UNIT 9 LAND UTILISATION AND CROPPING PATTERN

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9.0 OBJECTIVES

After going through this unit you will be in a position to:

- explain the concept of land utilization;
- identify the categories in which land is used;
- explain the shift in land utilization pattern;
- explain the pattern of agricultural production;
- appreciate the changes in cropping pattern over time; and
- identify the impact of the changes in cropping pattern.

9.1 INTRODUCTION

The scope of bringing in more land into cultivation is limited in any country. The physical conditions, geographical location, population size and growth, level of development, institutional framework, etc. determine the nature of land use in an economy. Moreover, the area available for cultivation is put to use for different crops keeping in view the quality of land, food habits of people and relative profitability of different crops. Thus, as food habits, relative prices and productivity undergo change, the cropping pattern may change over time. However, such changes should be commensurate with the land use planning in a country.

In the present unit we will learn about the land use and cropping patterns in India, particularly during the post-independence period. We will also bring out the probable reasons for the changes in these patterns.

9.2 LAND UTILIZATION PATTERN

In a broad sense the term land use pattern means the use of land resources under different ecological settings. The pattern of land use of a country at any particular time is determined by the physical, economic and institutional framework taken together. In otherwords, the existing land use pattern in different regions in India has been evolved as a result of the action and interaction of various factors, such as physical characteristic of land, the institutional framework, the structure of other resources (capital, labour, etc.) available. In addition, the geographical location of the region in relation to other aspects of economic development, viz., those relating to transport, industry, trade, etc. influence the land use pattern. A close scrutiny of the present land use pattern and the trends during the recent years will help us in understanding the Indian economic scenario.

9.2.1 Typology of Land Use

The total land in India can be divided into five categories from the land utilization perspective. These are: (i) Forests, (ii) Area not available for cultivation, (iii) Uncultivated land excluding current fallow, (iv) Fallow lands, (v) Cultivated Area.

The area not available for cultivation generally includes land put to industrial and other non-agricultural uses as well as barren and uncultivable land. Under the heading uncultivated land we include pasture, grazing land, tree cover and wasteland. On the other hand, fallow relates to land that is cultivable but is left unplanted. The cultivated land indicates the *net sown area*.

Let us look into the land utilization pattern for the year 1995. The total area of India is 328.73 million hectares (mha). The data available for land use classification for the year 1995 is for 304.83 mha. Of which forest area represent 22.43% (i.e., 68.39 mha.) (See Table 9.1). You can see from the table that the largest share of the total geographical area is occupied by the net sown area (46.8%) with 142.82 mha. On the other hand, the un-cultivated area comprising area under non-agricultural uses and barren and uncultivable land, represent 13.6 per cent of the total area. Other uncultivated land excluding fallow land which consists of i) permanent pasture and other grazing land, ii) land under miscellaneous tree crops and groves not included in net sown area, and iii) waste land is stretched over 29.08 mha. (9.6 per cent of the total geographical area). Of these, 11.24 mha. are under permanent pasture and other grazing land, 3.63 mha. under miscellaneous tree crops and groves and 14.21 mha. under wasteland. Fallow land occupies an area of 23.3 mha, i.e., 7.6 per cent.

9.2.2 Changes in Land Utilization Pattern

The picture that we observe for 1995 is quite different from that in 1950.

You can compare the land utilization patterns for the year 1995 over that in 1950 from Table 9.1. Some prominent features of the table are:

1) The area under forest cover has increased from 14.24 % in 1950 to 22.43% in 1995.

2) The net sown area, which represents area available for cultivation, has increased from 41.77% in 1950 to 46.85% in 1995. This has been made possible by bringing additional area into cultivation.

3) The area not available for cultivation has declined from 16.71% in 1950 to 13.54% in 1995. Here, the area under non-agricultural uses has increased while the area under barren land has declined. This implies that a large proportion of the barren land has been brought to economic use.

4) The area under uncultivated land excluding fallow land has declined. An important feature in this context is that land under miscellaneous tree crops, plantation, etc. has declined significantly from 6.97% to 1.19%.

There is also a marked increase in the gross cropped area by 56.26 mha. (131.89 mha. in 1950 to 188.15 mha. in 1995). The increase in the cropping intensity from 110.7 to 131.7 is an indication of *rabi* and kharif area put to cultivation. Development and construction of major, medium and minor irrigation projects has resulted in higher cropping intensity and more area under crops.

National forest policy lays down that the area under forest be steadily increased to 33% of the total geographical area of the country. There is now little scope for extension of cultivable area without creating imbalance in ecological settings. Intensive cultivation with extension of irrigation facilities and scientific methods of dry farming could meet the food requirements of the growing population.

Table 9.1 : Land Utilization Pattern (in mha**)**

Type of Land	1950		1995	
	Area	Percentage	Area	Percentage
A. Total Geographical Area	328.73		328.73	
B. Reporting Area for Land utilization	284.32		304.85	
1. Forest	40.48	14.24	68.39	22.43
2. Area not available for cultivation	47.52	16.71	41.28	13.54
a. area under non-agricultural uses	9.36	3.29	22.51	7.38
b. Barren and uncultivable land	38.16	13.42	18.77	6.16
3. Other uncultivated land excluding fallow land	49.45	17.39	29.08	9.54
a. Permanent pasture and other grazing land	6.68	2.35	11.24	3.70
b. Land under miscellaneous tree crops and groups not included in net sown area	19.83	6.97	3.63	1.19
c. Cultivable waste	22.96	8.08	14.21	4.66
4. Fallow land	28.12	9.89	23.3	7.64
a. Fallow land other than current fallow	17.44	6.13	9.77	3.20
b. Current fallow	10.68	3.76	13.53	4.44
5. Net sown area	118.75	41.77	142.82	46.85
C. Gross cropped area	131.89		188.15	
D. Cropping intensity (%)	111.07		131.70	

Source: Agricultural Statistics at a Glance:1999, Government of India

9.3 AGRICULTURAL LAND USE IN INDIA

In 1993-94, an area of 42.68 mha was under rice, 25.2 mha was under wheat, 33.5 mha was under coarse cereals and 101.49 mha under total cereals. An area of 23.4 mha was under total pulses; 124.8 mha was under total foodgrains, 2.94 mha under fruits, 4.2 mha under vegetables, 28.5 mha under total oilseeds, 8.36 mha under total fibers, 0.42 mha under tobacco, 3.74 mha under sugarcane, 2.36 mha under spices, 10.64 mha under other crops.

9.3.1 Scientific Cropping Pattern and Agricultural Land Use

In order to increase agricultural production from given land resources , it is necessary to use scientific cropping pattern. Cropping system approach holds many promises in this regard. The adoption of cropping system technology and its successful implementation depend on physical and socio-economic resources, which are available or are made available at the time when they are needed. Location specific and farm based cropping patterns have to be evolved with consideration of such determinants as land, topography, water availability, intensity and duration of sunlight, labour availability, cash or credit, power source and market demand.

Adequate resource utilization of a farm in integrated farming system with crops as major enterprise is the crux of the problem. Carandang (1980) has projected that the cropping system approach has two main components, viz., farm resources and production technology. Farm resources are of two types: physical and socio-economic. Physical resources include land, sunshine, and water. On the other hand, socio-economic factors include markets, labour, power, cash, etc. Production technology depends on nature of crops and varieties, tillers, fertility, weed management, insects management, disease control, inter-plant durations, water management, etc. Both farm resources and production technology need to be integrated on scientific basis.

9.3.2 Governmental Intervention for Scientific Land Use

A nation lives for thousands of years whereas individuals live for some decades. Therefore, individual activities should not be allowed to restrict the potentials for future generations. Any national government has to safeguard the interests of future generations without compromising the welfare of the present generation. Hence the need for better land use planning arise where both the public and private interests are taken care of.

In order to facilitate scientific and sustainable land use governments have promulgated various legislations. These legislations have been enacted mostly after Independence. Land Utilization Acts were passed in 1947 and 1949 respectively by Uttar Pradesh and Punjab governments. The Uttar Pradesh Soil Conservation Act, 1954 embodies soil conservation programmes. The states of Bihar and Punjab have passed Land Reclamation Acts. The Madhya Bharat Land Utilization Act of 1950 restricts keeping land fallow for longer periods. The Bombay Khar Land Act, 1948 and Punjab Land Preservation, Amendment Act 1953 were enacted to restrict misuse of land resources.

However these acts have not been able to check the mismanagement of land resources. Due to improper implementation and loose interpretation of laws there have been many instances of misuse of land.

9.4 SOIL CONDITIONS IN INDIA

Soil is an essential input for agricultural production. It supports plant growth. You may be aware that soil is transferable natural material, which is found on earth crust and provides natural medium to plant growth. The soil is a natural body, differentiated into layers of loose (unconsolidated) mineral and organic matter. The depth of soil varies across regions.

Soils of India have been classified into large number of groups and sub- groups. The main groups are:

i) **Red Soil-** The colour of the soil is red due to presence of various oxides of iron. These soils are poor in fertility and deficient in organic matter. This type of soil comprises vast area of Tamil Nadu, Karnataka, Goa, Daman and Diu, South Eastern Maharashtra, Andhra Pradesh, Chhattishgarh, Orissa and Jharkhand. It is also extended to Santhal Praganas of Bihar and Birbhum district of West Bengal to Jhansi and Hamirpur of Uttar Pradesh. The red soil in Tamil Nadu occupies the largest area and constitute nearly 2/3 of the cultivated area.

ii) **Laterite Soil-** This type of soil is yellowish red or red in colour. These soils are high in organic matter. These soils are peculiar to India with an intermittently moist climate. This type of soil is generally found in the summit of the hills of Karanataka, Kerala, Madhya Pradesh, the Eastern Ghats of Orissa, Maharashtra, West Bengal and Tamil Nadu. On the laterite (soil), at lower elevations paddy is grown whereas in higher elevations, tea, cinchona, rubber and coffee is grown.

iii) **Black Soil-** This soil type has characteristic dark colour, varying from dark brown to deep black. These soils contain high amount of organic matter. These soils are varying in depth from shallow to deep. Typically soil derived from the Deccan trap is the black cotton soil. It is prevalent in Maharashtra, western part of Madhya Pradesh, parts of Andhra Pradesh, parts of Gujarat, and some parts of Tamil Nadu. Many black soil areas have a high degree of fertility but some especially in the uplands are moderately productive. In Maharashtra these soils are derived from the Deccan trap and occupy quite large area.

iv) **Alluvial Soil-** These soils are dark in colour and contain lime. Considerable salinity and alkalinity are also found. The fresh alluviums are coarser in texture and show little or no horizonation. This is by far the largest and most important soil group in India contributing the largest share to agriculture. This type of soil is formed by the deposition laid by the Ganges and the Bramhputra system. Alluvial soil stretches over West Bengal, Uttar Pradesh and Assam on the Bramhaputra and Ganga river basins. The alluvial soil of Tamil Nadu, Kerala, and Gujarat found in the deltaic areas along the coast are the deposition of sediment of southern rivers.

v) **Desert Soil-** This type of soil is low in organic matter content. The colour varies from yellowish brown to pale brown. It contains many water-soluble minerals. These soils are predominating in western Rajasthan, Haryana, Punjab, lying between Indus river and Aravali range. The Rajasthan desert is a vast sandy plain including isolated hills at places. In many parts, these soils are alkaline to saline with unfavorable physical conditions.

vi) **Terai Soil-** This type of soil is found in the hills of Himalayan region, Jammu and Kashmir, Uttar Pradesh, Bihar and West Bengal. They are formed by the down -ward movement of materials from the lower Himalayan ranges.

vii) **Brown Soil-** In this case the surface soil is brown and moderately rich in organic matter. The organic content varies between 0.5 to 1 per cent. The soil is neutral to slight acidic in nature.

viii) **Saline and alkaline Soil-** They contain high contents of soluble salts. It is estimated that about 7 million hectares of land in the country are driven out of cultivation due to salinity. Three cases of salinity soil are recognized.

a) Saline Soil

This soil contains toxic core of soluble salts in the net zone. This is also called white alkali.

b) Non saline Alkali or Sodic Soil

These soils do not contain any large amount of neutral salt.

c) Saline Alkali Soil

This group of soil is both saline and alkali. This causes low yield of crops.

ix) **Peat Soils-** This type of soil usually develops from brackish water sediments. There is high accumulation of organic matter due to poor drainage condition. This soil contains high percentage of free alumina.

9.5 SOIL EROSION

A major factor responsible for the degradation of natural resources is soil erosion. It has been estimated that accelerated soil erosion has irreversibly destroyed some 430 mha of land area covering 30% of the present cultivated area in different countries of the world. Soil erosion is more severe in mountainous than in undulating area. The loss of topsoil resulting in reduced productivity is a most serious degradation problem in the Indian sub- continent.

9.5.1 Soil Erosion by Water

Erosion by water is the most serious degradation problem in Indian Context. At present soil erosion is taking place at a rate of 16.35 tons per hactare per year totaling 5334 million tons per year. Nearly 29% of the total eroded soil is permanently lost to the sea and nearly 10% is deposited in reservoirs.

9.5.2 Wind Erosion

Wind erosion is a serious problem in the Arid and Semi-arid regions, including the states of Rajasthan, Haryana, Gujarat and Punjab. Removal of natural vegetative cover resulting from excessive grazing and extension of agriculture to marginal areas is the major human induced factor leading to accelerated wind erosion. Wind erosion is also prevalent in the coastal area where sandy soil predominates.

9.5.3 Salinization

A large fraction of irrigation has been achieved through expansion of canal irrigated area. In almost all cases the ground water table which was several meter deep prior to the introduction of irrigation has been rising following the introduction of irrigation. When ground water table reaches within 2 meter of the surface, it contributes significantly to evaporation from the soil surface and causes soil salinisation. Nearly 50 per cent of the canal irrigation areas are suffering from salinization or alkalization or both. The main reason for these problems as you will see in Unit 10 are inadequate drainage and inefficient use of available water resources. The socio-political factors have also contributed to the salinisation problem.

9.5.4 Waterlogging

Another cause of soil degradation in irrigated area is water logging due to excessive water application and canal seepage. It not only hampers crop growth but also degrades soil and productivity reduces considerably. The adverse effect of waterlogging has affected the agricultural potential especially in eastern region. It is estimated that as high as 8 million hectares of land is exposed to waterlogging in the country.

Check Your Progress 1

1) What is cropping intensity? What area the measures of raising cropping intensity?

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2) Distinguish between red soil and black soil in terms of availability, fertility and crops grown.

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3) What are the important changes taking place in land utilisation pattern?

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9.6 CROPPING PATTERNS IN INDIA

Cropping pattern indicates the proportion of area under different crops at a point of time. Cropping activities go on all the year round in India provided water is available for the crops.

In India, 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. We explain these cropping systems below.

9.6.1 Types of Cropping Systems

a) **Mono-cropping:** Mono-cropping or monoculture refers to growing of only one crop on a piece of land year after year. It may be due to climatological and socio-economic conditions or due to specialization of a farmer in growing a particular crop, e.g., under rainfed conditions, groundnut or cotton or sorghum are grown year after year due to limitation of rainfall. In canal irrigated areas, under waterlogged condition, rice crop is grown as it is not possible to grow any other crop.

b) **Multiple-cropping:** Growing two or more crops on the same piece of land in one calendar year is known as multiple-cropping. It is intensification of cropping in time and space dimensions, i.e., more number of crops within a year and more number of crops on the same piece of land at any given period. It includes inter-cropping, mixed-cropping and sequence cropping. Double-cropping is a case where the land is occupied by two crops, which are grown in a year in sequence.

c) **Inter-cropping:** Inter-cropping is growing of two or more crops simultaneously on the same piece of land with a definite row pattern. For example, growing *setaria* and *redgram* in 5:1 ratio. Thus, cropping intensity in space dimension is achieved. Inter-cropping was originally practiced as an insurance against crop failure under rainfed conditions. At present, the 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.

For successful inter-cropping, there are certain important requirements:

1) The time of peak nutrient demands of component crops should not overlap.

2) Competition for light should be minimum among the component crops.

3) Complementarity should exist between the component crops.

4) The differences in maturity of component crops should be at least 30 days.

d) **Mixed-cropping:** Mixed-cropping is growing of two or more crops simultaneously intermingled without any row pattern. It is a common practice in most of dryland tracts of India. Seeds of different crops are mixed in certain proportion and are sown. The objective is to meet the family requirement of cereals, pulses and vegetables.

e) **Sequence-Cropping:** Sequence cropping can be defined as growing of two or more crops in a sequence on the same piece of land in a farming year. Depending on the number of crops grown in a year it is called double, triple or quadruple cropping involving two, three and four crops respectively.

In addition to the above systems, relay cropping and ratoon cropping are also in existence. Relay cropping refers to planting of the succeeding crop before harvesting the preceding crops. Ratoon cropping or ratooning refers to raising a crop with re-growth coming out of roots or stalks after harvest of the crop.

f) **Integrated Farming System:** Integrated farming system is a holistic method of combining several enterprises like cropping system, diarying, piggery, poultry, fishery, bee-keeping, etc. in a harmonious way so as to complement each other. The objective is efficient resource utilisation and maximization of profit in such a way so as to cause least damage to soil and environment.

9.6.2 Why Cropping Systems Differ?

Both climatic factors and resources of the farmers determine the cropping pattern on a farm. Though climate plays most vital part in crop selection, the area under crop is also influenced by economic considerations of the farmer, namely irrigation water, cost of inputs and prices of the products. In any locality, the prevalent cropping system is the cumulative results of past and present decisions by individuals, communities or government or their agencies. A basic requisite for higher cropping intensity is the availability of water either through precipitation or through irrigation. It is being increasingly realized that the land and water resources are not unlimited and the wise use of the same is imperative. This is especially so for the countries like India where the population pressure is continuously increasing.

Tropical countries like India are fortunate in that the temperature condition remain favorable practically throughout the year for growing crops. However, it is crucially dependent upon water supply through natural precipitation or irrigation facility. Multiple-cropping has been in practice in many parts of India since long. Similarly, mixed-cropping has been an ancient art in India. Mixed-cropping systems were adopted as an insurance against failure of crops due to seasonal conditions or due to attack of pests and diseases. In recent years it has been shown beyond doubt that there are many other advantages too.

Integrated farming system seems to be the answer to the problem of scarcity of land resources. This will increase the income level and improve the nutrition standard of small-scale farmers with limited resources. Researchers on multiple-cropping system, however, suggest that the resources of the farmers be given major emphasis so that technologically a mixed-cropping can be adopted. Gradually new concepts on multiple-cropping have started coming in and now there has been some accumulation of useful scientific information. The information is based on analytical work on different crop combinations and sequential growth of the crops. In this respect cultivated areas in the country can be broadly classified into three categories based on rainfall pattern:

i) Area where annual rainfall is above 1150 mm

ii) Area where rainfall ranges from 750-1150 mm

iii) Area where rainfall is below 750 mm

Most of the areas in Assam, Kerala, Orissa and West Bengal can be included in the first category. Basic problems in these areas pertain to limited irrigation and poor drainage. Most of the farmers are engaged in rice cultivation. Large parts of Tamil Nadu, Utter Pradesh and Andhra Pradesh fall in the second category and occupy about one third of the total cultivated area in the country. In these areas there is large potential for creating minor irrigation facilities. The third category also occupies nearly one third of the cultivated area, comprising parts of Andhra Pradesh, Karnataka, Maharashtra and Rajsthan. In these areas, unless major and medium irrigation facilities are provided, there is little hope for raising cropping intensity to a substantial extent.

The cropping pattern is influenced by:

- Traditional social practices and dietary habits
- The crops with practicable pest and disease control method and suitability with ecological environment.
- The crops which are most profitable (or are high-yielding)
- The combination of crops that result in profit maximization and cost minimization.

9.7 CURRENT CROPPING PATTERNS

Three important features mark the cropping pattern of India: i) Predominance of foodgrains crops, ii) Slight shift towards commercial crops, and iii) Noticeable increase in some individual crops.

Table 9.2

Cropping Pattern in India in 1995

Crops	Area in '000 hectares	% share in Gross Cropped Area
Rice	42965	22.84
Wheat	25853	13.74
Jowar	11722	6.23
Bajra	10320	5.49
Maize	6141	3.26
Ragi	1902	1.01
Barley	894	0.48
Other cereals and millets	1820	0.97
Coarse cereals	32799	17.43
Total cereals	101617	54.01
Total pulses	24281	12.91
Sugarcane	4144	2.20
Spices and condiments	2645	1.41
Total fruits	3040	1.62
Potatoes	1070	0.57
Onions	392	0.21
Total vegetables	4506	2.39
Groundnut	7969	4.24
Rapeseed and mustard	5769	3.07
Sesamum	2212	1.08
Linseed	894	0.48
Other oilseed	10326	5.49
Total oil seed	27070	14.44
Cotton	7967	4.23
Jute	760	0.40
Mesta	190	0.10
Total fibers	9014	4.79
Tobacco	408	0.22
Other crops	11322	6.02
Gross cropped area	188147	100

Source: Agricultural Statistics at a Glance.

Taking the major crops into consideration we can present a broad picture in the cropping pattern in India. The major pattern follows two distinct groups: *Kharif* (monsoon crops) and *Rabi* (post-monsoon crops). The *kharif* crop includes rice, sorghum, bajra, maize, ragi, groundnut, cotton, etc. The crop occupying the highest percentage of the sown area of the region is taken as the base crop. All other possible alternative crops which are sown in the region either as substitute for the base crop in the same season or as the crops which fit in with the rotation in the subsequent season, are considered as the pattern.

9.7.1 The *Kharif* Season Cropping Patterns

The *kharif* season cropping pattern comprises mainly rice and non-rice-based crops.

i) **Rice-based cropping pattern -** Rice is the best crop in this category and 9% of the area in India comes under rice-based cropping pattern. Nearly 45% of the total rice area in India receives 30 cm per month of rainfall during at least two months (July-August) of the south western monsoon and much less during other months. In contrast to these parts, the eastern and southern regions, comprising Assam, West Bengal, Coastal Orissa, Coastal Andhra Pradesh, Karnataka, Tamil Nadu and Kerala which receive 10-20 cm per month, also come under this cropping pattern. On the all India basis, about 30 rice-based cropping pattern have been identified in different states.

ii) **Kharif cereals other than the rice-based cropping pattern-** Maize, *jowar*, *bajra* form the main *kharif* cereals, *Ragi* and small millets come next, these are grown in limited area. Maize is grown in high rainfall areas, *jowar* in medium rainfall areas and *Bajra* in low rainfall areas. The extent of the area under these crops during south western monsoon season is: maize(5.6 mha), *jowar* (11 mha) and bajra 12.4 mha.

   Ragi is a *kharif* cereal (2.4mha) and is mainly concentrated in Karnataka, Tamil Nadu and Andha Pradesh. These states account for more than 60% of the total area under this crop.

iii) **Maize-based cropping pattern-** The largest areas under *kharif* maize are : Uttar Pradesh (14mha), Madhya Pradesh (0.58 mha) and Punjab (0.52 mha). In the four states namely Gujarat, Jammu & Kashmir, Himachal Pradesh and A.P; the area under maize ranges from 0.24 to 0.28 mha in each, whereas other states have much less area under it. On the all India basis, about 12 Maize based cropping pattern have been identified.

iv) ***Kharif jowar*-based cropping pattern-** The area under the *kharif jowar* in India is highest in Maharashtra (2.5 mha), closely followed by Madhya Pradesh (2.3 mha). In each of the states of Rajasthan, Andhra Pradesh, Karnataka and Gujarat, the area under this crop is between 1 and 1.4 mha. *Jowar* is mainly grown in areas having rainfall range from 10 to 20 cm per month, least for 3 to 4 months of the southeastern monsoon. On the all India basis, 17 major cropping patterns have been identified under this category.

v) **Bajra-based cropping pattern:** The area under bajra crop is about 12.4 mha. Rajasthan has about two-third of the total area. Maharashtra, Gujarat and Uttar Pradesh together have over 4.6 mha, constituting the remaining one-third area under the bajra crop. On all India basis 20 major cropping patterns have been identified with bajra as base crop.

vi) **Groundnut-based cropping pattern:** Groundnut is sown over an area of about 7.2 mha , mostly in five major groundnut producing states : Gujarat (24.4%) area, Andhra Pradesh, (20.2%), Tamil Nadu (35.5%), Maharashtra (12.2%) and Karnataka (12%). Five other states, viz, Madhya Pradesh, Uttar Pradesh, Punjab, Rajasthan and Orissa together have about 17.3% of the total area under groundnut as base crop. On the all-India level, about nine major groundnut based cropping patterns have been identified.

vii) **Cotton-based cropping pattern:** Cotton is grown over 7.6 mha in India. Maharashtra shares 36%(2.8mha), followed by Gujarat with 21% (1.6 mha), Karnataka with 13% (1mha) and Madhya Pradesh with 9%(.6mha) of the area. Together these four states account for about 80% of area under cotton. The other cotton growing states are Punjab, Andhra Pradesh, Tamil Nadu, Harayana and Rajasthan. On the all India basis about 16 broad cotton-based cropping patterns have been identified.

9.7.2 *Rabi*-season Cropping Patterns

The major cropping patterns prevalent in India during the *rabi* season are: i) wheat and gram based cropping pattern, and ii) *jowar*-based cropping pattern.

a) **Wheat and gram based cropping patterns**

These two crops are grown under identical climate and can often be substituted for each other. On the all-India level, about 19 cropping patterns have been identified with wheat and 7 cropping patterns with gram. The core of the wheat region responsible for 70 per cent of the area and 76 per cent of production comprises Punjab, Haryana, Uttar Pradesh, Madhya Pradesh flanked by Rajasthan and Gujarat in the Western region and Bihar and West Bengal in the Eastern region.

b) ***Rabi-Jowar*** **based cropping patterns**

On the all-India level, about 13 cropping patterns have been identified with the *rabi jowar*. Maharashtra has the largest number of these cropping patterns, wherein starting with the exclusive *rabi jowar*, bajra, pulses, oilseeds and tobacco are grown as alternative crops.

Check Your Progress 2

1) Distinguish between the following terms:

   a) double cropping and mixed cropping

   b) double cropping and sequence cropping

   c) mono-cropping and multiple cropping

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2) Describe the major cropping patterns followed in Northern India.

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3) What are the important cropping patterns during kharif season?

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4) Differentiate between rice-based and non-rice-based cropping patterns with suitable examples.

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9.8 CHANGES IN THE CROPPING PATTERNS

The trend in the land use pattern and cropping pattern over the last 50 years in India has shown increasing use of land for the purpose of cultivation with slight variations. The change in the land use pattern and cropping pattern is vastly affected by rapid urbanization. The higher cultivable area has been achieved by bringing large acreage of uncultivable land into cultivation.

9.8.1 Factors Affecting Cropping Pattern

The cropping pattern is highly influenced by personal, social, cultural and economic factors of the farmers. Apart from that, it is also affected by the climatic factors of a region.

The major factors are :

i) *Size of the Land Holding*

In India, marginal and small farmers represent the majority of farming community. So the mono crop paddy has become predominate as it fulfills the household needs and perpetuates the subsistence agriculture with little scope for commercial crop husbandry.

ii) *Literacy*

Majority of the farmers are ignorant of the scientific methods involved in mixed-cropping, mono cropping and other technological knowhow for practicing better cropping pattern.

iii) *Disease and Pest*

The cropping pattern also depends on the possibility of disease and pest infection

iv) *Ecological Ssuitability*

The cropping pattern of a particular region is highly dependent on the ecological condition (temperature, rainfall, humidity, etc.).

v) *Moisture Availability*

The source of irrigation greatly determines the type of the cropping pattern to be practiced. For example, in low rainfall area, dry land farming is the best possible way to profit maximization.

vi) *Financial Stability.*

The economic condition of the farmers also affects the cropping pattern. As the cash crops (for example, cotton) involve high capital investments, these are practised only in estate farming. The marginal section of the farming community adopts low cost crops.

9.8.2 Emerging Problems in Cropping Patterns

Over the years the emerging scenario in the cropping pattern points to the following observations.

1) The dominance of cereal crops in the foodgrains point to the poverty of the people. It meets the demand of the low-income people, in whose case a large proportion of income is spent on cereals. Even pulses which are the source of protein for this class of people is not grown on a significant scale. Most of the farmers being marginal and small are the net purchaser of foodgrains and hardly can afford the high input cost for raising a successful non-food cash crop.

2) The predominance of foodgrains group together with the fact that a significant proportion of agricultural production is concentrated in small farms, leads one to conclude that much of the cultivation is for self consumption.

3) The fact that large areas remains under foodgrains shows that land productivity has not increased at par with technological possibilities.

4) Despite significant changes in cropping pattern, the shift towards high valued commercial crops has been very small. The result is an insignificant impact on the growth of the crop output.

9.9 LONG-RUN EFFECTS OF CURRENT TREND

Cropping pattern presently in vogue in India is cereal biased and fails in assuring balanced food security. The cropping pattern does not depict a picture of diversified agriculture despite some commercialization and technological progress. Other associated aspects of the present cropping pattern are increased use of chemical fertilizers and pesticides, increase in water demand, and duplication of forest areas which are discussed below.

9.9.1 Increase in Use of Fertilizers and Pesticides

Higher production of foodgrains has resulted from more inorganic fertilizer and pesticide application. The NPK used has increased from 65.6 thousand tonnes in 1951-52 to

17318 thousand tonnes in 1997-98. The higher chemical fertilizer and pesticide application has led to toxicity in feeds.

Area where pesticides use has been increasing vigorously has seen insurgency among the insects and pests, led to disturbance in bio-system. In addition, there has been increasing use of hybrid and high yielding variety replacing the local varieties heading to almost extinction of the local variety.

9.9.2 Increase in Water Demand

In the last fifty years, the net sown area has been increased from 118 to 142 million ha. The increase in net sown area and increase in cropping intensity in turn increased the demand for water sources for irrigation. This increased demand is causing depletion of water resources. Competing sectors are being deprived of required water as agriculture consumes as high as 70% of total water use. The intensive cropping pattern is always in need of higher irrigation supply. This in turn pushes for development of sources of irrigation. The higher requirement of water deplete the ground water level. Increased demand for irrigation in turn requires major, medium and minor irrigation projects, which are highly expensive. The construction of irrigation projects many times faces bureaucratic hurdles and opposition from local residents because irrigation projects cause various social and environmental problems.

9.9.3 Depletion of Forest Areas

The present cropping pattern emphasized on bringing more and more land under agriculture thereby depleting the forestland. There has been an increase in the agricultural area through deforestation during the thirty years period 1950-81. The area under field crops rose from 118.7mha to 142.9 mha by bringing an additional 24 mha under crop through deforestation of private and rural forests or older fruit orchards. The land use pattern has moved towards higher food production leaving the forestry neglected.

Check Your Progress 3

1) Identify and explain the factors affecting cropping pattern.

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2) What are the problems due to changes in cropping pattern?

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9.10 LET US SUM UP

The scope of bringing in more land into cultivation is limited in India. Thus the existing land has to be utilized properly so that its productivity increases and consequently agricultural production is higher. In India, nearly half of total area is devoted to cultivation. During the past fifty years the land utilization pattern has undergone some changes. While the proportion of net sown area has increased, the proportion of uncultivated and wasteland has declined. Major crops such as rice and wheat not only occupy substantial share in total area under cultivation their share is increasing. This has implications for food habits, water demand and loss of bio-diversity.

9.11 KEY WORDS

Net Sown Area : The total operational holding of a particular farmer on which he can grow crop counted only once in an agricultural year is termed as Net Area Sown. This term denotes the total area under crops and orchards, counting areas sown more than once in the year only once.

Gross Cropped Area : Gross Cropped Area is the area sown under different crops in different seasons in a year on the available land.

Cropping Intensity (CI) : Cropping Intensity assesses farmers' actual land-use in area and time relationships for each crop or group of crops compared to the total available land area and time including the land temporarily. It is given (in percentage terms) by the ratio of Gross Cropped Area to Net Cropped Area. In simple terms, CI indicates the number of times a field is grown with crops in a year.

9.12 SOME USEFUL BOOKS

Government of India, 1999, *Agricultural Statistics at a Glance.*

Planning Commission, 2003, *Tenth Five Year Plan,* Government of India.

Mal, P., 2001, *Infrastructure Development for Agriculture and Rural Development*, Mohit Publications, New Delhi.

Singhal, V., 1996, *Indian Agriculture,* Indian Economic Data Research Centre.

9.13 ANSWERS/HINTS TO CHECK YOUR PROGRESS EXCERCISES

Check Your Progress 1

1) Cropping intensity is given by the ratio of gross cropped area to net cropped area. It can be increased by raising the number of times a piece of land is cultivated. Thus multiple cropping and mixed cropping would increase cropping intensity.

2) Read Section 9.4 and compare red soil and black soil.

3) Read section 9.2.2 and answer.

Check Your Progress 2

1) Read Section 9.6.1 and differentiate between the concerned terms.

2) Read Section 9.7 and answer.

3) Read Sub-section 9.7.1 to answer this question.

4) Read Sub-section 9.7.1 to answer this question.

Check Your Progress 3

1) Summarise the points given in Sub-section 9.8.1.

2) Read Sub-section 9.8.2 and answer.

UNIT 10 IRRIGATION IN INDIA

Structure

10.0 Objectives
10.1 Introduction
10.2 Extent of Irrigation in India
10.3 Sources of Irrigation
10.3.1 Sources of Minor Irrigation
10.3.2 Sources of Major and Medium Irrigation
10.4 Major versus Minor Irrigation: Comparative Analysis
10.4.1 Capacity Utilisation and Efficiency
10.4.2 Gestation Period
10.4.3 Cost Studies
10.5 Irrigation Management
10.5.1 Shortage of Funds
10.5.2 Utilisation Efficiency
10.5.3 Pricing of Irrigation Water
10.6 Environmental Effects of Irrigation
10.6.1 Displacement of Population
10.6.2 Destruction of Habitat
10.6.3 Impact of Minor Irrigation
10.7 Problem of Salinity and Water-logging
10.8 Suggestions for Better Water Management
10.9 Command Area Development Authority
10.10 Let Us Sum Up
10.11 Key Words
10.12 Some Useful Books
10.13 Answers/Hints to Check Your Progress Exercises

10.0 OBJECTIVES

After going through this unit, you would be in a position to:

- explain the role of irrigation in agricultural growth;
- identify the extent of irrigation coverage in various states of India in the post-independence period;
- distinguish among major, medium and minor irrigation projects;
- identify the sources of irrigation;
- compare the pros and cons of irrigation projects;
- explain the benefits of efficient utilisation of irrigation facility and scientific pricing of irrigation water; and
- explain the government schemes meant for irrigation development.

10.1 INTRODUCTION

Providing water to crops other than direct receipt of rainfall by plants is called irrigation. Irrigation is the process of watering the cultivated crops through artificial means. Irrigation plays both protective and productive role in the crop growth cycle. Irrigation is the application of the water to soil for the purpose of supplying moisture essential for plant growth especially during stress period. It provides an insurance against short duration drought during crop season. Irrigation boosts productivity and overall production. It also increases gross cropped area (GCA) through an increase in cropping intensity.

The timing and quantity of rainfall is beyond the control of human being. Moreover, the northwestern part of the country receives very little rainfall. Thus we cannot rely on rainfall alone for agricultural development. Irrigation facility, on the other hand, is controlled and thus quite desirable. So long as a major technical breakthrough in the art of rain-fed farming does not occur, the emphasis on irrigation is bound to persist.

Irrigation development comes to the forefront of infrastructure development strategy for agriculture. Out of total geographical area of 329 *million hectares* (mha), the gross cropped area (GCA) in the country is 186 mha and the net sown area (NSA) is only 142 mha. However, the entire cultivated area in India cannot be irrigated because of limited availability of water. It is estimated that the ultimate irrigated area of the country from all the sources is around 113.5 mha. Of these, the potential of major and medium irrigation is 58.5 mha while that of minor irrigation is 55 mha.

There has been rapid development of irrigation facilities in India since 1951. It has undoubtedly played a crucial role in increasing the food production, from around 50 million tonnes in 1951 to 206 million tonnes fifty years later. The increase has been achieved principally through improvement in the productivity of land, since the area under crops has increased only marginally. The liberal use of chemical fertilizers, the steady increase in the use of certified/quality seeds, and the extensive use of electricity in agriculture are among the other factors that have helped the rapid growth of agricultural production. The role of irrigation is of a catalytic agent because no farmer would invest on costly inputs like chemical fertilizers without assurance of the basic input, water, which is scanty in most parts of the country.

10.2 EXTENT OF IRRIGATION IN INDIA

Expansion of irrigation facilities along with consolidation of the existing system has been the main strategy for increasing production of foodgrains. Irrigation support is provided through major, medium and minor irrigation projects and command area development. With sustained and systematic development of irrigation, its potential has increased from 22.5 mha in 1951 to around 91 mha ha by 1999-2000.(see Table 10.1 for irrigation potential created up to 1994, and Tables 10.2 to 10.5 for related information).

Table 10.1 : Irrigation Potential Created and its Utilisation

(up to 1994; in thousand hectares)

State	Potential created			Potential Utilized			Percentage utilisation		
	1			2			3		
	a	b	c	a	b	c	a	b	c
	Major & Medium	Minor	Total	Major & Medium	Minor	Total	Major & Medium	Minor	Total
Andhra Pradesh	3039	2937	5976	3214	2649	5863	106	90	98
Arunanchal Pradesh	-	70	70	-	54	54	-	77	77
Assam	179	591	770	116	524	640	65	89	83
Bihar	2796	5087	7882	2745	4329	7074	98	85	90
Goa	13	19	32	15	21	36	115	111	113
Gujarat	1281	1934	3215	1343	1803	3146	105	93	98

Haryana	2058	1535	3593	1836	1479	3315	89	96	92
Himachal Pradesh	8	145	153	4	119	123	50	82	80
Jammu & Kashmir	174	368	542	150	351	501	86	95	92
Karnataka	1434	1480	2914	1308	1406	2714	91	95	93
Kerala	504	536	1040	669	487	1156	133	91	111
Madhya Pradesh	2025	2634	4659	1624	2372	3996	80	90	86
Maharastra	2080	2493	4573	1307	2211	3518	63	89	77
Manipur	62	51	113	78	41	119	126	80	105
Meghalaya	-	45	45	3	38	41		84	91
Mizoram	-	11	11	-	9	9		82	82
Nagaland	-	66	66	-	56	56		85	85
Orissa	1444	1265	2709	1333	1116	2449	92	88	90
Punjab	2386	3319	5705	2570	3217	5787	108	97	101
Rajasthan	2047	2438	4485	1926	2317	4243	94	95	95
Sikkim		23	23		17	17		74	74
Tamilnadu	1550	2130	3680	1458	2120	3578	94	100	97
Tripura	3	92	95	1	79	80	33	86	84
Uttar Pradesh	6876	19912	26788	5897	17294	23191	86	87	87
West Bengal	1370	2872	4242	1614	2298	3912	118	80	92
All India	31329	52051	83380	29216	46486	75702	93	89	91

Source: Centre for Monitoring Indian Economy 1999

Table 10.2 : Percentage Distribution of Irrigated Area under Principal Crops (1995-96)

State	Rice	Maize	Wheat	Total Cereal	Total pulses	Total Food grain	Groundnut	Rapeseed & Mustrd	Total Oil-seed	Sugar cane	Cotton	Tobaco	Total (all cross
Andhra Pradesh	94.8	15	72.7	69.9	1.2	53.8	16.8	…	17.6	95	14.9	33.1	40.7
Bihar	40.2	40.5	88.4	52.2	2.2	47.1	…	33.3	20.6	22.4	…	73.7	45.7
Gujarat	5.6	9.6	74.4	34	10.8	29.6	9.5	97.8	27.4	100	36.1	73	32.7
Haryana	99.4	15.4	98.3	83.3	25.6	76.8	50	66.8	68.1	97.2	99.5	…	78.2
Jammu & Kashmir	91.2	5.9	24.2	39.4	15.6	38.4	…	79.7	70.6	…	…	…	41
Karnataka	66.8	65.2	33.8	26.6	3.9	21.6	20.5	16.7	19.5	100	23.6	3.4	23.8
Madhya Pradesh	23.7	1.3	68.1	32.7	21.2	29.3	6.7	45.3	7.2	97.3	33.1	…	24.7
Manipur	32.5	…	…	31.6	…	31.5	…	…	…	…	…	…	27.7

Nagaland	44.3	…	100	34.6	…	32.6	…	75	35.3	…	…	…	31.6
Orissa	35.5	10.8	100	33.2	6.8	25.4	34.5	16.1	13.9	100	…	10	25.8
Punjab	99.8	56.7	97.1	96.6	72.5	96.1	50	87.4	88.8	94.9	99.6	…	95.2
Rajasthan	38.6	13.5	94.6	30.2	9.8	24.1	35.2	73.4	56.9	96.4	98	100	32.3
Tamil Nadu	92	53.2	…	68.4	6.6	58.2	27.7	…	35.5	100	36.8	100	50.8
Uttar Pradesh	62.3	31.3	92.5	70.3	27.5	64.3	1.5	75.2	51.4	88.2	91.7	100	65.8
West Bengal	27.2	…	89.3	29.9	3.2	28.6	…	85.2	70.9	50	…	…	29.8
All India	56.1	22.7	86.8	47.1	13	40.5	18.1	66.3	26.1	88.5	34.8	48.8	38.3

Source: Agricultural Statistics at a Glance 1999

Table 10.3 : Source-wise Distribution of Net Irrigated Area

(in thousand hectares, for 1995-96)

S.N.	State	Source of Irrigation					
		Canals	Tanks	Tube-wells	Other wells	Others	Total
1.	Andhra Pradesh	1539	747	709	947	181	4123
2.	Assam	362	...	...	...	210	572
3.	Bihar	1099	140	1728	96	617	3680
4.	Gujarat	593	35	724	1642	8	3002
5.	Haryana	1375	1	1353	...	32	2761
6.	Jammu & Kashmir	364	2	1	1	18	386
7.	Karnataka	950	230	372	428	322	2302
8.	Kerala	107	49	73	...	113	342
9.	Madhya Pradesh	1796	205	874	2294	759	5928
10.	Maharastra	538	369	...	1571	89	2567
11.	Orissa	949	305	299	537	...	2090
12.	Punjab	1356	...	2356	1	134	3847
13.	Rajasthan	1497	189	703	2797	46	5232
14.	Tamil Nadu	771	512	200	1127	15	2625
15.	Uttar Pradesh	3075	58	7771	390	381	11675
16.	West Bengal	717	263	689	23	219	1911
	All India	17142	3111	17937	11860	3460	53510

Source: Fertilizer Statistics, 1998-99, FAI, New Delhi.

According to a recent estimate the ultimate irrigation potential of India is about 140 mha. Contribution from major and medium irrigation projects will be 58.5 mha while minor irrigation has a potential of 81.5 mha. In the case of minor irrigation, 17.5. mha will be contributed by minor surface projects while 64 mha contribution will be from minor ground water projects.

It is estimated that the total annual precipitation over India is about 4000 *billion cubic metres* (bcm), which contributes 1,869 bcm to surface flow. But out of this surface flow, only 690 bcm (37 per cent) is utilized. The replenishable ground water potential in the country is 432 bcm. So the total utilizable water is 1122 bcm as per present estimates. You would have observed that most of the activities in irrigation sector in India have been construction driven, that is construction of reservoir, canal, field channel, etc. gets priority. Little attention has been paid to management of distribution of water for irrigation.

Table 10.4 : Outlay and Potential Created under Major and Medium Irrigation Projects

Period	Outlay: Expenditure (Rs. in crore)	Potential created during the plan (mha)	Cumulative potential created (mha)
Pre-plan period	Not available	9.70	9.70
First plan (1951-56)	376	2.50	12.20
Second plan(1956-61)	380	2.13	14.33
Third plan (1961-66)	576	2.24	16.57
Annual plan(1966-64)	430	1.53	18.10
Fourth plan (1969-74)	1242	2.60	20.70
Fifth plan (1974-78)	2516	4.02	24.72
Annual plan (1978-80)	2079	1.89	26.61
Sixth plan (1980-85)	7369	1.09	27.70
Seventh plan(1985-90)	1107	2.22	29.92
Annual plan (1990-92)	5459	0.82	30.74
Eighth plan (1992-97)	22415	5.09	35.83

Source: India 1996, Government of India

Table 10.5 : Potential Created and Utilised under Minor Irrigation Projects

Plan	Potential	Utilization
First Plan	14.1	14.06
Second Plan	14.8	14.8
Third Plan	17.0	17.0
Annual Plan	19.0	19.0
Fourth Plan	23.5	23.5
Fifth Plan	27.3	27.3
Annual Plan	30.0	30.0
Sixth Plan	37.5	35.3
Seventh Plan	46.6	43.1
Eighth Plan	10.7	9.4

Source: India 1996, Government of India

10.3 SOURCES OF IRRIGATION

A variety of structures comprise the Indian irrigation sector. These can be classified in more than one way:

1) major or minor irrigation

2) surface water or ground water bases

3) gravity flow or lift irrigation.

The first classification is peculiar to India as large-scale irrigation is under the head major and medium irrigation and small-scale irrigation under minor head.

According to the size, irrigation project may be

a) **Major Irrigation Project**

Having cumulative command area (CCA) of more than 10000 hectare or which cost more than Rs. 5 crore.

b) **Medium Irrigation Project**

Having cumulative command area less than 10000 hectare but more than 2000 hectare or which cost between Rs.20 lakh to Rs.5 crore.

c) **Minor Irrigation Project**

Having cumulative command area less than 2000 hectare or which cost Rs. 5 lakh in plain areas and Rs.30 lakh in the hills.

10.3.1 Sources of Minor Irrigation

The minor irrigation works include dug-wells, tube-wells, tanks, etc. Minor irrigation structures are created through tank, surface percolation wells, tube-wells and fluxial wells. The water source for a minor irrigation project could be either surface flow or ground water storage. While tank and pond irrigation are examples of surface flow, construction of well is an example of ground water storage.

a) **Tank irrigation**

Most of the irrigation tanks are located in Andhra Pradesh, Karnataka, Orissa, Tamil Nadu and West Bengal. These provide irrigation to gross area of about 4.5 mha. Tank is a multipurpose use source (pisiculture, ducking, washing, irrigation, flood control, agro-forestry, etc.) and has great importance particularly to maintain water supply to command area and to recharge ground water level.

b) **Tube-well and Filter point well**

Shallow tube-wells meant for irrigation are privately owned and tap shallow aquifers (groundwater storage). These are used to irrigate only a few hectares and have a life period of 5 to 15 years, while deep tube-wells generally tap deep aquifers and give a recharge of more than 125000 liters per hour and irrigate a gross area of 80 to 100 ha.

c) **Open-well**.

Open-wells are traditional sources of irrigation. The new wells constructed during any period do not make an addition to the total number to the full extent during that period as some wells go out of use. Open-wells are the cheap source of irrigation water use where topography is undulating and canal water does not feed the area. Open-wells are basically privately owned and the potential for irrigation is also not much.

10.3.2 Sources of Major and Medium Irrigation

Big dams and barrages built across rivers are sources of major and medium irrigation. Major irrigation done through canal draws their water from rivers or from artificial storage. River canals are of three types.

1) Inundation canal
2) Perennial canal
3) Storage canal.

Check Your Progress 1

1) Define minor, medium and major irrigation.

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2) What are the sources of minor irrigation?

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3) What are the sources of major irrigation?

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10.4 MAJOR VERSUS MINOR IRRIGATION: COMPARATIVE ANALYSIS

Both major and minor irrigation projects have their potential for water resource exploitation. However, both the types are different in nature and have their comparative merits and demerits. Tube-well technology is technically not feasible in non-alluvial tracts, which constitute nearly 70 per cent of Indian landmass. The option in these undulating plateaus and non-alluvial tracts is runoff collection in ponds and other water harvesting structures under minor irrigation projects or canal irrigation system under multipurpose river valley projects.

The factors which help us to make a choice between minor and major projects are: i) the availability of funds, ii) topographic positions, iii) social preferences, and iv) environmental considerations. You would have observed that a major project requires huge investments while a minor project require a small amount. Moreover, hilly areas will require different type irrigation than plain areas. We will take into consideration factors such as capacity utilisation, gestation lag and resource requirements while undertaking a comparative analysis of both the types of irrigation.

10.4.1 Capacity Utilization and Efficiency

The 'potential created' under any irrigation system is the area supplied with water delivery facility. On the other hand, 'potential utilized' is the area that is practically supplied with irrigation water for at least one season. Difference between the two can arise because some areas are planned to have irrigation facilities, but do not receive irrigation water. When the area that actually receives water is less than the area planned for irrigation, we say that there is under-utilisation of capacity. The phenomena of 100 per cent efficiency is rare and is not a ground reality.

Studies have shown that for the minor irrigation project, the capacity utilisation is only to the extent of 80 per cent in a normal rainfall year. The percentage varies across states : 50-60 per cent in Orissa and Tripura, 60-70 per cent in Assam, Goa, Karnataka, Minipur, Meghalaya, 70-80 per cent in west Bengal, Tamil Nadu, Kerala, and Arunachal Pradesh.

Minor irrigation is a low cost option. However, studies have shown that the production impact of minor irrigation is double that of major irrigation. Minor irrigation is mainly covered by tube-wells wherever ground water is sufficiently available. Different studies reflect that the rate of capacity utilization in the tube-wells averaged at 67 per cent for shallow tube-wells and 72 per cent for deep tube-wells. Capacity utilization in major irrigation projects is reported to be somewhat lower than that of minor irrigation. Sometimes it comes down below 60 per cent as conveyance loss, evaporation loss and field losses are more in major projects. However, situation may be completely different depending upon conveyance and distribution systems in each command.

Minor irrigation is mostly in private sector. Here benefits accrue directly to the owner. Thus proper maintenance of the project and management of water is taken care of. On the other hand, major and medium irrigation projects are generally owned by the government. Here it does not costs a farmer if there is mis-management or excess use of water. This appears to explain the higher efficiency of minor irrigation.

10.4.2 Gestation Period

The time lag between the investment and the return from development projects is called gestation period. The gestation period of irrigation projects is found to be very high as administrative and technical problems are compounded with legal problems. Many irrigation projects, especially large and medium ones, suffer from gestation lags.

In some cases the gestation lag exceeds two decades resulting in severe cost and time overruns. A medium scheme can generally be completed between 5 to 7 years. However, gestation period differs from project to project depending upon factors ranging from availability of finance to technical difficulties and now a days environmentally conscious groups or individuals.

In normal course of action also the gestation lag itself may vary over time. For a major project it may vary from 10 to 12 years if timely funding is available. In cases where funding and other constraints are present, the gestation lag could stretch up to 20 years. On the other hand, in the case of minor irrigation projects, the gestation period is usually one to two years. However, it depends upon availability of funds and organizational ability to get the project running.

Now a days, under different poverty alleviation programmes emphasis is given on minor irrigation projects as the gestation period, environmental impacts and investments are less. The gestation lags also may arise due to slow adaptability of irrigated agricultural practices by beneficiary farmers. The longer gestation period lead to cost and time overruns making the project often financially non-viable.

10.4.3 Cost Comparison

It is debatable whether minor irrigation is more cost efficient than major irrigation projects. The Planning Commission has estimated that investment needed for irrigating one hectare of land was Rs.1,530 in the Fifth Plan. It increased to Rs.36,210 per hactare in the Ninth Plan. For minor projects the cost of irrigation per hectare cultivated land was Rs.7331. However, the estimates are non-comparable as the values are expressed in the prevailing market prices of that period not adjusted for inflation over the years.

The cost of the major irrigation projects involves total capital investment for the construction of the reservoirs, dams, canal and conveyance systems up to the plot of land. The cost of the minor irrigation project involves the capital investment on the construction of the tanks, wells or tube-wells and the conveyance system. It is estimated that the project cost of minor irrigation project is around Rs.5 lakh for plain areas and Rs.30 lakh for hills. The cost of major irrigation project involves capital expenditure of around Rs.5 crore.

We present a summary of the distinction between major and minor irrigation projects in Table 10.6.

Table 10.6 : Major versus Minor Irrigation Projects

Major irrigation project	Minor irrigation project
1. Gestation period is high	1. Gestation period is low.
2. Investment cost and maintenance costs are very high.	2. Investment cost and maintenance costs are low.
3. Investment cost is more than Rs. 5 crore.	3. Investment cost is Rs. 5 lakh to Rs. 30 lakh.
4. It covers an area about 10,000 ha or more.	4. It covers an area about 1000-2000 ha or less.
5. Benefit-cost ratio of major irrigation project are generally less compared to minor irrigation project as the loss of water due to seepage, over use, unnecessary use of irrigation water and larger externalities.	5. Benefit-cost ratio of minor irrigation projects are generally higher than major irrigation projects due to less wastage of water by seepage and other means.
6. It has been observed that in the world as a whole, as much land goes out of production owing to water logging and salination every year as is brought under production through new projects	6. Depletion of natural aquifers is the major problem.
7. The costs over-run are much greater.	7. The costs over-run are less.

Check Your Progress 2

1) What are the reasons behind higher production impact of minor irrigation projects?

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2) Contrast minor irrigation with major irrigation with respect to capacity utilisation, gestation lag and investment cost.

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3) Bring out the distinguishing features of minor and major irrigation.

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10.5 IRRIGATION MANAGEMENT

A serious problem experienced often in irrigation works is the inability of the system to deliver the planned benefits owing to a variety of unforeseen developments. For instance, in storage reservoirs, sedimentation has been taking place at a much faster rate than was provided for in the project planning, resulting in diminution of storage space and its benefits. Canals have not been able to carry the authorized flows because the assumptions made or the design could not be achieved on the field. Canal cross regulators and flood disposal works provided were found inadequate for efficient functioning of the canal in many cases.

While irrigation has significantly influenced agricultural productivity, the yields are distinctly low with respect to international norms in most of the irrigated crops in the country. The average cereal yields (paddy, wheat, etc.) of 1.7 tonnes per ha achieved in India falls well below the international norm of 3 to 4 tonnes realized in well managed systems of the world. The gap is attributed to a number of factors such as: i) sub-optimal use of inputs, ii) obsolete cultivation practices, and iii) inefficient irrigation management. Given the sensitivity of crops to water stress and excess water and their effects on yield, irrigation management emerges as a major determinant of agricultural productivity.

The common problems of flow irrigation (canal) management are:

a) excessive canal seepage

b) inadequate water supply at tail end

c) insufficient drainage and water logging

d) main system deficiency

e) improper cropping pattern and crop calendar

f) lavish use of water

g) inadequate maintenance

h) poor revenue generation.

10.5.1 Shortage of Funds

Due to shortage of funds in most instances of major projects, the storage works or reservoirs were completed much ahead of the canal system. This resulted in abundant water availability for the limited areas opened for irrigation. As a result, the cropping pattern got distorted in favour of high water consuming crops irrespective of the suitability of the soil. In such situations the development of canals to its full length as originally planned will become difficult. The head-reach beneficiaries would appropriate excessive water due to cultivation of water-intensive crops. On the other hand, the tail-end beneficiaries may not get adequate amount of water as planned.

10.5.2 Utilisation Efficiency

While the role of irrigation in India's increased agricultural production is impressive, there is a need for retrospection to meet the future requirements of a continuously rising population. Since the 1950s, the aggregate growth rate of agricultural production has increased considerably. However, the present strategies may lead to stagnancy after a time calling for something new. In this context increasing the efficiency of irrigation is an important option. For sustained growth of agricultural production, irrigation will have to play a notable role commensurate with the high investment made in it.

It is estimated that the demand for food in future (2025 AD) will be around 345 million tonnes in India. That has to be met from rain-fed and irrigated farming. The national average yield from rain-fed agriculture is 1.25 tonnes per hectare and from irrigated agriculture it is 2.75 million tonnes. It has been estimated that 198 million tonnes of foodgrains will have to be produced from irrigated agriculture and 148 million tonnes from rain-fed agriculture.

Another point to be kept in view is that while there is significant decline of the share of agricultural sector in the GNP, the proportion of households dependent on agriculture has remained nearly constant. Irrigation activities will have to aim at the improvement of economic condition of farmers through better irrigation management practices and by extending benefits to new areas.

10.5.3 Pricing of Irrigation Water

In India irrigation water is not economically priced, as the present prices do not reflect scarcity value of water. The Vaidyanathan Committee recommended pricing of water as per the principle that can cover at least operation and maintenance cost and a part of capital cost. The Irrigation Commission in 1972 had recommended irrigation rates for cereal crops at 5 per cent and for cash crops at 12 per cent of the output. Presently the total receipt from irrigation sector does not cover even 2% of the gross output. However, farmers using water from private sources are paying much more than those depending on the publicly supplied irrigation water. The ability and willingness to pay has not been properly projected in the projects. The uneconomic pricing of irrigation water and electricity have induced the farmers for profligate use of precious water resulting in severe externalities like salinity and water-logging. Different committees have recommended that irrigation price should be increased to a level such that at least operation and maintenance cost and 1% of capital cost are recovered from beneficiary farmers.

10.6 ENVIRONMENTAL EFFECTS OF IRRIGATION

Irrigation results in an alteration of natural condition of the landscape by i) extracting water from the available sources, ii) adding water to fields where there was none or little, and iii) introducing man-made structure and features to extract, transferring and dispose of water. Irrigation projects and irrigated agriculture practices can impact the environment in a variety of ways, viz.,

a) Construction of irrigation projects

b) Water supply and operation of irrigation projects

c) Irrigated agriculture management practices

The consequences of minor and major irrigation could be different. In case of major irrigation there could be:

a) Relocation of the population of the area to be inundated

b) Negative impact on wildlife, particularly endangered and archeological patrimony

c) Relocation of the infrastructural system, i.e., roads, powerline, canal, etc.

d) Use of hazardous materials during the construction of large dams

e) Soil erosion and subsequent transport of sediments through runoff of excess irrigation water from croplands.

10.6.1 Displacement of Population

The gigantic dams costing hundred of crore of rupees have caused a great deal of harm to the people and environment. They displace crores of innocent people, mostly tribals and the poor. These projects have drown millions of hectares of rich forest. They have failed to prevent and control floods. Often panic discharges from these reservoirs have led to destruction through floods in the valley downstream. The average annual loss due to flood on standing crop, cattle, agricultural lands, houses, roads, railways, embankments, cottage industries, etc. are estimated to be anywhere between Rs.1000 crore to Rs.1500 crore.

In recent times, no major irrigation project has gone without protest. This has delayed the timely completion of projects and resulted in cost over-runs.

10.6.2 Destruction of Habitat

Large dams and multi purpose river valleys have become India’s most controversial environmental issues. The construction of large dams in India has resulted in depletion of thousands of hectares of forest land causing destruction of natural habitat of wildlife.

Construction of large dams (major irrigation project) involves huge forest cutting for the water reservoir. It also involves huge digging of soil and displacement of soil for reservoir construction. Huge loss of forest and soil accounted for the major and medium irrigation project construction and developments.

10.6.3 Impact of Minor Irrigation

Because of the localized nature of minor irrigation the above problems may not arise. However, there could be depletion in water table because of excessive extraction of water from under-ground sources, particularly through deep tube-wells. Groundwater development for irrigation purpose and its excessive use has given rise to problems of groundwater depletion. In Punjab, for example, pumping exceeds recharge by 33 per cent causing water-table to drop by about 1 meter per year.

In coastal areas there could be damage to groundwater resource due to ingress of sea water into inlands. Stocks of weed water, such as intrusion from naturally brackish groundwater into adjacent normal groundwater reserves are also reported from arid land tracts of Haryana, Rajasthan and Northern Gujarat.

Another major externality pertains to ground water depletion due to cultivation of water intensive crops in low rainfall areas by using ground water reserves. The quality and quantity of ground water has changed over the years. In fact better part of the cropping potential developed after Independence comes from well-irrigation and not from canal irrigation. Stories of receding water table have emanated from many pockets in northwest and southern India. A receding water table not only means higher capital and operational cost of irrigation in future but also lesser reservoir of ground water resources to fall back upon during drought year.

10.7 PROBLEM OF SALINITY AND WATER-LOGGING

Salinity is one of the most serious problems facing irrigated agriculture. Salinity is linked with the rise in ground water tables resulting from excess irrigation and poor drainage in major irrigation systems. The resulting shallow water table brings salt to the upper layers of the soil profile. The increase in salinity in some areas like Haryana, Punjab, western Uttar Pradesh results from unscientific water application in high water intensive cereal crops. Followed over a period of time with the consequent result of rising ground water table in canal-irrigated areas or increase in surface return flows causes increase in salinity. The problem of soil salinity because of canal irrigation was widely reported in western-Yamuna canal command area. It is estimated that 15 to 20 per cent of net sown area in India suffer from soil salinity or alkalinity.

Technological options are available for checking salinity problems. Scientific water pricing, on-farm development including precious land leveling, appropriate crop-mix and improved water application (like drop or sprinkler) reduces salinity effect. Salt scrapping, gypsum application, rescheduling irrigation, use of farmyard manure, kharif fallow methods are followed for contriving salinity problems. The use of brackish underground-water is checked through policy measures. Irrigation induced soil salinity problem in arid and semi-arid area result in loss of 2,00,000 to 3,00,000 hectares of irrigated areas every year because of soil salinity and water-logging. In India around 13 million hectares of irrigated land suffer from soil salinity and water-logging. The result of salinity is reflected in decline in production potential of important agricultural crops in fertile irrigated areas.

Surveys in different canal commands of the country corroborate the fact that there has been severe crop loss due to faulty water management practices. Improving water use efficiency in water delivery system, main distributaries and minor systems can check excessive water use and related problems like salinity, and water-logging, Withdrawing ground water may cause the land to subside, aquifers to become saline or may accelerate other type of ground water pollution.

Canal related water-logging–salinity affected 6 out of 20 mha under canal commands as reported by B. D. Dhawan. The adverse externalities of irrigation emerges from water-logging and salinity related problems in canal command areas and excessively used groundwater areas with increasing canal development activities. In the post-independence period the area under water-logging and salinity has been increasing.

10.8 SUGGESTIONS FOR BETTER WATER MANAGEMENT

Balanced development of irrigation sector, duly recognizing hydrological linkage between surface water and ground water resources, should be the aim of Indian irrigation planning. The demand for water for irrigation is ever increasing because of the rising population. Storing, diverting, and conserving or managing usable water resources efficiently can meet the demand. Continuous efforts need to be made to utilize the scarce water resources scientifically, judiciously and economically. It is suggested that there should be a close integration of water use and land use policies. Water allocation in an irrigation system should be done with due regard to equity and social justice. Disparities in the availability of water between head-reach and tail-end in all the systems of irrigation network like main canal, branch, distributary and scheduling of canal water supply should be minimized. Disparity between large and small farms should be obviated by adoption of a rotational water distribution system and supply of water on volumetric basis subject to certain ceiling.

The methods to be used for better water management are:

- Drip irrigation can be used for horticultural crops for water saving and better yields.
- Sprinkler irrigation can be used for closely spaced crops such as millets, pulses and oilseeds. Large-scale adoption of sprinkler in canal and tank irrigation project is necessary to use water efficiently and to increase the productivity.
- Diversification of crops and cropping pattern based on the availability of water/ rainfall in the canal and tank irrigated areas should be followed.
- Farmer should avail proper information about the availability of water for rational planning of the crop husbandry.
- Drainage system should be well developed and care should be taken of the conveyance channel.
- Large scale adoption of micro irrigation in well-irrigated areas for wide spread high value crops such as coconut, banana and grapes may be taken up.
- Adoption of pipelines even in the canal command areas to minimize water loses can be a good proposition.

Further these are some of the factors that deserve special attention for the implementation and smooth functioning of irrigation projects:

i) Checking the diversion of investible funds to subsidise payments (including hidden subsidies in canal irrigation) and to meet profligate ministerial and other government expenses.

ii) Minimization of environmental effects of big dam projects

iii) Eliminating the mounting inefficiencies in projects implementation (e.g., large time and cost over run) and in the management and maintenance of canal.

iv) Resolving speedily interstate water disputes.

Apart from removing hindrance from the apex level, the base level should be strengthened for efficient water use. The following suggestions are given for the optimum water use from the available sources:

a) Making the maximum use of rainfall for raising crops, utilizing irrigation for making up deficiencies.

b) Adoption of most suitable cropping pattern considering soil, climate and availability of irrigation supplies.

c) Making most efficient use of irrigation supplies by minimizing losses in conveyances by lining and adopting scientific methods of irrigation on properly prepared fields.

d) Deployment of irrigation supplies for maximum overall production and not necessarily maximum yields.

e) Reuse of water to the extent feasible.

f) Conjunctive use of surface water and ground water in accordance with precipitation in canal command areas.

10.9 COMMAND AREA DEVELOPMENT PROGRAMME

The central government sponsored Command Area Development Programme since 1974-75 with objectives of bridging the gap between creation and utilization of irrigation potential has been optimizing agricultural production from irrigated land in different states. Accordingly Command Area Development Authority (CADA) was created for effective conveyance of water to fields, drainage and on-farm development works. The programme broadly covers construction of field channels, land levelling, field drains and introduction of *warabandi* for rational supply of water to ensure equitable and assured supply of water to each and every farm holding. It also includes arrangement of supply of inputs and credits, agricultural extension, construction of markets and go-downs, and development of ground water for conjunctive use.

Prima facie, there is a vast scope for achieving improved yields from irrigated agriculture by introducing scientific water pricing method. Water Users' Associations are being formed in different states under the command of minor canals for better distribution of irrigation water. Water Users' Associations will have to be sponsored, encouraged, evaluated and replicated on an extensive scale. Research and development will have to be deployed widely for evolving various engineering and other strategies suitable for a variety of situations existing in the country. While government departments and agencies should provide overall guidance, direction, coordination and funding, the non-governmental organizations functioning in the field will all have to be involved in the task of organising the people and extension activities. It is now generally recognized that farmers' participation in management would go a long way in promoting sound water management practices. But the steps taken so far are in no way commensurate with the task ahead. The maxim of "some for all rather than more for some", which is particularly valid for irrigation systems can be achieved only through meaningful participatory management.

Check Your Progress 3

1) What are the environmental impacts of major irrigation projects?

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2) Why does the problem of salinity take place? How can we tackle this problem?

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3) What steps should be taken towards better management of irrigation water?

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4) What is the role of farmer and farmer associations in better water management?

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10.10 LET US SUM UP

Land under irrigation in India has increased from 22 million ha in 1951 to 90 million ha by the end of the Eighth Plan. This has helped in realizing a higher growth in foodgrains and yield. The irrigation potential of the country, however, are limited and the option of dry land farming needs to be considered.

Irrigation in India has resulted in number of environmental problems. Construction of large dams has resulted in loss of forest-land, displacement of people and resettlement problems. On the other hand, excessive extraction of ground water in low rainfall areas has resulted in depletion of water table.

The dream to touch the maximum feasible area of 113 million ha in 2005 AD can only be realized by water saving and using improved methods for surface irrigation. Drainage (removal of excess water from root zone) is as important as irrigation and proper action should be taken to provide drainage channel to remove excess water.

10.11 KEY WORDS

Salinity : Due to excess flow of water the water table comes up within three meters of the land surface. As a result, salinity of the land increases and productivity of land decreases.

Warabandi : According to this practice plots of land will receive irrigation water on stipulated days and not on other days. Thus excess water use in head-reach plots can be checked. This will lessen the excess water related problem such as salinity.

10.12 SOME USEFUL BOOKS

Dhawan, B. D., 1988, *Irrigation in India's Agricultural Development*, Sage Publications, New Delhi.

Mal, P., 2001, *Infrastructure Development for Agriculture and Rural Development*, Mohit Publications, New Delhi.

Ministry of Agriculture, 1999, *Agricultural Statistics at a Glance*, Government of India.

Mishra, K. M., 1990, *Irrigation and Economic Development*, Ashish Publishing House, New Delhi.

10.13 ANSWERS/HINTS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) Go through Section 10.3 and define these concepts on the basis of command area.

2) Read Sub-section 10.3.1 and answer.

3) See Sub-section 10.3.2 for the answer.

Check Your Progress 2

1) Go through Sub-section 10.4.1 and answer this question.

2) Read Section 10.4 and answer.

3) Bring out the distinct features of minor and major projects on the basis of Table 10.6.

Check Your Progress 3

1) Discuss the issues of displacement and destruction of habitat.

2) Read Section 10.7 and answer.

3) Read Section 10.8 and answer.

4) Read Section 10.8 and bring out the issues which can be tackled by the farmers.

UNIT 11 DRYLAND FARMING AND AGRO-CLIMATIC ZONING

Structure

11.0 Objectives
11.1 Introduction
11.2 Concept of Dryland Farming
  11.2.1 Nature of Rainfall in India
  11.2.2 Need for Dryland Farming
11.3 Policies and Incentives for Dryland Farming
  11.3.1 Rain-water Management
  11.3.2 Crop Production Technology
11.4 Need for Agro-Climatic Zoning
11.5 Agro-Climatic Zones in India
  11.5.1 Agro-ecological Regions by ICAR
  11.5.2 Agro-Climatic Regions by Planning Commission
  11.5.3 Agro-ecological Regions by NBSS and LUP
11.6 Biotechnology for Agriculture
11.7 Let Us Sum Up
11.8 Key Words
11.9 Some Useful Books
11.10 Answers/Hints to Check Your Progress Exercises

11.0 OBJECTIVES

After going through this Unit, you will be in a position to:

- explain the importance and features of dryland farming;
- summarise the policies, incentives, programmes and projects of government and non-government agencies towards dryland farming;
- explain the significance of ago-climatic zoning;
- identify various agro-climatic zones in India as categorized by different agencies; and
- appreciate the applicability of biotechnology in the field of dryland agriculture.

11.1 INTRODUCTION

We learnt from the previous Unit that irrigation potential of India is limited and all cultivable land cannot be irrigated. Thus a large part of the cultivated area has to depend upon natural rainfall. Therefore, we have to look into the prospects of rain-fed farming. Given the fact many parts of the country receive scanty rainfall we have to develop appropriate technology for these regions.

The importance of dryland farming can be appreciated from the following:

- In India rain-fed area accounts for 74% of the total cultivated area and contributes substantially to agricultural production. Out of the total 144 mha cultivated area, only 37 mha (26%) are irrigated and rest are rain-fed.
- Dryland area contributes about 44% of total foodgrain production and about 75% of pulses and oil seeds.
- A large number of industrially important crops such as cotton, and groundnut are cultivated under dryland condition.

11.2 CONCEPT OF DRYLAND FARMING

Dryland farming is the practice of crop production entirely with rainwater received during the crop session. In low rainfall areas of arid and semi-arid climates the crop may face mild to very severe moisture stress during its life cycle. A dryland crop refers to a crop grown on well-drained soil where the ground water remains far below the soil layers occupied by the crop root throughout the year. The water requirements of the crop are thus satisfied solely by natural rainfall, i.e., surface soil moisture from precipitation is the primary source of moisture for the crop.

11.2.1 Nature of Rainfall in India

There is wide variation in the amount of rainfall received in different parts of India. It is as low as 10 cm in western Rajasthan and up to 1000 cm in Meghalaya. India receives an average annual precipitation of 400 million hectare metres (mhm), of which 70 mhm is lost through evaporation. Of the remaining 330 mhm, around 150 mhm is absorbed by the soil while 180 mhm constitutes the run-off. Of the 180 mhm run-off, we have been able to utilise only 20 mhm through contruction of reservoirs and watersheds. Thus about 160 mhm of water is left as run-off to the sea through the rivers.

Nearly 80% of the total rainfall is received during the period July–September (about 90 days) in India. The amount of rainfall and its distribution during the rainy season determines the yield and production of crops. Factors such as: i) late onset of monsoon, ii) long dry spells during the season, and iii) early withdrawal of monsoon adversely affect production.

The amount of rainfall, its distribution, and water retention capacity of soil determines the 'crop growing period' in rain-fed areas. You will be surprised to know that growing period varies from 30 days to 300 days in India. Thus we have to select crops and cropping pattern keeping in view rainfall and soil quality in view.

Depending on the amount of rainfall received, farming in rain-fed areas can be of four types: i) Arid areas where rainfall is less than 50 cm per annum, ii) semi-arid areas with an annual precipitation of 50-75 cm, iii) sub-humid areas where precipitation is between 75-150 cm, and iv) humid areas with an annual rainfall of above 150 cm. In the arid and semi-arid areas there are prolonged dry spells during the crop growing period. Crop failures are more frequent in the arid and semi-arid areas. In the sub-humid areas there are dry spells during crop period, but the probability of crop failure is comparatively less. In the humid areas the probability of crop failure is rare but drainage of rain water is a major problem.

Apart from rainfall, two important factors responsible for increasing yield in rain-fed areas are: i) soil quality, and iii) availability of appropriate crop variety. In order to increase yield and production in rain-fed areas efforts have been made in two directions: i) the cultivable area of the country has been categorised into several homogeneous agro-climatic zones, and ii) research and development (R&D) efforts have been made to develop crop varieties and cropping pattern suitable for different agro-climatic regions. In this respect application of bio-technology in agriculture has played an important role. We will discuss about these two aspects later in this Unit.

11.2.2 Need for Dryland Farming

Dryland farming is the only way to utilize a vast geographical area with abundant sunshine and moderate fertility of soil. The productive capacity of these areas has not been exploited properly thereby keeping these areas as economically backward. As a result, economic and social inequalities among the farming community have gove up across regions.

The philosophy of dryland farming revolves around the principle that water is a limiting factor and one needs to maximize the efficiency of natural rainwater for crop production. The need for scientific approach towards farming in rain-fed areas is felt with the realization that the occurrence of drought is more or less inevitable. In rain-fed areas, emphasis has to be given on matching the crop to the soil and water availability and not vice-versa as it is with irrigated farming. Dryland farming has two dimensions:

- Growing and managing crops that can be profitable under the rainfall deficient years, during which drought tolerance and efficient water use are the main requirements.
- Growing and managing crops that are capable of making the best and efficient use of favourable environmental conditions provided during the good rainfall years.

Because of the uncertain nature of water availability in rain-fed areas, the risk of crop loss is higher. Such risks can be minimized by adoption of short-duration HYV and water-efficient crops. Moderate application of fertilizer containing nitrogen and phosphorus improves water efficiency. It is found that fertilizer helps the crops in withstanding the adverse effects of drought. It also recovers faster from drought when relieved from stress. You might be aware that weeds compete with crops for moisture and nutrients. Therefore, a weed free field for the first 30 to 40 days is crucial as they can cause a loss of 50 per cent to crop yield.

11.3 POLICIES AND INCENTIVES FOR DRYLAND FARMING

India experienced a rapid expansion in agricultural research system during the 1960s. During this period, however, the major concern was to increase agricultural production. Thus emphasis was given on development of crops suitable for the more fertile and irrigated areas. The development strategy of this decade is reflected in the Green Revolution that took place.

However, during the 1970s there was an emphasis on development of rain-fed areas. All-India Coordinated Research Project for Dryland Agriculture (AICRPDA) was initiated in 1970 at 23 centres representing different agro-climatic regions. Presently India has one of the strongest agricultural research system in the world. There is a network of 49 research institutes, 30 national research centres, 29 agricultural universities, 10 Project Directorates and a large number of All-India Coordinated Projects involving more than 24000 agricultural scientists and teachers.

Efforts on development of dryland farming have put emphasis on: i) rain-water and soil management, and ii) crop production technology. In order to increase production in rain-fed areas the government has taken several measures to harvest rainwater. Several schemes and projects on watershed development are going on in the country.

11.3.1 Rain-water Management

The planners have started realizing that it is quite difficult to obtain any incremental production from the conventional Green Revolution areas. For the second Green Revolution it is necessary to make the gray areas green. Hence emphasis has shifted to rain-fed areas, especially in the Eastern and arid peninsular India. Six programmes and projects have been launched for utilization of the potential of dryland areas. The objectives are:

i) Realisation of the projected requirement of about 240 m tons of annual food grain production and smoothen out annual fluctuations of food grain yield.

ii) Reduction in regional disparities between irrigated and vast rain-fed areas.

iii) Restoration of ecological balances by greening rain-fed areas through appropriate mixture of trees, shrubs and grasses, and

iv) Generation of employment for rural masses and reduction in large-scale migration from rural areas to already congested cities and towns.

These projects are as follows:

A) **National Watershed Development Project for Rain-fed Areas (NWDPRA)**

The National Watershed Development Project for Rain-fed Areas (NWDPRA) was launched in 1990-91. It covers 25 states and two union territories. The project started with the objectives of restoring ecological balance in rain-fed areas and sustainable biomass production. It focuses on:

a) Conservation, up-gradation and utilization of natural endowments in an integrated manner with low cost replicable technology.

b) Generating employment opportunities for the poverty stricken rural masses in the Rain-fed areas through directly involving the farmers and watershed beneficiaries in the planning and execution of all project works in the watershed by developing self-help groups.

Under this project the target was set for treating an area of 28 lakh hectares at a cost of Rs. 1100 crore.

B) **World Bank Assisted Watershed Development Projects**

The integrated watershed development projects (IWDP) has been in operation since 1991-92.The main objective of the project was to slowdown and reverse degradation of natural environment through the use of appropriate utilization of soil and moisture conservation technology and improved production methods.

C) **Agricultural Development Project**

The Agricultural Development Project (ADP) with the assistance from the World Bank is being implemented in various states to enhance sustainability in agricultural development and dryland agriculture.

D) **DANIDA Aided Projects under Dryland Farming**

The Government of Denmark launched integrated watershed development project in the state of Karnataka in 1990-91. Later on it was spread to various states. The second phase of this project has been negotiated and project became operational from 1995.

E) **European Economic Community Assisted Project**

European Economic Community assisted integrated watershed management project has been in operation since 1989.

F) **Swiss Development Corporation Assisted Project**

The project aims to develop 5 watersheds in five districts of Karnataka through the on-going participatory integrated watershed development project (PIDOW). It is in the process of extension to other states.

11.3.2 Crop Production Technology

Efforts in the direction of crop production technology have concentrated on development of high-yielding and appropriate varieties of crops and implements. Varieties of short-duration crops in sorghum, millet, cotton, pulses, etc. have been developed to match the short growing season of rain-fed areas. In spite of the fact that these crops yield less fodder, these are readily accepted by the farmers, because of higher yield and response to fertiliser application and crop management.

The drills plough, which is simple and suits animal power is affordable by small and marginal farmer and it accelerates seeding. It requires one-third labour and covers two times more area compared to traditional seeding. It can be manufactured with locally available materials at a cost of around Rs.400.

In addition to development of crop varieties, research on appropriate cropping system is also going on. Research on resource use optimization has led to the development of a number of alternative land use options which bring about stability by distributing risk among crops. These include tree or pasture based cropping in harmony with agriculture on catchment basis. Agro-forestry, horticulture, etc. are typical examples of alternative land use system. Multi-value crops that generate food, ensure uninterrupted supply of fuel and fodder, and are environment friendly have been identified. Besides stabilizing productivity, alternative land use systems also moderate the impact of drought.

Check Your Progress 1

1) What is the need for dryland farming?

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2) What are the different types of rain-fed areas?

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3) What are the important projects undertaken for development of rain-fed areas.

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11.4 NEED FOR AGRO-CLIMATIC ZONING

An agro-climatic zone refers to areas having similar climatic conditions. The extent of rainfall, soil quality, moisture level, etc. make it suitable for a certain range of crops.

The purpose of climatic classification is to: i) study the climate systematically, and ii) understand its general patterns and ecological conditions. It also helps in making reliable estimates of agricultural potential, and deciding issues related to technology transfer suitable to each of the climate zones. As it is not possible to replicate every experiment on every farm in each agro-climatic zone, a representative site is chosen and results are extrapolated to other sites of similar conditions.

The identification of agro-climatic zones helps us in devising land and water development strategies so that balanced agricultural development is achieved. It also helps in development of location specific research and development strategies. As a result, appropriate crop varieties and cropping patterns for each region are identified. It helps in planning for non-crop based agricultural activities like forestry, animal husbandry and fisheries and in identification of appropriate development projects and financial resources for each region.

You will see later in Unit 13 that Green Revolution resulted in wide regional imbalances in agricultural development during the 1960s and 1970s. Rain-fed areas remained untouched by Green Revolution which necessitated agricultural planning based on agro-climatic zones.

From macro-planning perspectives the main objectives of agro-climatic zoning are: (i) realization of a broad demand-supply balance in major commodities at the national level, based on potential and prospects of various zones, (ii) increase the net income of farmers, (iii) generation of additional employment, particularly for the landless labourers, and (iv) development of a framework for the scientific and sustainable use of natural resources particularly land, water and forests, in the long run.

Thus the important aspects of planning in agro-climatic Zones are:

a) *Crop planning:* Diversification and introduction of high value crops, evaluating their suitability on particular land mass.

b) *Irrigation plan:* Development of irrigation plans based on the agricultural and climatic condition.

c) *Research and Development:* Development of location specific high yielding strains of crops and livestock keeping in view the suitability of climatic condition and land mass position.

The Ninth Plan strategy for agriculture is based on a 25 year Perspective Plan for the Development of Rain-fed Areas. Emphasis is being laid on a regionally differentiated strategy. Broadly at the macro level these regions are grouped into four Agro-Economic regions:

a) High productivity zone, having either high level of irrigation or low rainfall with low irrigation situations. Usually these areas have a low incidence of poverty.

b) Low productivity zone, having relatively high rainfall, low to medium irrigation and high productivity potentials, but high level of poverty at present;

c) Low Productivity zone, having low rainfall, low irrigation, low level ground water, and high incidence of poverty

d) Agro-ecologically fragile zone, having low productivity, high run-off, and soil erosion. The areas include North Western Himalayas, North-East, deserts of Rajasthan, and drought-prone Gujarat.

11.5 AGRO-CLIMATIC ZONES IN INDIA

Several attempts have been made to delineate major agro-ecological regions with respect to soil quality, climatic condition and natural vegetation. Various agencies have attempted classification of agro-ecological regions. Some of these agencies are:

i) Agro-ecological regions by the Indian Council of Agricultural Research (ICAR)

ii) Agro-climatic regions by the Planning Commission

iii) Agro-ecological regions by the National Bureau of Soil Survey and Land-use Planning (NBSS & LUP)

We discuss these zones below.

11.5.1 Agro-ecological Regions by ICAR

The ICAR has classified India into eight agro-ecological regions. These are as follows:

i) Humid Western Himalayan Region: It consists of Jammu and Kashmir, Himachal Pradesh and Uttaranchal. It is characterised by high mountains and low valleys. The climate varies from hot to sub-humid tropics in the south to temperate- cold-arid in the north with rainfall ranging from 80 cm to 100 cm.

ii) Humid Bengal Assam-Basin: It consists of West Bengal and Assam representing Ganga-Brahmaputra alluvial plain. It is characterized by semi-stabilized sand dunes on alluvial terraces, latrite remnants in the west and numerous creeks and swamps in the deltaic tract. The rainfall ranges from 220cm to 400 cm.

iii) Humid Eastern Himalayan Region and Bay Islands: It consists of Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya and Andaman Nicobar island. It includes the eastern Himalayan and Arakan ranges with a wide range of elevation.The rainfall ranges from 200 cm to 400 cm.

iv) Sub-humid Sutlej–Ganga Alluvial Plains: It comprises Punjab, plains of Uttar Pradesh, Delhi and Bihar. The rainfall ranges from 30cm to 200 cm. The soils are highly disturbed in Bihar due to frequent floods.

v) Subhumid to humid eastern and south-eastern uplands: It comprises Orissa, Andhra Pradesh and Chhatishgarh. It is characterized by undulating topography, denuded hills, plateau, river valley and highlands. The rainfall ranges from 100cm to 180 cm.

Table 11.1 : Rainfall and Soil Types by ICAR

Agro-climatic Region	Average annual rainfall (in cm)	Soil Type
Humid Western Himalayan Region	80-100 cm	Sandy loam, loamy and acetic sub manture, loamy brown hillsoil
Humid Bengal Assam basin	220-400 cm	Alluvial, red and brown soil
Humid Eastern Himalayan Region and Bay Islands	200-400 cm	Red yellow alluvial and acidic latrite
Sub-humid Sutlej Ganga alluvial plain	30-200 cm	Alluvial, saline and alkali soil
Sub-humid to humid eastern and south eastern uplands	100-180 cm	Mixed black, red, yellow, red sandy, latrite, black alluvial soil
Arid Western plains	10-65 cm	Alluvial, black, latrite, mixed red and black soil
Semi -arid lava plateau and central highlands	330-750 cm	Alluvial, black latrite, mixed red and black soil
Humid to semi arid Western Ghats and Karnataka plateau	60-300 cm	Black, red, latrite and alluvial soil

vi) Arid Western Plain: It includes Haryana, Rajsthan, Gujarat and Dadra Nagar Havellis. It is characterized by alluvial plain with sand dunes, saline depressions and granite hills. The rainfall in this region ranges from 10cm to 65cm.

vii) Semi-arid lava plateau and central highlands: It comprises Maharastra, Goa, Daman Diu and Madhya Pradesh. The rainfall ranges from 70 cm to 125 cm except in the Western Ghats where it varies from 330 to 750 cm. Major soil groups are alluvial, black, latrite, mixed red and black , and yellow brown.

viii) Humid to semi-arid western ghat and Karnataka plateau: It consists of Karnataka, Tamil Nadu, Kerala, Pondicherry and Lakshadeep islands. The rainfall ranges from 60 to 300 cm. Major soil groups are black, red, letritic and alluvial.

11.5.2 Agro-climatic Regions by Planning Commission

The Planning Commission under the Seventh Plan divides India into 15 agro-climatic zones based on soil quality, geological formation, climate, cropping pattern and development of irrigation and mineral resources. These are:

1) Western Himalayan Region
2) Eastern Himalayan Region
3) Lower Gangetic Plains Region
4) Middle Gangetic Plains Region
5) Upper Gangetic Plains Regions
6) Trans Gangetic Plains Region
7) Eastern Plateau and Hill Region
8) Central Plateau and Hill Region
9) Western Plateau and Hill Region
10) Southern Plateau and Hill Region
11) East Coast Plateau and Hill Region
12) East Coast Plains and Ghat Regions
13) Gujarat Plains and Hill Regions
14) Western Dry Region
15) The Island Region

11.5.3 Agro-ecological Regions by NBSS and LUP

The NBSS and LUP has brought out agro-ecologoical regional maps of India consisting of 21 zones based on physiography, soil and bio-climatic conditions. These zones are grouped under six ecosystems. These are as follows:

a) **Arid Ecosystem**

1) Western Himalayas, cold arid eco-regions with shallow skeletal soils.
2) Western plains, hot arid eco-regions with deserts and saline soils.
3) Deccan plateau, hot arid eco-regions with mixed red and black soils.

b) **Semi-Arid Ecosystem**

4) Northern plains and central highlands, hot semi-arid eco-region with alluvium derived soils.
5) Central highlands and peninsula, hot semi-arid eco-region with medium and deep black soils.

6) Deccan plateau, hot semi-arid eco-region with shallow and medium black soils.
7) Deccan plateau and eastern ghats, hot semi-arid region with red and black soils.
8) Eastern ghats and Deccan plateau, hot semi-arid eco-region with red loamy soil.

c) **Sub-Humid Ecosystem**

9) Northern Plains, hot sub- humid eco-region with alluvium derived soils.
10) Central highlands, hot sub- humid regions with medium and deep black soils.
11) Deccan plateau and central highlands, hot sub-humid eco-regions with red and black soils.
12) Eastern plateau, hot sub- humid eco-regions with red and yellow soils
13) Eastern plateau and Eastern Ghats, hot sub- humid eco region with red loamy soils.
14) Eastern plains, hot sub-humid with alluvium derived soils.
15) Western Himalayas, warm sub-humid eco-region with brown forest and podzolic soils.

d) **Humid–Per Humid Ecosystem**

16) Assam and Bengal plains, hot humid eco-region with alluvium derived soils.
17) Eastern Himalayas, warm per- humid eco-region with brown hill soils.
18) Northeastern hills warm per- humid eco-region with red and latertic soils.

e) **Coastal Ecosystem**

19) Eastern coastal plains, hot sub-humid eco-region with alluvium derived soils.
20) Western Ghats and coastal plains, hot humid – per-humid eco-regions with red, lateritic and alluvium derived soils.

f) **Island Ecosystem**

21) Islands of Andaman Nicobar and Lakshadweep, hot per humid with red loamy and sandy soils.

Table 11.2 : Rainfall and Soil Types by NBSS & LUP

Sl. No.	Agro-climatic Regions	Average annual rainfall (in cm)	Area in%	Annual growing periods (in days)
1)	Western Himalayas, Cold arid ecosystem with shallow skeletal soils	15	47	90
2)	Western Plain, Hot Arid, Ecosystem with Desert and saline soils	30	9	90
3)	Deccan Plateau, hot arid eco-region with mixed Red and Black soil	40-50	14	90
4)	Northern Plain and Central Highlands, Hot semi-arid Ecoregion with alluvium derived soil	40-80	10	90-150
5)	Central (Malwa) Highlands and Kathiawar peninsula, Hot semi-arid eco-region with medium and deep black soil.	60-90	5.6	90-150
6)	Deccan plateau, Hot semi-arid eco-region with shallow and medium (including deep) black soils	60-100	10	90-150
7)	Deccan plateau and Eastern Ghats, Hot semi-arid eco-region with red and black soil	60-100	6.3	90-150
8)	Eastern Ghats (TN) Uplands and Deccan plateau, Hot semi-arid eco-region with red loamy soils	60-100	6.9	120-150
9)	Northern Plain, Hot sub-humid eco-region with Alluvium derived soils	100-120	3.7	150-180

10)	Central Highlands (Malwa and Bundelkhand), Hot sub-humid eco-region with medium and deep black soil	100-150	4.2	150-180
11)	Deccan Plateau and Central Highlands (BundelKhand), Hot sub humid eco-region with red and black soil	100-150	4.2	150-180
12)	Eastern Plateau (Chhatishgarh region), Hot sub-humid Eco-region with red and yellow soils	120-160	4	150-180
13)	Eastern (Chhotanagpur) plateau and Eastern Ghats, Hot sub-humid eco-region with red loamy soils	100-160	8.5	150-180
14)	Eastern plain, Hot sub-humid with alluvium derived soils	140-160	2.8	180-210
15)	Western Himalayas, warm sub-humid (including humid) eco-region with Brown forest and Podozolic soils	160-220	5.4	150-210
16)	Assam and Bengal plains, Hot humid (including sub-humid) eco-region with alluvium derived soils	140-200	3.6	270
17)	Eastern Himalayas, Warm per-humid eco-region with brown hill soils	200	2.4	270
18)	North eastern Hills (Purva natal) Warm per humid eco-region with red and latritic soils	160-260	3.3	270
19)	Eastern Coastal plain, hot sub-humid eco-region with alluvium derived soils	120-160	2.5	150-210
20)	Western Ghats and Coastal plains, Hot humid per-humid eco-region with red, latritic and alluvium derived soils	200	3	270
21)	Islands of Andaman Nicobar and Lakshadweep Hot per-humid eco-region with red loamy and sandy soils	160-300	0.3	270

Check Your Progress 2

1) What is the purpose of agro-climatic zoning?

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2) Which are the four major agro-economic regions in India ?

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3) What are the basic features of humid Bengal-Assam basin?

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11.6 BIOTECHNOLOGY FOR AGRICULTURE

Biotechnology refers to the use of living organisms for the manufacture of useful products. Micro-organisms such as useful traits of algae, bacteria, fungi, yeast, and cells of higher plants and animals can be combined to manufacture new varieties of crops. Thus the hybrid varieties of crops that we see today are the product of biotechnology.

The term "biotechnology" is derived by combining the words 'biology' and 'technology'. It concerns with the exploitation of biological organisms for generating products/ services that are useful to man. There are two important features of biotechnology:

- utilization of biological entities, their components or constituents, and
- generation of some product or services for enhancement of human welfare.

Biotechnology has affected many major areas of human activity and welfare such as industries, medicine, agriculture and environment. It has been used as an important force for creation of quality product, enriching human consumption and propagation of quality animal and plant life. It has also created ample scope for employment, trade and influenced national economy.

Contribution of biotechnology to agricultural development is represented by achievements in rapid clonal multiplication of plants of economic importance, production of virus-free plants, rescue of otherwise nonviable interspecific hybrid, production of hybrids from sexually incompatible combinations through hybridization, etc. Efforts are being made to improve photosynthetic efficiency, nitrogen fixation efficiency, nutritional quality of seed storage proteins, etc. through genetic engineering. Plant tissue culture is being propagated in different species for higher production, disease resistance and quick maturing of fruit crops.

Governmental Measures

Realizing the importance of biotechnology the central government set up the Department of Biotechnology in 1986 in the Ministry of Science and Technology for planning, promotion and coordination of biotechnology programmes in the country. The major tasks of this department are to evolve integrated developmental plan and programmes, identify specific R&D areas, establish infrastructure for advanced research and create a cadre of trained manpower. The biotechnology industry can be divided into conventional and modern categories. Conventional biotechnology industry deals with products like vaccines, diagnostics, antibiotics, biofertilisers, bio-pesticides and fermentation products like yeast, cheese, alcohol, citric acid, lactic acid, and glucose. Modern biotechnology industry deals with genetically engineered products. In the past five years, more than 100 projects involving an investment of over Rs 250 crore were provided by the government. Apart from the national laboratories engaged in agricultural research and state level agricultural universities, many units in the private sector are also interested in research in biotechnology. The consumption of biotechnology products in India amounted to Rs.1874 crore in 1992, of which products related to animal and human health accounted for 73%, agricultural products for 4% and industrial products for 23%.

Check Your Progress 3

1) What are the benefits of biotechnological research for agriculture?

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2) What measures have been taken by the government to promote the application of biotech in agriculture?

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11.7 LET US SUM UP

It is a fact that all cultivable area in India cannot be irrigated. Thus in a major proportion of cultivable area, we have to rely on natural rainfall. The problem is that the rainfed areas in India are quite diverse in terms of amount of rainfall and soil quality. Therefore, adoption of a uniform crop variety or cropping pattern does not solve the problem. In order to develop the rainfed areas we have to understand the climatic condition correctly, develop crop variety suitable to the climate, and transfer the production technology from lab to land.

Thus agriculture planning in India has adopted a regionally differentiated development strategy. The country has been categorised into a number of homogenous agro-climatic zones. For each region R & D efforts are going on to develop appropriate crops and cropping systems. Biotechnology has played an important role in developing high yielding, water efficient, disease resistant and short duration crops.

11.8 KEY WORDS

Agro-Climatic Zone : An agro-climatic zone refers to areas having similar climatic conditions.

Biotechnology : Biotechnology refers to the use of living organisms for the manufacture of useful products.

11.9 SOME USEFUL BOOKS

Planning Commission, 2003, *Tenth Five Year Plan*, Government of India.

Mal, P., 2001, *Infrastructure Development for Agriculture and Rural Development*, Mohit Publications, New Delhi.

Singhal, V., 1996, *Indian Agriculture*, Indian Economic Data Research Centre.

11.10 ANSWERS/HINTS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) Ultimate irrigation potential in India is limited. Thus cultivation in 74% areas has to depend upon natural rainfall.

2) Rain-fed areas can be of four types: arid, semi-arid, sub-humid and humid. See Sub-section 11.2.1 for details,

3) See Sub-section 11.3.1 and answer.

Check Your Progress 2

1) The purpose of agro-climatic zoning is to study the climate and devise appropriate development strategy, development of appropriate crops through R & D, and adoption of appropriate crop planning.

2) See Section 11.4 and answer.

3) The humid Bengal-Assam basin is characterised by alluvial and latrite soils. In this region the rainfall ranges between 220 cm and 400 cm.

Check Your Progress 3

1) See Section 11.6 and answer.

2) See Section 11.6 and answer.