clear from the above table that Bayana is the largest tehsil in terms of the geographical area of Bharatpur. Bharatpur Tehsil is the biggest as far as the population is concerned. Kaman and Pahari tehsils are at the bottom in terms of area and population respectively (Fig. 2.5).

PHYSIOGRAPHY

Topographically, the tehsils of Bharatpur, Kumher, Nagar and Nadbai are plain and levelled. The terrain of Bayana and Roopbas tehsils is considerably diversified by hills. The general aspect is that of alluvial plain, fairly well wooded and cultivated with detached hills in the north, hilly and broken territory called the ‘daang’ in the south, and low narrow ranges in parts of the western and north eastern frontiers. The land in the Bharatpur and Deeg sub-divisions of the district is generally fertile and usually flat. The marked fertility of the land contributes commendably towards increased revenue yield in comparison with other adjacent tracts of the same size. On the basis of contour forms, varied elevations and geomorphical features, Bharatpur district can be divided into the following physiographic units (Fig. 2.6)

- The Banganga Khadar
- The Bangar
- The hilly tracts
  - (i) The northern hilly tracts
  - (ii) The southern hilly tracts

1. THE KHADAR

The slope both from the north and the south tends towards the Bharatpur city which thus became the meeting point of the two deposit drainage slopes. There is a slight gradual fall from the north and a steeper fall of about 2 feet of a mile from the south, both inclinding towards the city of Bharatpur. Thus the city is easily susceptible to heavy floods, chiefly from the south. However, the greater thrust of these slopes is in the east towards Uttar Pradesh and culminates at the function of the rivers Yamuna and Chambal near Etawah in Uttar Pradesh. The flood waters from Bharatpur city from this slope, readily drainable in a south east direction towards the Khari River, which is a tributary of the Chambal River. Inundation area deposits are mainly a low land area with alluvial.

The flood-waters flowing into the depression of Bharatpur city are controlled and contained in a number of “Bundhs” (small dams) and lakes in the area.

Khadar area of Banganga river in the southern part of the district is an area of ‘newer alluvial deposits’ and covers the major part of the plain area of the district. The newer alluvial is found mostly along with the entire course of the Banganga and the Gambhir rivers and hence, remains liable to be inundated during floods.

The Banganga Khadar is predominantly a low-land area with alluvial deposits. It is characterized by flood inducted alluvial basin produced by the Banganga and its tributaries like the Ruparel. There are also isolated hills and low ranges in the northern part agriculturally it is very important as 70.75 per cent area is covered with alluvium. It concerns with the limited supplies of rainfall which inundates the low lying areas during the rainy season by the ‘bund’ irrigated technique, which is to log water with the help of a small dam, locally called ‘bundh’. It is a densely populated area of the district. Bharatpur is the largest city of this area. The flatness of the topography has resulted in the dense development of road network.

2. THE BANGAR

The ‘older alluvium deposits’ are known as ‘Bangar’ which contains carbonates of lime, usually occurring in nodules called ‘Kankars’ (pebbles) which are darker in colour. The Bangar terrain is found in the northern part of the district. In this area, the alluvial deposits are very deep and this alluvium has vast storage of underground water. It has encouraged tube-well irrigation network and has made agriculture prosperous. Topographically, this plain area presents a monotonus landscape with extensive road network.

The Bangar is generally rich in nodules of impure calcium carbonate. These nodules are of all shapes and sizes ranging from small grains to 14 mps of fairly big size. Small patches of saline and alkaline efflorescence are also found in this land. Alkaline formation is explained by the fact that the dominant constituent of the old alluvium is clay and sodium clay, which reaching with Kankar nodules, is turned into calcium clay and liberates sodium carbonate.

3. THE HILLY TRACTS

Although the general physiography of the district of Bharatpur is marked with alluvial plain yet some scattered hills are still found in the northern and southern parts of the district. These detached hilly areas are the northern exposures of the Aravalli ranges which stretch in Rajasthan from south-west to north-east. The Aravallies are remarkable in being perhaps the oldest folded mountain ranges not only in India, but also in the world. The rock formation of this system has undergone metamorphic changes and is very clearly marked from slates to slates. Hard and massive variety of slates used for building purpose is available near ‘Hatyori of Weir tehsil. Hills and broken ground characterize almost the whole territory, which lies within a tract locally known as daang in the south. The principal hills are on the northern border where several ranges run along, or parallel to the boundary line, forming somewhat formidable barriers. There is little beauty in these hills, but the military advantage caused the selection of one of their eminences in early times. These hilly tracts can be divided into two sub-divisions:

3. (A) THE NORTHERN HILLY TRACTS

The extension of the Aravalli hills can be seen in the north. Here the rocks of Delhi system were deposited in a geosynclines lying uncomformally upon either the Aravalli system or the Raialo series (Misra, 1962 P.32). These hills are found in Nagar, Kaman, Pahari and Deeg tehsils in the form of small table lands which have lesser height than that of Delhi’s in Alwar. There are two parallel ranges in the western most part of Kaman tehsil with the highest elevation of the northern Chhapra hills (369.41 meters) above sea level. One isolated hillock in the central part of Kaman tehsil can be seen which contains many caves. Along the Deeg-Nagar border there are hillocks rising to 322.78 meters MSL as Rasia hill. Thus, in Deeg sub-division, the hills are mostly of igneous origin and are a continuation of the Aravalli hills.

In Bharatpur sub-division, there is only one hill, named Mandholi, which lies to the east of Bharatpur city. Its highest Peak is 216.10 meters above the sea level. The important trees found on it are Karil, Papri, Neem, Pipal and Chonkra. Building stone is excavated from the hill and it is used for the purpose of house construction, wheels of flour mills and in the construction of roads.

There are some ranges of the Aravalli hills, extending over a length of above 274 meters, with maximum height of 30 meters, known as Pooth-Dhan-Wara and Dounga-Ki-Mori.

3(B) THE SOUTEHRN HILLY TRACTS

In Bayana sub-division, there is a big hill called the Damdama. It ranges from the village Kachaira and extends upto Jarkholi and other villages. There are few hillocks which extend from Baretha to Samari. The length of the hill is 29 km the height is 370.32 meters above the sea level. These hills are naked and bare except for some small thorny bushes which grow generally during the rains. Red building stone and mill stone are found here. Near the railway station, Bund Baretha on the western railway between Bayana and Roopbas railway stations, these stones are found in large quantities and several stone quarries are being worked. The elevation above the sea level of the more important hills in the district are found by trigonometrically survey is shown in the table 2.2.

Table 2.2

Major Hills

Name of Hill	Position		Elevation above the level of Mean Sea Level (meters)
	Latitude	Longitude	
Alipur	27^{0}9’ N	76^{0}59’ E	411.17
Chhapra	27^{0}44’ N	77^{0}00’ E	369.41
Damdama	26^{0}54’ N	77^{0}15 E	370.32
Rasiya	27^{0}26’ N	77^{0}12’ E	322.78
Usirra	26^{0}57’ N	77^{0}38’ E	245.66
Mandholi	27^{0}14’ N	77^{0}26’ E	216.10

The southern hill tracts can be observed in tehsils of Weir, Bayana and Roopbas. In Weir tehsil, the Kala Pahar (214 meters) is marked by the highest elevation of the entire region. Here the hills are more rough and rugged. On the border of Weir and Bayana tehsils are east-west stretching rectilinear ridges rising to 335 meters, above the sea level. Along the southern most border of Roopbas tehsil there are elongated ridges the extension of which can be seen upto Fatehpur Sikri in Uttar Pradesh (Fig. 2.6).

In Deeg sub –division, the hills are mostly igneous origin and are a continuation of the Aravalli hills. There are two paralles ranges in the western portion of Kaman tahsil. One isolated hillock is in the centre of Kaman tehsil which contains many caves. The ground between hill range and round about is mostly uneven.

STUDY AREA

The study of landuse is in a development region, because much more interesting technological developments have just started to affect the natural environment. Most of the area in Bharatpur district is still far away from the current development trends. About 40% of the total population is backward and have little knowledge of recent technological developments.

The district Bharatpur has an area of 5,006 square kilometers in state of Rajasthan and located in the Brij region, which bound on the north by Gurgaon district of

Haryana, east by Mathura and Agra districts of Uttar Pradesh, south by Dholpur and Karauli, on the southern west by Jaipur and on the west by Alwar district of Rajasthan. The Royal House of Bharatpur traces its history to the eleventh century. It has been included as a part of National Capital Region (NCR). Bharatpur is located at 27.22^0N, 77.48^0E, and has an average elevation of 183 meters (600 feet). Bharatpur is also known an 'Eastern Gateway of Rajasthan' (Komal and Jindal, 2009). Bharatpur is located in Mewat Region. The trio of Bharatpur, Deeg and Dholpur has played an important part in the Jat history of the Rajasthan. Three rivers, the Banganga, Ruparel and Gambhir across the district.

The area presents highly diverse rock types ranging from pre-cambrian meta-sediments to recent alluvial cover. The part of the study area in Bharatpur district is technical structurally and lithologically very complex and had attracted many workers (Heron, 1917, 1922; Ferimor, 1930; Pascoe, 1965; Iqbaluddin et al. 1978; Prasad, 1984; Singh, 1982, 1985, 1991). It comprises rocks of Delhi Super, Vindhyan Super Group and recent quaternary sediments. The Vindhyan rocks are exposed in the eastern part of the Bharatpur district. The great boundary fault strikes NE-SW and passes through Bayana and Roopbas tehsil. The Delhi rocks are wide spread in the Bharatpur district and the best exposures are found near Bayana town in the Bayana basin. The rock belonging to the Delhi Super Group area also exposed in the northern part of the district in Kaman, Pahari and Deeg tehsils. The Aligarh, Mathura and central part of Bharatpur district presents almost a uniform alluvial plan. The depth to bed rock has been reported at 730 mm Bharatpur (Aggarwal, 1982), and 340 meters at Aligarh (Anor, 1977).

The straographic sequence of the study area in Bharatpur district was established by Heron (1917). They used the term "Purana Group" and "Delhi system" and described the Bayana basin uder Alwar series and it is divided into five district stages namely Nithar stage, Badalgarh stage, Bayana stage, Damdama stage and Weir stage, in descending order of antiquity.

The rock belonging to Vindhyan Super Group has also been reported from Bharatpur district in the south eastern parts.

CHAPTER-3

DEMOGRAPHY, GEOLOGY, CLIMATE AND SOILS

DEMOGRAPHIC STRUCTURE

Population is one of the dominant factors determining the nature of human settlement in terms of size and economy. The layout of the settlement, and their vertical and horizontal growth are the direct outcome of the size of population, its pressure and density. A study of interrelationship between man and his settlement shows various trends and features of social interaction, socio-spatial and physio-cultural structure of the region, which together constitute its morphogenetic structure. Therefore an attempt is made here to discuss the demographic characteristic of the study area.

The socio economic profile of an area measures such factors as education, income, type of occupation, place of residence, and in some cases population ethnicity and religion.

Demography encompasses the study of the size, structure and distribution of the populations and spatial or temporal changes in them in response to birth, migration, ageing and death. Based on the demographic research of the earth, earth's population upto the year 2050 and 2100 can be estimated by demographers.

Bharatpur district ranks 9th in terms of population, 26th in terms of area and 2nd in terms of population density. Bharatpur disitrict has ten tehsils, in which Bayana tehsil has the highest number of villages (195) whereas Nadbai tehsil has the lowest number of villages (123). Bharatpur District has 1524 villages, out of them 1432 villages are inhabited and 92 villages are inhabited. In Bharatpur district 60 new villages and 1 new census town have created as compared to 2001 census. (Table 3.1)

Table 3.1

Bharatpur District

Demography

Name of District	Population	Literacy %	Male	Female	Cast in No.	
					SC	ST
Bharatpur	25,48,462	70.11	13,55,726	11,92,736	5,57,305	54,090

In Bharatpur District, Roopbas (Tehsil: Roopbas) is the most populous (15,755 persons) village; and Kaldaheri (Tehsil: Nagar), Jhoolka (Tehsil: Deeg), Rundh Rarah (Tehsil Bharatpur), Chak Khohri (Tehsil: Weir), Kundanwara (Tehsil: Roopbas) and Mai (Tehsil: Roopbas) are the least populations (01 persons) villages (Fig. 3.1).

Bharatpur district consists 80.6 percent rural and 19.4 percent urban population whereas the state percent of rural and urban population is 75.1 and 24.9 respectively. The sex ratio (Fig. 3.2) of Bharatpur District (880) is significantly lower than the state sex ratio (928). (Fig. 2.4) (Table 3.2).

Table 3.2

Sex Ratio by Tehsils, 2011

Tehsils	Sex Ratio			0-6 age Group		
	Total	Rural	Urban	Total	Rural	Urban
Pahari	895	895	0	912	912	0
Kaman	865	869	852	889	898	823
Nagar	870	873	848	884	889	836
Deeg	853	849	866	880	879	836
Nadbai	841	840	854	879	886	822
Kumher	858	857	864	872	878	832
Bharatpur	851	855	859	879	891	867
Weir	859	847	933	884	878	924
Bayana	814	807	853	859	858	862
Roopbas	843	843	0	858	858	0
Total	880	851	864	879	882	864

Source: District Statistical Abstract, Bharatpur

Juvenille sex ratio is also shown in the above table. Pahari tehsil has reported highest Juvenile sex ratio. In the Figrue 2.4, we find that northern Pahari tehsil has highest sex ratio whereas southern Bayana has lowest sex ratio in between 825 to 850. Most of the tehsils like Weir, Bharatpur, Kumher, Deeg, Nagar and Kaman have reported sex ratio in between 850 to 875. The literacy rate in Bharatpur District is 70.1 percent which is higher than the state average (66.1 percent) and it ranks 6th among the other districts of the state (Fig. 3.3). Gender gap of the literacy rate is 29.9 percent in the district. The scheduled caste and scheduled tribe population in Bharatpur District is 21.9 percent and 2.1 percent respectiviely. (Fig. 3.4 & Fig. 3.5) whereas the state percent of scheduled caste and scheduled tribe population is 17.8 and 13.5 respectively.

DENSITY OF POPULATION

Density of population has been found in between 300 to 400 persons per square Km. in Pahari, Deeg, Kumher, Weir and Roopwas tehsils whereas it is in between 400-500 in Kaman, Nagar and Nadbai Tehsils. (Fig. 3.6).

URBANISATION

Urbanisation or urban drift is the physical growth of urban areas as a result of global change. Urbanization is also defined by the United Nations as movement of people from rural to urban areas with population growth equating to urban migration. Levels of urbanization have been found it very diversified pattern. Except Bharatpur tehsil, other tehsil had reported very low level of urbanization i.e. around 15 percent (Fig. 3.7).

Fig. 3.7 explains urbanization level in the district. Bharatpur is district headquarters and Bharatpur has reported 55 percent urbanization followed by Deeg with 20.9 percent population living in urban areas. Kaman has also reported 19.5 percent urbanization. No urban populatin had been in Roopwas and Pahari tehsil. Most of the tehsils have shown as 10 to 20 percent urban population.

GEOLOGY

Geology of Bharatpur district has been studied in detail (Heron, 1917; 1922; Fermor, 1930; Pascoe, 1965; Iqbaluddin *et al*, 1978; Parsad, 1984; Singh, 1982; 1985; 1991). Geological information of Bharatpur district has been published by Geological Survey of India (Heron, 1978).

The study area presents highly diverse rock types ranging from Pre-cambrian meta sediments to recent alluvial cover. The part of study area in Bharatpur in tectonically, structurally and lithologically very complex and had attracted many workers (Heron, 1917; 1922; Fermor, 1930; Pascoe, 1965; Iqbaluddin *et al*, 1978; Parsad, 1984; Singh, 1982; 1985; 1991). It comprises rocks of Delhi Super Group, Vindhyan Super Group and recent quaternary sediments. The Vindhyan rocks are exposed in the eastern part of the Bharatpur district. The great boundary fault strikes NE-SW and passes through Bayana and Roopwas tehsils. The Delhi rocks are wide spread in the Bharatpur district. Bayana basin extends as an isolated sequence of out crops from Bayana in the south-east to Nithar in the north-west over a strike length of about 31 Kms. The rock belonging to the Delhi Super Group are also exposed in the northern part of the district in Kaman, Pahari and Deeg Tehsils. The Aligarh, Mathura and Central part of Bharatpur District presents almost a uniform alluvial plain. The depth to bed rock has been reported at 730 m in Bharatpur (Aggarwal, 1982), and 340 meters at Aligarh (Amon, 1977). The stratographic sequence of the study area in Bharatpur district was established by Heron (1977). He used the term “Purana Group” and “Delhi System” and described the Bayana basin under Alwar series and divided it into five district stages namely, “Nithar stage, Badalgarh stage, Bayana stage, Damdama stage and Weir stage, in descending order of antiquity. Basement rocks comprises Pre-Delhi metasediments and metabasites and are overlain by Railo Group, the oldest lithologic unit of Delhi in the area is the Railo Group, it is overlain by Alwar Group and the Ajabgarh Group, which are separated by unconformities, in Bharatpur district. The rocks belonging to Vindhyan Super Group have also been reported from Bharatpur district in the south-eastern part. The exposures correspond to the Rewa and Bhander groups represented by lower Rewa sandstone, Gamurgarh shales and upper Bhander sandstone. The Delhi Super Group and Vindhyan Super Group in Bharatpur district are separated by great boundary fault striking NF-SW. The rocks of Delhi super group lie to the northwest of the fault and those of Vindhyan Super Group to south-east of it (Fig. 3.9).

Table 3.3

Geological Set-Up

Super Group	Group	Formation
	Recent & Sub Recent	
Unconformity		
Delhi	Ajabgarh	Schist Phyllite, Marble Gneiss
	Alwar	Quartzite-schist, Conglomerate
Quaternary	Recent Alluvium Group	- Banganga recent alluvium formation - Bharatpur loam Deposit - Yamuna recent alluvial formation
UNCONFORMITY		
Vindhyan Super Group	Bhander Group	- Upper Bhandar sandstone - Gannaurgarh shales
	Rewa Group	- Lower Rewa sandstone
UNCONFORMITY		
Delhi Super Group	Ajabgarh Group	- Arauli formation - Bhakrol formation - Weir formation - Kushalgarh formation
DISCONFORMITY		
	Alwar Group	- Damdama formation - Bayana formation - Badalgarh formation - Jogipura formation
DISCONFORMITY		
	Railo Group	- Jahaz- Govindpura volconics - Nithar formation
Pre Delhi		

Source: C.G.W.B. 1987, Ministry of Water Resources, Western Region, Jaipur

DELHI SUPER GROUP

The rocks of Delhi Super Group are exposed mainly in southern and northern parts of the district. Both Alwar and Ajabgarh Groups are exposed but among these two, the rocks of Alwar Groups are the more extensively exposed.

Meta sedimentary sequence referable to the middle proterozoic, resting over the pre-Aravallis in the north eastern Rajasthan has been referred to as Delhi Super Group. The rocks of Delhi Super Group have been divided into Railo, Alwar and Ajabgarh Groups in the Bharatpur district of Rajasthan.

The quartzite interbedded with phyllite and schists have been mapped as Ajabgarh Group which are exposed in the Lalsot hills and continues northwards as isolated hills around Kaman and Pahari areas of Bharatpur district. These represent the northern most extension of Delhi Super Group, the distal exposures are seen around Barasana-Nandgoan in Mathura district and around Dungrawan in Gurgaon district of Haryana, which continues northwards into the union territory of Delhi (Fig. 3.8).

ALWAR GROUP

An assemblage of quartzite, arkose, schists and conglomerate metamorphosed to green schist facies, resting over Railo Group in the type area was assigned to Alwar Group. The Alwar Group of rocks based on lithological inhomogeneity between lower coarse clastics and upper orthoquartzite sequence and the middle argillaceous metasediments in the type area was divided into Rajgarh, Kakarawali and Pratapgarh formations.

In Bharatpur a domal outcrop of feldspathic sandstone and orothoquartizte exposed between Kaman and Pahari has been assigned Pratapgarh Formation of Alwar Group. The rocks of Pratapgarh formation are developed into northwesterly elongated dome. The outcrop is smooth, rounded extending over a length of about 10 km, from west of Kaman towards Pahari. The quartzite is dark-grey, medium to coarse grained, moderately sorted comprising quartz, feldspar and magnetite grains, which are cemented by siliceous and carbonaceous cement.

In the Bayana basin Nithar formation and Jahaz-Govindpura volcanic as representative of Railo Group and the overlying rocks of Damdama, Budgaon, Jogipura formations are representative of the Alwar Group in the Bharatpur (Fig. 3.8).

AJABGARH GROUP

The exposure of Ajabgarh Group is mainly present in north western part of the district in a limited area. The dominantly argillaceous sequence with the subordinate calcareous and arenaceous silicicalstics developed around Ajabgarh in the Alwar district and regionally metamorphosed to green schist facics was mapped as Ajabgarh series. Ajabgarh Group Consist mainly of phyllites, slate, impure limestone and quartzites (Fig. 3.8).

VINDHYAN SUPER GROUPS

The rocks of Vindhyan Basin represents the north-western extension of the Karauli sequence in the district. The Vindhyans in Bharatpur district are represented by the Rewa and Bhander Groups.

(i) Rewa Group

The Rewa Group in Bharatpur district is represented by a sandstone which forms low strike ridges from Nagal upto Baretha lake hence from northwards the continuity of the outcrops has been punctuated by wrench fault. The outcrops of the Rewa sandstone extend through Jatrauli along a NE-SW strike upto right bank of Banganga River, hence from north-eastwards the Vindhyans go under alluvial cover. The sandstone developed in the Bharatpur district as first bed of Vindhyan possibly represents the upper Rewa sandstone. It occurs as northeast – southwest trending strike ridge. The Rewa sandstone which is rusty brown in colour has well bedded arkose. The arkose is cemented by ferrugenous cement. The development of the arkose, possibly as the first bed of Vindhyan in Bharatpur district reflects a mixed metamorphic and igneous provenance, for the Vindhyan basement in Bharatpur.

(ii) Bhander Group

The Bhander Group is most conspicuously developed in the Roopbas tehsil of Bharatpur district forming the plateau along the southeastern boundary of the Bharatpur district. It occurs as natural fortification overlooking the plain of Ghambhir River. The Bhander Group is represented by Ganurgarh shale and upper Bhander sandstone.

ARAVALLIS

Aravallis are the oldest folded mountains of pre-cambrian period. These ranges are formed of archaeans, which have been grouped into following system by Heron (1953).

Table 3.4

Lithostratigraphic Sequence of the Aravallis in Bharatpur District

Super Group	Group	Formation/Lithology
Delhi System	Delhi system	Ajabgarh series and Alwar series.
	Raialo series	Garnetiferious Biotiteschist Limestone (Marble) and local Basalt Grit.
	Gwalior system	Quartzites, slates, Jasper beds and dolerites.
	Aravalli system	Impure limestone, Quartzite, schist, composite Geneiss Quartzite, Grits conglomerates local Amgoldoids, Tuffs and schists.
	Bended Gneissic	Gneisses and Composite
	Complex	Gneiss Pegmatites Granites and basic rock quartzites.

Source: Mining and Geology Department, Bharatpur.

All above the formations are seprated by well marked unconformities. The junction of upper Vindhyans with the older rocks of the Aravallis in Bharatpur district reveals an extremely long fault or great throw i.e. Great Boundary fault, which has brought almost horizontal strata of the Vindhyan sandstone in contact with the highly folded and foliated schists of the Aravallis. According to geologists like Heron, Coulson (1927-28) and Fermor (1930), the materials of the Aravallis have been deposited by mature streams under a rather uniform climate. It has been further suggested by geologists that in the beginning of protorozoic era there was a vast and a long geosynclines which received vast deposits of Delhi sediments by various geomorphic agents. The Delhi’s are post-archaean in age and post Dharwar in formation, which are metamorphosed subsequently and this process took place maximum in the central part of the Aravallis. The deposition of Delhi sediments was being continued upto lower Vindhyan period.

The mountain building took place in pre cambrian period and it was of great magnitude giving rise to a range higher than Himalayas and extended from Gujarat in south-west to beyond Delhi in north-east. Through the Palaeozoic and Mesozoic periods, the Aravallis were constantly attached by exogenetic forces and were reduced to a peneplain. But this peneplain condition could not remain for a longer time and the ranges were rejuvenated in Cretaceous period (Heron, 1953). This upheaval was not uniform throughout, but was like an arc being highest in the centre and sloping either way. It has been pointed out by Heorn that at the close of the Eocene period, the Aravallis were once again cut down to show some sings of peneplanation in the eastern ranges, but regarding this, he himself was not clear. It is certain that the range was partially reduced to peneplanation.

The Vindhyan had been deposited simultaneously on the eastern and the western sides of these mountains when the Aravallis were undergoing peneplanation in Palaeozoic and Mesozoic Eras.

CLIMATE

Climate is an important factor in modifying the topography of a region. It has been established that the distinctive assemblage of geomorphic process and landforms, occur in an area with specific climate. The climate is influenced mainly by the processess of weathering and secondary by the running water nominally accompanied by the action of wind during the dry season. Geographical investigation of the physical environment of agricultural relevance is an indispensable tool for those engaged in identifying the basic regional difference in agricultural formation and geographic associations.

The climatic conditions are almost the same throughout the district except minor variations in temperature and rainfall. But the seasonal variation is quite significant. During the month of October, an abrupt fall in temperature is noticed, which falls rapidly in subsequent months.

The climate of Bharatpur district is semi-arid to sub humid and characterized by hot summers and cold winters. The rain generally falls in the district during monsoon in month of June to September. Occasional rains are also observed in the month of January and February on account of western disturbances.

The temperature variations are mentioned in Table 3.5. In the last two decades (1981-2000) the maximum temperature ranged from 42.20^0C. to 48.80^0C while average temperature ranges between 22.7^0C and 31.30^0C. Average annual maximum humidity was 67 percent in the year 1991 and minimum 49.2 percent in 1984. Average temperature and relative humidity declined after 1992 and 1991 respectively. The recent datas of temperature and humidity is depecited in Table 3.6.

Table 3.5

Bharatpur District: Mean Temperature and Humidity

Year	Temperature in ^{0}C			Average Humidity in %
	Maximum	Minimum	Mean	
1981	44.0	8.0	26.0	49.6
1982	46.0	5.0	25.5	52.6
1983	47.0	2.0	24.5	52.6
1984	47.0	3.0	25.0	49.2
1985	48.0	5.0	26.5	53.0
1986	45.0	2.8	24.2	54.0
1987	46.6	3.0	24.8	56.5
1988	46.5	4.0	25.3	57.1
1989	46.8	2.2	24.6	65.3
1990	44.6	1.0	23.4	58.0
1991	45.0	0.5	22.7	67.0
1992	42.2	8.2	31.3	62.0
1993	47.6	4.0	29.3	65.0
1994	48.0	5.0	29.8	64.0
1995	45.5	4.0	25.5	65.0
1996	47.0	4.5	25.0	64.0
1997	46.8	4.5	25.1	63.0
1998	48.5	4.0	26.2	60.0
1999	48.2	4.4	23.3	60.0
2000	48.6	4.5	26.6	59.80

Source: Office, Indian Meterological Department, Jaipur

Table 3.6

Bharatpur District Temperature and Humidity

Years	Maximum Temperature	Minimum Temperature	Average Temperature	Humidity %
2009	44.9	4.3	33.7	63
2010	47.2	3.9	32.9	64
2011	45.2	1.3	32.9	62
2012	-	4.8	-	-
2013	46.6	-1.2	22.4	63
2014	48.2	-2.2	23.0	64
2015	48.7	2.30	22.8	62

Source: Office, Indian Meterological Department, Jaipur

May or June is the hottest month of the year with maximum temperature exceeding 45^0C on several occasions. Minimum temperature goes below 5^0C quite often during winter. i.e. in the month of January. The temperature starts increasing in the month of February till the maximum is reached in the month of May or June. The temperature starts falling gradually due to the on set of the south-west monsoon by the end of June. A slight increase in the maximum temperature is observed after the withdrawal of the monsoon in September (Fig. 3.10).

TEMPERATURE

The only meteorological observation in the district is at Dholpur and records for this station are available for only a few years. The period from March to June is one of continuous increase in temperature. May and June being the hottest part of the year. The mean daily maximum temperature in May is 46^0C and the mean daily minimum 26.4^0C. In the summer season, the heat is intense, and the scorching dust laden winds add to the discomfort. The maximum temperature sometimes reach 47^0C and above in this season. The setting up of the south-west monsoon by about the end of June lowers the temperature appreciably, but the relief from the heat is not marked due to the increasing dampness of the monsoon air. After the withdrawal of the monsoon by mid September, days become a little hotter, but the nights become progressively cooler. From November both day and night temperatures decrease rapidly till January, the coldest month, with the mean daily maximum temperature at 24.5^0C (Table 3.7) and the mean daily minimum at 7.1^0C. In association with cold waves which affect the district in the wake of western disturbances passing across north India during the cold season, minimum temperature may at times fall to near about the freezing point of water. The highest maximum temperature recorded at Bharatpur, during the short period for which data are available, was 47.1^0C on June 11, 1960. The lowest minimum temperature was 0.1^0C on November 19,1961. The temperature statics are as following from year 2007-2011 (Table 3.7).

Table 3.7

Temperature (in Celsius)

year	Maximum	Minimum	Mean	Humidity percentage
2007	46.0	4.0	27.0	55
2008	44.5	7.4	25.4	57
2009	46.3	5.4	27.2	54
2010	48.0	2.5	28.1	56
2011	48.3	2.8	26.2	58

Sources: Data is based on observations of nearby center of IMD, Government of India.

RAINFALL

The rainfall is fairly good in the district. The rainfall intensity gives more accurate understanding than normal rainfall of an area, because of the fact that the amount of the rainfall received in a particular period proves to be more than the rest of the months. Rain gauge is a device used to measure the concentration of precipitation at a place in a specific period of time. It gives a clear picture of the rainfall intensity and its subsequent effects on soil erosion and other hydrological parameters. The general distribution of rainfall across the district can be visualized from isohytes map. Most of the district received rainfall in range of 700-800 mm in year 2010. The annual average rainfall was 797.8 mm based on the data of available blocks for the year 2010. Nagar Block received maximum rainfall (1,188 mm) whereas minimum was in Weir block (587.7mm). Bharatpur receives most of its precipitation from south-west monsoon, which usually occurs in towards the end of June or early July and extends upto September at times to even October.

Table 3.8

Blockwise Annual Rainfall Statistics of Bharatpur District

Block Name	Minimum Annual Rainfall (mm)	Maximum Annual Rainfall (mm)	Average Annual Rainfall (mm)
Bayana	608.1	776.2	699.2
Deeg	781.4	993.8	896.1
Kaman	666.0	1,019.5	856.9
Kumher	757.1	851.6	788.4
Nadbai	707.0	788.0	753.6
Nagar	670.8	1,188.8	907.7
Roopbas	729.4	903.6	816.0
Sewar	754.7	843.2	787.2
Weir	587.7	743.2	675.0

Sources: Data is based on observations of nearby center of IMD, Government of India.

Block wise annual rainfall statistics derived from year 2010 meteorological station data is shown Table 3.8.

The annual normal rainfall of the district is 797.8 mm. The following table shows the annual rainfall and deviation from normal rainfall.

Table 3.9

Annual Rainfall and Deviation from Normal Rainfall

Year	Rainfall (in mm)	Percent variation from normal rainfall)
2007	487.0	-26.65
2008	788.0	18.69
2009	661.1	-9.46
2010	799.4	20.41
2011	751.8	13.24

Source: Board of Revenue (Land Records), Rajasthan

The rainy season remain active from 2nd week of July to 3rd week of September in the district. The south-west monsoon takes place during this period. Seasonal rainfall may be seen in the following statement:

Table 3.10

Yearwise Seasonal Rainfall of Bharatpur District

Year	Rainfall (in cm) during			
	South-west monsoon (June to Sept.	South-east monsoon (Oct. to Jan.	Intermediate period (Feb. to May)	Total Rainfall (in cm)
2008-09	737.3	0.13	3.02	76.88
2009-10	53.08	4.81	1.81	59.70
2010-11	72.91	4.42	4.63	81.96

Source: Board of Revenue (Land Records), Rajasthan.

The temperature in winter is favorable for crop of wheat, barley and mustard. However the acute coldness sometimes hampers mustard.

Table 3.11

Bharatpur District Rainfall Characteristics (1999-2010)

Tehsil	Avg. annual in mm	Rainy day	Minimum rainfall in mm and year		Maximum rainfall in mm and year		Average rainfall in	% rainfall in monsoon	Avg. rainy days in monsoon	% monsoon rainy days
Bayana	657	34	302	2002	1314	1995	583	88.8	28	82.5
Bharatpur	693	35	369	2000	1041	2005	621	89.6	29	83.5
Deeg	680	34	333	2000	1167	1996	603	88.6	29	84.0
Kaman	697	34	378	2006	1219	1996	608	87.2	28	80.3
Kumher	570	32	266	2006	825	2009	508	89.2	26	81.9
Nadbai	659	34	256	2000	1014	1996	585	88.7	27	81.0
Nagar	598	34	216	2002	1277	1996	527	88.2	28	82.1
Pahari	570	33	266	2006	1174	1996	496	87.1	26	79.2
Roopwas	639	33	388	2000	905	2010	574	89.9	28	86.0
Weir	638	31	296	2006	956	1996	579	90.8	26	85.3
District	640	33	350	2000	1030	1996	568	88.8	28	82.6

Source: Computed from Rainfall data of Water Resource Department, Govt. of Rajasthan.

The above rainfall characteristics in terms of average rainfall, number of rainy days in a year, minimum and maximum rainfall during the study period for whole year as well as during monsoon. The district has received 663 mm rainfall during 1995 and 2010 with average 33 rainy days. Drought has been found in 2000 with just 350 mm rainfall whereas in the year 1996, the district receives 1030 mm rainfall. Monsoon plays main role in precipitation. It receives 88.8 percent rainfall during monsoons. Kumher and Pahari have received less rain fall among the tehsils whereas Bharatpur and Kaman have reported highest rainfall. The unstable behavior of rainfall has impact on both ground water and surface water irrigation.

Distribution of normal rainfall has been shown in the Fig. 3.11 which states that some areas of central eastern part of the district receives more than 700 mm rainfall. Southern part of the district gets more rainfall than northern.

The rainfall distribution in the study area is unequal. Intensity of rainfall decreases from south-east to north-west. The average annual precipitiation of Nagar Tehsil which is situated in the north of study area is 636 mm. The annual precipitation of Kaman and Deeg Tehsil is 646 mm and 613.5 mm respectively (Table 3.12 & 3.13). The middle part of the study area receives more precipitation than the northern part. Bharatpur Tehsil receives an average annual rainfall of 674 mm. Therefore the measure of annual precipitation goes on increasing from north-western to south-eastern part of the study area. This unequal distribution of precipitation in the region also affects the crop production.

Table 3.12

Bharatpur District Increase & Decrease in Rainfall (2010-2015)

Year/Tehsil	Normal Rain	Actual Rain	Increase & decrease in rainfall (in cms)
2010	67.05	79.40	(+) 12.35
2011	67.05	75.17	(+) 8.12
2012	67.05	61.19	(-) 5.26
2013	67.05	73.10	(+) 6.05
2014	67.05	63.84	(-) 3.21
2015	67.05	53.95	(-) 13.10

Source: District Statistical Abstract, Bharatpur.

Table 3.13

Tehsilwise Annual Rainfall of Bharatpur District (2014-15)

Tehsil	Normal Rain	Actual Rain	Increase & decrease in rainfall (in cms)
Bharatpur	67.23	60.30	(-) 6.93
Kumher	50.16	81.90	(+) 31.74
Nadbai	58.63	56.40	(-) 2.23
Deeg	62.82	57.10	(-) 5.72
Nagar	49.63	59.90	(+) 10.27
Kaman	60.36	52.50	(-) 7.86
Pahari	50.51	40.50	(-) 10.01
Bayana	55.15	64.90	(+) 9.75
Weir	56.714	97.40	(+) 40.69
Roopwas	60.25	79.40	(+) 19.15
Bhusawar	56.88	52.00	(-) 4.88

Source: District Statistical Abstract, Bharatpur.

Areal variability of rainfall has been calculated by calculating the coefficient of variability by the formulae:

$$C_v = \frac{Q3-Q1}{2} \times \frac{100}{Q2}$$

Where C_v = Coefficient of Variability

Q_1=Lower Quartile, i.e. = $\frac{N+1}{4}$

Q_2= Median Quartile i.e. = $\frac{N+1}{2}$

Q_3= Upper Quartile i.e. $\frac{3(N+1)}{4}$

HUMIDITY

Relative humidity in the district is reported moderate to high except during the summer period. i.e. from March to June. The normal relative humidity is recorded (0880 per cubic metre) in the morning during non-summer months. The average relative humidity is as follows:

Table 3.14

Bharatpur District Humidity (2006-2015)

Year/Month	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2006	9.0	28.0	0.0	0.0	41.0	25.0	138.0	131.0	66.0	14.0	0.0	13.0
2007	20.0	11.0	0.0	0.0	7.0	22.0	399.0	197.0	144.0	0.0	0.0	1.0
2008	9.9	0.0	0.0	0.0	69.0	40.0	82.0	288.0	13.0	107.0	0.0	0.0
2009	0.0	5.0	15.0	0.0	39.0	38.0	809.0	53.0	82.0	0.0	0.0	0.0
2010	0.0	0.0	34.5	0.0	45.0	15.0	141.0	54.0	84.0	0.0	0.0	0.0
2011	0.0	36.0	37.0	0.0	36.0	155.0	88.0	81.0	106.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	11.0	28.0	220.0	167.0	150.0	206.0	4.0	0.0	0.0
2013	0.0	0.0	0.0	3.0	42.0	41.0	159.0	270.0	88.0	6.0	32.0	2.0
2014	17.0	8.0	0.0	8.0	0.0	40.0	147.0	127.0	370.0	0.0	34.0	3.0
2015	0.0	38.0	0.0	7.0	4.0	137.0	239.0	80.0	238.0	0.0	0.0	0.0

Source: Indian Meterological Department Govt. of India.

WINDS

Winds are generally light to moderate in summer and the early part of the south-west monsoon season. Wind strengthen slightly on some days. In the summer, winds blow from directions between north-west and south-west monsoon season. In the post monsoon and winter months winds are mostly from directions between west and north.

SEASONS

Meteorological categorization of the seasons are:

i. Pre-Monsoon – March, April, May
ii. Monsoon – June, July, August, September
iii. Post-Monsoon Season – October, November, December
iv. Winter Season – January, February

It is an established fact that the dividing line between the two seasons is purely hypothetical since a month can be evolved into the other season at different times.

i. Pre-Monsoon

This season is characterized by high temperature with a low relative humidity. In March with the northward movement of the sun the temperature rises rapidly. Atmospheric pressure falls over the heated land, but the sub-tropical anti-cyclonic cell persist. The Jet-stream which is a permanent feature gradually shift north wards and migrates to a high level (220 mbs). The isobars have a flat pressure distribution due to the increased heating of land. The pressure gradient is not strong enough and the isobaric pressure gradient is from the coast towards the diffused how on the Indian sub-continent. And it prevails more or less in the same pattern during the month of May. The temperature conditions during pre-monsoon, in the district, show an increasing trend.

ii. Monsoon (June, July, August, September)

In the beginning of June the features of the hot season just described are intensified, and the heat and drought becomes unbearable. The Jet-stream which had already started migrating northwards from April has now moved north of 30^0N latitude where its velocity is considerable weakened and the south-west monsoon set in. It is very intense in June, July and August and weakens in September. The air is saturated with vapour and thick masses of clouds cover the sky and cause heavy rain and thunder. The arrival of monsoon, over the eastern

Rajasthan is normally by the end of June, when the whole area is engulfed with equatorial maritime airmass.

The major portion of the rain that falls in the area is due to monsoon depressions which form at the head of Bay. These depressions cross the Indian sub-continent and merge with the seasonal low. During the rainy months the amount of surface runoff, sediments load and the magnitude of fluvial erosion are the highest. The value of relative humidity is the highest in this season due to heavy rainfall and the presence of abundant moisture in the atmosphere. During the monsoon the moisture is the highest in the atmosphere with the result evapotranspiration is minimum.

iii. Post-Monsoon (October, November, December)

The withdrawal of the south-west monsoon devotes the retreat of the rain bearing south-west winds. In this retreating period the prevailing local winds dominate the circulatory conditions and affect the south-west monsoon inversely. During this period i.e. October, November and December, there is hardly any rainfall, due to anti-cyclonic conditions prevailing on the area. The period is witnessed with clear skies, the sun shines again and the temperature rises for a few weeks before falling to its winter minimum. Jet streams make their appreence in late October which is about 900 mbs and as the season advances it comes as high as 988 mbs.

iv. Winter (January, February)

January is a beautiful fine month in most of the region. By January and February the anti-cyclone establishes itself over Rajasthan itself over Rajasthan and the temperate continental airmass which has now become cooler and drier prevails over the region with the high pressure, the pressure gradient slackns and the temperatures are at their lowest, with January and Februrary $17^0.50^0$C and 20.80^0C respectively.

The climate of the region can be better understood with references to three seasons. These seasons are summer season (march to mid-June), rainy season (mid June to September) and winter season (October to February).

1. The Summer Season – Summer Season ranges from March to June. Month of June is the hottest month of summers.

The averge summer temperature at Bharatpur is 28.9^{0}C. It gradually rises from 22.9^{0}C in March to 24.98^{0}C in April and 33.91^{0}C in May from May onwards a gradual fall in temperature is marked and the thermometer records 33.82^{0}C in June. But these average monthly figures do not give a clear understanding of the great variations in temperature. An analysis of the lowest minimum highest maximum and mean minimum and maximum monthly temperature (Table 1) in the summer reveals that the mean maximum temperature of the city rises to more than 42^{0}C in the month of June, while lowest minimum temperature of the city recorded during this season is as low as 9.86^{0}C in the month of March.

The westerly winds of the summer season are replaced by easterly winds of the rainy season. Easterly winds are dominant in July when the south-east monsoon are strong. The unsteadiness in the winds direction is an important feature of the season.

Generally, the monsoon reaches here by the end of June and continues upto September, sometimes extending to October, July and August are the main rainy months with 20.03 and 20.69 cms of average rainfall and 9 and 8.3 average rainy days respectively. The average rainfall from June to September is 53.87 cms.

The average rainfall for the last 15 years (2000-2015) is 58.5 cms. During this period between January and May, in some of the years, there were occasional rains, though negligible in quantity. November is the only month when there is no rain.

The rain in these months is very beneficial for oilseed crops. The rainfall occurring in the last month of this season (September) is ultra beneficial for Mustard and Taramera crops.

2. The winter season–Winter season’s period is from October to February.

The temperature in winter season decreases rapidly during the month of October and November and goes down to about 22^{0}C. The average winter temperature is 18.45^{0}C. The temperature in December and January remains constant with an average of 15.95^{0}C and 14.77^{0}C respectively. The average minimum temperature of these two months are 7.90^{0}C and 7.24^{0}C, while the lowest minimum recorded during these two months are 4.75^{0}C and 3.38^{0}C respectively. February indicate a trend of rapid increase with an average of 17.58^{0}C. The dry and cold wind of this season gradually blow from the north and northwest. The average rainfall of the winter season is about 2.8 cms. Light winds, moderate temperature, clear skies and dry bracing atmosphere prevail during this period from October to mid December. In this season cyclonic winds coming from eastern side causes little precipitation which is extremely beneficial for Rabi crops. It is also known as 'Mahavat'. Distributed weather is of rare occurrence. But in the rest of the wind season Bharatpur is visited by cold weather depressions which results in a short wet period charactrised by clouds and rains.

SOILS

Soil is the medium of plant growth. The general characteristics of soil types and their distribution in the district have a close relationship with its physiography. It is dynamic natural agent on the earth crust which is composed of minerals and organic materials and living forms, in which plants grow. It contains minerals such as nitrogen, phosphorus, sulpher, potassium, magnesium, calcium and iron as well as minute quantities of trace elements such as boron, iodine and cobalt which are necessary for plant growth. The importance of soil in agriculture cannot be overworked as it determines and decides the land use capacity as well as its carrying capacity, no agricultural planning is possible without a proper study of soil. The crop landuse and nutrition of an area are primarily determined by the soils of that area. For instance, while loamy soils respond well to cash crops the sandy soils do not but they are quite suitable for the cultivation of inferior crops like Jowar and Bajra (millets). Similarly alkaline or saline soils are suitable for the cultivation of Barley, Wheat, Maize and Pulses. Therefore classification of soil is very necessary for irrigation and agricultural planning. All over the world, people are becoming more and more aware of the importance of keeping their agricultural land permanently productive. They are realizing that productive land is the source of human sustainance and security, that it is the basis for the welfare of people everywhere, all times.

Our cultivator's standard of living predominantly depends on agriculture, which is often determined by a combination of the physical and chemical characteristics of the soils, and the crops and livestock raised on them.

The soils of Bhratpur district are classified into six types as given below:

1. Loamy Soils
2. Clay Soils
3. Light Black Soil
4. Sandy Loam Soil
5. Saline – Alkaline Soil
6. Red and Yellow Soil

1. Loamy Soils

This soil is also known as 'Domat Soil'. It has a mixture of sand and clay and lighter in colour. It occupies the largest area of the district. This type of soil is found in parts of the plains of Kaman, Deeg, Bharatpur, Nadbai and Bayana tehsils and it is dirty whitish in colour. It has low to very low in humus content. It is also mostly friable, dark in colour and rich in moisture contents. It is quite rich in phosphate but poor in nitrogen. It gives good production with the use of fertilizers and facilities of irrigation. It is suitable for Jowar, Pulses, Rapeseed-Mustard, Wheat and Gram crops. (Fig.3.12)

2. Clay Soils

This soil is locally known as 'Chiknot' and has much power of water retaintion. It is the richest natural soil and the second largest soil group of the district. Kaman, Pahari, Nagar, Nadbai, Bayana and Roopbas tehsils have reported significant spread of clay. It is dark in colour and friable. Cracks (Birras) are developed in this soil in summer season. It is more fertile, having 5 to 10 cms width and depth. It is more fertile and fertility increases with the use of fertilizers and manure. It has sufficient quantity of humus content. It is quite rich in phosphates and poor in nitrogen. It is suitable for the cultivation of Jowar, Pulses, Rapeseed-mustard, Wheat, Gram and
Rabi crops.

3. Light Black Soil

This soil is like desert soil in nature inferior in quality. This soil is not very deep and it occurs in the form of clays and loams of dark brown colour. Mixture of black soil and alluvial soils is often found in the river valleys and at the foot of hills and on high uplands. The soils are usually poor in phosphates, nitrogen and organic matter, but they are self sufficient in calcium and potash. They respond well to soil management and give better yields. They are found abundantly in the central part of the southern areas and boundary of Kaman-Pahari tehsils and Nagar, Deeg and Kumher tehsils at Bharatpur district.

4. Sandy – Loam Soil

Sandy loam soil is an important soil group of Bharatpur District. It is found in the tehsils of Bharatpur, Nadbai and Roopbas. Its texture varies from clays to sandy loam and it has varying tints. The A horizon of its profile is often deficient in phosphate and calcium while its nitrogen contents vary. Because of alleviation the B-horizon is generally richer and heavier. It is pale-brown to yellowish brown. In other parts the alluvial soils carry dark grey brown or dark brown shades. Saline and alkaline patches occur where the water table is high. Locally soils are noted for good productivity.

5. Saline – Alkaline Soils

This soil is locally known by various names such as ‘Reh’, ‘Kallar’ or ‘Usar’. These are the poorest soils of the region and are characterizes by general shortage of water. These soils are thin and gravelly and have no capacity of retaining the moisture. Saline – Alkaline soils have occupied an area of 25% of the total area of the district and are controlled mainly in Deeg tehsil and small patches are generally found in Bharatpur, Kumher, Nagar, Kaman and Pahari tehsils. These soils are generally sown with Kharif crops. Such as millets and fodder.

Soils have different varities. They differ from place to place. Likewise the soils of Bharatpur district are classified into five main classes on the basis of the district soil conservation department. They are newest alluvium, newer alluvium, older alluvium, black or regur soils and saline – alkaline soils.

6. Red and Yellow Soils

Red and yellow soils occur together in south western parts of the district. *i.e.* Weir and Nadbai tehsils. The surface texture of this soil varies from sandy to sandy loam. The yellow colour is due to higher degree hydration of ferric oxide silty loam to silty clay loams are common but in the plain of Banganga and Gambhir Rivers, it is sandy but they are poor in carbonate and humus content. They are suitable for Bajra and Gram crops. This is the degraded soil which is easy for ploughing (Fig. 3.12).

FACTORS OF SOIL GENESIS

Soil formation is a function of structure, climate, relief, vegetation, parent material, organic matter and time. In the area under study, these factors have direct or indirect effect on the soils.

1. Structure

The rocks of the area have been a source of material for soil formation. Main rock formation are of the Aravallis, the Gwalior and the Vindhyan system. When the soil is formed directly from the underlying rocks, the soil minerals present in the soil bear a direct-relationship to the original rock. For example the soils developed over the Vindhyans are reddish and on hilly soils have poor calcium content because of this reason the sandstones and limestones of the Vindhyan system are the meta-silicates of calcium, magnesium and iron. In Bharatpur the western and south-eastern portions have light black soils. Alluvial soil, in the area, is brought by rivers from the rocks of the surrounding areas, which are mostly mixed mineralogy i.e. limestone, sandstone and shales of the Vindhyan System.

The southern part (Roopbas and Bayana) of the district is dominated by rocks of the Aravallies. It is evident from the morphological studies of various profiles that the minerals mainly belong to the Vindhyans, Aravalli and Gwalior System showing in close relation between their origin and the parent material.

2. Climate

This is probably the most important factor (soils produced from the same parent material under different climates contrast). Climate governs the rate and type of soil formation and is also the main determinant of vegetation distribution.

Russian Pedologist Dokuchaev (1990) has stressed on climatic factor in soil formation. Climate influences the soil genesis through rainfall and temperature. The climate of the area is moderate (semi-arid to humid). Only the monsoon period has good concentration of rainfall. Besides this, the daily and annual ranges of temperatures are also high except in winter season, hence the rate of evaporation is high and humidity is low. Due to low humidity and low rainfall, soils are comparatively deficient in p.H. and exchangeable values. Moreover, due to sub-humidity and high evaporation from the upper layers of these soils, the carbon contents, clay content and aggregation saturation capacity are comparatively lower than the lower layers. The above condition is verified from the fact that a zone of lime accumulation is found below one metre in the Bharatpur district. With is increase of moisture the aridity of the area trends to increase the mechanical weathering which is sometimes augmented by the short rainy season. This leads to shallow thickness of soil formation. A thin layer of 'Kankar' has developed in the soil. This again verifies the aforesaid fact.

3. Relief

Relief is not static; it is a dynamic system. Relief influences soil formation in following ways:

- It influences soil profile thickness i.e. as angle of slope increases so does the erosion hazard.
- It has an effect on climate which is also a soil forming factor.
- Gradient affects run-off, percolation and mass movement.
- Its influence creates microclimatic conditions.

It influences the soil formation primarily as a factor affecting erosion and as a modifier of climate and water air relationship in soils. The south-west and north-west parts of the district are plateaus and are composed of upper Bhander sandstone and Gwalior shales, respectively The soil profiles over these parts are also immature because of rapid rate of denudation. Hilly soils are generally found on the piedmont areas. Over mountain tops, the soils are of clay types and in plain areas the soils are clayey and clay lowers in nature. Also the hilly slopes and hill tops are covered by hilly soils, whereas clay loams and sandy loams are found in patches in intermittent valleys. All this proves that there exists a clear relation between relief and soils.

4. Vegetation

Organisms influencing soil development range from microscopic bacteria to large animals including man. Bacteria and fungi assist in the decomposition of plants litter. This litter is mixed into the soil by worms organisms (soil animals) such as norms and beetles.

Soil horizons are less in distrinct where there in much soil organism activity.

Higher plants influence the soil in many ways. The nature of the soil humus is determined by the vegetation cover and resultant litter inputs. Roots contribute dead roots to the soil, bind soil particles together and can redistribute and compress soil.

In the district, the vagetative cover plays a significant role in reducing soil erosion, addition of the organic residues and development of the soil profiles. With the death of plants or shedding of leaves the process of humification and mineralization gives rise to organic and in organic acids and to the release of minerals present in the soils. Thus, plants act directly or indirectly as a factor of soil formation. Vegetative cover modify climate influence on the soils, especially, the erosion of the surface soil by water and wind is prevented. The plants and the layer of decaying organic matter, on the soil surface, trap the rainfall and reduce the direct effect of washing out of the soil with the flowing water.

Vegetation of the Bharatpur district does not vary to a great extent. It falls into two groups :

(a) Trees on slopes and tops of the hills comprising of Khokera, Kher, Babul, Dhok, Adusa, Ber and Aak.

(b) Trees and shrubs on the plain comprising of the Neem, Babul, Dhak, Ber, Oak, Ker, The Aravalli hills are caused by have thick vegetation and in contrast, the plain areas have a scanty vegetation, Because of the thick vegetation on the hill slopes, with the soils of the gentle slope having are rich in organic matter.

5. Parent Material

This is the material from which the soil has developed and can vary from solid rock to deposits like alluvium and boulder clay. It has been defined 'the initial state of the soil system.

The parent material can influence the soil in a number of ways :

In western Europe, Australia and the united states, it is the study of the parent material and time factor that take precedence in the study of soil formation. The effect of the parent material is clearly –perceptible in the development of soil profile in Aravalli hills. The soils in this area have developed mainly from the Gwalior metamorphic, Vindhyan sandstones and shales by weathering processes. So soil which have developed on the sandstones and quatzites are coarse soils with low base status. The soils on the limestones and shales are clayey and reddish-brown in colour.

6. Time

Soil development goes through a time factor. But the duration of time cannot be measured strictly in terms of years, because the time needed for a particular soil to develop depends on other factors of soil formation. For example, the soil development is more rapid in humid climate that supports good vegetation than in dry climate. Leaching plant nutrients are more rapid in co textured permeable parent material. Since this district is a part of multicylic topography, hence polygenetic soils are evident in various parts especially on the plateau and hilly tracts.

- Development of soil is very slowly. It takes about 400 years for 10 mm of soil to develop.
- Young soils retain many of the characteristics of the parent material. Over time they acquire other features resulting from the addition of organic matter and the activity of organisms.
- An important feature of soils is that they pass through a number of stages as they develop, resulting in a deep profile with many well differentiated horizons.

CHAPTER-4

FLUVIAL MORPHOLOGY

DRAINAGE

Drainage system in the district as shown in Fig. 4.1 is greatly influenced by its geological history and the location of the great Indian watershed line. The drainage of the Bharatpur district finally discharges itself into the river Yamuna. There are no perennial rivers in the district; the four rivers viz., the Banganga; the Gambhir; the Kakund and the Ruparel, which pass through the district flow only during the rain and remain dry entirely from two to three months after the rains. The Banganga which enter the district on the western border of Weir tehsil and flows due east towards Agra district and about midway in its course eastwards the river has left its old channel and now flows in a northerly direction toward Uchchain Road.

The flood water so discharged is again impounded and distributed by other works the largest of which is the Ajan Bund, a five embankment extending for 19 kms. across the direction of the flow. The Gambhir river also enters the district from the south western corner. After receiving the water of the Kakund about 13 kms. higher and after traversing about 56 Kilometers first towards the east and then in a north-easterly direction, it is joined with the Banganga near the village Kurka of tehsil Roopbas. The Kakund is a tributary of the Gambhir which enters the south-western border of Bayana tehsil from the Karauli side. It was formerly an affluent of the Gambhir but become famous with the construction of Baretha Bund, where its water are all held up and released to irrigate land further north in Bayana and Roopbas tehsils.

The slope both from the north and the south tends towards Bharatpur City which is the meeting point of the two opposite drainage slopes. Thus the city is easily prone to floods, chiefly from the south. However, the greatest thrust of these slopes is in the east towards Uttar Pradesh and culminates at the junction of the rivers Yamuna and Chambal near Etawah in Uttar Pradesh. The flood waters from Bharatpur City are due to this slope, readily drainable in a south-easterly direction towards the Khari River which is a tributary of Chambal river. Such waters as are left still uncontrolled, flow into the moderately inundate the low lying land in the south-west of the city. This flood water is used for filling the moat around the fort of Bharatpur city which remains filled with water all the year around. All the major rivers of the district originate from outside the district and are ephermeral. The Banganga river rises from Jaipur district. It has easterly flow and disappears in the sandy track near the Ghana Bird Sanctuary, Bharatpur before meeting any big river. The river Gambhir originates from Sawai Madhopur district and enters the district is southern part and passes the district to meet the Yamuna river in Uttar Pradesh. The river Ruparel Originates from the Thanagazi hill in Alwar district, it enters Bharatpur district near Gopalgarh and is held by Sikri Bund.

There are four lakes in the district, viz, the Moti Jheel situated about three Kilometers west of Bharatpur City and it is used for irrigation purposes; the Keoladev Jheel is situated about five Kilometers south-east of Bharatpur City and famous for its duck shooting; the Madal Jheel is situated on the northern border and filled by the Ruparel river, and is used for irrigation purposes and finally, the Jheel-Ka-Bara is situated about 14 Kilometers north of Bayana town under the hill.

DRAINAGE DENSITY

Drainage density is defined as a measure of the texture of a drainage system, expressed as the ratio of total length of all stream channels within the unit area. Drainage Density is influenced by underlying lithology, climate and character of the terrain. It has been found high on the impermeable but easily erodible rocks. Drainage density is believed to reflect the operation of complex factors controlling the surface run off as well as considered an important governing factor in denudation processes. Drainage density for the present study has been calculated by the following formula:

$$Dd = \frac{\sum L}{A}$$

Where,

D_d = Drainage Density

$\sum L$ = Total length of stream channels in a unit area

A = Area of Unit.

The water table in the district ranges from 3 to 20 meters. The drainage density is a measure of the texture of a river basin. The higher the density of drainage, the greater is the frequency of floods and vice-versa. The drainage density is also very high on impermeable but easily erodible rocks such as conform found in the southern part of the district, which have clay soils:

The relief, infiltration capacity of the soil and the initial resistance of the terrain to erosion are also important factors deciding the magnitude of drainage density which characterizes the degree of drainage development in the district.

The drainage density in the northern and the central parts of the district varies between 0.2 and 0.3 per square kilometers. In the southern part, drainage density varies from 0.3 to 0.5 per square kilometers in area around Roopbas. In Bayana and Weir tehsils, it varies from 0.5 to 0.7 per square kilometers (Fig. 4.2).

DRAINAGE MORPHOMETRY

The drainage morphometry has been worked out in an attempt to develop relationships between drainage basin parameters and run off characteristics, basin shape, sub-soil material, infiltration and relief characteristics (Zeritt, 1932; Boulton, 1965). The present day drainage in Bharatpur district is developed as superimposed over paleo flood plain deposit. There has been a drainage mutation in Banganga sub-basin due to (post Himalayan collision tectonics) strain generated in the Indian Shield by continued plate accretion in the Indian Ocean region (Iqbaluddin, Mohammad, 1986) in the area, which is manifested by drainage and topographic anomalies.

For the purpose of morphometric analysis the present drainage system has been divided in four sub-basin namely Banganga, Gambhir, Kakund and Kaman. The Morphometric analyse of the drainage system has been attempted for quantification of micro-watershed in term of stream order number (NU), stream length (IV), bifurcation ratio (R6), stream length ratio (SR), stream frequency (F), drainage density (D), basin perimeter (P), basin length (X16), basin elongation (R_e), basin circularity (R_c), form factor (R_f) and infiltration number (XI) (Schemar, 1956;

Cham, 1964; Strahler, 1964; Nantiyal, 1994). The details of the morphometric analysis of the four sub-basins as briefly discussed below (Table 4.1):

BANGANGA SUB-BASIN

The Banganga sub-basin covers an area of about 259.37km^2 in the south-central part of the district. The perimeter of the sub-basin is about 86 km and maximum basin length (16) is 33.75 km. The total number of streams (NU) of the various orders is 40, out of which the number of 1st order stream is 31, the number of second 2nd order is 8 and that of 3rd order is 1. The total length of 1st order Channels is 106.25km, the 2nd order is 49.0 km and of 3rd order is 18.75 km. The bifurcation ratios (R_b) between 1st/2nd orders is 3.87 km and between 2nd/3rd orders is 8.0. The stream length ratio (SR) for 2nd/1st order is 0.45 and for 3rd/2nd orders is 0.39. The values of drainage density (D) is 0.667 and that of stream frequency (F) is 0.154. The elongation ratio (R_e) is 0.536, circularity ratio (R_c) is 0.44.The values of infiltration number (I_f), is 0.102, form factor (R_f) is 0.227 and overland flow (1g) is 0.749.

GAMBHIR SUB-BASIN

The Gambhir sub-basin covers an area of about 534.37 km^2 in the southern and south-western parts of the district. The basin perimeter (P) is about 141.25 km. and maximum basin length (Ib) is 42 km. The total number of streams (N_u) of various orders is 83, out of which the number of 1st order stream is 63, the number of 2nd order is 6, the number of 3rd order is 3. The total stream length (l_u) of all orders is 289.50 km, the length of 1st order stream is 181.0 km, the length of 2nd order is 70.75 km, the length of 3rd order is 19.50 km and that of 4th order is 18.25 km. The bifurcation ratio (R_b) of 1st/2nd orders in 3.93, that of 2nd/3rd order 5.33 and between 3rd/4th orders is 3.0. The values of stream length ratio for 2nd/1st orders is 0.89, for 2nd/3rd orders is 0.27 and for 4th/3rd orders is 0.93. The value for drainage density (D) is 0.541 whereas for stream frequency (F) is 0.155. The elongation ratio of the basin is 0.621 and circulatory ratio (R_c) is 0.336. The value of form factor (R_f) is 0.302, infiltration number (I_f) is 0.084 and overland flow (l_g) is 0.923.

KAKUND SUB-BASIN

The area covered by Kakund sub-basin is 84.37 Km^2 in the southern part of the district on Vindhyan plateau. The perimeter (P) of the basin is 48.5 km. The total number of streams (N_u) of various orders is 27, out of which the number of 1^{st} order stream is 20, the number of 2^{nd} order streams is 6 and 3^{rd} order stream is 1. The total stream length (l_u) of all orders is 85.75 km. The length of 1^{st} order stream is 52.0 km, 2^{nd} order is 26.25 km, length of 3^{rd} order is 7.25km. The bifurcation ratios (R_b) of $1^{st}/2^{nd}$ orders is 3.33 that of 2^{nd} $/3^{rd}$ orders is 6.0. The value of drainage density (D) is 1.016 whereas steam frequency (F) is 0.32. The elongation ratio (R_l) of the basin is 0.576 and circularity ratio (R_c) is 0.45. The values of form factor (R_f) is 0.26, infiltration number (l_f) is 0.325 and overland flow (l_g) is 0.491

KAMAN SUB-BASIN

The Kaman sub-basin covers an area of about 796.87 km^2 in the northern part of the district. The basin perimeter (P) is about 110.25 km and maximum basin length (1_b) is 46.25 km. The total number of streams (N_u) of various orders is 33 out of which the number of 1^{st} order streams is 25, the number of 2^{nd} order is 5, the number of 3^{rd} order is 2 and 4^{th} order is 1. The total stream length (l_u) of all orders is 214.25 km. The length of 1^{st} order stream is 102.5 km that of 2^{nd} order is 30.5 km length of 3^{rd} order is 41.25 km and that of 4^{th} order is 40.0km. the bifurcation ratio (R_b) of $1^{st}/2^{nd}$ orders is 5, that of $2^{nd}/3^{rd}$ orders is 2.5 and between $3^{rd}/4^{th}$ orders is 2.0. The values of stream length ratio for $2^{nd}/1^{st}$ orders is 0.2, for $3^{rd}/2^{nd}$ orders is 0.4 and for $4^{th}/3^{rd}$ orders is 0.5. The value for drainage density (D) is 0.269 and stream frequency (f) is 0.041. The elongation ratio (R_e) of the basin is 0.689 and circularity ratio (R_c) is 0.823. The value of form factor (R_f) is 0.372, infiltration number (I_f) is 0.011 and overland flow (l_g) is 1.859.

Table 4.1

Drainage Morphometric Analysis

Drainage Parameter	Kakund sub-basin	Banganga sub-basin	Gambhir sub-basin	Kaman sub-basin
Stream order				
1st order	20	31	63	25
2nd order	6	8	6	5
3rd order	1	1	3	2
4th order	-	-	1	1
Total	27	40	83	33
Stream order length in kms.				
1st order	52.00	106.25	181.00	102.50
2nd order	26.50	49.00	70.75	30.30
3rd order	7.25	18.75	19.50	41.25
4th order	-	-	18.25	40.00
Total	85.75	173.00	289.50	214.25
Bifurcation Ratio (R6)				
1st/2nd order	3.33	3.87	3.93	5.00
2nd/3rd order	6.00	8.00	5.33	2.50
3rd/4th order	-	-	3.00	2.00
Stream length Ratio				
2nd/ 1st order	0.50	0.45	0.39	0.20
3rd/ 2nd order	0.27	0.39	0.27	0.40
4th/3rd order	-	-	0.93	0.50
Parameter in (P_1) kms.	48.50	86.00	141.25	110.25
Basin length (l_b) in kms.	18.00	33.75	42.00	46.25
Area in sq. km	83.375	259.375	534.375	796.875
Drainage Density (D)	1.016	0.667	0.541	0.269
Stream frequency (F)	0.320	0.154	0.155	0.041
Basin elongation (R_e)	0.450	0.440	0.336	0.823
Infiltration number (I_f)	0.325	0.102	0.084	0.011
Form factor (R_f)	0.260	0.227	0.302	0.372
Length of over land flow (L_g)	0.491	0.749	0.923	1.859

Source: Calculated by Researcher.

STREAM FREQUENCY

Stream frequency is an index for denoting the unquestionery process for fluvial erosion system. It is controlled by various factors viz. climate, underlying rock and vegetation. Stream frequency is the number of streams per unit area which has been calculated for the present study by Strahler's Method taking a unit of one square of two centimeters. The formula is as following:

$$\text{Stream frequency: } \frac{\sum N}{A}$$

Where,

$\sum N$= Total number of streams in the unit area and

A = Area of the unit

The stream frequency is governed by rainfall intensity, erosional proportionality factor, evaporation, infiltration rate, characteristics of rocks and run off.

Table 4.2

Stream Frequency Distribution

S. No.	Size class	Frequency	cumulative	(%) frequency	(%) Cumulative
1.	0.00-2.00	292	292	55.19	55.19
2.	2.00-5.00	217	509	41.02	96.21

Source: Calculated by Researcher

The above table illustrates that most of the frequencies are concentrated in the first size class.

Table 4.3

Categorized Distribution of Stream Frequency

S.No.	Size Class	Category Area of the Total	Percentage
1	0.00-2.50	Low	88.33
2	2.50-4.50	Medium	10.28
3	4.50 & above	High	1.38

Source: Calculated by Researcher

In the present study of the Bharatpur district stream frequency ranges from 0.00 to 5.00 streams per square kilometers. Considering the range of values, stream frequency has been divided into three different categories namely low, medium and high. The above table 4.3 portrayed details of the category of stream frequency in the district.

1. The Area of Low Frequency

The area below 2.50 stream frequency lies in this category. It is concentrated in the south-west and south eastern parts of the Bharatpur district. The category of low frequency covers a significant area of about 88.33% of the total area. It shows the fact that this category covers the maximum area of the Bharatpur district. It mostly occurs on the plains and foothills areas of the district which are compose of alluvial soils.

2. The Area of Medium Frequency

The category of medium frequency consist the 2.50 to 4.50 streams per square kilometer. It is falling on about 10.28 percent of the total area. It is noticed in the central south-west part of Bharatpur district.

3. The Area of High Frequency

The last category covers an area of merely 1.38 per cent with the stream frequency of 4.50 and above stream per square Kilometers. This category falls almost in the areas of high attitude.

The study reveals that the distribution of stream frequency is quite uneven. The lower category shares a major part of the district which is obvious in the plain area.

There is rapid increment of area upto second size class which exhibits that larger portion of frequencies lie in these size classes. Comparatively a small proportion of frequency has been observed in the third size class.

Bharatpur district falls in parts of Ruparel, Banganga and Gambhir River Basins. Tehsilwise distribution of basin area in given in Table. 4.4.

Table 4.4
Tehsilwise Distribution of Basin Area

S. No.	Name of Tehsils	Area in river Basin (sq. Km)		
		Banganga	Gambhir	Ruparel
1.	Pahari	3		483
2.	Kaman	119		314
3.	Nagar	162		308
4.	Deeg	398		
5.	Nadbai	439	0.4	
6.	Kumher	508		
7.	Bharatpur	468		
8.	Weir	508	274	
9.	Bayana	48	483	
10.	Roopbas	61	466	

Source: Calculated by Researcher.

All the Rivers in the district are ephemeral in nature. River Banganga, which passes through the south central part of the district, disappears in the sandy tract near Ghana. Gambhiri River flows in the southern part, where as Ruparel flows in the northern part. Drainage density in the northern and central part varies between 0.2 and 0.3 Km/Km^2 whereas in the southern part, it varies from 0.3 to 0.5 Km/Km^2.

IRRIGATION RESOURCE

For sustainable agriculture development soil and water inputs are most important. In Bharatpur district, three types of Irrigation resources are in vogue. They are tube-wells, wells and canals, besides, the natural inflow of water from the bunds and streams also serve as irrigation source. Bharatpur district as a whole accounts for about 32.16 percent area under irrigation by source of total geographical area. Further Bharatpur tehsil has about 37.94 percent irrigated area and Nadbai and Weir tehsils have about 55.57% and 39.74% irrigated area respectively. Bharatpur receives water from the Banganga river while Nadbai and Weir which are agriculturally well developed, have mostly tube-well irrigation as the main source. Because of the Gambhir river irrigated area in Roopbas tehsil account for 32.25

percent. Contrary to this, Deeg, Nagar and Bayana have lesson percentage of irrigated area. The position of different source of irrigation is presented in Table 4.5.

Table 4.5

Irrigation by Source 2000-2015 (in Hectare)

Tehsils	Tube wells	Wells	Canals	Tanks	Other	Total Average Irrigated	Total Geogra-phycal Area.
Bharatpur	14928.3	162.65	87.45	-	3659.90	18969.45	37.94
Kumher	11633.55	506.0	6.00	-	17.88.10	13448.50	29.71
Nadbai	21198.25	1201.5	-	-	2179.50	24823.65	55.57
Deeg	10530.75	111.45	-	0.7	64.80	10843.45	21.65
Nagar	10753.75	424.55	376.60	-	1385.45	12599.95	26.76
Kaman	9160.85	183.60	953.35	-	133.85	10412.75	29.48
Pahari	10225.85	183.90	-	-	145.60	10571.85	27.81
Bayana	8587.3	8025.90	1563.70	15.3	382.30	18845.95	23.44
Weir	19321.8	4790.35	-	-	310.70	24396.05	39.74
Roopbas	13200.8	3344.85	962.80	-	401.60	17707.60	32.25
Total	130733.30	18971.65	3947.35	16.05	10453.6	163119.85	32.16

Source: Land Record (Revenue), Collectorate, Bharatpur.

Tubewell irrigation is the most popular means of irrigation in Bharatpur, which constitutes 80.15 percent of the total area. The well irrigation by traditional method is the next important source with 11.63 percent of total average irrigated area. At present canal irrigation is only 2.42 percent area. In Nadbai, Weir and Bharatpur tehils tubewell irrigation is very popular, while in Bayana tank irrigation is also done.

CHAPTER-5

MORPHOMENTRY ANALYSIS

MORPHOMETRIC ANALYSIS

Morphometric analysis referes as the quantitative evaluation of form characteristics of the earth surface and any landform unit. We have discussed upon various geomorphic processes in the previous chapters. The present chapter presents a detail synthesis of the morphometry. Morphometry in general terms means the measurement and mathematical expression of the configuration, shape and dimension of earth form.

Many geomorphologists have put in their best effort in morphometric analysis of a region. Some of such geomorphologists were Dixit (1960), Hack (1960), Bose (1961), Clarks (1966), Strahler (1971), Thomas (1972), Agarwal (1972), Pal (1972), Bannet (1975), Sharma (1977-78), Mackinder (1887) and Wentworth (1957) are worth mentioning in this context.

ANALYSIS OF RELIEF

The highest value of relief at 450 meters is noticed near Ludhawai village of Bharatpur tehsil while the lowest value of relief at 300 meters observed near Bacchamandi village of Weir tehsil.

The analysis of relief of Bharatpur district indicates three distinctive zones of high, medium and low relief.

1. ZONE OF HIGH RELIEF

The zone ranges from 450 to 600 meters. This zone captures a small zone mainly in extreme southern part (Bayana tehsil), some parts of north-east (Kaman, Bharatpur and Roopbas tehsils) and little areas in south-west (Weir tehsil and Nadbai tehsil). Geologically it is a geotectonic zone formed mainly by the Vindhyan sediments lying on the archean formation. A major portion of the district is covered by the recent and sub-recent unconsolidated sediments on which ravines are still developing.

2. ZONE OF MEDIUM RELIEF

It ranges from 300 to 450 meters. This zone covers mainly the north-western (Pahari tehsil and Nagar Tehsil), little areas of northern part (Kaman tehsil) and southern part (Bayana tehsil). Geologically it includes Vindhyan Super Group formations, Gwalior formations and alluvial plains. The villages covered by this zone are Akbarpur Meo (Nagar tehsil), Balraka (Nagar tehsil), Badha (Nadbai tehsil), Chhatarpur (Nadbai tehsil), Baisora (Bayana tehsil), Damdama (Bayana tehsil), Madhogarh (Pahari tehsil) etc.

3. ZONE OF LOW RELIEF

The zone of low relief ranges between 150 to 300 meters. It covers the maximum areas of Kumher, Weir and Roopbas tehsils. Some part of it is also traced in the north of Pahari tehsil and Kaman tehsil. It is basically flat plain area. Geologically, it is formed by Vindhyan Super Group formations and alluvial plains.

SLOPE

The study of slope is one of the most significant aspects of geomorphology. Slope is an angular inclinations of terrain between the hill tops and the valley bottoms. It is an important factor in the physical conditions resulting from various geomorphological processes. The physical landscape is obviously no more than an assemblage of such slopes, and the dimensions and appearance of the slopes given to any area is essential for morphological character.

Slope is defined as the angular inclinations of terrain between hill tops (crest) and valley bottoms, resulting from the combinations of many causative factors like geological structure, climate, vegetation cover, drainage texture and frequency, dissection index, relative relief.

Slope introduces complexities and variations in the landscape of a region. There is no exaggeration in saying that geomorphology is primarily a study of slopes. It is considered to be the most important aspect of geomorphology, thus the study of slope is not only important from academic point of view. The study of slopes in geomorphology is given more importance because not only slopes do comprise the greater part of landscape but as an integral part of the drainage system they provide water and sediments to the streams. Keeping this fact in mind the regional slope analysis has been done of the study area that may prove helpful and is also correlated with the next part landuse. Davision (slope decline) and Penckian (parallel retreat and slope replacement) models of slope development belong to this phase of qualitative study of slopes. Modern phase is dominatd by quantitative analysis of slopes based on data derived from topographical maps and aerial photographs, measurement of slope angles of the study area, instrumentation of processes acting on the hill slopes. The work of R.A. Savigear, A Young, Waters etc. belong to this phase. Besides significant contribution to slope analysis has been made by T.L. Rich (1916); C.K. Wentworth (1930); AC Lawson, E. Raize and J. Henry (1937); R.E. Horton (1945), H. Baulig (1935); W.C. Calif (1940); A. Wood (1942); L.C. King (1953); A. N. Strahler (1980); D.M. Miller and C.H. Summarsoo (1960), Young (1961, 1963, 1972); Savinder Singh and R.S. Pandey (1982; 1987); Savinder Singh and S. P. Agnihotri (1982) etc. But in the present research work the method proposed by Wentworth has been used, as it is most widely used and convenient method of slope determination for the preparation of slope zone Map.

The formula is as follows:

$$\text{Tan } \Phi = \frac{N}{L} \times \frac{V.I.}{3361}$$

Where,

Tan Φ = Slope angle in tangent values.

N = Number of contour Crossing in a grid

V.I. = Vertical Contour Interval.

L = Length of the grid in kilometers.

3361 = Constant value of sin Φ

The Bharatpur district also has a complex tectonic and geomorphic history. The great boundary fault movement in the cretaceous period has thrusted the older Gwalior towards the younger Vindhyans. As a matter of fact, the district possessed both endogenetic and exogenetic slopes. The endogenetic slopes, subsequently are altered, obliterated and modified by exogenetic processes acting on them thereby complicating the nature of slopes in the district.

A slope map (Fig.5.1) of the study area has bean prepared by using Wentworth's formulae. The map itself is an indicator of the regional wise slope values in the district.

The district gently slopes from north-west to south–east. After calculating the tangent values, the desired degrees have been in Table 5.1

Table 5.1

Bharatpur District Slope Analysis

S. No.	Slope in degrees	Area in sq. km.	Percent of the total area	Remarks
1.	Below 3^0	4388	78.61	Level
2.	3^0-5^0	543	9.73	Gentle
3.	5^0-10^0	574	10.28	Moderate
4.	Above 10^0	77	1.38	Moderately steep
	Total	5582	100.00	

Source: Calculated by Researcher

The above table reveals that a major portion of the district i.e. about 79 percent has a level land. It has proved helpful in the construction of canals, roads and agricultural fields. Less than 2 percent of the area has steep and hilly slopes, mostly lying in the central hilly region. Rest of the area, i.e. about 20 percent has a slope varying from 3^0 t0 10^0, lying specially in the transitional belt between the hills and the plains. The 'Barad' and 'Kherad' area have moderate slopes.

The dominance of level and gentle slopes suggests the levelling is being done by the denudational processes. The north-western plains have a number of isolated hillocks, hence the areal variations in the slope can be observed. The general slope of the district is towards the south and the west to north-east. A glance at the relief and slope maps, reveal a great relation, i.e., higher the altitude greater is the slope. A significant factor of this analysis is that the south-eastern plateau has an elevation of more than 150 meters but the slope variation is not very significant. It is due to the table – land character of the region.

The slope values of the district have been categorized into four generalized size classes as given in Table 5.1.

1. **Level Slope of Low Land Plains** (Below 3^0)

   Level slope of lowland plains covers large part of the district. This includes large parts of Bharatpur, Bayana and Weir tehsil.It occupies a significant area of about 4388 square kilometers, i.e. 78.61 percent of the total area of the district. Most of this lies in the recent and sub-recent alluvial plains. The average heights of this category range between 220 to 260 meters. The slope of the land is less than 10 meters per kilometers.

2. **Gentle Slope Zone** (3^0 to 5^0)

   This Zone is noticed along the eastern boundary of Pahari tehsil. This gentle slope covers an area of about 543 square kilometers, which is 9.73 percent of the total area. The extension of this category is upto 260 to 340 meters height. The slope of the land is between 10 to 20 meters per kilometer.

3. **Foothills and Hill Tops of Moderate Inclination** (5^0 to 10^0)

   The slope Zone of 5^0 to 10^0 covers an area of 574 square kilometers (10.28 percent) of the total area. This Zone is observed in form of patches in south-east Roopbas, north-west Nagar and north-east Deeg. This zone covers very less portion of the district. In the eastern part of the district it is on the Vindhyan formations. The general elevation of this category varies from 340 to 450 meters. The land slope of this zone layers from 20 to 80 meters per kilometers.

4. **Hill tops With Steep Inclination** (Above 10^0)

   This zone covers the least part of the district i.e. only 77 square kilometers and forms 1.38 per cent of the total area. This zone includes south-central Kumher tehsil where Vindhyan hills runs. The slope of the land is more than 150 meters per kilometers and general elevation is also more than 450 meters.

REGIONAL SLOPE DISTRIBUTION

In the present case study the average slope map (Fig. 5.1) and an enumeration of areal distribution of the slope shows is less than 3^0 which indicates the uneven nature of the slope throughout the entire area. About 9.73 percent of the total area lies between slope group of 3^0 to 5^0, while the moderate slope values lie between the range of 5^0 to10^0 covering 10.28 percent of the total area, whereas the highest slope values of more than 10^0 covers only 1.38 of the total area. The general land of the district varies from 328 meters to 546 meters from the sea level. The land gently slopes from north-west to south-east. In this district the maximum slope values ranging between $25^0$29'to $75^0$16' is noticed around Gwalior system and $25^0$35' to $75^0$49' is noticed around Vindhyan system, both these ranges run in the northern and central part of the district. There lithology is basically associated with folding and faulting. On the other hand the minimum values of slopes have been observed in the alluvial plains between Gambhir, Chambal, Banganga, Barah, Parwati and Rooparel rivers.

The study of regional slope analysis plays a dominant role in the agricultural, civil engineering, road and urban planning. Especially the agricultural practices are very much influenced by the slope changes. Therefore, the study of regional slopes are of immense use for practical

purposes.

SLOPE HISTOGRAM

The slope histogram (Fig. 5.2) shows that the maximum values of the frequency of occurrence 343 has been noticed at an angle of less than 3^0 slope. The next surface exhibiting the frequency of occurrence 85 is between 3^0 to 5^0 slopes. The third observed frequency of occurrence 32 is noticed at an angle between 5^0 to 10^0 slopes. The last and the uppermost frequency 7 are noticed at an angle of more than 10^0 slope (Fig. 5.2).

The slope histogram also reveals that there exists inverse relationship between the frequency of occurrence and slope, which means the frequency of occurrence decreases with an increase in the degree of slope, thus both variables exhibits a negative function.

Table 5.2

Frequency Distribution of Slope Values Bharatpur District

S. No.	Slope category	Frequency	Cumulative frequency	Frequency (%)	Cumulative frequency (%)
1.	<3^0	343	343	78.61	78.61
2.	3^0-5^0	85	428	9.73	88.34
3.	5^0-10^0	32	460	10.28	98.62
4.	7-10^0	7	467	1.38	100.00

Source: Calculated by Researcher.

The above table 5.2 depicts frequency distribution of slope values in Bharatpur district.

ANALYSIS OF HILL SIDE SLOPES

In different parts of the world a large number of studies have been done on the hill side slope, a new branch of geomorphology. There are three theories of slope evolution which are termed as slope decline by WM Davis (1909), slope replacement by Penck (1927) and parallel retreat by King (1957). Besides the pioneer studies of Davis; Penck and King, the contribution of Savigear (1952), Culling (1963), Young (1963), Birot (1949), Wood (1942), Fair (1947) and Strahler (1952-54) are worth mentioning and they have worked on this problem in different environment. In India, the problem of slope evolution has been studied by Pandey (1968), Rai (1971), Subramanyan (1976), Sharma and Padmaja (1977-78) and Kumar (1978).

It has been postulated by Davis (1909) that in the most temperate zone, slope declines and he stated that slope flattens during the progress of erosion cycle from youth to maturity to old age. The valley sites are reduced under weathering and surface creep to smaller and smaller angles on the contrary, it was Penck’s thesis

(1927) that steep slopes retreat without loss in their inclination and that steepness disappears only because upper part of the ridge is consumed. Gentle slopes replace steep slopes only when the gentle gradients below the ridge meet at the divide. Penck's ideas were further testified by Baryan (1940), Fair (1947), King (1949) and Pollister (1956). They suggested that in hot semi –arid regions parallel retreat of slopes is prominent. Davis (1930) advocated that in hot semi arid regions parallel retreat of slopes in prominent. Davis (1930) advocated that the climate exerts a dominant influence on the development of hill slope. Birot (1949), Fyre (1959), Campana (1958), Galon (1954) and Savigear (1952) stated that where the weathered materials from the hill slopes are washed of completely, parallel retreat of slopes takes place, but where the transportation is impeded the slope declines. King's theory claims for more than either of others and involves a more serious departure from the view proposed by Davis. It has points of contact or affinity with the views of both Penck (1927) and Wood (1942) and one of its chief virtues is its critical scrutiny of processes gained by first hand observations of slope undergoing denudation Woolridge and Morgan (1959), King (1957) recognized four elements in a hillside slope; the waxing slope, the free face, the detrital slope and the waning slope. Dumanowski (1960) supported the uniformitarian theory of King and stressed that similar hill slope elements had developed in humid, monsoon and arid climates. The findings of Dumanowski in Egypt are in conformity with findings of Dresch (1949) in Mediterranean Africa. Strahler (1952) stressed the importance of geomorphic processes for influencing the slope development.

Oliver and Tudder ham (1962) worked out the developments of slopes at coober peddy in South Australia. Young (1963) has also studied and suggested a technique of slope measuring and mapping. Culling(1963) has formulated a mathematical model of slope development and soil creeps under humid climate.

Keeping in view, the close scrutiny of various above mentioned contrasting view on the evolution of hill slopes an attempt has been made here to testify and analyze the validity of various theories.

The problem of evolution of hill side slopes and the analysis of processes forming elements of slope is more complicated then the analysis of regional slope. The evolution of hill side slope through time has provided more lively discussion than perhaps any other aspect in geomorphology. Several geomorphologists have analyzed the hill slope in different parts of the world situated in different environments.

SLOPE FORMING FACTORS AND PROCESSES

Many processes rather than a single one are responsible for the form of hill slopes and in addition the evidence suggests that changes occur on slopes much more slowly than in stream channels. For this reason, less is known about the combination of processes which are occurring on hill slopes in various environments. Recently Dresch (1949), King (1957), Twidale (1960) and Dumanrowski have stressed the over riding importance of structure in the formation of slope. Worth of weathering and mass movement processes and work of running water also influence the slope formation.

The hill side slope forming factors and processes vary with reference to the varying environment. Structure, climate, relief and vegetation are the basic factors which play a vital role in slope formation. In the present area hill side slope has been formed due to the combined result of weathering, mass movement, soil creep, soil wash or surface wash and sheet erosion.

ELEMENTS OF SLOPE FORMATION

Being a reason of diverse rock type difference in lithological and structural characteristics the weathering processes and the environmental factors dominate in different parts of the district.

During the study of hill side slopes of the district it was marked that in the Vidhyan country and Aravalli hills have all the four elements in well developed form or in some places they are still developing. It was found that due to the physical and mechanical weathering the plant roots along the joints and fault aid in the widening of joints and fractures and led to the physical disruption of rocks. These disintegrated pieces of rocks generally fall down from the crest and scraps in bedded pieces and accumulate in the form of scree. It is interesting to note that in the Aravalli system (Gwaliors) shales are much less friable and fissibe, compact, have thicker layers, harder transverse by rectangular prismatic joining. Therefore due to mechanical weathering they break into sharped brick or tile like fragments. In the present study Bharatpur district, field observation reveals the presence of following slope elements.

1. Crest (waxing slope)
2. Scarp (Free face)
3. Debris slope (Constant slope)
4. Pediment (waning slope).

CHAPTER-6

EXISTING LANDUSE

Land has been the important and fundamental resource and the medium of production from ancient times. Therefore every region whether that is plain, plateau, field, uneven /rough terrain, it points towards the historic background of cumulative social level and regional unstable geographical facts. On the other hand it also develops the side of nature as resources provider. Geomorphology and local environment plays a major role in life and living standard of man.

Atharva Ved describes the importance of land and water as “Let the earth put us into the same rich fortune which were enjoyed by our predecessor, upon which flourish the Oceans, great rivers and other types of water, which causes and produces different kind of grains and other vegetation, and which nourishes all the breathing and moving animals. The total land available sets the limits within which the competing human needs have to be met. The needs of agriculture industries and other domestic uses often result in diversion from one use to the other. Diversion of agricultural land uses to non-agricultural land uses distinctively affects the growth in agricultural sector. Even the available land is cope up with the problems of soil erosion and degradation of different magnitude. Water is a important natural resource that supports all forms of life on this mother earth that plays an indispensable role in agricultural and industrial development and sustaining human life. The only source of water is rainfall. The water is limited as (i) soil moisture (ii) stored water in surface storage like reserviors, tanks, ponds and in open wells etc. (iii) ground water in sub-surface (iv) sea water (iv) waste water like sewage and effluent. Depending upon the rainfall, its intensity and frequencies, an area becomes drought or flood affected. Land or the soil acts as storage for all the water. Land being the major non-renewable natural resource is inelastic in nature. Due to the increasing population there is lot of pressure on land on the other hand, the land is subjected to soil erosion and land degradation problem due to rain or wind action and faulty cultivation practices resulting in loss of top soil, in which all nutrients are available. This leads to poor yields, uneconomic returns, reservoir sedimentation, reduction in storage capacity and shutdown in hydropower stations, ecological imbalance, environmental pollution, droughts and floods. Hence the conservation, development and management of the land resources which ensures the physical, chemical and biological health of soil profile is of prime importance and there should be provision for water resources management, right from soil moisture, conservation to flood control. Achieving agricultural development on an ecologically sustainable basis can be attained only when conservation, development and management of land and water resources are assured.

PATTERN OF LANDUSE

Landuse evolves the management and modification of natural environment or wilderness into built environment such as fields, pastures and settlements. A coherent of account geomorphological and hydrological features of the region would help in showing the relationship between landforms and agricultural development. The analysis and distribution of various types of soils helps in studying the problems of water logging. Landuse is a significant aspect of agricultural study. In order to increase the food production, a proper utilization of land resources is very necessary. Landuse in the district indicates that in the commanded area planned use of land resources has started after the introduction of canal irrigation in 1960.

In the Bharatpur district, the net area sown and the total cropped area have had a very meagre increase in a decade for years (2000-01 to 2006-07 to 2012-15) in which the study has been done for. It has increased from 3,33,917 hectares (2000-01) to 3,44,272 hectares (2006-07) to 3,71,313 hectares (2012-15) and 2,52,313 hectares (2012-2015). On the contrary there are some areas, specially ravine lands, where the use of land resources are still inadequate due to the lack of water supply, presence of ravines and ignorance of the cultivators consequently, there has been a increase in the double cropped area in the district i.e. 81,560 hectares in 2000-01 and 10,89,09 hectares in 2006-07 and 11,73,40 hectares in 2012-2015).

The present chapter proposes to examine the general and existing landuse pattern of the Bharatpur district keeping the above facts in mind. Land use statistics have been taken from the publications of the Statistical Department, Collectorate, Bharatpur and Land Records Department, Collectorate. Tehsil level statistics of ten tehsils were used for analyzing the distributional pattern of general landuse (Fig. 6.1).

The census of India has classified land utilization in different categories and some has been done in present study table 6.1 (2000-01, 2006-07, 2012-15) brings out the main elements of landuse in Bharatpur district as a whole (Fig.6.2). In table 6.2 land utilization has been grouped into major landuse categories, as the percentage of area under individual categories is relatively insignificant.

Table 6.1

Land Classification of Bharatpur District (2000-2015)

Tehsils	Total Geographical Area	Forest	Non-Agri. uses	Usar	Net sown area	Gross sown area
Bharatpur	50131	2854	5656	15	38225	56408
Nadbai	44493	0	2717	17	39123	63480
Deeg	50092	1042	2826	2189	42221	58028
Nagar	46937	0	2757	1996	40563	59767
Kaman	35388	3240	1827	772	28100	43865
Bayana	80386	19302	3521	8233	41896	69080
Weir	33422	5631	1679	865	23431	39980
Bhusawar	27974	927	1678	995	22846	38332
Roopwas	54911	646	3194	2624	46117	69226
Kumher	44980	3	2946	31	41021	56176
Pahari	38017	0	1333	3781	29786	44354

Source: District Statistical Abstract, Bharatpur

Table 6.2

Major Landuse Categories of Bharatpur District (2000-2015)

Description	Years									
Total Geographical Area (506731 Sq. Km.)	2000-03	2003-05	2005-07	2007-09	2009-10	2010-11	2011-12	2012 -13	2013-14	2014-15
1. Forest	6.20	6.48	5.98	5.98	5.98	6.64	6.64	6.64	6.64	6.64
2. Non-Agricultura-ble land										
(i)Land used in other than agriculturable uses	7.45	5.85	5.85	5.92	5.92	5.92	5.92	5.92	5.92	5.92
(ii)Usar	2.96	2.96	4.24	4.26	4.75	4.75	4.72	4.75	4.75	4.75
Total	10.13	10.13	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17
3. Other uncultivated land excluding fallow land										
(i) Permanent Pasture land	1.50	1.51	1.51	1.51	1.51	1.73	1.74	1.74	1.75	1.75
(ii) Horticulture	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Total	2.02	2.02	2.02	2.05	2.05	2.06	2.07	2.08	2.07	2.08
4.Fallow land (i) Other fallow land	1.70	1.70	1.72	1.72	1.72	1.74	1.74	1.76	1.76	1.79
(ii)Current fallow land	1.12	1.12	1.12	1.12	1.14	1.14	1.17	1.17	1.17	1.68
Total	2.81	2.81	2.81	2.82	2.82	2.88	2.88	2.89	2.89	3.47
5.Net sown area	77.20	77.20	77.20	77.22	77.24	78.22	78.22	77.62	77.62	77.62
Total	100	100	100	100	100	100	100	100	100	100
6. Gross sown area	115.15	115.11	117.80	117.80	117.80	116.80	116.71	116.71	116.71	118.14
7.Landuse more than once	38.50	38.50	38.50	39.56	39.56	38.42	38.50	38.50	40.52	40.52

Source: District Statistical Abstract, Bharatpur

The above 6.2 table shows that at the district level forest area is constant. But Bharatpur district has shown major increase while other tehsils have depicted constant increase. In the category of area not available for cultivation the land put to non-agricultural uses have shown increase in all the tehsils due to the accelerated erosion by rivers. Along with it the barren and uncultivable land has also shown constant increase. The other uncultivated excluding fallow land in various categories has shown overall decline in the district. Net area sown in the district has shown stability due to bad land topography, flood hazards and hilly areas. The area under total cropped area is discernable in the district due to increase in settlements and roads. Area sown more than once has increased and concentrated to some tehsils due to the availability of water for irrigation, provision of manures and nature of crops the farmers intend to grow.

GENERAL LANDUSE IN BHARATPUR DISTRICT

Landuse involves the management and modification of natural environment or wilderness into built environment such as fields, pastures and settlements. It has also been defined as "the arrangements, activities and input people undertake in a certain land cover type to produce or to maintain it."

According to Rajasthan Statistical Abstract, change in landuse pattern is the inclusion of many reasons which is determined according to physical format of culture and art. On the otherhand future plannings and various types of development schemes are based on local resources. As per Directorate of Economics and Statistics, Rajasthan, land use pattern has been categorized into five major types. This landuse pattern is full of complexity in every region but here it is analyzed on the basis of following points:

1. Forest and grassland region.
2. Land not suitable for agriculture
   (a) Land under non-agricultural uses
   (b) Usar or land not suitable for agriculture
3. Uncultivable land excluding fallowing
   (a) Permanent Pastures
   (b) Horticulture and tree crop

(c) Wasteland

4. Fallowing

   (a) Other than current fallow

   (b) Current fallow

5. Net sown area

Table 6.3

General Landuse in District Bharatpur 2015

S. No.	Landuse	Area (in hectare)	% of the total land
1	Forest	33645	6.64
2	Uncultivable land	21518	10.19
3	Other uncultivated land excluding fallow land	30134	2.07
4	Fallow land	7543	3.47
5	Net sown area	506731	40.52

Source: District Statistical Abstract, Bharatpur

Total geographical area of the district is 50,67,31 hectares. Table 6.1 and table 6.3 depicts the general land use categories both at tehsil and district level (Fig 6.3). The sailent features which are discernible in the intra regional variations may be identified as follows:

1. Forest land is more in the south, south-east, west, north-west (Bharatpur District) than in the north-east, south-east, east and occupies significant proporotions of the uplands of the Vindhyans and Aravallis (Fig. 6.4).
2. The area of the barren land and uncultivated land is significant in hilly tracts, ravines, stony waste and sandy lands.
3. The proportion of fallow land is also high all over the south, north-west, north-east of the district, as the irrigation facilities are limited and the rainfall, too, is scanty and confined to the south-west monsoon season alone.

4. The net area sown is confined to fertile lowlands lying in the south and the east and the uplands with relatively good soil cover.

1. FOREST

This category includes all areas under forest under any legal enactment dealing with the forests. Forest in the district area covers about 7% of district's area. The forests are mainly found in Bayana, Weir, Roopbas and Bharatpur tehsils of the district (Fig. 6.4). In the year 2014-2015, 6.64% of the total land was under forest and of this 6% of area is under protected forests and 0.62% of area is the forest of Bharatpur district falls under central India dry deciduous type Dhok or Dhad *(anogeisseus pendula)*, Khair *(Acacia catecheu)* as the main species. The other trees found are Arjun *(Acacia leucopholea)*, Dhak *(Butea-mansoperma)*, Ber (*Zizyplus mauritiana*), Kachnar *(Bauhinia racemosa)*, Kurchi *(Hollrrhena anti dysenterica)*, Birbira *(Dichrosta chys cinera)*, Hingot *(Balanites Aegyptica)* and Jharber (*ziziplus mummulalaria*), besides this Babul *(Acecia nilotica*), Kadam (*Mitragyau parviflora*), Kabuli Kikar (*Prosopis julilora*), Karil *(Kapparis deciduous*) are also found. One of the important products of economic value found in Bharatpur is 'Khas'. The forest of this district falls under central India, dry deciduous type (Fig. 6.5).

The district has a national park known as 'Keoladeo Ghana' which is a famous as breeding place for Siberian Cranes. Most of the dense forests are situated on the main exposures of Aravalli series. These series are very well stocked with valuable species of Anogeissus pendula, which is gregarious. The escarpments are covered with trees of fair growth and density and the slopes are also fairly well covered. The different types of forest found in the district may be further classified as Dhok forest, Khair forest, miscellaneous forest, Ravine Scrub, Grassland and degraded forests. In Bharatpur district Bayana and Weir tehsils had the highest and dense forest (1% and 3% respectively). Area under forest gradually decreases as one moves from south-west to north-east part of the district. Tehsils Nagar and Kaman have very small area under forest.
The remaining tehsils have depicted constant increase in the forest area.

2. LAND NOT AVAILABLE FOR CULTIVATION

This category consists of land put to non-agricultural uses i.e. undulating terrain. With or without scrubs, rock out crops, built up land and water bodies, hills, river beds, ravine infested areas, railways, building etc. According to statistical figures 2.07% of reporting area was classified as land not available for cultivation. The district has 2.96 percent in 2000-01, 4.26 percent in 2001-02, 4.26 percent in 2002-03, 4.75 percent in 2003-04, 4.72 percent in 2004-05, 4.71 percent in 2005-06, 4.71 percent in 2006-07, 4.76 percent in 2007-08, 4.76 percent in 2008-09, 4.02 percent 2009-10, 4.56 percent in 1995-10, 4.24 percent in 2010-11, 4.24 percent in 2011-12, 4.25 percent in 2012-13,4.25 percent in 2013-14 and 4.24 percent in 2014-15 of such land. A sustainable part of the district is rugged being unfit for cultivation. Tehsil of Bharatpur district concentrated more than 4.76 percent in tehsils of Nagar, Roopbas and Kaman and less than 4% percent (total geographical area of respective tehsil) in the remaining. As mentioned earlier, barren land area is more in Bayana tehsils, accounting for15% of the total reporting area.

3. OTHER UNCULTIVATED LAND

This category of land consists of:

(i) Cultivable waste

(ii) Permanent pastures

(iii) Land under miscellaneous tree crops and groves

The cultivable waste land is that land which can be used for cultivation, but the same is not being taken up for cultivation at all, or having been cultivated for some time, has not been cultivated successfully for more than five years. Most of this category of land lies in isolated blocks or within cultivated holdings. In Bharatpur district this category was reported to some extent in each of the tehsils where Bayana tehsil has one third of the total area under this category. Weir, Kaman, Deeg were the other tehsils having concentration of such lands. Culturable wastelands in these tehsils are not presently under cultivation but the same can be reclaimed for agriculture and fodder crops through suitable measures. Area under permanent pastures and tree crops was also higher in those tehsils having higher proportion of cultivated wasteland, which may be ascribed to low fertility of land and concentration of livestock population. By adopting suitable measures these areas may be turned into rich grazing grounds as well as for raising of fodder crops.

In Bharatpur district, the area of the other uncultivated land excluding fallow land was greater in 2014-15 in the tehsils of Bharatpur with 2.07 percent. In most of the tehsils this was found to be about 1.30 percent. In the district as a whole it was 2.15 percent.

Permanent pastures and other grazing lands are earmarked in every village at the rate of 0.12 hectare per cattle head according to the settlement rules. Bayana tehsil of Bharatpur district has the maximum pasture land. The lowest pasture area is in Kaman tehsil, because of cattle population.

4. FALLOW LANDS

The terms fallow is applied to lands not under cultivation at the time of reporting, but which have been sown in the past. Fallows are divided into two categories – (a) fallow land which has not been cultivated for three to five years (b) current fallow which was not cultivated for one year only i.e. the current year. For present study, however these two categories are grouped together. The total of fallow land and net area sown gives the extent of ‘arable land’ in contrast to land that is not cultivated at all.

Fallowing is that agronomic practice where a cultivable land holding is left unutilized for last agricultural years. If an agricultural field remains fallow for last agricultural year then it is defined as current fallow. Other than current fallow, is the agricultural land holding which has been cultivated during last five years except current fallow land. In India, fallowing has been widely practiced as a natural way of preserving soil nutrient lost during agriculture. In this way soil remains fertile for larger duration.

Bharatpur district had experienced around 3.47 percent area under land use category of fallow land other than current fallow. Other fallow land in the district has reported marginal increase and then decline with same intensity. But, there were many significant changes during the study period. Nadbai tehsil has noticed comparatively higher incidence of this type of fallowing but it has reported gradual decline. Bharatpur, Roopbas and Nadbai have observed significant increase in the share of other fallow land. Changes in fallow land is shown in Fig. 6.7 & Fig. 6.8.

Bharatpur district records 3.47 percent of land under fallow lands. According to table 6.4 the area of the fallow lands in different tehsils increased from north to east and south west to south. It was lowest in Bhusawar tehsil (400 hectares). In Bayana 3138 hectares, Nadbai 2338 hectares, Bharatpur 2916 hectares, Pahari 2297 hectares, Roopbas 1638 hectares and Nagar 1320 hectares (Fig. 6.6).

Table 6.4

Pattern of Fallow Land (2000-2015)

Tehsils	Fallow Land (In hectares)	
	Current fallow land	Other fallow land
Bharatpur	1505	1141
Nadbai	653	1685
Deeg	514	457
Nagar	740	580
Kaman	462	469
Bayana	1154	1884
Weir	543	390
Bhusawar	211	189
Roopbas	593	1037
Kumher	343	429
Pahari	1833	464

Source: District Statistics Office, District Bharatpur, Rajasthan.

5. NET AREA SOWN

India has largest net sown area in the world and around 45 per cent area has been reported as net sown area. Rajasthan is the largest state of India. But net sown area is less because of Thar deserts. Bharatpur, on the other hand reported very high proportion of net sown area where 77.62 per cent of the total geographical area has been classified as net sown area. This high proportion of land under net sown area has made it one of the best agriculturally developed district of India. The district has experienced 2 percent increased in the share of net sown area during the study period (Fig.6.9). In fact, during first half of the study year net sown area decreased by 0.5 percent but the later half had observed positive growth (1 per cent) of net sown area. It means agriculture is practiced in more than three fourth area of the Bharatpur district.

The tehsilwise distribution of net area sown in the 2012-15 is shown in Fig. 6.9 and Fig. 6.11 and Changes in net shown area between years 2007-15 is shown in Fig. 6.10. The tehsils of Bharatpur district, Bharatpur (38225 hectares), Nadbai (39123 hectares), Deeg (4221 hectares), Nagar (40563 hectares), Kaman (28100 hectares), Bayana (41896 hectares), Weir (23431 hectares), Bhusawar (22846 hectares), Roopbas (46117 hectares), Kumher (41021 hectares) and Pahari (29786 hectares). The lowest area was recorded in Bhusawar (22846 hectares) tehsil of the district (Fig.6.11). The lowest area net area sown was due to a large portion of area under hills, ravines and forests. Landuse area statistics of Bharatpur district is shown in Fig. 6.12.

Table 6.5 Illustrates that five tehsils is of high intensity and two of medium classes are situated in plain and hilly areas of east and south-west parts.

Table 6.5
Net Sown Area & Intensity of Bharatpur District

Tehsils	Area of Net Area Sown (in hectares)	Intensity
Roopbas	46117	Very High
Deeg	42221	Very High
Bayana	41896	Very High
Nagar	40563	High
Kumher	41021	High
Nadbai	39123	Medium
Bharatpur	38225	Medium
Pahari	29786	Low
Kaman	28100	Low
Weir	23431	Very Low
Bhusawar	22846	Very Low

Source: Calculate by Researcher.

The reason behind stability of net area sown is lack of good quality soils increase in ravine erosion and unequal irrigation intensity.

6. DOUBLE CROPPED AREA

This category of land represents the area on which crops are cultivated more than once during the agricultural year. The density of cultivated land and production of cereals, pulses and commercial crops in 2000-01 in the different tehsils of Bharatpur district have been described. In 2000-01 the area under double cropping was very limited. Only on 14266 hectares of land the double – cropping was practiced. In all the tehsils of the district, it was below 20.6 percent. Pahari Tehsil had the lowest area under double cropped area in only 14568 hectares.

In 2006-07 the maximum area of double cropped area was found in Bayana (27184 hectares) and Nadbai (24357 hectares). Kumher has shown decline or say constant stability over the district. It is to some extent due to the non profitable nature of farming, decline of soil fertility, low rainfall, inadequate irrigation facilities and negligence of ignorant farmers towards the intensification of agriculture.

TOTAL CROPPED AREA

The large parts of the district are level, owing recent and sub-recent deposits of alluvial soils. Sub-recent area are undulating or rolling in nature. 118.14 per cent of the total geographical area is under cropped land which is discernable from table 6.2.

From the point of view of tehsilwise differences the total cropped land very from a maximum of 38332 hectare in Bhusawar tehsil to a maximum of 69226 hectares in Roopbas tehsil.

Tehsilwise distribution of the total cropped area in the year 2000-2015 is clear from table 6.1. Tehsils Roopbas and Bayana had shown highest area under total cropped area i.e. Roopbas (69226 hectares) and Bayana (9080 hectares). Bhusawar and Weir tehsils has shown lowest area under total cropped area i.e. Bhusawar (38332 hectares) and Weir (39980 hectares).

CROP ASSOCIATION REGIONS (BASED ON INSPECTOR LAND REVENUE CIRCLES)

Just as natural vegetation is supposed to be the index of its geographical environment; crops do to a great extent exhibit the influence of their natural as well as cultural and technical background. Therefore, geography of crops forms an integral part in a landuse study. But rarely does a crop grows in incomplete isolation. It is always grown in company of some other crops, either simultaneously or in succession.

Recently the study of combinational analysis in geographical studies has increased greatly and the importance of this type of study is increasing day by day. Any study of crops on the regional scale must take into consideration the combinational analysis and the relative position of the crops. The studies of combinational analysis will ultimately minimize the chance of oversimplified generalization. A general understanding of the particular combination of crops and relative importance of each in an area may be helpful in interpreting some aspect of social and economic geography of the region and this will also reflect the variable positions of the individual crops.

Such studies are fruitful in many ways, firstly it provides an adequate understanding of an individual crop geography; secondly crop combination is in itself an integrative reality that demands definitions and distributional analysis and lastly such regions are essential for the crop construction of still more complex structure of valid agricultural regions. Moreover crop-combination regions may be used to evaluate if a particular combination would lead to dietary adequacy or inadequacy in the essentially agricultural landscape.

In this research work, an attempt has been made to study the crop association regions with a view to (i) testing the procedure of combinational analysis in an essentially agricultural region with vast agricultural potentialities and diversity of crops, and (ii) evaluating the consistency or otherwise crop association regions that emerge in the final analysis in order to interpret the role of local environment, if any, in the formation of these regions. Following symbols can be used for various crops S-sugarcane, B-Bajra, J1-Jo, J2-Jowar, M-Maize, O-Oilseeds, R-rice, W-wheat.

Percentages of 'gross cultivated land' occupied by individual crop will be calculated in order to assess the relative land occupancy position of each crop. Crops occupying less than one percent of gross cultivated land will be left out of consideration since they occupy a negligable acreage in comparison to the major crops of the region. The percentage will be arranged in ascending order and the ranking of crops will be marked for delineating crop combination regions.

The method of assessing the relative strength of individual crops is to rank them according to their importance; the crop occupying the highest acreage being the dominant crop. The problem is not only to point out the dominant crop and neglect others, but it is to group all the major or primary crops thereby delineate some obvious patterns of the crop associations. This is done, by grouping together the crops ranking as first, second and third and so on each unit.

A number of statistical procedure have so for been introduced to demarcat the crop-combination region or set of elements that play significant role in any particular system. A most valuable formula of crop – combination analysis was advanced by the J.C. Weaver in 1954 in his study on the crop combination regions in the Middle West. For determining combination having minimum deviation Weaver calculated deviation of real percentages for all the possible combinations in the unit considered against a theoritical standard which was obtained by dividing 100 per cent in one crop, 50 per cent in each of two crop – association, 33.3 percent in each of three crop – association regions and so on. To start with Weaver's formula has been applied in research work also. The Weaver formula is as follows:

$$\delta = \sqrt{\frac{d^2}{N}}$$

$\delta =$ Value of crop combination

D= difference between actual crop percentage in a given unit and
appropriate percentage in the theoretical curve.

N = Number of crops in a given combinatioin.

Weaver method require much calculation work so it is an an improvement over Doi's method. According to him the combination having the smallest $\sum d^2$ will be the combination formed by the major crops only. It was found that the results are more realistic in comparison to those worked out by other methods. It is easy in calculation within a short time. Doi's modified formulae is as follows:

$$\delta = \sum d^2$$

Rafiullah also introduced a new deviation formula which, although affected by the laborious calculations is quite suitable for sharp delineation in the primary crop–combination. The formulae introduced by him are:

$$\delta = \sqrt{\frac{Dp^2 - D^3 n}{N}}$$

D_p = Positive difference

D_n = Negative difference from the medical value of the theoretical curve value of the combination.

n = number of functions in the combination

Therefore (all the above 3 formulaes have been applied) to know the diversity of crop–combination found in Bharatpur district.

The study of crop combination regions constitute an important aspect of agricultural geography as it provides a good basis for agricultural regionalization and same is applied on Bharatpur District. The crops are generally grown in combinations and it is rarely that a particular crop occupies a position of total isolation in a given areal unit at a given point of time.

In Bharatpur district, the cultivation of crops is the dominant economic activity and of the total reporting area of about 506731 hectares represent the net sown area. In order of the area covered by the most important crops are rice, wheat, sugarcane, Jowar, Maize, Bajra, Jo and Oilseeds. These crops occupy about 96 percent of the net cropped area, but because of double cropping their total area actually represents 80 percent of the gross cropped area. Crops occupying less than one percent of the gross cultivated area have not been included as they occupy an insignificant area. The agricultural statistics relate to the district unit and are the averages of fifteen years (2000-2015).

The first or first two or first three crops and so on, occupying the major area of the gross cropped land are selected on the basis of their areal strength i.e. area occupied by each one of them in a given year.

Monoculture is not prevalent in the district and farmers generally follow diversity cropping patterns, there is no merit in adopting this method (first ranking crops) for the delineation of crop combinations as it helps in ascertaining the areas of dominance of the first ranking crops. About 165750 hectares of area was covered by wheat, 106969 hectares of Bajra and 46113 hectares Jowar in the district.

In the year 2000-01 wheat, Jowar, Bajra and Jo have dominated the region. Wheat was dominant crop grown in all the tehsils. Bajra was the dominant crop mainly in Bhusawar tehsil.

The role of various physiographic formulations include soil characteristics and water conditions. Drainage, climate etc. are significant in many respect viz. it in shaped a definite type, character, direction of development etc. in increase of production in a year.

In the year 2006-07 wheat, Bajra, Jowar and Jo have been the dominant crops gram. Reason behind the increase in production of these crops was that the soils are calcareous in nature with organic carbon and nitrogen contents, still they are comparatively fertile.

Therefore the crop diversification or combination implies obtaining of the maximum number of crops from the soil. The differential multiplicity of cropping in the areal units is partly the result of the interactions of variable agro-climatic phenomena and partly the differential effects of economic and cultural forces. Such crop production associations are the outcome of recognizable variants, such as, the considerable intensity of irrigation, the fertile soil cover, the high agricultural density and the marketing facilities.

CHAPTER-7

AGRICULTURAL METHODS AND TECHNIQUES

The regional economy of the Bharatpur district is dominated by the agricultural and associated activities but the main methods and techniques employed in the farming vary from one part to the other. Variation in the agricultural practices are due to several physio-economic factors. The nature of relief, degree of dissection of flood plains, socio-economic background and the degree and extent of mechanization individually or collectively influence agricultural methods and techniques in the district under study.

The agriculture in the district is making shift from farming towards irrigation. But still there are some areas viz. ravine lands and hilly tracts where the method and techniques of cultivation are old fashioned and more properly are backward vis-à-vis the agricultural development. The relief features, nature and extent of slope are main factors which retard the implementation of new methods and improved implements in this area.

This chapter deals with land holdings, agricultural implements, manures and fertilizers, improved agricultural practices, research programmes, soil conservation works and water resource development and its effects.

LAND HOLDING

Land holding is an important aspect of agricultural methods and techniques because a large number of holdings are declared as uneconomic. New agricultural technology is natural to the size of the farm, still there is a minimum size of the farm below which farming becomes unprofitable, whatever the technology used in it. Another problem of land holdings in the district is that they are not found in one compact block. These are mostly subdivided and scattered all over. It affects the yield per acre as well as the type and quality of implements with which the farmers of the district work. The average size of holding in the area varies greatly from one place to another depending upon the heterogeneity of land forms. The average size of the holding in the district comes to 3.6 hectares. (Table 7.1)

Table 7.1

Average Holding in Different Parts of the Bharatpur District (2015)

1.	Tube wells irrigated lands	5.0 hectares
2.	Ravine lands	6.0 hectares
3.	Hilly regions	1.6 hectares

The average size of holding in the district is comparatively greater in some areas (2-2.4 hectares) but smaller than some district (4.8-5.2 hectares). The low average holding in the hilly tehsil of the Bharatpur district seems to be due to the lack of accessibility into small areas that could be brought under cultivation. The average size of the holding is far greater in the ravine infested villages than in the commanded area and the hilly section.

Besides smaller size of the average holding in the district, most of the holdings are scattered and fragmented. On account of fragmented small holdings and conventional aversion of farmers, it is difficult to follow new methods and improved agricultural practices and thus modernisation is lagging behind in the district. Regarding this problem, Mehta (1958) has recommended the adoption of the system of rectangularisation on the lives of Punjab with suitable modification. His recommendations have been executed in the canal irrigated region and this pattern has facilitated the layout of irrigation channels and the efficiency of irrigation. In a few villages of the commanded area the system of rectangularisation is being adopted.

The causes of scattered and small size of operational holdings which are either marginal or sub-marginal are:

(i) Growing population in the district on the fixed supply of land.

(ii) The law of inheritance where land of the father gets divided among all his sons.

(iii) Decline of joint family system.

(iv) Decline of handicrafts and village industries displaced village artisans and compelled them to take refuge in agriculture which increase pressure on land and resulted into smaller holdings on a large scale.

(v) Absence of organized credit institutions, the money lender would annex part of the land holding of the borrower leaving only a very small holding.

(vi) Family attachment to landed property is such that sufficient or not they will remain attached even to a small piece of land rather than look out for alternative employment.

AGRICULTURAL IMPLEMENTS

The land resources in the country being limited, the additional production will have to be achieved by increasing the use of agricultural inputs like high yielding variety seeds, fertilizers, pesticides, improved agriculture implements, credit technology and irrigation.

But the agricultural implements which are commonly used in the Bharatpur district are old fashioned and the improved agricultural implements such as tractors, iron plough, razor, sprayer, helho, seed driller and winnower have recently come in vogue and are not in very extensive use. A country plough known as hal, the bukher, leveller, spade, sickle and sowing baskets are the only equipments that the average farmer possesses in the district. Even an iron plough is not in common use in the district. This is because of its heaviness and difficulty in repairing locally. The use of tractor in agriculture of course, is very recent, but it is extensively used in Nadbai, Kaman and Bayana tehsil. Lack of labour and grow more food campaigns are responsible for the advent of mechanisation of cultivation in the district due to the reduction in the cost of cultivation; tractors are becoming more and more popular. But its high price, costly maintenance and operation are beyond the capacity of the average farmers.

The modern implements are not common in the ravine infested area of the district. Firstly, the available land for cultivation in these tracts is undulating and the tractor is inoperable in these areas. Secondly, the water table in low, irrigation facilities are limited and the use of manures and fertilizers are uncommon so these factors collectively affect the crop production adversely. The low crop production means the poor status, farmers of ravine infested land are unable to afford the cost and maintenance of tractors and modern implements as well.

MANURES AND FERTILIZERS

The use of manures and fertilizers is not a common practice in the Bharatpur district except the area under irrigation (Banganga and Gambhir Commanded Area). Low yield of crops in the area at present is largely due to the lack of supply of plant nutrients to the soil. After every harvest the soil becomes poorer in plant nutrients which are not made up by the application of manures and fertilizers. Most of the areas, specially the ravine lands and hilly areas do not receive any kind of fertilizers either organic or inorganic.

Among the plant foods, nitrogen and phosphorus are by far the most important ones for the soils of the district. The Table 7.2 gives the amount of nitrogen and phosphorus required by some of the major crops every year in the district.

Table 7.2

Amount of Nitrogen and Phosphorus used by some Major Crops every year in Bharatpur District

Crops	Nitrogen (Lbs)	Phosphorous (Lbs)
Mustard	50	16.5
Maize	32	21
Wheat	50	21
Sugarcane	90	180
Rice	30	20
Oilseeds	18	10.5

Source: The Agriculture Department, Bharatpur.

The agriculture department, Bharatpur has tentatively fixed doses of nitrogen and phosphorus for different crops (Table 7.3)

Table 7.3

Requirement of Nitrogen and Phosphorus in the form of Manures and Fertilizers per acre for Different Crops in the Bharatpur District.

Crops	Nitrogen (Lbs)	Phosphorous (Lbs)
Maize	40	30
Rice	40	30
Cotton	60	40
Groundnut	-	30
Rabi Fodder	20	80
Cereal	30	15
Legume	20	30
Green Manure (Sanai & Guora)	-	40
Sugarcane	100	100
Wheat	40	30
Rabi Pulses	-	20
Oilseed	20	-

Source: The Agriculture Department, Bharatpur.

At present, farm yard manure is more commonly used by the average farmers, but unfortunately most of the cow dung produced is used as a fuel due to the lack of firewood supplies. In Bayana, Deeg, Kumher tehsil, in the Bharatpur districit there is a lack of firewood. Therefore, most of the cow dung produced is used as a fuel by the average cultivators. In these tehsils manure supplied at the rate of 15 to 30 cart load per acre. Use of fertilizer is receiving a great change due to the wide propaganda through the Agriculture Department and Block Development Scheme, yet it is limited to a few crops like sugarcane, wheat, maize, jowar, mustard and rice in the district. A great stress is being laid on the conservation of organic manure, use of green manure and fertilizers. Since 2001-02, 10 per cent of the irrigated area in the commanded Area, Bharatpur district was kept for growing green manure crops which has to keep increasing 5 percent every year according to five year plans.

In order to encourage the large scale use of fertilizers and proper doses according to the soil fertility status, the Department of Agriculture, Bharatpur, Rajasthan has started taking soil samples from all Panchayat Samities of Bharatpur district, so the cultivators get information about the status of their land and may also know the response of fertilizers in relation to their soils. It is proposed by the government to have similar surveys of the land under each Panchayat Samiti. Atleast once every year.

The use of manure and fertilizers is still uncommon in the some tehsils of Bharatpur district. Ignorant farmers of these badly eroded tehsils of the district even do not know how to conserve manure and how to utilize chemical fertilizers. Besides this Agriculture Department, Bharatpur, have not yet taken concrete steps to popularize it in villages and encouraging the use of organic and inorganic fertilizers. In his presidential address to the twelth international conference of soil science in February, 1982, Dr. J. S. Kumar while outlining the major soil problems stated that “nutrient deficiency is the major limiting factor for crop production in the most of the world’s soil.”

IMPROVED CROPS

One of the methods of increasing food production in the district is to introduce improved methods of rice and wheat cultivation and the use of new variety of seeds. The Japanese method of rice cultivation has found some favour in the district. But as the method requires the application of heavy quantities of compost and chemical fertilizers, adequate supply of water, careful selection of seeds and considerable labour in transplanting the seedlings and in hoeing the field regularly.

The Sankar Jowar and Maize have also found some favour in Bharatpur district. The yield per acre of this variety has been reported larger than local variety. In Kumher tehsil new varieties of wheat have also been introduced by the state agriculture department, Rajasthan. Common varieties of wheat in this part are C581, NP718, Malvi, Kalyansona and C236. A few advanced cultivatore have started growing these new varities. The results have been found encouraging.

Rice is comparatively important crop in the district as it requires a heavy soil with plentiful supply of water. But the some areas of Bharatpur district that are close to the river of Bharatpur district prepare land a month before sowing and transplanting. The field is usually watered and puddled twice or thrice and then levelled by means of a pata before transplanting the seedling or sowing the germinated seed. In Bharatpur, Roopbas, Kaman tehsils the rice production has increased i.e. 19277 hecatres (Bharatpur tehsil), 17838 hectares (Roopbas tehsil) and 15930 hectares (Kaman tehsil) in the year 2014-2015. Along with this farmers and producers both will get the facility of audio visual system which will keep both the parties aware of new facilities coming in the market.

RESEARCH PROGRAMMES AND DEMONSTRATION

In the recent years, in order to get an answer to all the needs due to change from dry to wet cultivation in the Bharatpur district, research farms and demonstration centers have been established. The following research farms are significant for the problem of irrigation agriculture.

All types of problems relating to irrigation and agriculture are studied, examined and undertaken in farms are:

1. Selection of new variety of paddy, wheat, groundnut, sugarcane crops etc.
2. Working out water requirements of important crops and the study of different methods of irrigation.
3. Working out cultural methods like time of sowing seed rates, spacing and optimum doses of fertilizers for all the important crops.
4. Study of different types of crop rotation with 100 percent to 300 percent intensity.
5. Study of change in physical and chemical nature of soils as affected by different methods of irrigation and crop pattern.
6. Study of diseases and pests for the new introduced crops.
7. Study of seepage losses along the river side.

The efforts are being made to make the farmers familiar with the improved practices at the earliest, essential simple demonstrations trials regarding improved varieties, fertilizers methods and rate of water application is done on cultivator's fields on a large scale. This will not only educate peasants but will confirm the results obtained on government farms.

SOIL CONSERVATION WORK

Soil conservation is the use of land, within the limits of economic practicability, according to its capabilities and its needs in order to keep it permanently productive. Soil conservation work has been done with the mutual cooperation and collaboration of the forest and agriculture department in Bharatpur district. It is confined to the reclamation of ravines and afforestation of a very few of the easily accessible ravines and gullies near Gambhir and Banganga river. The Tehsils where the soil conservation work has been done are Bharatpur, Kaman, Deeg and Bayana tehsils. About 8,301,324 hectares of area is under ravine lands in Bharatpur district.

Realising the importance of such a magnitude of national importance, The Government of India, Ministry of Food and Agriculture, established a soil conservation and research centre at Bharatpur district. Marginal Bunds are constructed along the periphery of ravines to control the run off from the table lands and agricultural fields passing over the ravine heads.

Due to the above measures the ravine infested area was covered by thick natural vegetation according to landuse capability consisting of Acacia arabica, Prosopsis juliflora, Balanites roburji and Cenchrus setigerus etc.

At the bottom of the barren ravines, brushwood and bolder check dams were put which functioned well in reducing the flow of water. The vertical side of the ravines in the centre were established by providing vegetative cover. Ipomea carnea has proved to be very effective on the toe of the side walls.

Haopblia Integrifolia (80 percent survival), Pongamia Glabra (95 percent survival), Glyricida Maculata (65 percent survival), Albizia leble (80 percent survival) and Azadirchta Indica are a useful economic forest species in the ravine lands. Bamboo has also been introduced in the graded ravine bottom, one year old seedlings were planted in 1½ x 1½ x 1½ pit dug at the bottom of ravine and has given 73 percent survival. An experiment trial has also been introduced of hybrid eucalyptus species and teak plantation on the marginal and ravine lands and its survival percentage has been good and the results were quite encouraging.

Experiments on soil under different vegetative covers below 2^0 slopes have been made in Bharatpur district. Among the various kinds of vegetative covers – natural cover, cultivated fallow, cynadon dactylon, groundnut, blackgram and Jowar have been tried in the district. Natural cover and cynadon dactylon gave minimum soil and water loss; black gram and groundnut gave intermediate loss, while maximum soil loss was reduced in Jowar and cultivated fallow pits. Among the cultivated crops groundnut gave the minimum soil and water loss and thus this is recommended for the introduction into the cropping pattern so as to reduce the erosion losses. The soil conservation work at present is confined to those gullies and ravines which are at 5 meters depth. Contour bonding levelling and graded contouring are most commonly used method of reclamation in the district.

WATER RESOURCE DEVELOPMENT

The Chambal is the only perennial river and the possibility of harvesting the water resource is sufficiently good. Because of this, considerable work on the water resource development has taken place in the district. The priority has been given to the agriculture and water resources development particularly for irrigation and water supply. It has been possible to construct storage dams at various places in the district which are as follows:

Chambal –Dholpur-Bharatpur Water Supply Project

Chambal is the Rajasthan's only river that flows throughout the year.

This project is designed to supply drinking water to Dholpur and Bharatpur district, keeping in mind drinking water requirement of year 2016. Ground water level of Bharatpur district is saline in nature. It is getting further saline due to ions dissolved by land degradation day by day.

Chambal-Dholpur-Bharatpur project is being proposed to supply pure and clean drinking water to Bharatpur and Dholpur district.

Project will be completed in 2 stages both Ist and IInd stage of this project will take into account the following regions: (on the basis of counting year 1991).

- 154 villages of Bharatpur region.
- 111 villages of Kumher region.
- 141 villages of Roopwas region.
- 165 villages of Nagar region.
- 120 villages of Deeg region.
- 109 villages of Kaman region.
- 130 villages of Pahari region.

Thus, in total 930 villages will be benefitted.

In the second stage of project, drinking water from Chambal river is being proposed to be supplied to 89 villages of Bharatpur along with Deeg, Kaman, Nagar, Kumher, Roopbas and Pahari region. The 2nd stage of project is designed keeping in mind the drinking water requirement to 2031.

Table 7.4

Summary of Chambal-Bharatpur-Dholpur Drinking Water Scheme

Ist Stage : Part-1

- Design year – 2016
- Beneficiary City Region – Bharatpur
- Beneficiary village Region –
  (i) Dholpur Region – 69 villages
  (ii) Bharatpur Region – 143 villages
- Beneficiary city population, 2016 – 405684
- Beneficiary village population, 2016 – 395580

Proposed water quantity – 59.48 MLD

Ist Stage : Part-2

- Design year – 2016
- Beneficiary City Region – Bharatpur, Kumher, Deeg, Nagar, Kaman
- Beneficiary village Region –
  (iii) Dholpur Region – 69 villages
  (iv) Bharatpur Region – 930 villages
- Beneficiary city population, 2016 – 568514
- Beneficiary village population, 2016 – 1724702

Proposed water quantity – 130.32 MLD

2nd Phase

- Design year – 2031
- Beneficiary City Region – Bharatpur, Kumher, Deeg, Nagar, Kaman
- Beneficiary village Region –
  (v) Dholpur Region – 69 villages
  (vi) Bharatpur Region – 930 villages
- Proposed Beneficiary city population, 2031 – 7,95,920
- Proposed Beneficiary village population, 2031 – 24,14,583

Source: Office, Chambal – Dholpur, Bharatpur River Project Department, Bharatpur (Rajasthan).

Table: 7.5

Villages to be Benefitted Under the Project

S. No.	Tehsils (Bharatpur district)	No. of Villages to be Benefitted					
		Ist Stage		IInd Stage		IIIrd Stage	
		(1991)	(2001)	(1991)	(2001)	(1991)	(2001)
1	Bharatpur	75	75	79	82	154	157
2	Kumher	40	43	71	74	111	117
3	Roopwas	28	28	113	114	141	142
4	Nagar	-	-	165	164	165	164
5	Deeg	-	-	120	119	120	119
6	Kaman	-	-	109	114	109	114
7	Pahari	-	-	130	132	130	132
	Total	143	146	787	799	930	945

Source: Office, Chambal – Dholpur, Bharatpur River Project Department, Bharatpur (Rajasthan).

CHAMBAL RIVER VALLEY PROJECT–WATER MANAGEMENT

Rajasthan Government has developed Chambal Project to meet the water demands of Bharatpur district. It is still under construction phase.

It would be beneficial if it should be managed keeping in mind the geographical features of state. During the monsoon season when water level is increased and much of the water is wasted, the water can be diverted to Gambhir and Banganga River, thus preventing the damages due to floods in Chambal.

Moreover, water can be brought from Chambal River to Gambhir River near Shree Mahaveer Ji by constructing a canal, and this water can be further shifted to Banganga River through feeder Canals by constructing a small dam near village Kalsara in Karuli region of Bharatpur district. This will raise ground water level of Banganga region.

This Chambal water can be further transferred to Ruparel River by constructing small dam on Banganga River near Kala-Pahad.

In this way, ancient irrigation practice of Bharatpur district can be rejuvenated. Along with it, requirements of drinking water, irrigation can also be met and water needs of Keoladev National Bird Sanctuary can also be fulfilled.

The Bhimlet Project

Another project of irrigation is the Bhimlet Project. The construction of the dam is 15 meters high across the river Mangli, was started in the first five year plan (1953-54) and it is now complete. The canal system has also been completed and it consists of a kilometer of main canal and 8 kilometers of minor canals. It is estimated that the final irrigation capacity will be 1240.00 hectares (3,100 acres) of land.

IRRIGATION

Irrigation is always synonym with agriculture. From ancient to modern era irrigation has been around for as long as humans have been cultivating plants. Archaeological investigations have proved that from ancient Egyptians until the middle of 20th centrury, irrigation technology, water transfer and agriculture system were prevalant. Irrigation can be defined as the replacement or supplementation of rain water with another source of water. It is a science of artificial application of water to the land or soil. However when relates to agriculture, irrigation is one of the major section to assist in the growing of agricultural crop.

OTHER SOURCES OF IRRIGATION

Bharatpur district has total geographical area of 507073 hecares. The area under irrigatioin is 365071 hectares which is about 41.53 percent of the total geographical area (Fig. 7.1). From Irrigation point of view Bharatpur district has been divided into Deeg and Bharatpur Divisions. Nadbai, Kumher, Bharatpur and Weir tehsils come under Bharatpur division comprising 52 dams in which rainy water is being released through canals and river irrigation. Under Deeg division come 185 villages of Kaman, Pahari and Deeg tehsils for irrigation. Irrigiation department has built ‘Guargaon Canal’ whose total length is 53 km. Pahari, Deeg and Tail distributes have been taken from ‘Gurgaon Canal’ and total length of their rivers and distributaries comes to 276 km. The total area irrigation by different means of irrigation in 2016-17 is 365071 hectares and the total area under irrigated sources and non-irrigated sources is 242662 hectares. The main sources of irrigation in the district are tube-wells. (Table 7.1) Prominent rivers of the district are Banganga, Gambhir, Ruparel and Chambal. Important river basins are Banganga, Gambhir and Ruparel. There are only four medium irrigation projects namely:

1. Baretha (Bayana), Capacity – 1860 CCA in hectares
2. Ajan (Lower) Bharatpur, capacity – 500 CCA in hec. capacity
3. Chambal Project
4. Bhimlet Project

In addition to these, several minor irrigation projects also exists in the district viz. 20 in Bayana, 42 in Weir, 22 in Bharatpur, 11 in Nadbai, 44 in Roopwas, 9 in Kumher, 8 in Deeg etc.

Table 7.6

Tehsilwise Irrigated Area by Different Sources

S. No.	Name of Tehsils	Total Irrigiated area (in hec.)	Irrigated area (in hec.)				
			Tube wells	Wells	Ponds Lakes	Canals	Other
1	Bharatpur	36822	4203	0	0	1	-
2	Bayana	37070	2901	18	0	9	-
3	Deeg	33163	3654	0	0	-	-
4	Kaman	21981	1417	3	0	17	-
5	Kumher	35411	3179	6	0	-	-
6	Nadbai	38538	7001	0	0	-	-
7	Nagar	36156	2237	0	0	-	16
8	Pahari	26918	3421	0	0	-	-
9	Roopbas	40707	4791	38	0	5	
10	Weir	22089	2434	13	0	-	-
11	Bhusawar	19840	2625	9	0	4	-

Source: Calculated by Researcher

The main sources of irrigation in the district are tube wells, wells, canals and tanks. The total irrigated area by different sources is given in Table 7.5. Amongst the various sources of irrigation the tube wells account for the largest area in the district. While wells account for the second largest area in the district (Fig.7.2), canals occupy the third place in Bharatpur District under the sources of irrigation (Fig. 7.3). The ravines and hilly sections are insignificant from the point of view of Tube well irrigation. This is chiefly because of the complicated relief features for constructing Tube wells and limited agricultural land. After the introduction of Tube wells irrigation, the agriculture is making shift from dry farming towards irrigated farming. Due to the expansion of tube wells irrigation facilities the following changes in the agricultural pattern have been noticed in the Bharatpur District.

1. After the introduction of tube well irrigation new crops like Paddy, sugarcane, Cotton (Hybrid), Maize, Jowar and fodder crops have been introduced in some villages of the commanded area in the district. Although the change in the cropping pattern is very slow but it is believed that as a result of extensive efforts by Agriculture Department, these new crops shall gradually replace the old crops in the Tube wells irrigiated tracts. It is also expected that this change will accentuate the use of the Tube wells and wells water properly.
2. Per acre yield of Wheat, hybrid Maize and Jowar is also increased with expansion of irrigation facilities. The increase in yield per acre is due to the expansion of irrigation facilities, use of fertilizers and introduction of new varieties of Wheat, hybrid Maize and Jowar. The yield per acre in most of the villages has increased but the regions where problem of water logging is there has been a decrease in per acre yield of Wheat, Jowar, Maize and Gram in Bharatpur and Bayana tehsils.

   The table 7.5 indicates Bayana and Bharatpur tehsils are covered significant area in well irrigation. In these tehsils, the tube wells form more than 60 percent of the total irrigation area (Fig. 7.4). The table 7.5 also indicates a marked decrease in Bhusawar, Deeg and Pahari tehsils. Due to this declining trend in the irrigated area, the tehsils of the ravine and hilly tracts are legging behind in agricultural development Water from the wells in the region is lifted by means of either the persian wheel locally known at Rohat where the water level is high or by means of buckets known as Charas which are either made up to leather or iron and are used where the water table is low.

   Total irrigated area net and gross irrigated area shown in Table 7.7.

Table 7.7

Tehsilwise Net and Gross Irrigated Area (2014-2015)

S. No.	Tehsil		Net Irrigated Area		Gross Irrigated Area	
	Name	Area	Area	% of total area	Area	% of total area
1	Bharatpur	36822	23217	45.56	23546	46.21
2	Bayana	37070	23487	29.04	24296	30.04
3	Deeg	33163	11619	23.57	11678	23.69
4	Kaman	21981	11468	34.01	13597	40.32
5	Kumher	35411	18517	40.74	18585	40.89
6	Nadbai	38538	32424	72.58	32538	72.84
7	Nagar	36156	13798	29.65	14463	31.08
8	Pahari	26918	11499	29.95	13451	35.04
9	Roopbas	40707	36889	49.88	27140	50.34
10	Weir	22089	29855	49.22	31189	51.34
11	Bhusawar	19840	20146	50.22	23219	41.30

Source: District Statistical Abstract, Bharatpur

A detailed study of Irrigation in the district reveals that (i) the highest percentage of area under irrigation by all sources is concentrated in the area of Vindhyan hills and river basin (ii) percentage is highest in those tehsils where the preponderance of tube wells exist (iii) the areas growing Wheat, Jowar, Maize, cover highest percentage under irrigation (iv) the areas which are either hilly or ravine infested have lowest area under irrigation.

The total irrigated area has increased in all the tehsils (Table 7.7). The expansion is conspicious in the tehsils of the district (Fig.7.5, Fig. 7.6). It is because of the provision of expansion of tube wells. On the contrary, there has been a little progress regarding irrigated area in the hilly and ravine infested tehsils of north-west and north-east (Fig. 7.6). The table 7.3 shows the expansion of total irrigated area in the tehsils of Bharatpur District.

Table 7.8

Expansion of Total Irrigated Area in Bharatpur Distrtict

S.No.	Tehsils	Total Irrigated Area in Hectares		
		2012-13	2013-14	2014-15
1	Roopwas	39788	39800	40707
2	Nadbai	39019	39020	39089
3	Bharatpur	37191	37195	38000
4	Bayana	36922	36922	37060
5	Nagar	35434	35440	36156

Source: District Statistical Abstract, Bharatpur

Apart from the projects described above, the irrigation department of Rajasthan has undertaken surveys for the flowing river project in the district. Very little work has been done on the availability and the use of ground water in the district. However, the under ground water department is considering the possibility of investigation and use of ground water in those parts of the area where there is scarcity of Tube wells, canals water and surface water.

The water table in the district indicates that the ground water level fluctuates with the rhythm of rainfall. It also depends on the local lithological condition and porosity of sub soils. The water table in the plain areas varies from 10 meters to more than 20 meters. The water level near dams and canals is usually high. While in the ravine infested regions of the district, it seldom occurs below 20 meters. The low water table to a great extent retards irrigation development.

In the hilly sections of the district, the wells are few because of stony nature of the terrain. So in these tracts underground water resources should be developed along the pediment zones, where the possibility of sub-surface water is immense.

TEHSILWISE IRRIGATED AREA UNDER DIFFERENT CROPS

Tehsilwise irrigated area under different major crops in Bharatpur District (2014-15) is shown in Table 7.8.

Table 7.9

Tehsilwise Irrigated Area under Different Crops

(Area in Hectares, 2012-15)

Tehsil	Bajra	Wheat	Gram	Jo	Rice	Mustard	Potato
Bharatpur	0	19277	53	217	31	16758	831
Nadbai	0	14143	1	184	0	24128	336
Deeg	0	15278	15	365	464	18356	281
Nagar	0	14818	1	297	0	20267	18
Kaman	19	15930	17	152	1160	10961	14
Bayana	0	20471	163	218	2	15582	60
Weir	0	9108	22	62	0	12348	53
Roopwas	0	1738	85	426	166	20430	454
Kumher	0	13059	2	264	6	16562	625
Pahari	0	015567	0	305	74	10309	6
Bhusawar	0	10251	55	91	0	9327	48

Source: District Statistical Hand Book, Bharatpur.

CHAPTER-8

CROPPING PATTERN

A large proportion of Indian population has always sought its livelihood from the soil and even today its majority of population as Indian agriculture is crop oriented. The large size of Indian sub-continent accounts for the diversities in agricultural practices. These are made possible by considerable spatial and temporal variations in climate resulting from differences in the rainfall over immensely varied soils and the form of surface, by variably intensity of irrigation, human elements, and distribution of natural resources. Collectively or singly, these factors exert profound influence on agricultural economy of India thus resulting in marked regional differences in the matrix of the geography of agriculture.

Agriculture with its allied occupations of animal husbandry and dairying, forms the main basis of the economy of Rajasthan. Although rich in minerals, the resources have been developed fully thus changing the basic agricultural economy of the state. Agriculture is the main occupation of the people. Almost 79 percent of its population is engaged in agriculture and allied pursuits for their livelihood. Agriculture contributes about 55 percent to the state's total income.

After analyzing inter tehsil variation on various aspects such as demographic features, land holding pattern, gross cropped area, gross irrigated area, rainfall pattern etc. in the previous chapters, this chapter focuses on inter district variation in cropping pattern and changes in it over the period.

This chapter deals with tehsil wise cropping pattern of different crops in Bharatpur district *viz*. cereal crops – Wheat, Bajra, Maize, Barley and all other cereal crops. In pulses crops Moong, Moth, Gram and all other pulses, total food grains crops, in oilseeds crops Groundnut, Sesamum, Soyabean, Rapeseed and Mustard and other oilseed crops, Cumin, Coriander, Cotton, Guar and all crops in state (Fig. 8.1).

The cropping pattern follows two distinct seasons; Kharif Season from July to October and Rabi Season from October to March. The crops grown between March to June called Zaid. The crops are grown solo or mixed (mixed cropping) or in a definite sequence (rotational cropping). The land may be occupied by one crop during one session (mono-cropping) or by two crops during one season (double cropping) which may be grown in a year in a sequence.

1. The yearly sequence and spatial arrangement of crops or of two crops and fallow on a given area.
2. The cropping pattern indicates the percentage of area under different crops (table 8.1) and at a point of time cropping activities go on all the year round in India provided water is availed for the crops.

Table 8.1

Percentage of Crops Area (2014-15)

S.No.	Crops	Percentage of total area
1	Food grains	67.84
2	Sugarcane	0.11
3	Species	0.28
4	Vegetables	0.66
5	Oilseeds	22.54
6	Others	8.54
	Total	100.00

Source: District Statistical Abstract, Bharatpur

3. The cropping pattern used on a farm and their interaction with farm resources.
4. Growing two or more crops on the same piece of land in one calendar year is known as multiple cropping.
5. It includes inter – cropping, mixed cropping and sequence cropping.
6. Double cropping is a case where the land is occupied by two crops, which are grown in a year in sequence.
7. Cropping pattern refers to the proportion of area under different crops at any given point of time in a unit area, or the yearly sequence or spatial arrangement of crops on a given area, cropping activities may run all the year round, provided water is available for crops. It may be of different types such as inter cropping, mixed cropping and crop rotation. The agricultural lands when are occupied by one crop called as mono cropping, or by two crops, called as double cropping, or

more than two crops, termed as multiple cropping. As per availability of water, cropping pattern varies.

8. Growing two or more crops simultaneously on the same field, inter-cropping was originally practiced as an insurance against crop failure under rained conditions. At present main objective of inter-cropping is higher productivity per unit area in addition to stability in production. Inter cropping system utilizes resources. efficiently and their productivity is increased.

INTER CROPPING

The degree of spatial and temporal overlap in the two crops can vary some what, but both requirements must be met for a cropping system to be an intercrop. Numerous types of intercropping, all of which vary the temporal and spatial mixture to some degree, have been identified. These are some of the more significant types:

MIXED CROPPING

Mixed cropping is the growing of two crops (eg: corn and soyabeans) intermingled together in the same field.

- It is a common practice in most of dry land tracts of India. Seeds of different crops are mixed in a certain proportion and are sown. The objective is to meet the family requirement of cereals, pulses and vegetables.
- Also referred to as mixed cropping. eg: Sorghum, Pearl, Millet and cowpea are mixed and broadcasted in rainfed conditions. Bharatpur district is also no exception. Though 11 percent of the total area of the district is covered by hills and rocky terrain, and about 5.14 percent by forests, there are vast stretches of good arable land. About 70.6 percent of the total population, earn their livelihood directly or indirectly from agriculture. Major portion of the district is denoted to food crops and the commercial crops occupy the little area. The main crops are wheat, Gram, Bajra, Jowar, Rice, Sesamum, Cotton, Guar, Potato in both Kharif and Rabi season (Table 8.2).

Table 8.2

Cropping Pattern in 2000 to 2015

Crop	Mean 2000-02		Mean 2002-05		Mean 2005-10		Mean 2010-15	
	Rank	Percent area	Rank	Percent area	Rank	Percent area	Rank	Percent area
Mustard	1	45.5	1	49.4	1	42.1	1	44.6
Wheat	2	35.5	2	30.7	2	28.1	2	28.8
Bajra	3	24.7	3	20.7	3	18.3	3	19.9
Jowar	4	18.3	4	16.1	4	18.3	4	9.3
Fodder	5	7.9	5	5.3	5	4.8	5	4.7
Gram	6	4.2	6	7.1	6	3.1	6	1.0
Guar	7	3.6	7	2.1	7	1.8	7	0.3
Barley	8	1.9	8	0.9	8	0.9	8	1.0
Vegetable	9	1.0	9	0.3	9	0.4	9	0.3
Potato	10	0.4	10	0.1	10	0.8	10	0.6

Source: Calculated from various issues of District Statistical Abstract of Bharatpur District.

As per share of crop in cropping pattern of the district, Bharatpur emerged as Mustard Region since it is rank one crop (Fig.8.2). In fact, Mustard, Wheat and Bajra have remained top three crops of the district. However, the share of Gross Cropped Area under these crops was varying over time. On an average more than one third of Gross Cropped Area has been found under Mustard. Maximum area under mustard was sown during the year 2000-02 which was 45.5 per cent and during the year 2005-10 it came down to 42.1 percent. Wheat emerged as the second most important crop of the district throughout the study period. The main crops are Wheat, Gram, Bajra, Jowar, Rice, Sesamum, Cotton, Guar, Potato in both Kharif and Rabi season (Table-8.2). The total productivity under Kharif crops in the district is 1325 kilogram per hectare and in Rabi crops is 3689 kilogram per hectare.

The production of major Rabi and Kharif Crops is shown in table 8.3. (Fig. 8.3).

Table 8.3

Production of Major Crops (MT) in 2000-05

Tehsils	Jowar	Bajra	Guar	Wheat	Barley	Gram	Mustard
Bharatpur	3087	55878	1416	77108	651	198	33974
Nadbai	5308	18352	4287	38152	344	24	45822
Deeg	6983	10726	1030	60472	1514	716	41769
Nagar	7964	18336	1407	51671	872	1441	35976
Kaman	5988	13044	788	65099	457	46	22778
Bayana	155	46000	5775	61467	569	261	20260
Weir	531	24270	2737	31878	145	90	12348
Roopbas	559	20435	6777	53510	1275	825	27631
Kumher	4030	4004	413	30184	485	837	10921
Pahari	7019	11330	116	31134	628	393	13326
Bhusawar	266	13659	1594	18964	188	581	9272

Source: Calculated from various issues of District Statistical Abstract Bharatpur District, Rajasthan.

AREA UNDER VARIOUS CROPS

Average area under major crops grown in the Bharatpur District has been shown in the table 8.4 for year 2000-15. Mustard occupied maximum area (204415 hec.) in district whereas Wheat emerged as the second most important crop with 102205 hec. Area cultivated under Wheat was found maximum in Bharatpur tehsil (12686 hec) (Fig. 8.4).

Table 8.4

Average Area in Hectare under Major Rabi and Kharif Crops (2000-15)

Tehsils	Jowar	Bajra	Guar	Wheat	Barley	Gram	Mustard
Bayana	269	14636	769	10684	193	3107	16937
Bharatpur	247	4208	63	12686	545	1839	20368
Deeg	6155	4333	41	9300	807	5965	23460
Kaman	3010	7013	101	10891	553	2606	9885
Kumher	5360	3669	41	9300	807	5965	23460
Nadbai	2203	11568	241	8904	230	3050	27431
Nagar	3629	6753	399	10311	746	5678	18327
Pahari	2039	3902	45	9830	454	3010	11352
Roopwas	286	11276	431	9609	266	2488	26936
Weir	724	15243	515	9645	175	2686	27453
District	26150	82602	2618	102205	4553	34957	204415

Source: Calculated from various issues of District Statistical Abstract Bharatpur District, Rajasthan.

It is hoped that as a result of extensive efforts of Agriculture Department the new crops shall gradually replace the old crops in the canal irrigated tracts and it is expected that this change will be accentuated by the use of the canal water properly. Agricultural development in Bharatpur District under different tehsils is shown in (Fig. 8.5).

It is intresting to note that since after the introduction of canal irrigation, the cropping pattern in the Bharatpur District has gradually been making shift from dry cultivation to irrigation agriculture. On the contrary, within the hilly tract, the plateau and the ravine lands, there has been no change. The cropping pattern deteriorating hydrological condition of soils due to the continuous soil erosion and ravine formation. Thus, only crops like Bajra and Barley are grown in these tracts which can adjust themselves to the poor soil and inadequate drainage.

While discussing the cropping pattern in the district, it should also be remembered that the environmental conditions in the district vary from place to place and they greatly influence the cropping pattern and the yield of crops. Particularly the soil characteristics and relief features determine the intensity of cropping. For example, Wheat and Jowar are grown in clay and clayey loam where the irrigation facilities are adequate; natural drainage and fertility status are sufficient to feed the plants well. Bajra and Barley which may be grown in inferior soils are cultivated in the sandy and sandy loams of the badly ravine infested areas of the district. However geomorphic and hydro geological features limit and determine the degree and intensity of cropping in various parts of the district.

The cropping seasons and techniques and major crops have been dealt here. Detailed discussions of major crops have been given by the statistical method.

PRINCIPLE CROPPING SEASONS

Predominantly there are two main cropping season in the district. They are the Kharif (Unalu) and the Rabi (Syalu). The Cropping seasons follow the seasonal rhythm of temperature and rainfall.

KHARIF SEASON

Kharif season starts with the onset of monsoon from the end of June and sowings are completed usually by the middle of July. Distribution of rainfall is very important for Kharif crops in the district as the soils are heavy and their working depend on timely rainfall. Land operations are started only after the first shower. Further, in case of continuous rainfall the soils which are heavy in texture and retain more moisture offer some difficulty village operations. Alternate heavy showers and a break is desirable for timely operations. Harvesting of Kharif crops starts from the end of October and continuous till December.

RABI SEASON

The Rabi season starts from the end of October and sowing is completed by the end of November. Monsoon rainfall is stored in the heavy soils of the district for the Rabi crops. Inadequate rainfall during this period results in failure of Rabi crop except in the irrigated tracts. Inspite of the storage of moisture from rains received during August and September small winter rainfall is also important for successful Rabi crops.

In the Bharatpur district when the statistical records of principle cropping seasons are seen on an average total area under Kharif and Rabi Crops was 3220419 hectares (2014-15), total production under Kharif and Rabi crops was 6411083 tonnes (2014-15), total productivity under Kharif and Rabi crops was kilogram per hectares and total irrigated area under Kharif and Rabi crops was 2041057 hectares in 2014-15.

CROPPING TECHNIQUES

There are three principal cropping techniques viz. mixed cropping, crop rotation and double cropping.

1. MIXED CROPPING

Mixed cropping is the most common practice in the Bharatpur district. In the Kharif season the practice of raising a variety of crops as a mixture is more common than the rabi crops. The combination of mixed cropping are as follows: Jowar- Bajra- Tur and Groundnut; Maize and Barley are grown mixed which is known as “Baijer”. At places wheat is grown mixed with gram called gulchani. It is a common practice where the soil is retentive of moisture. Mixed farming in Bharatpur district takes place in Bayana, Bhusawar, Roopbas and Weir all these tehsils cover the central part of the district.

DOUBLE CROPPING

Double cropping is a very common practice, where the irrigation facilities are available due moisture holding capacity of sandy loams and loamy sands and permeable nature of soils. However, within some years there has been a decline in the double cropped area. In Bharatpur district Cotton, Sugarcane, Bajra, Til, Jowar, Maize, Rice are grown in Kharif season, while crops like Wheat, Barley, Gram and Linseed are grown in Rabi season. The double–cropping Kharif cropped area is around 32.8 per cent (2014-15) with Cotton, Rice, Bajra, Till and Maize as chief crops in the Bharatpur district. While double-cropping Rabi cropped area is around 29.3 percent (2014-15) with Wheat, Barley, Gram, Linseed as chief crops grown in the Bharatpur district. The double cropping pattern is mainly followed in north-eastern and south-eastern parts of the district. In the district double cropping is practiced wherever irrigation facility is good and soils are fertile.

CROP ROTATION

Crop rotation is the practice of growing a series of dissimilar or different types of crops in the same area in sequenced seasons. It is done so that the soil of farms is not used for only one set of nutrients. It helps in reducing soil erosion and increases soil fertility and crop yield. It is an important aspect of crop pattern. It varies from one place to another depending upon the nature of soil, irrigation facilities and the extent of double cropped area. The crop rotation followed by the farmers (2014-15) is shown in Table 8.5. Fallow-mustard is the most widely used crop rotation by the farmers in Bharatpur district. Next important crop rotations were Jowar (Fodder) Wheat + Mustard (19 percent) and Bajra – Lentil + Mustard (13percen). Further, only a few farmers took mustard after Jowar.

Table 8.5

Crop Rotation

Crop Rotation	Frequency
Jowar-Wheat + Mustard	3
Bajra - Mustard	9
Bajra – linseed + Mustard	13
Bajra – gram + mustard	5
Fallow mustard	41
Jowar – wheat + mustard	19
Jowar - mustard	4
Dencha - mustard	6

(i) **Hilly Region**

(a) Maize – Wheat - Maize - Wheat

(b) Fallow – Wwheat – Fallow – Barley/Wheat

(c) Fodder – Linseed

(d) Sugarcane – Maize

(e) Cotton – Fallow – Wheat

(ii) **Ravine Lands**

(a) Jowar – Fodder – Bajra – Wheat

(b) Fallow – Barley – Bajra – Gram

The general system prevailing in the district is as follows (K refers to Kharif season and R refers to Rabi Season).

(i) Barani Area (unirrigated Area)

(a) Jowar (K) – Fallow (R) – Fallow (K) – Wheat (R)

(b) Jowar (K) – fallow (R) – Fallow (K) – Gram (R)

(c) Jowar mixed with Moong or Urd (K)–Fallow (R) – Fallow (K)

(d) Jowar (K) – Fallow (R) – Till (K)

(e) Jowar and Arhar (K) Fallow (R)–Groundnut (K) –Fallow (K)–Wheat (R)

(ii) Irrigated Area

(a) Maize (K) – Wheat or Barley (R)

(b) Maize (K) – Potato or Sweat Potato (R)

(c) Chillies (K) – Winter vegetables (R)

(d) Cotton (K) – Fallow (R) – Maize (K) – Wheat (R)

(e) Groundnut (K) – Fallow (R) – Sugarcane (R) – Fallow (K) – Potato (R)

(f) Paddy (K) – Lentiles or Gram (R)

In the ravine lands there is no systematic crop rotation pattern in order to maintain soil fertility under different water allowance classes in the Chambal Commanded Area of Bharatpur District.

The system of crop rotation is still traditional in some of the tehsils of Bharatpur district. In these tehsils farmers have not yet realize the significance of new system of crop rotation. It is hoped that through the efforts of development blocks this system will gain acceptance in the time to come.

KHARIF CROPS

Kharif crops or monsoon crops are sown with the beginning of the first rains in July, during the south-west monsoon season in India. The Kharif season lasts from June to October. Kharif means “autumn” in Arabic since this period coincides with the beginning of autumn/winter in the Indian sub-continent. It is called “Kharif Period.” Kharif crops are dependent on the large quantity of rain water as well its tuning. Main Kharif crops in Bharatpur district are Rice, Bajra, Cotton, Sugarcane, Jowar and Millets. The area of each Kharif crop to net sown area is given in Table 8.4. The total productivity under Kharif crops in Bharatpur district covered is 636970 hectares or 2313 Kg/hec.

1. **RICE** - It is grown under irrigated condition. It occupies 22.54 per cent of net sown area. In Bharatpur district Deeg and Kaman tehsils comprises 40 and 60 percent of net sown area. The Japanese method of rice cultivation has been introduced and it has gained some favour.

   The State Agriculture Department, Rajasthan, has recommended popularisation of Japanese method of rice cultivation in the commanded area.

2. **BAJRA** – It is an another important Kharif crop of the district. It is food crop of poor people. It is also used as cattle feed. Bajra is grown in inferior quality of soils mostly on yellow brown sandy and sandy loams with adequate drainage. It requires manuring but is hardly manured in the area. Bajra is an important crop of ravine lands of district and it occupies an significant position. Among the tehsils Bayana (22792 hec.), Roopbas (13623 hectare), Weir (12135 hec.), Nagar (9168 hec.), Nadbai (9176 hec.) denote the highest area in hectares (Fig. 8.6), whereas the productivity of Bajra in Bharatpur disitrict is highest in Bharatpur Tehsil (above 1600), Nagar and Kaman ranks second in productivity of Bajra (Fig.8.7). In these tehsils rainfall is low which enables the cultivation of nothing else but Bajra in the Kharif season. Moreover it is easier to grow for the farmers as it does not require much labour. Besides this the soils of this part is sandy loam to loamy sand which is favourable for its cultivation.

3. **COTTON –** Cotton is the most important fibre crop and cotton seed is used as a vegetable oil and a part of fodder for milch cattle for better milk production. Cotton is a Kharif crop and grows in tropical and subtropical areas. Cotton requires modest rainfall. It is one of the predominant rainfed crops. Cotton requires uniformly high temperature (21^0C to 30^0C). It grows in areas having at least 210 frost free days in a year.

   Optimum soil for Cotton is the Black soils. Cotton growing is known as less mechanized farming in Bharatpur district. So needs cheap labour. Main cotton producing tehsils are Pahari, Nagar, Kaman, Bharatpur and Deeg. Among these tehsils Pahari is the largest cotton producing area with 1081 hectares area of total cropped area.

4. **SUGARCANE** – Sugarcane belongs to bamboo family of plants. It is one of the most important Kharif crops. Sugarcane is a tropical and subtropical, perennial grass that forms lateral shoots at the base to produce multiple stems, typically 3 to 4 meters high and about 5 cm in diameter. The stems grow into cane stalk, which contributes about 75% of the entire plant. A mature stalk is typically composed of 11% to 17% of fibre 12% to 16% of soluble sugars, 2% to 3% of non-sugars, and 60-70% of water. As Sugarcane crop is sensitive to the weather, soil type, irrigation, fertilizers, insects, disease control cultivars, and the harvest period, care should be taken to follow best crop management practices for higher yield of Sugarcane. It requires best crop management practices along with input fertilizers to get maximum yield. Sugarcane belongs to bamboo family of plants and is indigenous to India. It is the main source of sugar. It also provides raw material for manufacturing alcohol. The part of Sugarcane is also being used as fodder for animals. In Bharatpur it is mainly grown in Pahari (1081 hec.), Nagar (941 hec.), Kaman (536 hec.) and Bharatpur (259 hec.) tehsil. In Bayana (0 hec.) and Weir (0 hec.) there is no production of sugarcane. In 2010-11 the production of sugarcane is 49 (hec.), 181 hectares in 2011-12, 231 hectares in 2012-13, 101 hectares in 2013-14 and 34 hec in 2014-15. The above area of sugarcane shows that in recent years area was high in the year 2012-2013 that is 231 hectare. The area is decreasing since 2013-14 (101 hec.) to 2014-15 (34 hec.).

5. **JOWAR –** Jowar as the staple food of the people is not only the main Kharif crop but is it also the major crop of the district. Apart from its use as food crop its plant forms a very good fodder for cattle.

   In Bharatpur district Jowar is mainly associated with the heavy clay to clay to clayey loam soils but it is also grown in sandy loams. It is taken mainly as a rainfed crop and only 5 percent of the total Jowar area is taken under irrigation in Bharatpur district. In Bharatpur district among the major crops the area of Jowar as a main crop in different tehsils are 8043 hec. in Kumher tehsil, 7964 hec. in Nagar tehsil, 7019 hec. in Pahari tehsil, 6983 hec in Deeg tehsil, 5974 hec. in Kaman tehsil., 5308 hec. in Nadbai tehsil all these tehsils are the major tehsils in Bharatpur district that have the largest net sown area under Jowar production. However geographically north, north-east part of the district is significant for Jowar cultivation and the percentage of Jowar decreases in the north-west and south-west part of the district. In Bharatpur district tehsils like Kumher, Nagar and Pahari yield per acre of Jowar is very high because of wetness in the soil.

6. **TILL** – It is important Kharif crop in the district. It is an important oilseed grown under unirrigated condition. Till is grown mostly in the areas where soil is loamy or clayey loam with good drainage conditions. Main tehsils where Till is grown are Roopbas (826 hec.), Bharatpur (477 hec.), Bayana (426 hec.), Nadbai (360 hec.), Kumher (297 hec.) and Deeg (221 hec.). It is grown mixed with pulses and maize. The yield per acre is 2 to 3 maunds.

7. **GROUNDNUT** – Groundnut is also an important oilseed grown in the district as a Kharif crop. It is very suitable crop as a soil binder and for checking erosion. Groundnut is grown only in commanded area of the district. That part of land which is unsuitable for Jowar and other Kharif crops yields groundnut. Generally 1 to 2.15 percent of net sown area is devoted to this crop.

   Since it is a soil binding crop it should be raised on the marginal ravine fields of Gambhir river in order to stabilize the soils and to check further erosion.

8. **PULSES –** Important pulses grown in the district are Moong, Urad and Tur. These pulses are usually grown mixed with either Jowar or sometimes with

Maize. Tur occupies significant position in the ravine infested areas of Bharatpur.

RABI CROPS

Rabi crops or Rabi harvests are agricultural crops sown in winter and harvested in the spring. The term is derived from the Arabic word for spring, which is used in the Indian subcontinent, where it is the spring harvest (also known as the “winter crop”). The Rabi crops are sown around mid-November, after the monsoon rains are over, and harvesting begins in April/May. The crops are grown either with rainwater that has percolated into the ground, or using irrigation. A good rain in winter spoils the Rabi crops but it good for Kharif crops.

The major Rabi crop in Bharatpur district is Wheat, followed by Gram, Barley, Mustard and Potato. The net sown area under Rabi crops is given in Table 8.4. The detailed study of the main Rabi crops will point out how these crops are governed by the topographic conditions, soil texture and structure and the hydrological conditions. The total area under Rabi crops covered in the Bharatpur district is 2273566 hectares.

1. Wheat

Wheat is the most important food crop and the main Rabi crop of the district. In the area under study Wheat is grown both as a dry crop and as an irrigated crop. As a dry crop its cultivation is confined almost to the ravine and hilly sections of the district where the soil is sandy loam to loamy sandy. Rich clayey soil. Free from gravel, stones or coarse sand of uniform texture, is best suited for Wheat crop. All Wheat growing soils in the district are more clayey. In the irrigated tracts due to the heavy nature of soils, the problem of water–logging has been creeping, thereby, reducing the yield per acre of Wheat.

The distribution of Wheat shows (Fig.8.8) that the percentage of the area under Wheat decreases from north-west to north-east. The descending trend of Wheat percentage may be explained by the occurrence of poor soil, low moisture content and rugged hilly and ravine topography.

The tehsils of Bharatpur has more than 40 percent of net sown area of Wheat. Largest portion of first class Wheat growing soils clayey and clayey loams with sufficient moisture content, level land and the use of modern implements like tractor and thresher have jointly enabled the cultivators to have larger Rabi area under Wheat cultivation.

In the ravine land and hilly tracts of the valley in the district, the percentage of Wheat area is low ranging from 10 to 20 percent. It is because of the poor soil, undulating topography, low moisture content of the soil and the inadequate irrigation facilities. Moreover concentrated efforts of farmers to grow Bajra in the Kharif is the other reason for the decrease in the Wheat land.

In the recent years, a number of improved varieties of Wheat have been introduced by the State Agriculture Department and the Development Blocks. C581, NP708, Malvi and C236 are the main varieties which are most adaptable to the soils and the hydrological conditions of the district. The newly introduced varities have given larger yield per acre. Generally the yield of Wheat under unirrigated conditions is 4 to 5 mounds per acre, while under irrigation and manuring it is 12 to15 mounds per acre.

It is surprising to note that the acreage under Wheat has decreased from 1991-92 to 2006-07 but the acreage under Wheat has increased after 2007-08, 2008-09, 2009-10, 2010-11. It was highest in the year 2010-11 (54932 hec.). After 2011 it again starts decreasing. The reduction in the Wheat area in Weir (9108 hec.) and Bhusawar tehsil (10251 hec.) is well marked. The reason of this declining Wheat area in these tehsils is due to the increase in area under Jowar and Gram after 2006-07, as indicated in Table 8.4. In Bharatpur District the productivity of Wheat is highest in Bayana, Weir, Nagar and Kaman tehsils (Fig. 8.9).

After the introduction of canal irrigation the area of irrigated Wheat has increased considerably. The 2006-07 statistics reveal that nearly 30 to 40 percent of the total Wheat area of Bharatpur and Kaman tehsils in irrigation is done mainly by canals. The irrigated Wheat area has also shown slight increase in the hilly tracts and ravine lands because of the increasing number of wells and tanks. The reason behind the increase in production in these tehsils is the availability of rich clayey soil free from gravel, stones or coarse sand of uniform texture.

2. GRAM

It is also the important rabi crop of the district. It is a pulse which belongs to the natural order legume. The Gram is grown almost on every type of soil in the district but the best soil for its cultivation is the heavy clay soil which is found in the district. The soil has a very high moisture retaining capacity. This capacity helps germination and the maturity of the crop. Generally, that soil is denoted to Gram which is unsuitable for Wheat. Nagar, Roopbas, Kumher, Deeg and Bhusawar tehsils are the main Gram producing areas.

Gram is generally grown mixed with Wheat and Barley, when it is grown with wheat it is called Gulchani and with barley it is called Baijer.

Most of the Gram is grown in Nagar and Kumher tehsils. It is an important source of nutrients livestock food.

3. BARLEY

Barley is a grain crop which resembles Wheat in many respects. Barley or Jo is another food crop of poor people. Very little area is devoted to this crop in the district. It is grown in those soils which are lighter in texture or less moisture retentive and are not suitable for Wheat and Gram. This type of soil is found in north-eastern part. Deeg (1514 hectares), Roopbas (1275 hectares), Nagar (872 hectares), Pahari (628 hectares) are the main Barley production tehsils in Bharatpur district. Barley is grown both under irrigated and unirrigated conditions. Very small proportion of Barley growing area is irrigated in the commanded area because greater part of canal water is shared by Wheat. Bajra, Jowar and pulses (arhar, moong and urd) are the main crop of rainy season. The area under Bajra in the ravine lands of Bharatpur district is low. Here Jowar is predominant Kharif crop.

Wheat, Barley, Mustard and Gram are the main Rabi crops. Actually Wheat occupies an insignificant position. Lack of irrigation, sandy and loamy nature of soils and less moisture retaining capacity of soils have collectively made these parts of the district unsuitable for Wheat. In such conditions Barley and Gram as a mixed crop is grown. Mostly all crops are cultivated under dry conditions.

4. Mustard

The Importance and potential of rapeseed-mustard crop is well known as it is key oilseed crop that can help in addressing the challenge of demand. Rapeseed-Mustard (Brasica species) is the major Rabi oilseed crop of India. In Rajasthan, the mustard crop is mostly cultivated in Alwar, Bharatpur, Jaipur, Dholpur, Sawai Madhopur and Sikar District. Bharatpur, eastern district of Rajasthan is the largest mustard growing division covering about 48 percent of the total production of state. Therefore a study was carried out to access the trend in area, production and yield of mustard crop in Bharatpur region of Rajasthan. The area, production and yield of mustard crop in Bharatpur region has been witnessing an increasing trend since 2001-2013 decade due to increasing usage of Rapeseed-Mustard seed oil in food. In Bharatpur region of Rajasthan, area under crop declined and reached a level of 7.61 lakh hectares but again increased from 2011-13. Area for the mustard crop in Bharatpur District is fluctuating.

Table 8.6

Area of Mustard in Lakh Hectares

Bharatpur District	2001-03	2003-05	2005-07	2007-09	2009-11	2011-13	2013-15
	1.66	2.14	2.25	2.07	2.01	2.2	2.04

Source: Agriculture Statistics at a Glance, 2000-02 to 2011-15

PRODUCTION OF MUSTARD

The production of mustard in Bharatpur region which was about 5.25 lakh tones in 2001-03 increased sharply and had doubled 11.85 lakh tones during 2009-11. However, there is some slightly declining position in mustard production during 2013-15. Lower production of mustard crop was due to lower sowing and fall in sowing was delay in monsoon arrival. Also delayed harvesting of Kharif crops ensured a delayed sowing of mustard crop. Higher temperature during sowing period also had an adverse impact on the sowing which directly affected the production of mustard crop.

Table 8.7

Production of Mustard in Bharatpur District (lakh tones)

Bharatpur District	2001-03	2003-05	2005-07	2007-09	2009-11	2011-13	2013-15
	2	2.89	2.96	3.04	3.6	3.59	2.9

Source: Agriculture Statistics at a Glance, 2000-02 to 2011-15

TRENDS IN YIELD OF MUSTARD CROP

The yield of the mustard crop in Bharatpur District has also increased from 105.5 kg/hc. in 2001-03 to 1587.5 kg/hec in 2009-11. The productivity may decrease due to deficient rains and a phase of severe hot weather in 2013-15 (Fig.8.10).

Table 8.8

Yield of Mustard in Bharatpur District (kg/hec)

Bharatpur District	2001-03	2003-05	2005-07	2007-09	2009-11	2011-13	2013-15
	1047.5	1359	1311	1451.5	1788	1635.5	1424

Source: Agriculture Statistics at a Glance, 2000-02 to 2011-15

According to table 8.9 the area of mustard is Bharatpur district has increased from 5.31 lakh hec in 2001-03 to 35.98%. In Bharatpur district, the production of mustard crop is 5.95 lakh tones in 2001-03 which is 38.56% of Rajasthan, and it has increased in 2013-15 by 10.41 lakh tones, and it is 32.02% of Rajasthan (Fig. 8.10).

Table 8.9

Comparision in Area (lakh hec), Production (Lakh tones) & yield (Kg/hec) of Bharatpur District.

Year	Bharatpur District		
	Area	Production	Yield
2001-03	5.31	5.95	1057.5
2003-05	7.9	10.25	1325
2005-07	8.66	10.82	1269.5
2007-09	7.61	10.2	1326.5
2009-11	7.46	11.85	1587.5
2011-13	8.02	11.6	1443.5
2013-15	7.72	10.41	1347.5

Source: Agriculture Statistics at a Glance, 2000-02 to 2011-15

PRODUCTION AND PRODUCTIVITY OF MAJOR CROPS

Wheat, Mustard and Bajra are the major crops in Bharatpur. Total production was 616330 MT.

Table 8.10

Production and Productivity of Major Crops

Season	Name of Crop	Production (MT)	Productivity (Kg/Hec.)
Kharif	Bajra	152.034	1460
	Arhar	0.105	0.795
	Til	0.715	434
	Groundnut	0.035	1418
	Guar	4.25	919
	Cotton	1698 (Bales)	308
	Methi	0.006	1200
Rabi	Wheat	464.033	3422
	Barley	10.147	2838

CROPPING PATTERN IN RAVINE LANDS

Less than 50 percent of ravine villages area is under plough and out of this, very little is occupied by Wheat and Gram, which are the crops of fertile soil and well drained region of the south-east. In the ravine villages the fertility of soil has decreased by continuous washing away of the top soil every year. In this tract, therefore only such crops are grown which may flourish and withstand poor soils and hydrological conditions.

Ludhawai (Bharatpur tehsil) and Dharampura (Bharatpur tehsil), Borai village (Kumher tehsil) reveals that in the ravine infested lands there are three sites where cultivation is being practiced i.e. bottom of wide ravines slip off slopes of rivers and the marginal lands. The fertility status of the soil of ravine bottom is very low but the soil on slip of slopes is very fertile which supports Wheat and Gram crops without manuring and irrigation. The reason is that in these parts of the district every year new soil is being deposited by the river during the monsoon period. In these small and scattered pockets farmers of ravine lands usually grow Wheat, Barley and Cash Crops like Tobbaco.

In the ravine bottoms only Rabi crops are harvested. During the rainy season these tracts ussally remain under water. So in these lands Rabi crops are cultivated under dry conditions.

CHAPTER-9

MORPHO-AGRICULTURAL REGIONS

The comprehensive study of the physiography and agricultural development presents a diversified picture of geomorphic features and agricultural pattern within the Bharatpur district. The geomorphological characteristics and hydrological conditions of the various parts of the region have created an agricultural pattern that is very varied. Therefore, the regional analysis of morpho-agricultural features is imperative in order to project the future plan of land resource utilisation of the region in a rational way. An attempt is being made to bring out morpho-agricultural regions of the district on the territorial differentiation of geomorphic features and crop pattern and evaluate them according to their land capability.

The study of work on geomorphic regions reveals that when the area of a continental size is considered, in that case the climate becomes the common denominator. In smaller area geological structure of rocks, relief and erosional peculiarities of the region become more important while in still smaller area, morphometric properties as slope, form of the ground, quantitative properties of streams and surface morphology are used as criteria of geomorphic regions.

The agricultural regions of the world or part of it may be delineated on the basis of climate, relief, land capability and crop combination.The early attempts were made in this direction by Jonasson (1925) and Baker (1926). The agricultureal regions of Europe and America as recognized by these authors are primarily based on climatic elements. Hartshorne and Dicken (1935) adopted a different line for delimiting North America and Europe into the agricultural regions. In these studies, crop isopleths have used for delineating agricultural regions instead of climate.

Owen (1941), Higbee (1947), Erug and Tunediek (1952), Stamp and Weaver (1954) have demarcated agricultural regions on the basis of relief features. Ayyar (1967) has divided the upper Narmada Basin into the agricultural regions on the basis of topography, soil and crop combination. Kamp (1968) has determined agro-geograhical regions of Denmark on the basis of soil capability.

An attempt is being made to bring out morpho-agricultural regions on the basis of Land capability classification.This methodology has been contemplated here to show the different degrees of productivity of the land and its suitability for raising different kinds for crops. The measurement of land capability gives a scientific judgement for the conservation of land. The conservation is also necessary to maintain its utmost capability and inherent productivity under particular ecological condition and grouping of land on the basis of physical and cultural factors is indispensable for planning the agricultural economy through sound cropping system and conserving the land resource for its judicious future use. It also helps us to find out its efficiency for specified uses and proper diagnosis for a long time production. In this way, landuse capability classification helps to organise soil factors for conservation by considering the physical factors directly affecting the land productivity. There is a need for such studies in view of increasing population density and decreasing per capita supporting capacity of the land.

Land capability classification is “a field investigation of soil properties, slope, degree of soil erosion and changing land use patterns which form the basis for future planning of soil and water conservation.”

The present scheme of the morpho agricultural regions is a simple one. Geomorphic contrast has been used for delimiting the agricultural regions in the Bharatpur district. The geomorphic contrast between the hilly section of the central part from north to south, the plain of north-east and north, the plateau of south-west and west is so obvious that the region stands divided into four broad geomorphic regions *viz.*, the hilly section of the central part, the plateau of south-west and west, level riverine plain of the Chambal and dissected ravine belt while dividing the district into morpho-agricultural regions, these geomorphic boundaries were the main consideration, because agricultural pattern is mainly controlled by geomorphic features of the various regions. For instance, the central south and north hilly region has been demarcated on the basis of relief using 304 meters contour line and was the lower boundary. In contrast to this, the boundaries of the agriculturally stagnant region of west and south-west plateau has been marked on the basis of extent of outcrops of the upper Bhander sand stones. The ravine tract has been distinguished from the lowland section on the basis of degree of dissection and ravine topography.

The plain section, a prosperous agricultural region, is demarcated on the basis of level riverine plain, rolling surface, except on interfluves, adequate rainfall and fertile clayey soils. Further, within the lowland of the valley, there are important local variations on account of the land capability and the water resources. Therefore, it has again been divided into there micro-morphoagricultural regions. The north-western part of the lowland is appreciably suitable for Wheat as the main crop and Jowar as the secondary crop. So, the name employed to this micro region is Wheat-Jowar sub region. The south-eastern part is favourable for Jowar as first ranking crop and Wheat as second; therefore, the name given to this part is Jowar-Wheat sub region. The first ranking crops of the ravine infested region of the district are Bajra and Barley. In all following major and sub morpho-agricultural regions of the Bharatpur district have been distinguished.

(i) Agricutlurally negative hilly region of central part from north to south.

(ii) Agricutlurally stagnant rolling plateau of south-west and west.

(iii) The Alluvial plains- prosperous agricultural region

  (a) Wheat-Jowar sub region.

  (b) Jowar-Wheat sub region.

(iv) The ravine lands-problem areas of agriculture.

I. Agricutlurally Negative Hilly Region from North to South

The centrally stretching north to south border hills form a district morpho-agricultural region which is agriculturally a negative area. Rugged topography is the foremost factor governing agriculture here. It is handicapped by the steep slopes and resultant hill wash and inadequate water for irrigation. The 300 metre contour line marks the lower boundary of the hilly section right from Bayana tehsil in the south-west to the Roopbas tehsil in the north-west.

GEOMORPHIC CHARACTERISTICS

The main geomorphic characteristics of the Bharatpur line of hills are composed of the Gwalior rocks and stratified Vindhayan formations. The great boundary fault which runs along the hills divides the Vindhyans from the Gwaliors. The Gwalior quartzites, the Kaimur, upper Rewa and Lower Bhander Sandstones form ridges while shales form longitudinal and strike valley.

The drainage of the hilly regions is intresting in many ways. The ultimate arrangement of sandstones and shales in the Bharatpur has given rise to anticlinal valleys and synclinal ridges. The resultant pattern of this part is trellis drainage pattern. The Gambhir is the major stream of Bharatpur. On the whole drainage pattern is irregular. Streams in Bharatpur are non-perennial.

The soils on the hills are very thin and reddish brown in colour. In the longitudinal valleys, the soil profile is somewhat developed. Generally soils are heavy clay and clayey loam on the out crops of shales. The soil is comparatively more fertile in Bharatpur because this has been developed on the Bhander limestones.

The hilly section of Bharatpur is characterized by dense forests. All hills are invariably wooded. Forests on the slopes and tops of hills comprise of following trees:

(i) Dhokera – Anogeissus pendula
(ii) Kher – Acacia catedu
(iii) Babul- Acacia arabica
(iv) Tendu – Deospyros tomentosa
(v) Dhak – Butea frondosa
(vi) Adusa – Adothoda vasica
(vii) Ber – Zizyphus jujubae.

AGRICULTURAL CHARACTERISTICS

A considerable part of this agricultural region is rugged and not fit for cultivation. The longitudinal valleys with good soils and level ground are common sites where cultivation is being practised. Only 2.5 percent of the total area is cultivated and in most of the areas the proportion is not higher than 1 per cent. Like the lowland region, the hilly region is also a land of grain production. More than 60 percent of the arable land is devoted to Wheat and Maize crops. Maize is an important Kharif crop of the region. Til is grown to a little extent where irrigation is not possible. Cotton, Chillies and Sugarcane are the other Kharif crops Wheat is an important Rabi crop.Wheat generally follows Maize. In such a case manuring is not done as

Maize is heavily manured. Barley is another important crop which is sown mixed with Wheat.

In the hilly region there are some areas where the agricultural practices are different than the ones mentioned, variations in such areas are given below:

1. The characteristic feature of the sathur anticline valley is that it is flooded during the rainy season, and hence, only Rabi crop is grown. Wheat is the important Rabi crop which is grown under barani (unirrigated) conditioin. Manuring is not commonly practised.
2. The area in the east of the hilly sections has soils of very light manure with poor moisture retentive capacity, so only Kharif crops are grown except for Gram in Rabi in small area. Important Kharif crops are Jowar and Til, Moong is grown as a mixed crop.
3. In some parts of the Bharatpur district, the soil is too sticky and plastic to be workable. Therefore only Rabi Crops are grown where the soil is light in texture near nallhs, Kharif and Jowar is also cultivated.

The methods and techniques of agriculture in the hilly section are traditional. The average holding is 1.6 hectares. The small holdings are due to the limited agricultural land that could be brought under cultivatin.Mixed cropping is a common practice but double cropping is uncommon. Irrigation is conspicuous by its absence. The implements with which the villages work are country plough (hal) and bakhar. The complicated nature of hilly topography is the main factor that retards the introduction of new implements.

II. Agriculturally Stagnant Rolling Plateau of South-West

The upland agricultural region is found in south-west in form of Dangland. The extent of upper Bhander sand stone forms the boundary of this section. This upland terminates on the south by the Chambal scarp. It slopes from south-west to north-east.

GEOMORPHIC CHARACTERISTICS

This highland is composed of upper Bhander sandstone underlain by shales. The soils are developed on the sandstone due to the long continuous weathering processes. The surface colour of soils is red. Generally soil layer is very thin therefore sometimes it is difficult to work with country plough. Due to this nature of soil and the stony character of terrain agriculture is not practiced throught. Only in those parts where soils are thick and water is unavailable. Cultivation is being practiced than otherwise.

The drainage pattern of this highland section of the district is very peculiar and significant as well as for the river valley development projects. The Chambal River after crossing breaks the Bharatpur scarp in the direction of dip near about Bharatpur tehsil and forms a conspicuous gorge. The course of the Chambal has been superimosed to a depth of nearly 150 meters on the south-west plateau. Due to this Gorge (Course) the various dams have been constructed on the Chambal River. The overall pattern of the drainage is sub parallel. Except the Chambal and its major tributaries most, of the streams are dry during summer. The drainage pattern of the north-eastern highland section is a consequent type. The streams which descend from the Chambal scarp are of a subsequent type.

The agricultural regions are appreciably suitable for the growth of grasses and trees and therefore, the area is characterized by dense forests. On these uplands for a long distance together there is no settlement and the only noticeable feature is the dense grasses.

AGRICULTURAL CHARACTERISTICS

The region is mostly inhabited by Jats who are poor in cultivation. However their economy is based on animal husbandry. The natural grasses and vegetation give helping hand to their occupation. The farmers grow Wheat and Barley in Rabi and Jowar in Khaif season, where water is available and soil is clayey. The possibilities of developing this agricultural region are there. Small reservoirs can be constructed across many streams for minor irrigation works. But this region will appreciably be suitable for forests, therefore, plantation should be made on a large scale.

III. The Low Land (The Alluvial Plain)

This is the largest morpho-agricultural region of the Bharatpur district. In the southern part of the Bharatpur district it is sharply limited.

GEOMORPHIC CHARACTERISTICS

This region in the Bharatpur district represents the lowland region. The Bharatpur district forms part of eastern Rajasthan plain lying east of Aravalli after hill ranges. Most of the area of the district is occupied by Alluvial Plains which forms part of Banganga River Basin. The height of ground level generally varies from 180 to 220m. Bharatpur and Nadbai tehsils of the district consists of plain area. Alluvial Plains area is fairly well wooded and bordered with detached hills in the north. It is gently undulating, the interflueves between the rivers being slightly higher.

The whole of the area is composed of the alluvial soils. The soils in the Bharatpur district are clayey loams to clay getting heavier with depth. The soils along the banks of the rivers are sandy loams to loam are lighter in texture. Kankar layer is found below 0.92 to 1.22 meters. All over the plain surface soils are crumb in structure and mostly friable while the soils at lower depth tend to have a composed (blocky) structure and are firm and sticky. The permeability of surface soils is moderate and low at lower depth.

The major physiographic characteristics of this section is that it is known for its ravines. The bank of Banganga and its tributaries are greatly dissected due to the ravine formation. Simlarly all other tributaries of the Gambhir, Kakund etc. are also attented by strips and long belts of ravines. The width of the ravine belts here varies from 1 Kilometre to 2 Kilometers. The depth ranges from 20 meters to 30 meters. It increases towards lower reaches of the Banganga River.

AGRICULTURAL CHACTERISTICS

More than 50 percent of the total area is cultivated. In Bharatpur, Kaman and Bayana tehsils alone the percentage of Net sown area is more than 60 percent. In Bharatpur tehsil it is exceptionally high about 70 percent. The distribution of net sown area is largely determind by availability of moisture. The whole south and south-western part comprising of Bharatpur tehsil is area under Wheat production.

Jowar occupies the second positon and western part of the district. Gram occupies the third place after Wheat and Jowar. Here the agriculuture varies with the changing physical condtions, from the predominating Wheat area of the north-east and eastern part to the more favourable Jowar producing western region. Differences in the agricultural character are chiefly the result of variation in soil capability, hydrological conditions and technological development.

III (a) Wheat – Jowar sub region

The Wheat – Jowar sub – region is the north-eastern, eastern and western part of the lowland. This sub-region comprises Bharatpur tehsil and Bayana tehsil. This agricultureal sub-region has been demarcated on the basis of soils and crop combination.

The soils of this sub-region have calcareous variants at places. These sois are moderately heavy in texture. Near streams soils are sandy loams and loamy sands. The surface soils have crumb, structure. The clay content in the surface layer is higher than the subsequent layers.

AGRICULTURAL CHARACTERISTICS

The most important characteristics of this sub-region from the point of agriculture are as follows:

1. Inspite of the development work, the net sown area is only a little above 30 per cent of the total area. A light increase in the net sown area has been noticed in 2000-01 and 2006-07. This expansion in the net sown area may be attributed to the provision of soil conservation work.
2. The sub-region is essentially a double cropped area. The area under double – cropping has increased from 6 percent of the net sown area in 2000-01 to 12 percent in 2006-07. Obviously it is because of the expansion of the canal irrigation.
3. The agricultural pattern is uniform, grain occupies 80 percent (30 percent of net sown area) followed by Jowar (25 percent) and gram (17 percent). Til, Maize, Barley, Rice and Sugarcane are the other less important crops sown in less than10 percent of the net sown area.

4. Irrigation facilities are increasing. Amongst the various sources of irrigation, Tubewells account 75 percent of the total irrigated area. Remaining 25 percent of the area is irrigated by canals and tanks. Nearly 32 percent of the total cropped area is irrigated.
5. The techniques and implements of agriculture are in fact still old fashioned. But with the advent of irrigation work and the development blocks, new implements like the tractor, harrow and leveller have been introduced. The Japanese method of paddy cultivation is also gaining acceptance.
6. In recent years due to the efforts of the Agricultural Department at Bharatpur, new varities of Wheat, Hybrid Maize and Jowar have been introduced. Common varities of Wheat in this region are C581, NP718, Malvi and C236. Sankar Jowar and Maize are also giving good results.
7. Under the irrigation, manuring is a common practice in which farm manure is applied at the rate of 15 to 20 cart loads per acre. Sugarcane and Wheat get maximum application at 20 to 30 cart loads per acre. Due to the efforts of Block Development Officers, chemical fertilizers has doubled during the last decades.
8. The study reveals that with the introduction of the canals and rapid industrialization in Bharatpur the value of land is increasing fast. The farmers of the area are awakening to a new consciousness. Their tie with land is becoming stronger with the increase in the yield per acre. Moreover due to industrialization the prices of vegetables and other cash crops has increased. Therefore, the cultivation of cash crops has gained some favour in this sub-region.

The possibilies of developing this part are immense. Slowly with the extensive efforts of the Agriculture Department Bharatpur the new varieties will naturally replace the old ones as of Jowar and wheat and it is also hoped that this change will come quite fast. Moreover the Wastelands may also be brought under cultivation with the help of soil conservation measures.

III (b) Jowar – Wheat sub region

Jowar – Wheat sub region is the north, western and north-western part of the Bharatpur district. About three-fourths of the area in the district is covered by this sub-region.

GEOMORPHIC CHARACTERISTICS

The soils of this sub-region are heavy clayey in texture. These are deep black in colour. Surface soil have blocked in structure. Moisture holding capacity ranges between 25.40 to 54.03 per cent. The clay content of the surface layer is comparatively lower than the subsequent layers but the moisture holding capacity is unvariably higher ranging between 36.79 to 52.31 percent possibly because of the organic matter. The soils near the rivers are lighter in texture.

AGRICUTLURAL CHARACTERISTICS

1. In Most of the tehsils which constitute this sub-region the net sown area is less than 60 percent. The low percentage of the net sown area in Bharatpur District is due to the hill topography. A high percentage of 70 percent of the net sown area is recoroded in the centre of the sub-region.
2. Double cropping is a common practice. Inspite of the provisions of Tube well irrigation, the percentage of double cropped area is very little and is between 1.05 percent to 8 percent. But the double cropped area has increased between 2000-01 and 2006-07.
3. More than 20 percent of the total area is wasteland. This proportion is very low in comparison to the wheat-Jowar sub region. But the percentage of the other uncultivated land excluding follow land is some what higher in this sub-region than in the wheat-Jowar sub region.
4. Jowar is the first ranking crop of this sub-region. More than 30 percent of the net sown area is denoted to this crop In Bayana tehsil percentage of Jowar to the net sown area is more than 40 percent. The soil of this stretch is very favourable for this crop. Moreover, efforts are under way by the Agriculture Department, Bharatpur to specialise this area for Jowar. In fact, due to the efforts of the Agricultural Department the percentage of Jowar growing area has shown some increase but yield per acre has gone down because of water-logging in the heavy clayey tracts. Wheat and Gram are the second and third ranking crops respectively. The soil and climate are suitable for these crops. Wheat and Gram are grown both as a mixed crop. Other crops of this sub region include Til,

Barley, Maize, Groundnut, Rice, Linseed and Bajra. These crops occupy a small percentage of the net sown area.

5. Irrigation facilities are increasing. More than 80 percent of the total irrigated area is irrigiated by Tubewells. Wells are secondary sources of irrigation.
6. Manuring is also done mostly in irrigated tracts. Due to the publicity by the block development and Panchayat samities the consumption of chemical fertilizers has increased.

III. The Ravine – Lands – Problem Area of Agriculture

The problem of ravine and gully erosion in the district can be studied properly by understanding geomorphic and hydrologic factors. Ravines form a conspicuous topographic feature of the district. The planning commission has estimated that 36.69 lakh hectares of agricultural land has been estimated under ravines along the Banganga, Gambhir Chambal and its tributaries in Bharatpur district. The problem has assumed urgency because the ravines are fast spreading into agricultural lands. The deterioration of land has not only affected the agricultural land but also inhabitants, roads, railways and other public properties. These ravines in Bharatpur district are mainly distributed along the lower and middle courses of Banganga and also on the right bank tributary areas.

The ravines of the Banganga and its tributaries are of varying depth and they may be classified into there grades on the basis of their form, size, depth and width.

Type of Ravine	Depth	Width
G1	Upto 1 m	18 m
G2	1-5 m	18-25 m
G3	5-20 m	25 m

At present G3 type of ravines are very rare and are only evidenced near the confluence of the Banganga in the district. G2 type of ravine are found along the banks of all the rivers in the district and G1 type of ravines are found some distance away from all the rivers of the district.

GEOMORPHIC CHARACTERISTICS

The development of ravines is a conspicuous topographic feature of this district. The depth varies from 10 to 20 meters. It depends on the soil characteristics, nature of slope and intensity of vertical corrosion by the ephemeral streams, most of the ravines downstream are shaped. The alluvial knolls are common in the midst of ravines. From a distance these given an appearance of mesa like topography.

AGRICULTURAL CHARACTERISTICS

The main characteristics of this, from the point of view of the agriculture may be summarized as follows:-

1. The whole ravine belt is an area of very poor soil. The soil is sandy loam to loamy sand in texture. In the lower reaches of Chambal and its tributaries soils are sticky and plastic. Kankar layer is found 1 to 2 meters below the surface Permeability throughout is moderate.

In the ravine infested part less than 50 percent of the total area of village is net sown area. On a very little area double – cropping is practised.

CHAPTER-10

GEOMORPHOLOGY AND LANDUSE PLANNING

The comprehensive study of the physiography and Slope suitability is the degree of appropriateness of land for certain use. Slope suitability could be assessed for present condition. Actual slope suitability is a slope suitability that is based on current soil and land conditions, i.e. without applying any input. The information is based on soil or land resources surveys. Land suitability is an important step to detect the environmental limit in sustainable landuse planning. It deals with the assessment of land performance for the specific use that is crop production in the present study. A land suitability evaluation in the watershed has been carried out through close examination of the indicators of land suitability. Agriculture land suitability assessment of land performance when used for alternative kinds of agriculture (Ne *et.al.* 2011; Mu 2006). Prakash, 2003). The principle purpose of agriculture land suitability evaluation is to predict the potential and limitation of land for crop production (Pan and Pan, 2012).

Continuous utilization of agriculture land in past decades, regardless of land suitability has caused much more districting than provide the resources (FAQ, 1976, 1983, 2007). Hence proper evaluation based on agriculture landuse planning is essential to solve this problem. Land evaluation methodologies have shifted from broad based to specific assessment with increasing use of quantification (Elshik et al., 2010; Nmer, 2006). Significant amount of literature and research has been dedicated to intelligent systems for landuse and management.

The agricultural landuse pattern, indeed, is the result of interaction of geomorphic and historical socio-economic factors. In Bharatpur District the influence of geomorphic features on agricultural landuse has been investigated and presented, since land utilization in relation to geomorphology particularly in semi-arid environment, has received less attention of the investigators. However the valuable work in this direction has been done in Poland under the leadership of Professor Klimaszewski (1982). This study illustrated a method comparison of geomorphological maps and geomorphological evaluation maps with necessary explanatory text to the Kasakov region. The Division of the landuse Research, CSIRO, of Australia and Cooke et.at. (1974) have also contributed a lot in the similar direction.

The Gluesh and Singh (1965), Iyer and Srinivasan (1977), Sen and Singh (1977), Subramynam (1978), Vaidyanadhan (1980), Vats and Singh (1982, 1983 and 1986), R.K. Rai, S.N. Patnaik, P. Panda and V. Singhania (1984), D.K. Painuli (1984), Dutt, G.K. (1985) studied the landuse in relation to landforms.

SLOPE SUITABILITY AND AGRICULTURE

Slope of land is also one of the important physiographic aspects influencing the agricultural land use of an area. The effects of slope on agriculture may be an both directions, in the form of the restraint on cultivation and accessibility. The indirect effect of slope manifestes itself in pedological and climatic modifications including the position of water table, development of soils, drainage and the relative freedom from frost. One can never ignore the fact that too steeply sloping areas could be brought under cultivation because of inherited limitations.

It is a universal fact that with the increase in steepness of slope the use of every simple farm machinery becomes different. Neither there any information available about how cultivation cost vary with steepness, nor it is possible to lay down any practical limits for the safe operation of different kinds of equipment. At the same, if depends on the present economic circumstances and on the way in which the equipment is operated, for instance; one way ploughing is possible with a tractor on virtually any slope with a covering of soil (Coppock, 1971). It is indeed very difficult to estimate the actual operational costs of different slopes. Nevertheless, it is a matter of common experience to find the operational cost rising with the increase in steepness and viceversa. Farmers would not prefer steeper slopes where alternatives are available. Steeper slopes are generally avoided and ploughed only if gurranted by population pressure. For example in hilly places population pressure is progressively increasing, farmers led by circumstances are bringing steeper slopes under the plough to raise both subsistence grain crops and trees side by side.

Livestock farming may be equally affected by slope. It is difficult for animals to move on and graze in the pastures situated on very steep slopes. Under such conditions, they soon get exhausted and, thus require additional feed and fodder. Eventually, the overall production of dairy cattle will largely be affected. Perhaps, it is for this reason that low-grade animals such as goats, sheep etc. are found to be ideal substitutes to thrive on relatively steeper slopes.

Though study of slopes is very useful for landuse studies and for the preparation of land capability maps. Yet surprisingly no comprehensive study for such type.

Slope accessibility is the most important factor in agricultural landuse in mountaineous regions at any slope or elevation, and inaccessibility at places can put all the developmental efforts in reverse gear. Slope accessibility according to Wingo (1961), is a relative quality accuring to any land by virtue of its relationship to a system of transport. In the modern age there is scarcely and purely subsistent economy prosperity of an area, resulting from the sale of produce and purchase of stores which binds with the improvement of access (natural accessibility). The term accessibility has been used here in a relative sense as it largely depends on many variables, of which depends the economic development of a region is the most important. For the plains, two main elements of accessibility i.e. distance and time, may be considered whereas for mountaineous regions various elements such as distance, slope, roughness and time and energy expanded by the farmers while moving from place of residence to fields are to be taken into account to establish an accurate coefficient of accessibility. Thus, in the later case, the first three elements relate to the absolute or the physical aspect of accessibility since these can be quantified, while the last two pertain to the relative aspect. Asthana (1968) has observed that the steep angle of slope makes the journey on foot quite exhausting. Further, he made an attempt to establish a precise mathematical relationship between the angle of slope and the distance transverse by man. He said that the time an energy expanded by farmers in transversing from place of living to fields increase with increase in angle of slope, hence low intensity of agricultural landuse.

Every farmer dwelling in mountaineous areas faces problems of access while travelling to different places. He had to plough his fields located at different slopes and elevation. He has to make hay for his livestock both for daily consumption and for offseason. He has to graze his livestock on different elevations and slopes. He must go to the nearby market to sell his produce and buy provisions. In the absence of adequate easy mountain passes and tracts, the farmer may therefore waste much of his time and energy.

Easy access is essential for perishable agricultural commodities like vegetables and fruits grown in mountaineous area although technological developments have reduced its significance. Milk, Mutton, beef, pork etc. cannot be kept for a long time, and therefore need quick and efficient transportation to the market. Moreover in the case of vegetables and horticulture products, freshness is an important equally important aspect. Perhaps because of this reason vegetables and fruits are grown near the markets. The weight and volume of the produce in relation to its value also influences the distance over which it can be transported to selling places. Production of bulky commodities tends to be located near markets (Coppock, 1971). Potatoes and Sugarcane are the most important representatives of this kind. However, bulky crops, if one of required quality, may be able to enter more distant markets within or outside the country, provided accessibility is easy.

Now slope and soil erosion along with influencing each other also influence agriculture. Theoretically speaking, soil erosion is caused by a number of factors operating in combination. These include intensity of rain, permeability of the soils, chemical and physical properties of the rocks (which control their disintegration and subsequent weathering) and the vegetation cover. All these factors not only vary spatially but react differently to local conditions, subject to the combination of other aspects. For example, in a region of high rainfall, the surface runoff may not be uniform as it depends on the permeability of sub-soil. Sandy or gravelly soils are highly permeable; Consequently, these types of soils soak a considerable quantity of rain water. If there is a clayey layer immediately below the previous layer, it checks further flow of water underneath. As a result the upper stratum soon gets saturated, and the excess rain water flows on the surface, accelerating the process of soil erosion depending on the degree of slope. However, the erodibility may be effective provided there is an optimum degree of slope since the depth of flow of water is zero at the crest and increases down slope.

These controls alone ensure that there will be no erosion until the depth of water and slopes acquire an erosive force (Leopold, 1969). The other element of the slope wich effects erosion is its length where compound slopes are responsible for erodibility differentials. The intersification of soil erosion is due to the volume of water accumulating on a long slope and the consequent increased velocity of run-off (Beneet, 1955). In view of all the controls of soil erosion, which vary spatially it becomes rather difficult to make a precise assessment of soil erosion. There are two important pre-requisites for the study of the regional pattern of erodibility: (i) appraisal of the various controlling factors, and (ii) intensive field observation and recording of various hydrological data. For identification of index of soil erosion, drainage texture is an ideal shortcut.

On sloping land, water flows down before it finally gets absorbed in the ground. The quantam of precipitation lost by run-off increase correspondingly which probably explains why sloping land is found usually dry despite the heavy rainfall it may receive. It is an estabilished fact that both run off and soil erosion varies according to steepness of slope. It has been proved experimentally by Kohnke and Bertrand (1959) that if the degree of slope is doubled the erosion per unit area is increased two and a half times. When run-off occurs, water happens to accumulate while flowing down slope over the lower part of a slope; obviously its quantitiy and momentum are bound to increase. It was also computed by them that on an average soil erosion increased one and a half times per unit area when the slope length was doubled. It is true that all soils contribute to erosion, but it is also true that erosion is greater on steeper slopes than on greater slopes. At the same time erode more on a slight slope and may erode less than clay, but on a steep slope the reverse is true, that is clay may erode more than sand. Run-off carries not only clay and sand particles but also makes gravel and boulders roll down to lower slopes which cause damage to standing crops. Occasionally the boulders are so large that it becomes difficult to remove them physically from the small, terraced fields. It is common phenomena that heavy rain pouring own on bare soil of a hill side carries away clay and silt and deposists them elsewhere. This process seals the pores of the soil lying on the down slopes so as to form an impervious covering which prevents drainage into the layers situated beneath. In this, the land if left unchecked may back their way into fertile lands. Often the exposed surface of a hill-side may this subside toward the gullies preventive measures are needed to avert this damage.

Moreover, apart from the lower terraced slopes even the upper ones are affected by run-off, particularly when it is of a sufficient volume and momentum, consequently the upper terraces are valuable to the forces that produce severe erosion, which makes them guilled and rounded. Rainwater easily flows over them during its course from the up-slope terrace to the down-slope one. Occosionally, terrestrial rains accompanied by a cloud burst, such slopes carrying down everything with it. Even human lives and cattle may be lost in such cases. A successful balance between landuse and slope has not yet been attained in many parts of the world. Hence, preventive measures are needed to control the menace of run off and soil erosion to arable land, many other different forms of terraces and stone faced terraces may be used for successful cropping on slopes. Like bench terraces are used which are made by bulding walls across a slope so that the soil may accumulate up-slope.

On sloped fields, irrigation efficiency is bound to decline unless some effective measures are adopted, such as terracing and levelling of irrigation fields with provision of retaining well. There is a good deal of terracing on highlands and water is ingeniously led from it and filters down to the terraces below. Irrigation water is conducted from up-slope to down slope and from terrace to terrace by a complex system of artificial channels. If slope water is not available for a region, it should be lifted up slope through mechanical devices for irrigation. The necessity of such devices is felt particularly during dry spells in course of an agricultural year. Since water cannot be retained on sloping fields, sprinkle irrigation would prove more beneficial to recharge the soil moisture without dry soil erosion. This process steeps the soil intact and thus helps in maintaining the agricultural potential of the area. The possibilities of such irrigation systems are being explored in the mountainious areas.

The regional variations in physiographic units in an area expose serious problems of agricultural practices. The effects of slope direction on agricultural land use are inseparable from physiographic conditions, since at any altitude the agroclimate at macro and micro levels varies on different slopes. Effects are indirect through the modification of climate and are primarily local. There may be a month’s difference between the ripening of crops on the south facing and north facing slopes. The slope aspect is certainly important in the growing of early maturing crops. Variations in slope aspect within the same farm may also prolong the grazing season by providing both early and late pastures.

In regions of high relief the contrast resulting from angles at which the sun's rays strike the ground surface is heightened by the difference between the number of hours of possible sunshine on different slopes. The angle of slope in relation to the sun rays is always important when the sun has shifted far south in winter. A northward facing slope may then only partially be exposed to sunshine whereas the south-ward facing slope may be aligned in such a way so as to receive enough sunshine. There are differences from the point of view of agricultural land use between the sunny side of the velley and the shady side. Even the gentle slopes are often important to the local farmers, the reason being that a field which is inclined very gentle towards south is almost certain to produce more grains crop, grass or hay than other field in the same farms with a very gentle tilt towards north. Sunshine also plays a significant role in plant growth.

So putting it more precisely the slope aspect is one of the important variables for plant growth. This is because of variations in temperature on the these kinds of slopes, i.e. those directly facing the sun and the ones not facing the sun at all are obvious with reference to slant and duration of the rays.

REGIONAL SLOPE DISTRIBUTION

The slope both from the north and the south tends toward the Bharatpur city which thus becomes the meeting point of the two opposite drainage slopes. There is a slight gradual fall from the north and a steeper fall of about 2 feet a mile from the south, both inclining towards city of Bharatpur. Thus the city is easily prone to floods, chiefly from the south. however the greater thrust of those slopes is in the east towards the UP and cultivates at the junction of the river Yamuna and Chambal near Etawah in UP. The fall in this direction (East) is about 5 feet a mile. The flood waters from Bharatpur city are, due to this slope readily drainable in a south-easterly direction towards the Khari River, which is a tributary of Chambal River. The Bharatpur city are controlled and contained by a number of 'Bunds' and lakes in the area. such waters if left uncontrolled flows iinto the low lying land in the south-west of the city. This flood water is used for filling the fort of Bharatpur city which remains filled with water all the year around.

Two Kilometers south-east of Bharatpur city, the Keoladeo National Park is situated between $27^0$76” to $27^0$12’2” north and $77^0$29’5” to $77^0$33’9” east with an area of 29 km^2. It is flat with gentle slope towards the centre forming a depression, the total area of which is 8.5 km^2. The average elevation of the park is about 174 meters. The park has a boundary wall all around and is surrounded by agricultural fields and villages. It was first declared as bird sanctuary in March, 1956 and then a Keoladeo National Park in August, 1980.

In the present case study the average slope map and enumeration of aerial distributon of the slope between less than 3^0 intervals of slope groups indicated that there is an unveven distribution of slope throughout the entire area. About 88.34 percent of the total area lies between slope groups of below 3^0 and 3^0-5^0. And it occupies 42 percent of the net sown area in the district. While the highest slope value from more than 10^0 covers only 1.38 percent (200 square kilometers) of the total area. The slope at the foothills extends from 5^0 to 10^0 and covers only 10.28 percent i.e. about 1100 square Kilometers of the total area and has only 5.78 percent of net sown area.

The landuse mapping units of the study area have been discussed geomorphic regionwise. The landuse legend and the extent of area under different landuse are furnished in chapter 6. The following area the land systems recognized in the district shown on geomorphological map.

1. Structural Hill Systems

This system consists of hills of the Aravallis and Vindhyan groups. Hills with an elevation of about 500 metres are found in continous ranges from Roopwas to Bayana. These hills are composed of the Vindhyan sandstone with intermittent layers of shales and limestone. The drainage of the structural hill region is different in many aspects.On the whole, the drainage pattern is irregular. Shallow soils are scattered in almost all of the foothills of Bayana and Roopwas, soils of this zone are of light texture and yellowish brown in colour because of their development on the sandstone and quartzites. The Vindhyan formations are thickly wooded, bulk of such forests are confined to hills in Bayana and Roopwas tehsils.

The mixed cropping is common practise but double-cropping is almost unusual, water with good recharge is available in the wells. Due to limited agricultural land, the holdings are very small with an average 1.6 hectares.

2. The Upland or Plateau System

This upland agricultural region runs from the west of the Bayana and Roopwas along the Great Boundary Fault. The whole of the upland is composed of gently tilted upper Bhander sandstone underlain by shales. The lower Bhander sandstone along the Boundary Fault are vertical and form the strik ridges. The streams of the region have carved out the hills into remants.

3. The Alluvial Plain System

This is the largest land system of the district. On the west of the plain, it is bounded with the Aravallis and in the east with the Vindhyan. It is composed of the flood plains, the natural leeves and the ravine belt. It is essentially an agricultural plain built of deposits brought predominantly by streams flowing through it. The water composition varies from loam to clay loam. The soils are deep and medium black, greyish, dark Brown. Kankar layer is found below 0.92 to 1.22 metre. The permeability of surface soils is moderate and low at lower depth.

Plains are characterized by recent deposits occurring slightly at higher elevation than flood plains. Bajra is grown in Kharif season and Wheat is grown during Rabi Season, on these land units. The lowlands of recent deposists are cultivated with Sugarcane and Wheat during Rabi Season.

The area is highly dissected by water erosion, having deep soils with texture varying from sandy loam to loam.

RECOMMENDATION FOR BETTER LANDUSE PLANNING OF THE DISTRICT

Landuse planning seeks to order and regulate land use in an efficient and ethical way, thus preventing landuse conflicts, Government uses land-use planning to manage the development of land within their juridictions. In doing so the governmental unit can plan for the needs of the community while safeguarding the natural resources, for the systematic assessment of land and water potential in order to select and adopt the best landuse options. Often comprehensive plan landuse plan provides a vision for the future possibilities of development in neighbourhoods, districts cities or any defined planning area.

Today, successful planning involves a balanced mix of analysis of the existing conditions; extensive public engagement; practical planning and design; and financially and politically feasible strategies for implementation current processes including a combination of strategic and environmental planning. It is becoming more widely understood that any sector land has a certain capacity for supporting human, animal and vegetative life in harmony, and upsetting this balance has dire consequences on the environment. Planners and citizens often take an advocacy role during the planning process in an attempt to influence public policy. Due to a host of political and economic factors, governments are slow to adopt land use policies that are congruent with scientific date supporting more environmentally sensitive regulation.

Since the 1990s, the activities, environmentalists approach to planning has grown into the smart growth movement, characterized by the focus on were sustainable and less environmentally amazing forms of development.

Landuse planning is the systematic assessment of land and water potential, alternatives for landuse and economic and social conditions in order to select and adopt the best landuse options. Its purpose is to select and put into practice their landuses that will best meet the needs of the people which safeguarding the resources for the future. The driving force in planning should be the need for change, the need for improved management or the need for a quite different pattern of landuse dictated by changing circumstances. In the process all kinds of landuse are involved like agriculture, forestry, wildlife conservation, urban and industrial expansions Tourism and amenities planning also provides guidance in place of conflict among the competing use by indicating which areas are most valuable for any particular landuse. Landuse planning can be wired as iterative and continuous process, whose aim is to make the best use of land resources by:

- Assessing present and future needs and evaluating the land's availability to meet them.
- Indentifying and resolving conflicts among competing uses and needs.
- Devising alternative options and choosing those that best fit identified targets.
- Learning from experience.

Knowledge on area and distribution of land uses plays an important role in district planning. An attempt has been made here to study existing landuse pattern and changes in the landuse pattern of Bharatpur district. Major findings in landuse pattern of Bharatpur district (a) that the land use pattern in Bharatpur district is not similar to that of general landuse pattern prevalent in Rajasthan state, as a whole and (b) agriculture sector is the predominant user of land occupying about 75 percent of the reporting area, (c) forest cover in the district is not very significant and it has been depleted from 5.6 percent to 3.1 per cent (d) the area under pastures and tree crops is also negligible and (d) area under wasteland eroded land, undulating terrain with or without scrub and rock out crops has been increased from 6.34 to 7.89 percent, the area under salt affected land sandy area and water logged area has been decrease from 6.83 percent to 2.99 percent.

CHAPTER-11

GEOMORPHOLOGY AND LANDUSE PATTERN AND ITS IMPACT ON AGRICULTURAL DEVELOPMENT AND PLANNING

Geomorphology is the study of landforms, their origin and distribution with the help of geology of region. India has taken a big stride in the field of geomorphology in the past two decades. Various universities, central and state government organizations such as the Geological Survey of India, the Survey of India, the National Atlas Organization, the Soil and Landuse Survey the Central and State Ground Water Departments, the Space Application Research Organization, Ahmedabad; the National Remote Sensing Agency, Hyderabad, have initiated serious geomorphological research according to their needs and raquirements.

In the geomorphological study of a particular region and the knowledge of its geology is most essential. The genesis of the present day landscape has largely to be sought in the geology of the region. Landuse is a significant aspect of agricultural study in order to increase food production and for proper utilization of land resources. It is very essential geomorphological study has addresses the relation of cultural landscape features, such as landuse, with landforms in different environments and under different landuse regions correspondence analysis (CA) is used to identify correlations among landuses and landforms. Research showed a significant correspondence between geomorphic and landuse entities. Alluvial landforms is associated with simpler patterns of human activities. Denudational landforms, on the other land, depictes more complex and diverse landuse patterns. Agricultural and grazing activities occures in both gurtte and steep denudation landforms (Fig. 11.1).

Geomorphologically, the rocks of Bharatpur district belong to Delhi and Vindhyan Super Group. Almost the entire district is covered by alluvium with few isolated hills where rocks of schist and quartzite Delhi Super Group are exposed. The lower part of Delhi Super Group is characterised by a thick pile of conglomerate – quartzite at assemblage of Alwar group, Ajabgarh Group unconformably overlies the

Alwar Group comprising lithologic assemblage of carbonaceous shale, phyllite ferruginous quartzite and white quartzite. Vindhyan Super Group of rocks is represented by sandstone, limestone etc., which are exposed in the southern part of the district in Bayana and Rupbas blocks. (Fig. 11.1)

The occurrence of various geomorphological units in the district are given in table 11.1

Table 11.1

Geomorphological Units in Bharatpur District

Origin	Landforms	Occurrence in the district
Fluvial origin	Alluvial plain	Formed due to fluvial activity, consists of gravels sand, silt and clay. Terrain mainly undulating.
	Valley fills	Formed by fluvial activity at lower topographic level.
	Ravines	Small, narrow, deep depression usually carried by running water.
	Flood plain	Surface of relatively smooth land adjacent to a river channel. Subjected to periodic flooding.
Structural origin hills	Plateau	Flat landscape, bordered by escarpment on all sides. Formed over horizontally layered rock formation with steep slopes.
	Dissected plateau	Plateau, criss crossed by fractures forming deep valleys.
	Linear ridges structural hills	Low narrow ridges having high run off linear to accurate hills associated with folding.
	Denudational hills	Steep sides comprising of varying lithology with joints, fractures and lineaments.

Source: Geological Survey of India.

GEOMORPHIC ZONES

The Bharatpur district has been divided into following six geomorphic zones based on photographic and geotechnical elements :

1. Structural Hills and Valleys of Delhi Super Group
2. Vindhayan Plateau
3. Aligarh older Alluvial Plain
4. Burried Pediment
5. Banganga Recent Flood Plain
6. Aeolian Deposits

1. STRUCTURAL HILLS AND VALLEYS OF DELHI SUPER GROUPS

The hills and ridges of the Bayana, Ajabgarh and Alwar groups from hogback, cuesta and domal outcrops aligned in NE-SW to ENE – WSW directions in the northern and southern parts of the district (Fig. 11.2). The following three geomorphic sub-units have been identified in this zone.

(a) Cuesta:

Cuesta ridges correspond to Bayana group and are aligned in a linear pattern in ENE-WSW direction developed near Deeg in the north and around Bayana in the southern part of the district. This geomorphic unit was identified by its dark tone, linear pattern, isolated hillocks, parallel pattern of first order channels and scanty or no vegetation. The cuesta exhibit asymmetrical ridge profile. The cuesta topography is controlled by gently dipping strata with moderate resistance to erosion.

(b) Hogback Ridges:

The hogbacks occur as NE-SW trending sleep ridges of Delhi Super Group with symmetrical profile defining the main architecture of the Aravalli ranges, forming natural fortification on the western boundary of the district. The dip slopes and obsequent slopes are nearly symmetrical and smooth. The ridges are defined by tonal bounding, linear forms, parallel drainage and symmetrical profile. Vegetation cover is scanty and resistance to erosion is high. These are seen prominently in the Pahari and Kaman tehsils. The Kaman ridges terminate at Barsana in Mathura district, while the Pahari hogbacks continue northwards in Haryana and Delhi states, in south these merge with the Lalsot hills of Rajasthan.

(c) Erosional Hills

The erosional valleys have developed within the Bayana hill ranges and in Pahari and Kaman Tehsil of Bharatpur district. These are characterized by depressed topography, carved out by soft lithologics in the rocks of Delhi Super Group. The erosional valleys are sandwiched within the hogback zone and exhibit restricted agricultural practice, centripetal drainage and form rib and furrow topography due to their low to moderate resistance to erosion.

2. VINDHYAN PLATEAU

The Vindhyau plateau in the southern part of the district forms the monolith overlooking the AOAP (Aligarh older Alluvial plain) of Bharatpur and Bayana valleys. This zone is defined by cuesta ridges of the upper Bhander sandstone and hogback ridges of Rewa sandstone of Vindhyan Super Group. The hogback ridges strike in ENE-WSW direction in a linearly stretched belt aligned parallel to the great boundary fault which separates the Vindhyan plateau from the rocks of Bayana Group and Delhi Super Group.

The cuesta occupy a higher topographic elevation than the Vindhyan plateau and range in elevation from 220 m to 318 m. These are characterized by structurally controlled drainage, the drainage density is medium to low and resistance to erosion is moderate to high. The cuesta in the Vindhyan are inliers of remnants of paleo-planar surfaces in the area. Besides, these hogback and cuesta ridges, the Vindhyan plateau is also characterized by association with loess and ravines.

3. ALIGARH OLDER ALLUVIAL PLAIN

The Aligarh older alluvial plain (AOAP) covers major part of the district under Kaman, Pahari, Deeg, Kumher, Nadbai and Bharatpur tehsils. (Fig.11.2). It is characterized by well developed paleo-drainage system which originated from the Vindhyan uplands and Bayana hills in the south and flowed towards north. The alluvial plain has a sharp contact with the burried pediment zone. It has irregular boundary outline and extensive agricultural activity is characteristic of this unit. The zone represents almost uniform plain with elevation ranging from 178 to 190 mm. The sears and paleo-channels of the paleo-drainage are characteristic elements.

(a) Paleo Channel

The paleo-channels correspond to the north flowing paleo-drainage. (Fig.11.2), which originated from the south and predates the newer alluvium (Iqbaluddin, 1994). This paleo-drainage was sinous with medium to high drainage density.

The paleo-channels are recognized by their medium to dark tone, curvilinear pattern, uniform texture and continuity beyond the district boundary along the Mathura border.

A younger set of abandoned paleo-channels in the south of Bharatpur and Nadbai define the earlier channel courses of the river Bangnga and are helpful in reconstructing the channel migration of the Banganga River. These are recognized by light tone uniform texture, linearity of tone, sharp contact, development of channel sinuosity etc. The landuse pattern is defined by agricultural activity. The Banganga paleo-channels are separated from the north flowing paleo-drainage by the roughly east-west trend by these channals. The Nadbai-Bharatpur water divide separates the Banganga paleo channels in the south from the north-easterly flowing paleo-drainage of Aligarh older alluvial plain.

(b) Sears

These are the remnants of the highly sinuous north flowing paleo-drainage system, which were cut off from the main channel. These are recognized north-east of Nadbai and north of Bharatpur (Fig. 11.2) by accurate shape, uniformity in tone, isolated occurrence and depressed relief, characterized by loss of hydraulic continuity with parent channel.

4. BURIED PEDIMENT

This geomorphic zone occupies a significant area in the north, south –west and north-eastern parts of the district fringing the structural hills of Delhi’s and

Vindhyan plateau. The zone is characterized by undulated topography, accidental slope, thin alluvial cover, higher elevation as compared to the Aligarh older alluvial plain and favorable soil conditions for agriculture.

5. BANGANGA RECENT FLOOD PLAIN

This included the flood plain deposits of the Banganga and Gambhir River, which correspond to quaternary period. These two rivers are characterized by their overall sinuous courses which locally become braided and the two finally confluence in the north-west of Rupbas town forming a low lying plain adjacent to Vindhyan plateau in the south. It is recognized by its dark to medium hue, sharp contact with adjacent geomorphic zone, irregular boundary outline, low settlement density, restricted landuse pattern, association of point gully erosion, scars, badland topography, sand bars, etc.

The Banganga river possibly indicate a drainage amongly defined by the higher channel with in the western part, as it enters from the adjacent Sawai Madhopur district. The drainage mutation in the area has possibly taken place in the quaternary.

6. AEOLIAN DEPOSITS

Sand dunes and the loess deposists are reported from the Nabdai, Nagar, Bayana and Rupbas tehsils. The sand dunes comprise 785 percent sand , the grains are fine sub-angular to angular and forming 6-8 m high heap of sand. Texturally the sand is very well sorted to well sorted, fine to medium grain, possess high porosity, devoid of any biocover and has internal drainage. These are the aelion features which have been brought to the area by wind action but do not show the direction of the wind. Texturally these reflect uneven texture, irregular shape and outline and are spatially associated with the Aligarh older alluvial plain, Vindhyan plateau and Bayana hills.

LANDUSE PATTERN AND ITS IMPACTS ON AGRICULTURAL DEVELOPMENT AND PLANNING

Agricultural development is a complex process of interaction between the Physical input-output relations of the agricultural system and the social and economic milieu of the national economy in the dynamic equilibrium and landuse accelerated growth through judicious management of land and water resources.

There are two misconceptions about the landuse planning. One is that the lanuse planning is relevant for the developing countries only. Secondly, some opinion makers in the developing countries like India-which are now experiencing liberalization of industrial sector, have the misconception that opening up agricultural sector to the free market forces at one go ever without any agreed agricultural policy, will bring about a significant boost in the growth rates of agriculture. Agriculture itself has become increasingly complex and needs a new set of rules and institution to bring about this structural re-adjustment. Now more than ever, the entire gamut of social economic institutional and legal dimensions of agriculture have become very relevant in addition to a re-appraisal of the traditional technology, the market forces can be moulded to sub serve:

- The interests of 60 percent of the population still dependent on agriculture.
- Landuse planning (LUP) as resource management tool; for formulating astrologic agricultural policy initiatives for development.
- Landuse management as a dynamic concept.

The socio-cultural and economic factors have significantly influenced over landuse both in rural and urban areas in the district. Land forms, slope, soils and natural resources are some of the important factors which control the landuse pattern of the district. Data is based on district statistics outline 2014-15. The landuse pattern of district is presented in Table 11.2.

Table 11.2

Landuse, Bharatpur District

S.No.	Landuse	Area in Hectare	Percent
1	Total Geographical area	506731	-
2	Forest	33645	-
3	Uncultivable Land	3001	5.92
4	Land not Cultivated Including Pasture Land; Barren Land Trees, Grooves & Orchards; Pada land	21518	4.25
5	Uncultivable Land Apart	10446	2.06
6	Pada Land	14767	2.91
7	Actual Sown Area	396354	78.22
8	Gross Sown Area	587087	-
9	Area sown more than once	190733	-

Source: District Statistics Outline, Bharatpur (2014-15).

Land resources are limited and finite. If human populations continue to increase at the present rate there will be twice as many people in the world about 60 years later, therefore there is an increasingly urgent need to match land types and land uses in the most rational way possible, so as to maximize sustainable production and satisfy the diverse needs of society while at the same time concerning fragile ecosystems and our genetic heritage.

Landuse planning is fundamental to this process. It is a basic component, whether we are considering mountain ecosystems, savannahs or coastal zones, and underlies the development and conservation of forestry, range and inland as well as coastal resources. Landuse planning is also a key element in all types of agricultural development and conservation. It is an extremely complex subject, combining physical, social and economic aspects of landuse with an assessment of potential future needs. Landuse planning is the systematic assessment of land and water potential, alternatives for landuse and economic and social conditions in order to select and adopt the best landuse options. Its purpose is to select and put to practice those landuses that will best meet the needs of the people while safeguarding resources for the future. The driving force in planning is the need for change, the need for improved management or the need for a quite different pattern of landuse dictated by changing circumstances.

All kinds of rural landuse are involved : agriculture, pastoralism, forestry, wildlife conservation and tourism.

CONCEPT OF LANDUSE

Land is the function of four variables land, water, air and man. Each has its role to compose its life history. Land constitutes its body water runs through its veins likes blood, air gives it life and man acts as a dynamic agent to reflect its types, pattern and distribution. In fact, man the user of land, is himself the product of atmospheric behavior, hydrological action and lithospheric expressions.

'Man can survive without air for a few minutes, without water for a few hours and without food for a few day.' The use of land likewise was limited. As man multiplied, their wants also increased and became complex. Consequently the uses of land also increased, subsequently the methods and technology of landuse also changed. Man has been making his own map on the face of the earth to portray his link, adaptation, creation and destruction.

Agriculture landuse is constantly changing with time. The landuse pattern of a country or a region at any particular point of time is determined by the physical, economic and institutional factor and their interplay over a period. Agriculture is major sector in the economy of Bharatpur. The sustainable use of agricultural land is therefore essential to economic growth, human well-being, social equity and ecosystem services.

LANDUSE PATTERN: CROPPING PATTERN

The alluvial, clay loam and sandy loam soils found in the district are fertile. The district is the largest producer of wheat in the state. The cultivable land and the area sown in the district are as below:

Table 11.3

Landuse Pattern of Bharatpur District

S.No.	Details of Land	Area (in Hectare)
1.	Cultivable Land	421350
2.	Gross Area Sown	596919
3.	Area Sown More Than Once	396466
4.	Net Area Sown	343621
5.	Gross Irrigated Area	333627

Source: Basic Statistics, 2015 (DES, Govt. of Rajasthan)

Rabi and Kharif, both are the main crops in the district. Wheat, Bajra, Jowar, Mustard, Gram, Barley Guar are the main crops from production point of view in the district. The details of cropwise sown area in the year 2014-15 is as given below:

Table 11.4

Cropwise Sown Area (2014-15)

	Crop	Area sown (Hectares)	Production (Tones)
(a)	**Food Grain**		
	Wheat (Rabi)	157196	704731
	Jowar (Kharif)	54932	34170
	Bajra (Kharif)	122028	235022
(b)	**Pulses**		
	Gram (Ravi)	4885	8572
	Tur (Kharif)	301	301
	Masur (Rabi)	2981	3879
(c)	**Oilseeds**		
	Rapeseed mustard	202688	374189
	Sesamum	2748	1120
	Taramira	632	258
(d)	**Other commercial crops**		
	Guar	2967	4338
	Potato	3819	44284

Source: Agriculture Statistics, Department of Agriculture, Govt. of Rajasthan.

GEOMORPHOLOGY: SLOPE, RELIEF AND DRAINAGE

The morphometric analysis of the surface drainage has been carried out for the four micro-watersheds of Bharatpur district, Rajasthan to quantify the drainage morphometry of the district. The morpho-chronology of landscape evolution has been described Banganga represents anamabus drainage, which causes large scale invadation during rainy season. The strain of post-collision Himalayan tectonics resulted in slope mutation in Bharatpur district which changed slope from westerly to easterly. The landform characteristics of Bharatpur district have been archived at the National Informatics Center, District Data Base, Bharatpur.

SLOPE

The slope of land is one of the important physiographic aspects of agricultural geography. The topography of the district is generally flat with large saucer sloped natural depressions. Leaving aside the hilly areas, there is a little, gradual fall from the north trends the city of Bharatpur, and a fall of above 2 feet in a mile or 0.60 meters in 1.60 km, from the south, also towards the city. Because the rocks are not uniform in character, differences in erosion result in star-step profiles. The adjoining and separating of the gullies cause many isolated irregular spires, small flat-topped buttes or mesas, and produce a landscape of jagged, fluted and seemingly inaccessible hills.

Bharatpur and Nadbai tehsils are consisted of plains and leveled area. On the other hand, Bayana and Rupbas tehsils have more spread of hilly areas. These hills are part of Aravalli system which is found in isolated patches. Relief of the district does not report much variation as the altitude of 200 m contour cuts the district from its central part. Southern part of the district has noticed more ravines whereas isolated hills are distributed in the southern and northern section.

It is clear from Fig. 11.3 that most part of the district is flat with slope below 1.16 degree. However, slope has experienced slight increase up to 4.05 degree and it results into wetland during rainy seasons. Southern and northern hills reportedly have steep slope.

DRAINAGE

Water is a prima necessity of human being next to air. The existence of water bodies has played a very important role throughout human history in the birth of many great civilization of the world, including that of India. Water had been the centre of attraction and people have been settled along banks of small tributaries of rivers, avoiding big rivers because of the fear of flood which recurred frequently in them due to increasing pressure of population they settle along the banks of big rivers also.

In Bharatpur district there is no perennial river. The important rivers flowing through the district are Banganga, the Gambhir, the Kakund, the Ruparel and Parvati. These rivers flow only during rains and dry up for entirely two or three months. In Fig. 4.1 the drainage system has been shown.

THE BANGANGA RIVER

This river enters the district on the western border of Weir tehsil and follows due east towards Agra district. It spills freely over its northern banks as it passes through the district and about mid way in its course eastwards, the river has left its old channel and now flows in a northern direction towards Uchchain along the Bayana Uchchain road. The diversion of river has been induced artificially by the building of Bayana Uchchain road. The flood waste so discharged is again impound and distributed by other work the largest of which is the Ajan Bund a five embankment extending for 19 Km across the direction of flow. It feeds many important canals for irrigation, the most well known of which are the Uchchain and Pathena canal which centrally fill Ajan Bund in Bharatpur depends on the river which keeps the water in the wells sweet is filled up from the water of Anjan Bund, it has more than 2589.9 sq. Km. The important villages situated on its banks are, Kamalpur bachyhren, Chonker wada, Kalan, Kherli Gujjar, Dharsoni, Shahpur and Barkhera.

The rivers also enters district from the south western corner, after retrieving the waters of Kakund, about 13 km higher and after traversing about 56 km. first towards the east and then in north-east, it is joined with Banganga near the village Kurka of tehsil Rupwas. It usually ceases to flow about two months after the rainy season. It is not so useful for irrigation as Banganga is, but all the Kehri village, in the Bayana tehsil depend for their fertility on its water. A part of it is come- into Pichuna canal and then it enters the old Banganga river bed. The silt of this stream is highly fertile and crops are commonly grown in the river bed after the rainy season. The river is made to spill largely of the district by means of natural and artificial channel Dhana, Ghotai, Bakholi and Shekhpur, all leading off from the southern bank. There is also considerable natural spill from northern bank. This irrigation is valuable, the crop grown in the flooded land being remarkably good.

THE KAKUND RIVER

It is a smaller river entering the south-west border of the Bayana tehsil from the Karauli side. It was formally an affluent of the Gambhir River but it has become famous with construction of Baretha Bund where its water is held up and from where it is released to irrigate land further in Bayana and Rupbas tehsil. It fact this is only work of irrigation which except in years of very scanty rainfall can be consider a source of perennial irrigation. Its course for several kilometers is over an elevated plateau from whire it descends by a series of falls near the village Gurha Dang and it's one of the falls called Dir whose water is very deep and never dries up. The village situated on its banks are Chainpura and Baretha.

THE RUPAREL RIVER

This rises from the Thana Ghazi hills in the Alwar district and entering this district near Gopalgarh, is held up by Sikri Bund, a five embankment excluding for about 19 km along the western boundary which curves round in a southern direction from where its water is distributed to Pahari tehsil and Nagar tehsil in the proportion of 5.8. It is not design to store water but merely to held it up for distribution, according to the requirements of agriculture, to the main courses to which, through these outlets, the water is led flow in the north east towards Gopalgarh, Pahari and Kaman and the others in south east towards Deeg, Kumher and Bharatpur.

THE PARVATI RIVER

This is a seasonal river. It rises in Karauli close to the western border and after a north-easterly course of about 96.5 km falls into the Banganga. It has two small tributaries Mendka and Mendki.

LAKES

There are four lakes in Bharatpur district namely Moti Jheel, situated about three km west of Bharatpur city used for irrigation purposes, Keola deo Jheel situated abut 5 km south east of Bharatpur city and famous for its duck shoot. Madal Jheel, situated on the northern border and filled by the Rupbas river which is used for irrigation purpose and belly Jheel Ka bara, situated about 14 km north of Bayana town under the hill.

CHAPTER-12

CONCLUSION

In the previous chapters, an attempt has been made to bring into light and explain some basic geomorphological problems of the Bharatpur district and how they make an impact on the landuse planning of the district, with the help of quantitative and crop combination techniques.

The Bharatpur distirict is a part of stable Indian table-land. As the region is a part of very old landmass, its geomorphic history is not very well connected

The interplay between physical elements and human factors are extremely complex and multi-dimensional and the relationship that exist between man and land is of paramount importance. In a densely populated country like India and a under developed state like Rajasthan, feeding the growing population on a traditional agricultural system becomes a difficult task. Thus, in this context correct measurement and evaluation of land resource has become absolutely necessary to bring the processes of agricultural landuse and crop production on a sound footing.This has a great relevance for as present study area, where cultivation has been carried out since time immemorial and in which a high proportion of rural population is dependent on primary vocation. The objectives of sustained production can only be achieved through the analysis of morphological character of the region. As gemorphological analysis or approach attempts to express the integration of all elements of the land it recognizes the causal links between them through an understanding of the genesis of landform themselves.

The proceeding chapters of the present study, gives a systematic account of geomorphological character of the region, existing landuse and a decadal change in landuse pattern. The study reveals that the impact of geomorphology is multifaceted, as various landforms and land surface configuration determines land utilization type and changes that have occurred as result of change in morphological character.

In Bharatpur district, agriculture is the predominant source of occupation. Because of the topographical constraints, the scope of irrigation is very limited and cultivation depends mostly on monsoon rainfall. Physical conditions like landforms, soils and distribution of water resources affect cropping pattern and practices. The foregoing discussion throughout the study presents a synthesized account of geomorphology and landuse. The main findings of the area are being summarized as following :

1. As it has been discussed earlier, the study area has a unique location, with schist and quartzite of Aravali and Delhi system in North; sandstone of upper Vindhyan Range in south-east. The formation of Bharatpur district is almost entirely of the sedimentary class. The hills in the western side of the district represent the geological formation of the Delhi system. The highly diverse rock types ranging from pre-cambrian meta sediments to recent alluvial cover. The Vindhyan rocks are exposed in the eastern part of Bharatpur district. The Delhi rocks are wide spread through the Bharatpur district mainly in southern and northern part.

   The geomorphic history is therefore closely linked with the evolution of these systems. The landforms and morphology has envolved through various endogenetic and exogenetic forces.

   Various sets of land forms have been developed according to the nature of rocks of Aravalli system and the Vindhyan system. Faults and lineaments have controlled the evolution of various forms of topography in the area.

2. The climate of Bharatpur district is semi-arid to sub-humid and characterized by hot summers and cold winters. In the last two decades, the maximum temperature has ranged from 42.20^0C to 48.80^0C while average temperature has ranged from $22^0.7^0$C to 31.3^0C.

   The temperature increases from the month of February and maximum temperature is reached by the month of May or June. The temperature starts falling gradually due to the on set of the south-west monsoon by the end of June. A slight increase in the maximum temperature is observed after the withdrawal of the monsoon in September. Average annual maximum humidity was 67% in the year 1991 and minimum 49.2% in 1984. The annual average rainfall was 797.8 mm based on the data of available blocks for the year 2010.

   Bharatpur receives most of its precipitation from rainfall occurs during monsoon in the month of June to September. Occasional rains are also observed in the month of January and February on account of western disturbances. South-west monsoon, usually occurs towards the end of June or early July and extends upto September and at times to even October. Meterological characterization of the season are:

Pre-Monsoon	-	March, April, May
Monsoon	-	June, July, August, September
Post-Monsoon	-	Oct., Nov., Dec.
Winter	-	Jan., Feb.

Winds are generally high to moderate in summer and early part of the south-west monsoon season.

In the summer, winds blows from directions between north-west and south-west monsoon season.

In the post monsoon and winter months, winds are mostly blown from directions between west and north.

3. Soils of the region have resulted from various factors like climate, relief, rock types and vegetation. On the basis of their morphological and textural characteristics, the soils of the district have been classified into 6 types:

   (i) Loamy soils (ii) Clayey soils (iii) Light Black soil (iv) Sandy

   Loam soil (v) Saline – Alkaline soil (vi) Red and Yellow soil.

   Soil formation is a function of climate, relief, vegetation, parent material, organic water and time.

4. The study of fluvial morphology reveals that the drainage system is greatly influenced by the geological history and location of great Indian watershed line. The drainage of Bharatpur district finally discharges itself into river Yamuna. There are no perennial rivers in the district. The district has four rivers the Banganga, the Gambhir, the Kakund and the Ruparel and rivers flow only during rain and remain dry entrirely from two to three months after the rain.

   There are four lakes in the district viz the Moti Jheel, the Madal Jheel, Keoladev Jheel and the Jheel-Ka-Bara. The water table in the district ranges from 3-20 meters. The drainage density varies from 0.2 to 0.7 per square kilometers in the district.

In Bharatpur district, 3 types of irrigation resources are in vogue, they are tube-wells, wells and canals. Apart from these bunds and stream natural inflow of water are also used as irrigation resource

5. The analysis of relief morphometry gives an expression of configuration, slope and dimension of earth form.

   The highest value of relief 450 m is noticed near Ludhawai village of Bharatpur while the lowest relief 300 m is observed near Bacchamadi village of Weir tehsil.

   The Bharatpur district also has a complex tectonic and geomorphic history. The great boundary fault movement in the Cretaceaous period has thrusted the older Gwaliors towards the younger Vindhyans. The district possessed both endogenetic and exogenetic slopes. The endogenetic slopes subsequently are altered, obliterated and modified by exogenetic processes acting on them, thereby complicating the nature of slopes in the district.

   About 79% of Bharatpur has a level land, less than 2% of the area has steep and hilly slopes, mostly lying in the central hilly region, about 20% area has a slope varying from 3^0-10^0, lying specially in the transitional region between the hills and the plains.

   The dominance of level and gentle slope suggests the levelling is being done by the denundational processes. The general slope of the district is towards the south and west to north-east.

   The lack of tree cover along the rivers also increases run off and overland flow. The relationship between runoff, sediment yields, rainfall and discharge are directly related with each other.

6. In the present study an attempt has also been made to study and analyse the existing land utilization. In order to increase the food production, a proper utilization of land resources is very necessary.

   Total geographical area of district is 50673 hectares in which forest area covers about 6.64%, uncultivable land 10.19%, other uncultivated land (excluding fallow land) 2.07%, fallow land 34.7% and net sown area covers about 40.52% of the total land.

In the year 2014-15, 6.64% of the total land was under forest, of this 6% of area is under protected forest and 0.62% of the forest area of Bharatpur district falls under central India dry deciduous type Dhok or Dhad (Anogeissus pendula), Khair (Acacia catechue) as the main species. The other trees found are Aruaaj (Acacia leucopholea), Dhak (Butea – Mans-soperma), Kurchi (Holderhena anticlysenterica), Birbira (Dichrosta chys cinera), Hingot (Balavites aegyptica) and Jharber (Ziziplus mummulalaria). Besides this Babul (Acecia nilotica), Kadam (Mitragyan parvifolora), Kabuli Kikar (Prosopis julilora), Karil (Kapparis deciduvous) are also found.

The district has a National Park known as 'Keoladeo Ghana' famous as breeding place for Siberian Cranes.

Most of the dense forests are situated on the main exposures of Aravalli series. In Bharatpur district, Bayana and Weir tehsil has the highest and densest forest (1% and 3% respectively). Tehsils Nagar and Kaman have very small area under forest.

Bharatpur has very high proportion of net sown area, 77.62% of total geographical area has been classified as net sown area. Agriculture is practised in more than three – fourth area of Bharatpur district.

In 2006-07, the maximum area of Double Cropped Area was found in Bayana (2784 hec) and Nadbai (24357 hectores). Kumher has shown decline or say constant stability over the district average. It is to same extent due to the non profitable nature of farming, decline of soil fertility, low rainfall, inadequate irrigation facilities and negligence of ignorant farmers towards the intensificational of agriculture.

In Bharatpur district, the cultivation of crops is done area wise and most important crops are Rice, Wheat, Sugarcane, Jowar, Maize, Bajra, Jo and Oilseeds.

Monoculture is not prevalent and farmers generally follow diversified cropping patterns.

7. From agriculture point of view the average size of land holding in the district is 3.6 hectares. In a few, villages of the commanded area, system of rectangularisation is being adopted.

Agricultural implements which are commonly used in the district are old fashioned and the improved agricultural implements like tractor, iron plough, razor, sprayer, seed driller and winnower have recently come in vogue. A country plough Kaman, spade, sickle and sowing baskets are the only equipments that an average farmer possess in the disitrict.

The modern implements are uncommon in ravine infested area of the district as available land for cultivation in these tracts is undulating and the tractor is inoperable in these area. Secondly the water table is low, irrigation facilities are uncommon, so these factors collectively affect the crop production adversely.

Low yield of crops in the area at present is largely due to the lack of supply of plant nutrients to the soil. Most of the areas specially the ravines and hilly areas do not receive any kind of fertilizers and either organic or inorganic cow dung is used as a fuel by most of cultivators due to lack of firewood in Bayana, Deeg and Kumher tehsils. Improved methods of rice and wheat cultivation are being practised now-a-days in some tehsils. Soil conservation work is also carried out in some tehsils.

Chambal project meet the water demands for agriculture in the district although the main sources of irrigation in the district are canals, wells and tanks.

8. Regarding cropping area in Bharatpur district, food grains occupy 67.84%, Sugarcane 0.11%, Species 0.28%, Vegetables 0.66%, Oilseeds 22.54% of the total area of the district. Various cropping patterns like, Inter Cropping, Mixed Cropping, Sequence Cropping, Double Cropping is prasticed in the district.

   Though 11% of the total area of the district is covered by hills and rocky terrain, and about 5.14% by forests, there are vast stretches of good arable land and about 70.6% of the total population earn their livelihood indirectly from agriculture.

   The main crops grown are Wheat, Bajra, Jowar, Rice Sesamum, Cotton, Groundnut and Potato in both Kharif and Rabi season.

   Mustard crop accounts for the highest percentage area (44.6%) with Wheat (28%) and Bajra (19.9%) were at second and third place during 2010-15.

   In the district on an average total area under Kharif and Rabi crops was 653763 hectares (2014-15), total irrigated area was 2041061 hectares (2014-15) under both Kharif and Rabi seasons. Mixed farming is mostly takes place in central part of district i.e. Bayana, Bhusawar, Roopbas and Weir.

Double cropping Kharif cropped area was about 32.8 percent in 2014-15 with Cotton, Rice, Bajra, Til and Maize as chief crops, while double cropping Rabi cropped area was around 29.3% (2014-15) with Wheat, Barley, Gram as chief crops were grown in Bharatpur district. The double cropping patterns mainly followed in the north-east and the south-east parts of the district. It is followed wherever irrigation facility is good, soils are fertile and crop rotation is practised with fallow. Mustard is the most widely used in crop rotation by the farmers in the district.

Main Kharif crops in Bharatpur district are Rice, Bajra, Cotton, Sugarcane, Jowar and Millets. The total productivity under Kharif crops is 636970 hectares in the district.

The major Rabi crops in Bharatpur district are Wheat, Gram, Barley, Mustard, and Potato. The total area under Rabi crops covered in the Bharatpur district is 1496344 hectares.

The percentage of area under wheat decreases from north-west to north-east. The descending trend of Wheat percentage may be due to the occurrence of poor soil, low moisture content and rugged, hilly and ravine topography.

In the Ravine Land and hilly tracts of the valley in the district, the percentage of Wheat is low, ranging from 10-20%. It is because of the poor soil, undulating topography, low moisture content of soil, and the inadequate irrigation facilities. Moreover continuous efforts of farmers to grow Bajra is the other reason for decrease in the wheat land.

After the introduction of canal irrigation, the irrigiated Wheat area has increased considerably. The irrigiated Wheat area has also shown slight increase in the hilly tracts and ravine lands because of the increasing number of Wells and Tanks. The reason behind the increase in the production in these tehsils is the availability of rich clayey soil free from gravel, stones or coarse sand of uniform texture.

Most of the Gram area is in Nagar and Kaman tehsils. Deeg, Roopbas, Nagar and Pahari are the main Barley production tehsils in Bharatpur district.

Wheat and Bajra are the major crops in Bharatpur, total production was 616330 Mega tones for both crops.

9. The slope from both north and south becomes the meeting point of two opposite drainage slopes, thus the city is easily prone to flood, chiefly from the south. This flood water collected from bunds and lakes in the area is used for filling the most amount of area in the district which remains filled with water all the year around.
10. Geomorphologically the racks of Bharatpur District belong to Delhi and Vindhyan Super Group. Almost the entire district is covered by alluvium with few isolated hills where rocks of schist and quartzite. Delhi Super Group is exposed. The lower part of Delhi Super Group is characterized by a thick pile of conglomerate quartzite assemblage of Alwar Group. Ajabgarh Group which overlies the Alwar group comprises of lithologic assemblage of carbonaceaous shale, phyllite ferruginuous quartzite and white quartrite. Vindhyan Super Group of rocks is represented by sandstone, livestone etc. which are exposed in the southern part of the district in Bayana and Roopbas blocks.

    The Bharatpur district has been divided into six geomorphic zones based on photographic and geotechnical elements namely: Structural Hills and Valleys of Delhi Super Group, Vindhyan plateau, Aligarh older alluvial plains, buried pediment, Banganga recent flood plain, Aeolin deposists
11. Out of total geographical area of Bharatpur district (506731 hectares), forest covers 33645 hecatres, uncultivable land occupies 3001 hectares; barren land, pastures and uncultivated land occupies 31964 hectares; gross sown area is 58707 hectares and area sown more than once is 190733 hectares.

SUGGESTIONS

Based on the detailed study of physiography and agricultural resources of the areas and its existing landuse, the following suggestions may be proposed for agricultural development.

1. Soil conservation techniques can be practised on an extensive level and village farmers should be made educated about new irrigation and cultivation techniques.

2. The problem of water logging and its related problems may be overcome by following measure (i) suitable sites along the irrigation channels should be chosen for draining the excessive water from the fields and channelizing it to the fields suffering from water scarcity.
   (i) After draining out the water from the fields, following steps may be taken to correct the acidity of the soil and increase its fertility:
      (a) Mixing time in the soil.
      (b) Cultivation of grasses to add nitrogen and organic matter or humus, for about 3 years.
      (c) Rearing the cattle on these grasslands
   (ii) On the reclaimed fields those crops should be gram which can withstand a longer period of these conditions. Paddy and Sugarcane cultivation belts should be developed. Cultivation of Jowar, Gram and Wheat must be restricted in the reclaimed water logged areas.

Suggestions for better landuse planning in the district are as follows:-

1. There is a fairly good scope for increasing the area under irrigation as wells have good recharge capacity and water is also present good quantity in district.
2. Most of the total cropped area is still unirrigated. Thus, it becomes essential to extend irrigation facilities from existing tanks and canals to new digging of wells and canal construction.
3. On the structural hills, there is very little possibility of agricultural development due to rugged topography. It is advisable to grow only tree plantation and pastures for dairy industry. Falling of trees should be checked to avoid soil erosion and gullying. Besides this overgrazing should be stopped.
4. In the plain areas, where salinity due to irrigaton has increased up, the sprinkler irrigation and dip irrigation has been suggested with some changes in cropping pattern.
5. In the district, a more detailed knowledge of geomorphological conditions for understanding the process of the formation and degradation of soils and landscape is needed. Dynamism of slope development should be taken into account while planning the cultivation of undulating terrain. Fracture Zones of sandstone and limestone of Vindhyan system can also be utilized for well

digging. Identification of paleo channels in the area, will help to arrest the flood hazards.

6. It is essential to bund the fields and levels the hummocks in order to check erosion.
7. Green manuring like Dhaincha should be introduced every third year to reclaim the saline soil. In addition to this salt tolerant crops like Barley and Wheat should be introduced and the places where the water is of good quality, free available flooding of saline soils may be practiced to remove surface salt.
8. Large scale planning is required in order to minimize the loss and damages caused by floods. To begin with, a geographical survey of the area must be undertaken.
9. Demarcation of all the disorganized courses before planning any flood control measures should be done.
10. Instead of cultivating the valley sides, the farmers should be persuaded to grow eucalyptus groves which in addition check the erosion of valley sides and the slumping of soils into river bed. This will provide more economic wealth to farmers than the income from crops.
11. As the ravine erosion poses a serious problem in agriculture and irrigation of the district, this may be tackled by following measures-
    (a) It should be pre-requisite for the ravine land to carry out a physical survey at the village level. In such survey emphasis must be given to the classification of ravine lands, collection of soil samples and hydrological information.
    (b) Besides, data on the socio economic status of the villagers should be collected in order to trace out their indifferent attitude towards the adoption of soil conservation methods.
    (c) On the basis of these information allotment of ravine lands should be made on priority basis. For different classes of ravine following uses may be suggested:
        (i) Permanent vegetation should be grown on the marginal lands of ravines according to the hydrological conditions.
        (ii) Peripheral bunds all along the periphery of ravines should be constructed for ckecking the further extension of ravines. For the safe

disposal of water from the agricultural land suitable structure must be provided.

(iii) Ravines upto 3 meters depth can be reclaimed for the agricultural purposes by the mechanical method with minimum investment. On these reclaimed lands green manuring should be done for about 3 to 5 years for restoring soil fertility and improving hydrological condition. Crops such as Gram and Groundnut should be grown which have greater soil binding capacity.

(iv) Provision for assured irrigation facilties and government subsidy to farmers to level these hilly lands would have the way in solving the problem of ravine lands.

(v) The ravines of more than 3-4 meters may be reclaimed for housing purposes only around Bharatpur where the land reclaimation is increasing rapidly due to industrialization.

(vi) Deep ravines of more than 10 meters depth and degraded ravines where Kankar layer has been exposed should be strictly put under forest cover. In these areas plantation of Bamboo and Jiliflora species should be grown. These species would not only protect the land from further erosion but also give economic returns within the shortest possible period. But a proper care must be taken such that these plantations may not encourage dacoit activity in these areas.

12. For achieving sustainable development the agricultural labourers, small and marginal farmers should be specially assisted and made them educated of new revolutionary agricultural practices and steps should be taken to increase their earnings by developing farm and non-farm activites in rural areas.

The new agricultural policy should emphasis the following areas of development at the state level:

(i) Subsidy to the farmers should cover investment in large and medium irrigation projects.

(ii) Places water utilization has taken place to a substantial extent, say more than 100 percent of water – recharge then in those areas new wells should not be allowed to be dung and strict control on water-use should be enforced.

(iii) Mushroom, asparagus, fruits and vegetables should be given greater attention in future. This would also help in the development of tourism in the state.

(iv) Agricutlural Development should be coordinated with the simultaneaous development and management of resources like water, soils, rainfall and temperature.

(v) The privatization of the production of foundation seeds has brought encouraging results. The incentive price scheme for Rapeseed and Mustard has helped in increasing the production of oilseeds at the state level. These activities should be continued in future with greater vigour.

(vi) In unirrigated areas, less water using crops like Bajra species, Guarseed, Moth etc. should be grown.

13. The various programmes for increasing agricultural production in the district like National oilseeds Development Project should be made aware among farmers. In Kharif-Oilseeds, Sesamum, Soyabean and Castorseed are important and in Rabi-Oilseeds, Rapeseed, Mustard, Taramira and Linseed are important.

During 1984-85 and 1985-86, the centre’s share in centrally sponsered scheme was 100 percent, while from 1986-87 onwards, it was 50:50 between the centre and the state.

An additional programme was launched from 1987-88 to increase the production of oilseeds, and it was called oilseeds production thrust programme with full financing by the centre.

Farmers were given subsidity on mini-kits, demonstration, improved agricultural implements, plant protection cover and fertilizers.

Summary

Geomorphology is one of the significant branch of physical geography. This branch of geography is entering into a new era of discovery and scientific excitement centered on expanding scale of concern in both time and space. The catalyst for this development includes the technological advances in global remote sensing system, mathematical modelling and the dating of geomorphic surfaces and processes.

Its importance is not only due to its being an academic discipline in geography but also for its practical applications in various fields, in particular agriculture and landuse planning alongwith planning of agricultural resources. Since the terrain plays a significant role, therefore, the regional geomorphological studies are being used more and more in agricultural studies. The increasing use of aerial photography has given a helping hand in the conduct of these studies.

The present work on 'Geomorphology and Landuse Pattern and It's Impact on Agricultural Development. A Case Study of Bharatpur District' is a study of the applied geomorphology and landuse pattern with the special reference of Bharatpur District. It deals with the geomorphology of this region and landuse pattern system because landuse is the surface utilization of all developed and vacant land on a specific point at a given time and space. It deals with the development of agricultural activities of the region. Crop combination regions and their impact assessment on local and surrounding environment have been analysed in this study. In this sequence several factors have been taken under consideration in order to conduct a crop-combination analysis of present agricultural activities and thereafter a plan is being suggested for the sustainable development of this region. This study not only helps in understanding the problems or benefits of cropping but also provides significant and useful information about crop management and the right way of doing cropping pattern. It also helps farmers for making new strategies for the development of cropping area and for decreasing degradation of land through proper methods of farming.

The objectives of this research are related to study the geomorphology and landuse patterns and its impact on agricultural development in Bharatpur District. The main objectives are : to study genesis and development of surface features of Bharatpur District; to identify and delineate land systems, land units on the basis of landuse planning; to examine the relationship between fluvial morphology and landuse; to

study the changing picture of landuse and suggesting measures for improving the quality of landuse with reference to the geomorphology of the region; to examine the spatial distribution of crops, and other landuse activities; to ascertain the spatial concentration of landuse phenomena; the reasons why certain area are lagging behind is agricultural productivity; to diagnose at the micro level the causes of existing agricultural backwardness and then to suggest suitable strategies to enhance productivity.

Bharatpur District is located between north latitude $26^0$50’ and $27^0$50’ and east longitude $76^0$53’ $77^0$45. It is bounded in north by Haryana state, in the east by Uttar Pradesh and towards south and west by Dholpur, Karauli and Alwar District and cover an area of 5066 sq. kms. which is 1.46 percent of the total area of state and ranks 24^{th} in the state, in respect of size. In slope, the district is a flat bottomed and irregularly incised skewed, bizarre figure. Administratively, the district is sub-divided into three sub-divisions which are Bayana, Bharatpur and Deeg. These are further sub-divided into ten tehsils namely – Bharatpur, Kumher, Nadbai, Deeg, Nagar, Kaman, Pahari, Bayana, Weir and Roopbas.

Bharatpur District is located in the eastern plains of Rajasthan state. The Gambhir, Banganga and Ruparel rivers drain the district. As per census 2011, total population of the district was 25,48,462 with urban and rural population is 49,5099 and 20,53,363 respctively. Bayana is the largest tehsil in Bharatpur District in terms of the geographical area. Bharatpur tehsil is biggest as far as the population is concerned. Kaman and Pahari tehsils are at the bottom in terms of area and population respectively.

Geologically the area presents highly diverse rock types, ranging from pre-cambrian meta sediments to recent alluvial cover.

It comprises rocks of Delhi Super Group, Vindhyan Super Group and recent quaternary sediments. The Vindhyan rocks are exposed in the eastern part of the Bharatpur District. The Great Boundary fault strikes NE-SW and passes through Bayana and Roopbas tehsil. The Delhi rocks are wide spread in the Bharatpur District and the best exposures are found near Bayana town in the Bayana basin.

The climate of Bharatpur District is semi arid to sub humid and characterized as long and intense hot summer, medium rainfall and a short mild winter. The temperature normally varies, from 5^0C in the month of January to $45^0$9’C in May. The heat is intense and is accomplished by the hot and westerly wind ‘Loo’. During the months of May and June, the weather remains sultry. Winter rain is uncertain.

The monsoon usually breaks in the last weak of July. Generally light to moderate winds prevail throughout the year.

Soils of the region are different in varities due to the differences in their parent rocks, topography, vegetation and other climatic conditions. Soils of this entire region are divided in six categories; i.e. loamy soils, clay soils, light black soil, sandy loam soil, saline – alkaline soil, red and yellow soil.

Sufficient rain in the region has led to mainly tropical dry deciduous forests. The region is having about 24.14 percent of total area under forest cover and presents a great variety of natural vegetation. These forests can be further divided into dry teak forests, mixed forest and grasslands. Trees like Dhokra, Tendu, Khair, Mahua are common in the region. Anogeissus and Pendula or Khaldi forests are common in the study area. The mixed forest comprises neem, Peepal, Karonda, Imli, Aam, Bamboo, Khirni which also come under deciduous species of the district. Grasslands are common in between forest and agriculture land. Alongwith the above natural factors, transportation facilities through rail, road are also available in these regions.

Apart from a long list of pioneer scholars and their works have been discussed for both geomorphology and landuse sections to understand the progress of the subject over the period. International and Indian scholars like K. Brayn (1925), A.L. Coulson (1927), H.H. Bennett (1939), A.N. Strahler (1952), R.J. Chorley (1971), G. Padmaja (1976), V.C. Gardiner (1981), P.S. Dhinwa (981), O.P. Singh (1982), J.G. Mulay (1982), R.D. Gurjar (1982), K.M. Hironi (1982), H.S. Sharma (1982), N.W. Hudson (1983). K.R. Dikshit (1983), L.C. Agrawal (2002) etc. and number of others has contributed to a great deal in bringing quantification in geomorphology.

Several elite people like A.M. Heron (1938), M. Hussain (1963), M. Shafi (1969), J. Tricart (1972), J. Singh (1974), S. Singh (1978), C.S. Yadav (1979), B.N. Jha (1979), N.K. De (1982), C. Sen and D. K. Painuli (1984), B. Singh (1984), V.C. Jain (1987), L. Symon (1989) and R. B. Singh (1996) etc. have done various works in the field of landuse activities. Brief reviews of recent researches are also given in this section alongwith these established works.

Methodology adopted for this research comprises Drainage Density, Stream Frequency, Wentworth Method, Weaver Method, Doi Method and Rafiullah Method. For the methods both primary and secondary data have been used as much as possible. Field survey of some villages, several government and non-government departments, topographical sheets and websites (Internet) have been taken as an information source for this research.

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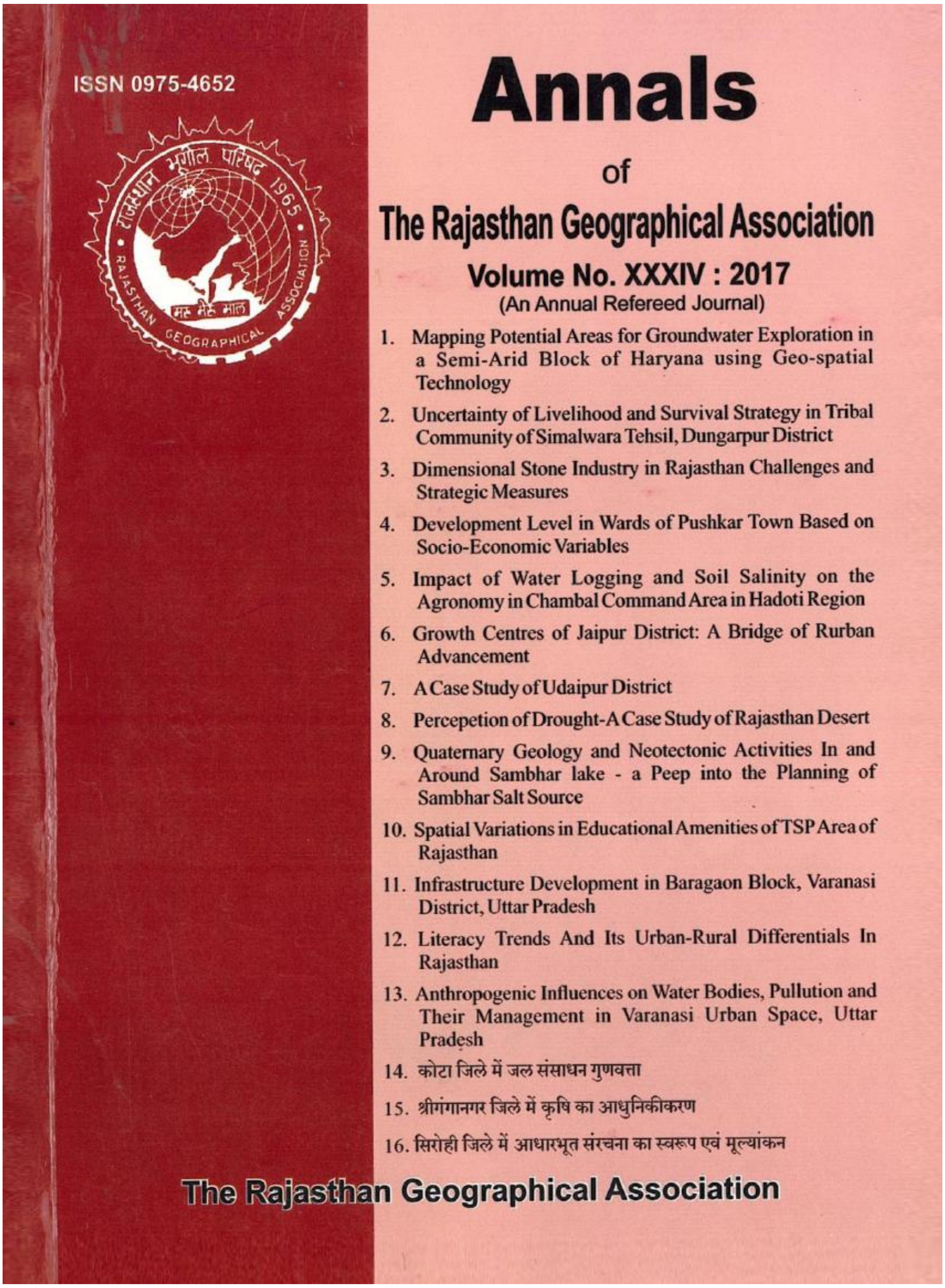

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Impact of Water Logging and Soil Salinity on the Agronomy in Chambal Command Area in Hadoti Region

L.C. Agrawal and Nishtha Sharma

Abstract

The present paper is an attempt to analysis the impact of water logging and soil salinity on the agronomy in Chambal Command Area (CCA) with pre and post installation of sub-surface drainage in Hadoti region including experiences of farmers. The Chambal Command Area comprises of 3, 85,000 hectares area of which 59.48 percent (2, 29,000 hectares) is under irrigation in Hadoti region. Water logging and soil salinity problems were detected following the introduction of irrigation in 1960's. The Sub-Surface Drainage (SSD) is mainly provide to control water table depth at a pre-determined level; to allow enhanced root development of crops; to leach excess salts and prevent salt accumulation within the root zone at levels higher than the tolerance level of crops; and to provide enhanced soil traffic ability during growing season. The paper discusses the reasons of water logging and soil salinity and redemption from water logging and soil salinity. The following paper evaluates the impacts of pre and post installation of Sub-Surface Drainage (SSD) on the agronomy in the area. This paper also focuses on the effects of water logging and soil salinity on farmer's economic and social life in the study region.

Keywords: *Chambal Command Area (CCA), Sub Surface Drainage (SSD), Right Main Canal (RMC), Left Main Canal (LMC), On Farm Development (OFD), Rajasthan Agricultural Drainage Research Project (RAJAD), Farm Yard Manure (FYM).*

Introduction

After the beginning of planning process in India, a large number of irrigation projects were constructed for increasing agricultural productivity. However, it was realized that the potential created was not utilized fully and a substantial gap existed between the potential created and potential utilized. A Command Area Development Programme was launched in 1974-75 with the main objective of improving utilization of irrigation potential and optimizing agricultural production and productivity from the irrigated areas by integrating all functions related with irrigated agriculture.

Prior to the introduction of irrigation, crops grown in the area were either rain fed or matured on residual soil moisture. The traditional crop, Sorghum, was not very remunerative and farmers have preferred to let their land lie fallow in the Kharif to replenish the soil moisture, thus allowing the staple crop, wheat, to be grown on residual moisture in the Rabi. Now-a-days, cropping pattern in Chambal Command Area has changed and farmers exclusively growing Soyabean as a main crop in Kharif season. Mustard and Wheat are other dominating crops.

Since the introduction of irrigation in 1960s, the Chambal Project ran into serious problems of water logging and increasing soil salinity, aggravated by the undulating nature of the terrain, lack of proper water management and traditional rain fed farming practices. Neither the farmers nor the lands were ready to receive the water for irrigation. The rural population, accustomed to rain fed farming, did not know how to utilize the irrigation water. In addition, proper field distribution systems were not installed to receive and drain water.

In the present paper an attempt has been made to study the impact of water logging and soil salinity on the agronomy in Chambal Command Area with pre and post installation of sub-surface drainage.

Study Area

Chambal Command Area (CCA) is situated in the south-east of Rajasthan between 25 and 26 degrees north latitude and 75 to 76 degrees east longitude (Fig.1).The total Chambal Command Area is 3, 85,000 hectares of agriculture land out of which 59.48 percent (2,29,000 hectares) is irrigated by canals. Chambal River is a main river in the study area. Chambal acts as a trunk Channel, its tributaries i.e. Parbati, Kalisindh, Parwan and Mej are like branches.

Chambal Irrigation Project construction began in 1953 and was substantially completed by 1971, with irrigation beginning in 1960. Regulating structures on Chambal River include two storage reservoirs with power stations, a smaller pondage with third power station and the Kota Barrage which diverts water into the Canal system. The 372 kilometers long Right Main Canal (RMC) serves 1, 27,000 hectares in Rajasthan as well as the Madhya Pradesh Command Area. The 168 kilometers long Left Main Canal (LMC) serves 1, 02,000 hectares area.

Project area is an elongated basin in the former alluvial plain of the Chambal River. The average slope is slight (about 0.08 percent) but the basin is deeply incised by the main river and its four major tributaries. These channels and the network of meandering gullies (nallahs) tributary to them from the primary drainage system of the area.

The surface of CCA is constructed by igneous rocks, having different properties i.e. when the surface is wet it puddles and in dry very hard crust, the spade does no penetrate in the ground earth for one inch or two inches, so vertical spade has to use for earth work. The tilling in wet and dry spell is very difficult task. Farmer has to wait for the favorable moisture for the ploughing which delays the sowing time of crops.

Past History of Water Logging and Soil Salinity in Chambal Command Area

Agriculture even in its most modernized and mechanized farms, is still earth-bound and controlled by natural factors such as soils, climate, topography and the rest.

At the inception of the irrigation canals in 1960 in CCA, there was a siltation of production in agriculture sector for few years, but started to decline the productivity nearly after ten years of the inception of the canals. And the water-table of the ground reached nearby 1.5 meters to 3 meters, but in monsoon it was nearby 30 centimeters at the low lying area. And to the adjacent to main


LOCATION MAP OF CHAMBAL COMMAND AREA
INDIA
0
600KMS
RAJASTHAN
0
180 KMS
RAJASTHAN
JAIPUR
JODHPUR
BUNDI
KOTA
CHAMBAL COMMAND AREA
0
20 KMS

canals and distributaries the water is /was oozing during canal regulation.

The farmers felt that their fields have been waterlogged and affected with soil salinity. Due to this regardless water logging and soil salinity problems, thee agronomy of the farmers was castaway.

Reasons of Water Logging and Soil Salinity in CCA

The main reasons of water logging and soil salinity in CCA are:

(a) Rolling type topography

(b) Fractured sandy soil

(c) Heavy Rainfall in monsoon

(d) Underground surface has variant layer of depth of earth and stone

(e) Some patches have/had natural salinity

(f) Absence of rotational water supply in irrigation system among farmers

(g) Excess irrigation with dependability on fields

(h) Wild irrigation with ponding

(i) Seepage drains plugged with siltation and vegetation

(j) Unawareness of the farmers

Redemption from Water Logging and Soil Salinity

Pre-installation of sub-surface drainage various methods to reclaim the soil and lowering the water table were adopted by the government with the help of extension department among the farmers.

The government tried to solve this twin problem through OFD and excavating seepage drains adjacent to main canals, distributaries and minors, but these surface drains were plugged with vegetation and silt due to unawareness of the farmers because the drains were/are used to carry out irrigation water by the farmers. On the other hand, the farmers who had their own infrastructure, they scrapped the upper layer of the soil of their fields, raising high ridges, giving thresh of canal and puddling well, raised the crop of rice.

In spite of it the farmers added gypsum, FYM and several ploughing in dry period, alternative year sowing the crop of Berseem (green fodder) on their fields. So like this some farmers at some extent solved the problem of soil salinity, but the water logging problems remain uncontrolled. So, during from 1970 to 2016, the farmer of the area had suffered great loss economically and mentally due to water logging and soil salinity.

In this tight fiscal period by the mercy of God, the work of OFD was done in our area in the year 1994, with the help of Rajasthan Government. The farmer got relief and there after the work of SSD was done in Jan 1996, with the help of Canadian Government through Indian Government, Rajasthan Government and RAJAD by Agro drain a private contractor from Canada using trench less plow, when the wheat and mustard was standing in the fields. On the day when plow entered into the fields farmers felt good although it caused 15 percent damage to the crops, because farmers had the vision of getting higher yields thereby they could compensate the present loss by getting the additional income in future, because, over the two years farmers had observed the changes occurred on the SSD installed land in the area. It was surprising for us to see legumes crops and gram on the same land where it was difficult to grow these crops otherwise. To our utter surprise after the work of SSD the conditions of the fields becomes very good, the salinity and water logging condition of the fields are removed.

Impacts and Benefits of Post Installation of SSD on the Agronomy in Chambal Command Area

The SSD work is like **"Surgery of Sick Land"** when the surgery of land was done by installing SSD. The farmers felt relief knowing that the wounds of their land will be cured by eroding salinity through SSD pipes over the time, because SSD work had ameliorated the water logging and soil salinity on the farm in very short period, through perforated pipes by effusion of water. Major benefits of Sub-Surface Drainage (SSD) are as follows:

Tilth

Tilth of the land takes place near about 8 to 10 days in winter and in rainy season. It depends upon temperature and sunshine.

Pre-SSD tilth in land, in winter season took place near about 20 to 25 days, and in rainy season it was uncertain some fields remained without growing any crops throughout the year. This problem occurred only in those areas where the surface was not level.

Hand tillage become very difficult work due to boggy ground. Then the farmers started to till the land with tractors, in spite of using tractor by the farmers for ploughing, they had to face many obstacles due to wet, boggy and stiff ground making poor griping power and bagging of tractor. The earth of tractors tires was rammed, rugged and resorted. The cultivator's tilling constructed clods, the earth did not loose well. So five to six times had to plough the land that the sunshine might dry the earth, but the farmer and the tractor could not achieve any success in demolishing the wet clods. Same conditions were faced in winter. On some farms the fall ploughing was done. Post SSD tilling frequencies are three to four for preparing one crop-wet clods nil.

Crops

Pre-SSD, due to water logging and soil salinity, it became an implied condition for the farmers that they would have to raise the crop of rice, because it is a such crop which has much water resisting capacity. Due to uncertainty of tilth, the farmer's discretions became negative in summer season and so for winter. In winter season only the wheat crop could be raised, other crops like mustard, coriander, grams and root crops became totally dormant. Post SSD, the farmers have expressed discretions to raise the crops i.e. cereal crops, legumes crops and root crops.

Hoeing and Harvesting

Pre-SSD these activities had to do mostly by manual labour. On the farm the spade or hoe did not penetrate at the proper depth due to buggy ground and damp weather, the earth remained unloose and changed into wet clods. The shavings of weeds reburgeoned due to buggy ground. In rice aquatic grasses became great problem, some weedicides had become failed. Hoeing in rice is mostly done by manual without the help of any hand tool. The aquatic grasses shavings remaining in field and made the water enrich, helping to growth to remaining aquatic grass and philamenteous algae. Generally all the activities of earth work for example the excavation of water-course, ridge shaving etc. caused considerable difficulties.

Harvesting was mostly done by manually. Near about 40 percent of rice crop caused the problem of lodging because the surface remained wet, the root and steam of the plant became poor or rotten. Rice post harvesting fields in some area, philamenteouc algae prevailed on the surface, always made delay in tilth and sowing for the next crop. Post-SSD hoeing work has become very easy, the earth looses very fast allow to penetrate the spade or hoe up to proper depth gently. Generally weeds are combated mostly by weedicides through spray machine mounted by tractors and harvesting is done by combine when the crop is fully matured. Crop logging in rice 90 percent solves.

Fertilizer

Pre-SSD commercial fertilizers were given in much quantity, due to infertility of the soil caused by water logging and soil salinity. Post SSD less commercial fertilizer near about 27 percent saving in kilograms per hectare near about 93.75 kilograms for one crop.

Pesticides

Water logging and soil salinity impeded orderly crop rotation and combating weeds was especially difficult because ridges and hedges between plots harboured insects plant diseases and weeds. So like this, poor crop and higher dose of commercial fertilizer gave the invitation to many pests, and the farmer started to spray in revolutionary manner, which made the most expensive operation in preparing for crop. Post SSD work, pesticides saving near about 67 percent.

Productivity

Pre SSD productivity decreased through many aspects. They were:

(a) Infertility of soil due to salinity.

(b) Long tilth and fall ploughing made delay for the next crop.

(c) Micro nutrients wastage through excess irrigation and rainy water.

(d) Population of plants became less, damaged by wet clods and irrigation and rainy water.

(e) Some seeds were damaged by wet surface.

(f) Some terrains changed into permanent pasture covered with moss, white salinity and boggy land.

Overall these whole reasons decreased the productivity of the area.

Post SSD productivity has increased near about 40 percent to 45 percent. The reasons are early sowing, proper tilth, wet clods nil and seed germination 90 percent. Plants population does not become less.

Quality

Due to water logging the crop was affected from stem rust, red rust and black leaf rust which caused the crop not fully matured and then be reap red with the sickle. Intense heat, excess winter and too much wet surface, so all these affected the quality of grains i.e. under size and spotted. In Basmati rice not superfine slander grains and unexquisite aroma, the color of paddy grains looked fade.

Post-SSD, quality of food grains has improved with size and colour. Especially in basmati rice important characters have been found. They are:

(a) Pleasant and exquisite aroma

(b) Extra long superfine slander grains

(c) Delicate curvature

(d) Soft texture

(e) Sweet taste

(f) Extra elongation with a least breadth wise swelling on cooking.

Seed Rate

Pre-SSD, seed rate in wheat per hectare was

187.5 kilograms. Post -SSD, seed rate in wheat per hectare is 125 kilograms means 33.33 percent less.

Irrigation

Pre-SSD less irrigation only two frequencies of irrigation in wheat crop were given. At the first frequency the crop of wheat showed mineral deficiency because the drainage system was not there. Post-SSD irrigation to crops has become just double.

Double Cropped Area

Pre-SSD near about 20 percent arable land became unusable, on the 30 percent land one crop was raised and the remaining 50 percent area was used to double crop. Field ways became muddy and baggy. Post-SSD hundred percent areas are under double crop rotation except field drains and ways.

Trees and Natural Vegetation

Pre-SSD in water logging and soil salinity area, the trees became withered dwarf and grew only in sheltered places. So water logging on the ground for many months, or so rainy that the soil was wet of the time, and the grass of moor land was affected from stem rust, red rust and infected with toxemia which was not appealed by the animals and dehydration in cattles. Post-SSD trees and natural vegetation are rehabilitating with spurt growth of trees.

Environmental

Pre-SSD:

(a) Due to damp weather and boggy ground for many months the trees and natural vegetation withered away or became dwarf.

(b) Much diesel consumption by machineries was used.

(c) Poor crops gave invitation to many diseases and pests.

(d) Revolutionary spray vats of pesticides, resulting to bill many farmer's friend i.e. birds (sparrow, crane etc.) frogs, tortoise, snakes and fishes and earth worms.

(e) Some dipping vats of water in low terrain gave invitation to mosquitoes.

(f) Even the drinking eater of wells and hand pumps was badly affected; the colour of water became rusty and creamish which caused the injury to teeth and bones.

(g) Even the vulture which eats the dead animals flesh used to migrate to somewhere else from August to November because in this period, heavy spray of pesticides was being done by the farmers to protect their crops. Casualties of cattles were also at high rate in this period due to dehydration and F.M.D etc. Due to muddy way and non existence of proper graveyard for dead cattles, cattles were thrown on beaten path or anywhere on open ground where their bodies remained rotten and polluted the environment.

Post-SSD work: all these problems have been overcome or rectified by SSD.

Social and Economic

Soil salinity and water logging had affected to the farmer's economic and social life as well as to the national economy.

(a) Slackness in the habit of work among some famers. Partial people became idle, due to shortage of work throughout the year.

(b) Some people became smuggler and litigant due to shortage of income sources.

(c) A poor peasant had to cover his deficit by borrowing and ultimately by selling his land. Within few years some farmers became landless and did not liberate from the clutches of local money lenders. If there was a crop failure in successive years, even the middle income farmers went bankrupt and lost their lands to the village moneylenders. So the majority of owner farmers turned into share cropper and land labour.

(d) The ploughing became the most expensive operation in preparing the land for crops.

(e) Residential houses changed into ranch houses due to boggy ground and poverty. Near the village where curtilage fields are situated remained absolutely full with water as the type of dipping vats throughout the year. The polluted water with animals dug, dust and other wastage etc. affected the human health as well as animals.

(f) Shortage of cooking fuel, only dung cakes were used, exhausting much smoke polluting the air.

(g) Children could not reach at school due to muddy way and poor economic condition.

(h) Non existence of dry way farmers was inaccessible to urban areas for selling their production. A large part of production was being purchased by the village money lenders in village at cheap rate.

(i) Economic condition of some farmers became too much poor that he could not attained medical aid.

In spite of all these, the activities of much diesel consumption, high seed rate, pesticides, more labour, poor productivity and poor quality of crops etc. and the crop failure in successive year at any time deficits to the poor peasant as well as to the national economy.

Conclusion

The foregoing analysis of water logging and soil salinity on the agronomy in Chambal Command Area in Hadoti region with pre and post installation of sub-surface drainage and including experience of farmers at different locations leads to the following conclusion.

1. SSD removed excess water from the soil and created a well-aerated root environment and thus good growth of the plant.
2. By removing excess water from the soil drainage provided a surface soil layer dry enough to handle farm machinery earlier which facilitates in timely sowing.
3. Increased number of days was available for field work.
4. Reduced the need of fertilizer and thus reduced the cost of production.
5. SSD benefited not only to farmers but also to regional or and even to national economy.
6. Post SSD, the farmer, who has near about 3.2 hectares of land, for producing the crops and tending the animals, employs one man as a labour, for the whole year.
7. Post SSD, the farmers are interested in tending the animals of high lactation i.e. buffaloes and cross bread cows, near about two or three head for domestic and dairy purpose are tended.
8. Due to siltation in productivity after SSD

work, the farmers have close proximity to the Agriculture Supervisor for the latest seed varieties, soil analysis, fertilizer dose and pesticides etc.

9. To maintain the fertility of the soil and pests control, fall plough is done in summer after harvesting the crops of wheat, barley, mustard and coriander etc. On farms green manure is prepared to increase the fertility of soil.
10. Cooking fuel is collected on fields, the stubble of mustard and its supplement manure is being spread on fields, and dung cakes are less consumed.
11. Less micro-nutrient has to aid for the growth of the crop and crop-rotation can be performed.

Over all it can be said that the farmers remain busy throughout the year in their farming activities, after SSD work, and has became judicious, proficient and economically well development. The results of SSD work are very significant, exuberant, striking, aggressive production and beneficiary from all aspect.

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Geomorphology and Land Use Planning Bharatpur District (Rajasthan)

Abstract

The present paper is an attempt to analyze the geomorphology and land use planning in Bharatpur district (Rajasthan). The attempt has been made here to analyze the existing land use pattern and changes over a period of time with the aim of creation data base for the process of planning at micro level. Major findings of the analysis have been discussed in detail.

Keywords: RS Data, GIS, Land Use and Geomorphology.

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Introduction

Planning of land development requires in the first instance collection of available information on land use and trends of its variation with time. In the state of Rajasthan, because of vast arid tracts the resources have not as yet been fully assessed and whatever information is available has not been rationally utilized to upgrade production. The paper deals with the land use planning in Bharatpur district. The main object is to find out the land use in different categories and the trends of variations so that the characteristics of land utilization may be analyzed of future planning.

The study of land use and agricultural land use changes is studied in detail by considering the concept of land, land use, land cover and land use changes.

Land is the basic, fixed and limited natural resource. Land plays the key role in the determination of man's economic activities as well as social and cultural progress. All agricultural, animal and forestry productions depend on the quality and productivity of land. The term 'Land Use' is used to describe the use of an area of land of a certain time is put to. It is related to human activity associated with a specific piece of land. The general land use of region is the end result of physical, economic and social factors. These factors play a significant role in shaping the general land use. The geographic aspects mainly physiography, climate, soil and the socio-economic aspects such as population, irrigation, urbanization, industrialization, transportation etc. play a significant role in shaping the general land use.

Aim of The Study

In general notion that geomorphology is the science of landforms but the studies of A.N. Strahler (1952) and R.J. Small (1970) demonstrate that it is the study of quantification in the present time and giving rise to the branch of modern geomorphology known as Morphometery. The studies of H.S. Sharma (1979, 1982) also show the geomorphic factors combine together have played very important role in the processes and social systems of agricultural activities in shaping their taxonomic characteristics in one side, and the agricultural enterprise system including cropping pattern associated with the natural factors on the other, which have conditioned the definite enterprise systems in a much more complex way. Considering this hypothesis the efforts were made during the study that upto what extent geomorphic parameters affect the distribution of agriculture in the Bharatpur district.

Thus agriculture is seen with a complex phenomena and function of their closely but widely associated geographic control in different parts of the district. It would be quite in sequence to see the different levels of agricultural setup in contrast to the physiography, soil and water resources embodying geomorphic control in the district. This has great relevance for an agricultural area such as present study area where cultivation has been carried out since times immemorial and in which a high portion of rural population is dependent on primary vocation. The objectives of sustained production can only be achieved through an analysis of morphological character of the region. As geomorphological analysis or approach attempts to express the integration of all elements of the land complex,

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recognized the casual links between them through an understanding of the genesis of landform themselves.

Review of Literature

The present status of geomorphology is the result of the gradual but successive development of the geomorphic thoughts postulated in different periods by innumerable philosophers, experts and geoscientists in the subject and outside the subject.
In comparision with American and European countries the progress of the research in geomorphology in India is as follows:

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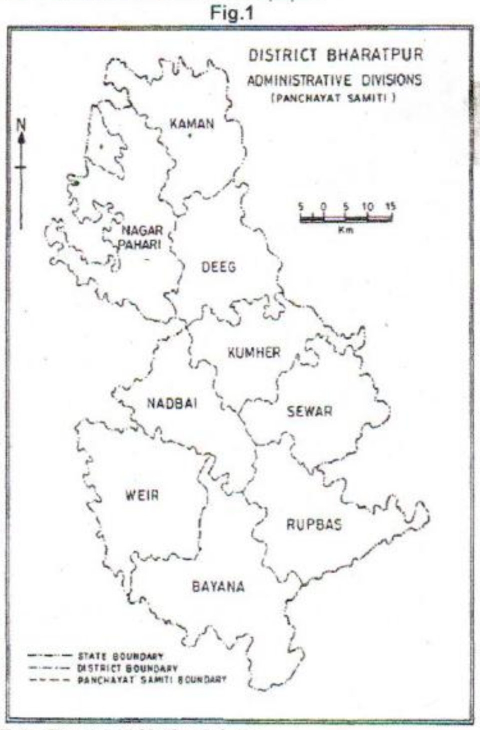
Study Area

Bharatpur district of the state of Rajasthan in India, located between 26 degree 04 minutes to 27 degree 50 minutes North latitudes and 76 degree 50 minutes to 77 degree 50 minutes East longitudes. The total area of the district is around 5085 sq. km. The district is divided into eight tehsils viz. Kaman, Nagar, Nadbai, Deeg, Weir, Bharatpur, Rupbas and Bayana (Fig. 1). Bharatpur town is the district headquarters which is well connected by Rail and Road network with Jaipur, Mathura and Delhi. Major part of the district has a good drainage system and forms part of "Ruparel River Basin" in the northern part, "Banganga River Basin"in the central Part, "Gambhir River Basin" in the southern part.Geologically the rocks of the Bharatpur district belong to Delhi Vindhyan Super group. Almost the entire district is covered by alluvium, with few isolated hills where rocks of schist quartzite's Delhi Super Group are exposed. The influence of geomorphic features on agricultural land use has been discussed in this paper.

Fig.1



Data Base and Methodology

The present study is based on primary and secondary data from 1995 to 2015 duration. Primary data were collected by the field survey and secondary data are collected by the published reports by various departments. Survey of India Toposheets on 1:50,000 and 1:2, 50,000scales, census of India reports and cadastral maps were also used in the study. The multi-date remote sensing data has been used for the study.

Land Use of Bharatpur District

The total area for land utilization purposes of the district is 507,448 hectares, whereas the total geographical area of district 810,010 hectares. The figure shows the land use pattern of the district.

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Fig. 2

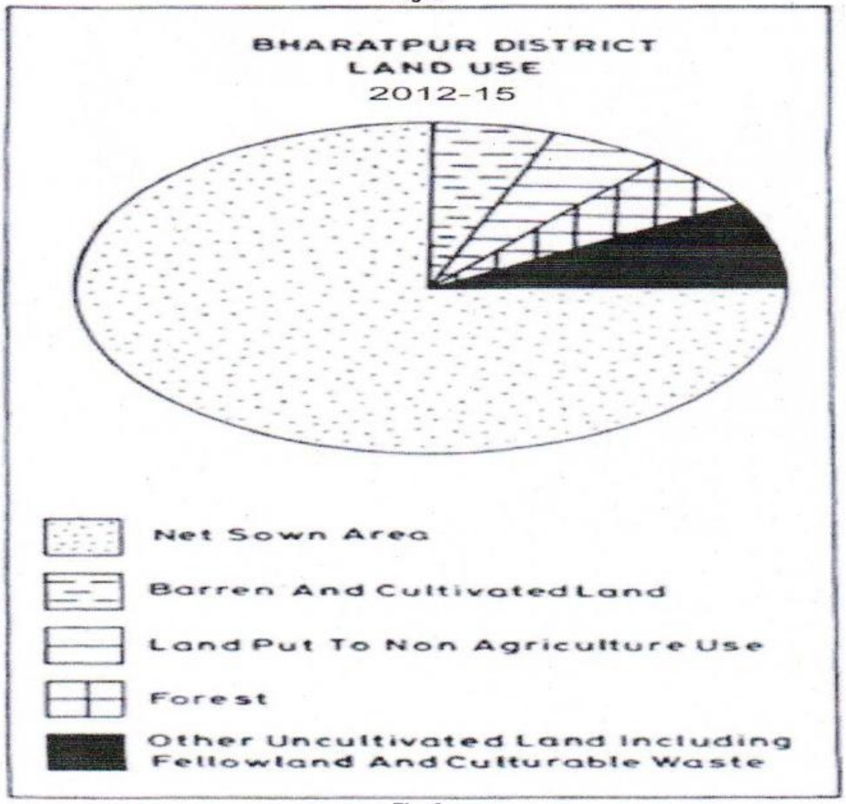
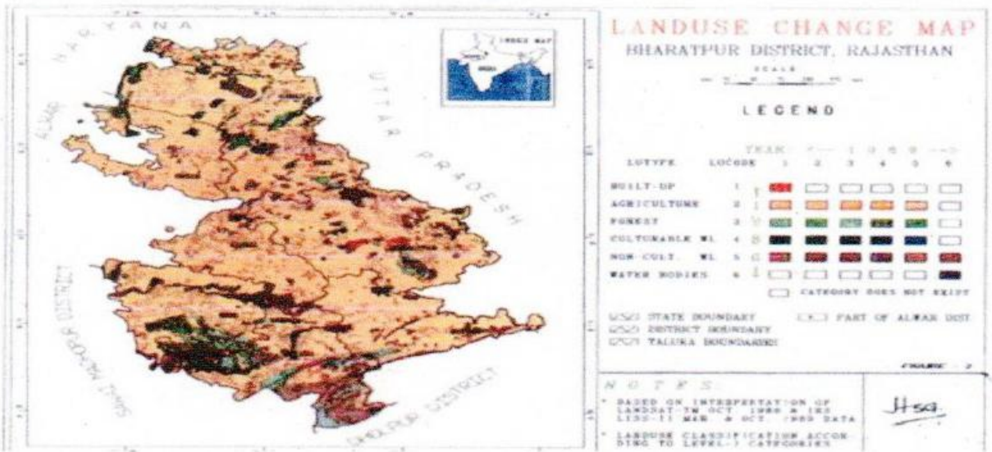


Fig. 3



: Bharatpur District, Project Report, p209

Changes in Land Use

In order to analyze the changes in land use we pattern at regional and area level, time series data for a longer period would be desirable. Changes in land use pattern have been studied during 2012-2015 on the basis of remote sensing data which may be taken as indicatives of the trends in the emerging land use pattern. From table 1

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Table -1. Change Matrix of Landuse classes between 2012-15
(Based on RS Data, All figures are in sq.km.)

S N.	SLT		2012-2015		B	Total	B	D	F	DF	MF	SF	ER	UN	WL	SA
			ROC	WB												
1.	-	Built up land	-	--	B	37.76	37.76	3313..40	-	-	-	-	-	-	-	-
2	--	Crop land	-	4.87	C	33.93.30	2.25	92.80	72.73	-	-	-	-	-	-	-
3	-	Fallow land	-	3.07	F	667.52	3.23	-	568.05	-	-	-	-	0.37	-	-
4	-	Dense forest	-	-	DF	44.90	-	-	-	10.52	23.16	11.30	-	-	-	-
5	-	Medium forest	-	-	MF	72.67	-	-	-	-	20.84	39.58	-	12.25	-	-
6	-	Sparse forest	14.26	-	SF	167.94	-	-	-	-	-	50.91	-	102.67	-	-
7	-	Eroded land	-	3.32	ER	28.46	-	-	-	-	-	-	25.14	-	-	-
8	-	Undulating land	95.72	-	UN	221.92	-	-	62.88	-	-	-	-	63.32	-	-
9	-	Water-logged	-	-	WL	64.44	-	37.53	-	-	-	-	-	-	26.91	-
10	46.39	Sandy Area	-	-	SA	-	-	164.95	-	-	-	-	-	15.44	-	-
11	-3.18	Salt Affected	26.89	-	SLT	-	-	7.06	15.71	-	-	-	-	-	-	-
12	-	Rock out-crop	13.31	-	ROC	71.93	-	-	-	-	-	-	-	58.62	-	-
13	-	Water bodies	-	31.77	WB	31.77	-	-	-	-	-	-	-	-	-	-
Total	26.89		123.29	43.03	0043 508517	0043.24		719.38		10.52	44.00	101.80	40.58	237.23	26.91	52.57

It is observed that the district has registered an increase in cropped land from 3393 sq. km. to 3615 sq. km. during 2012-2015 which might have been facilitated by the reclaiming measures taken by the government. The sandy area, water locked area and salt affected land amounting to about 164.95 sq. km., 37.53sq. km. and 7.06 sq. km. respectively have been converted to agricultural use in 1995. Increase in cropped land may also be partly due to the improvement of irrigation facilities during 1995-2015. With the increase of cropped land there should have been decrease in fallow lands but on the contrary it has also recorded a marginal increase particularly in the tehsils of Kaman, Bharatpur etc. Decrease in forest area indicates unhealthy trends of land use pattern almost in all the tehsils even area under dense forest cover has decreased from 44.98 sq. km. in 2012 in the district. The reduction of high and medium density forest cover has resulted an increase in the spares forest cover and scrub land of area under rock outcrops and wastelands.On the other hand, reduction of original spares forest cover 2012-2015 has resulted in increase of area under rock out crops and waste lands. The reduction in forest cover may be due to the constant felling to trees for fuel and fodder in the hilly tehsils of Bayana, Rupbas and Weir. There is some increase in the area under water bodies which may be because of the normal rainfall in the year 2012. The area under water bodies has increased especially in and around Baretha reservoir. The area under salt affected land and waterlogged area has decrease during 2012-2015. Mainly due to the reclaiming measures taken by the government, It is striking to note that eroded lands have been increase by 12 sq. km. during the three years period pointing to the degradation of forest cover resulting in erosion at foot hills and low lands. With the growth of settlement and non-agricultural activities, buildup area has also increase particularly around the town of Bharatpur. Obviously such growth in buildup land has been at the cost of agricultural land. Based on the above analysis, the following observations are noteworthy:

Land under Agriculture

The cropped land and fallow land together constitute the extent of land under agriculture. As may be seen from the statistical data and figures computed from the remote sensing data in table -2

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TABLE - 2 COMPARISION OF LAND USE CATEGORIES FROM STATISTICAL AND REMOTE SENSING DATA

(All figures are in Sq.km. Figures in brackets indicate percentage)

SN TEHSIL	TOTAL AREA		AGRI. LAND		FOREST LAND		OCT. LAND		NOCT LAND	
	CENSUS	RS	CENSUS	RS	CENSUS	RS	CENSUS	RS	CENSUS	RS
1. KAMAN	734.1	742.3	597.0	615.2	---	24.8	28.5	48.5	108.5	53.7
2. NAGAR	471.0	472.3	416.9	435.8	---	4.6	6.3	17.0	47.8	15.0
3. DEEG	500.9	507.1	432.8	413.3	9.5	28.4	9.3	48.4	49.3	17.0
4. NADBAI	446.7	443.4	419.8	428.8	---	---	3.0	10.9	23.9	2.6
5. BHARATPUR	954.8	949.7	826.8	821.0	75.8	20.7	16.8	56.8	82.9	57.1
6. WEIR	614.0	603.0	460.0	465.6	64.8	61.5	34.9	41.7	54.1	34.3
7. BAYANA	803.9	808.4	442.3	383.0	151.4	133.6	51.3	113.6	158.9	178.8
8. RUPBAS	549.1	559.0	469.9	498.1	6.5	12.1	14.7	24.4	58.1	24.4
TOTAL	5074.5	5085.1	4065.7	4060.8	308.0	285.5	164.8	361.0	583.5	382.9
	---	---	(80.1)	(79.9)	(6.1)	(5.6)	(3.3)	(7.1)	(11.5)	(7.5)

Proportion and extend of total agricultural land in 2012 was comparable (about 80%) in the district. The distribution of cropped area was highly uneven ranging from 46% in Bayana tehsil to about 96% in Nadbai tehsil. In Bharatpur, Deeg and tehsils cropped land was more than 80% and in the remaining three tehsils of Kaman, Weir and Rupbas, it was between 60 to 80 percent.

Land under Forest

Forest Area interpreted from satellite imagery relate to actual forest cover and is generally less than the forest area given in the statistical year book which, by and large indicates total area under the control of forest department. Interestingly, however there is not much different in Bharatpur district the forest area in both sets of figures which works out to about 6% of the reporting area. However, at tehsil level, some differences a noticed between two sources i.e. statistical data show about 8% in Bharatpur tehsil as against 2% of the reporting area in the RS data. Revenue figures do not record area under forest in Nagar and Kaman tehsils where as interpretation of RS data indicates about 1% and 3.3% of the reporting area under forest cover in these tehsil, respectively. Bayana and Weir tehsils had the highest and dense forest cover spread over in patches along the nalas, roads, railways and on isolated hillocks. Area under forest cover gradually decreases as one move from south west to north east part of the district.

Other Uncultivated Land

This category included cultivable wasteland permanent pastures and land under miscellaneous tree crops and groves. As far as land under this class is concerned there is vast different between the two data sources. Statistical figures reported 3.25% of the reported area under this category against 7.1% in the RS data. This difference may be attributed to the categories of land included under this category. This category was reported to some extent in each of the tehsils, where Bayana tehsil has One third of the reporting area. Weir, Kaman and Deeg were the other tehsils having concentration of such lands.Cultivable waste lands in these tehsils are not presently under cultivation but the same can be reclaimed for agriculture and fodder crops through suitable measures. Area under permanent pastures and tree crops was also higher proportion of cultivated wasteland, which may be ascribed to low fertility of land concentration of livestock population. By adopting suitable measures these areas may be turned into rich grazing grounds as well as for rising of fodder crops.

Land Not Available for Cultivation

This category consists of land put to non-agricultural use i.e. undulating terrain with or without scrubs, rock out-crops, built up land in water bodies. Comparison of two sets of datasources portrays of deceptive picture in this regard. According to statistical figures 11.5% of the reporting area was classified as land not available for cultivation against 7.5% in RS data which appears to be on the lower side in view of the larger number of human settlements and other non- agricultural activities existing in the district. This is further substantiated by the facts that in all the tehsils, statistical figures recorded higher percentage of land under this category in all the tehsils against the RS data. Barrenlands are more in Bayana tehsil accounting for about 15% of the total reporting area. Land under non- agricultural uses including build up land, water bodies, transport network etc. was concentrated more in Bharatpur Tehsil because of location of big urban settlements and other non- agricultural activities.

Conclusion

1. It is observed that the land use pattern in Bharatpur District is not similar to that of general and land use pattern prevalent in Rajasthan State as a whole.
2. Agricultural land is widely distributed throughout the district. Its concentrations however relatively lower in Southern tehsils particularly in Bayana and relatively higher in the north- eastern parts of

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the district comparison Kaman, Deeg, Bharatpur and Nagar tehsils.

3. Forest cover is mainly in the south western parts of the district in tehsil of Bharatpur around Ghana Bird Sanctuary Area.
4. Area under pastures is mainly confined to Kaman, Bayana and Weir tehsils while plantation and tree crops are more pronounced in the Weir tehsil.
5. The Cultivable wasteland is relatively more concentrated in Bharatpur, Kaman and Bayana tehsils and interestingly the barren lands are also comparatively more in the latter two tehsils because of rocky terrain and poor soil conditions.

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