**Unit-I**

**Introduction:** Agriculture is the largest livelihood sources in India with nearly two thirds of people dependent on it. Rainfed agriculture is as old as agriculture itself. Growing of crops entirely under rainfed conditions is known as dry land agriculture. Depending on the amount of rainfall received, dry land agriculture can be grouped in to three:

**Definitions:**

1. **Dry farming;** is cultivation of crops in regions with annual rainfall less than 750 mm. Crop failure is most common due to prolonged dry spells during the crop period. These are arid regions with a growing season less than 75 days. Moisture conservation practices are necessary for crop production.
2. **Dry land farming**: is cultivation of crops in regions with annual rainfall more than 750 mm. In spite of prolonged dry spells crop failure is relatively less frequent. These are semi-arid tracts with growing period between 75 and 120 days. Moisture conservation practices are necessary for crop production. However, adequate drainage is required especially for vertisols or black soils.
3. **Rainfed farming:** is crop production in regions with annual rainfall more than 1150 mm. crops are not subjected to soil moisture stress during the crop period. Emphasis is often on disposal of excess water. These are humid regions with growing period more than 120 days.

**Magnitude of problems of Rainfed Agriculture**

* The land degradation in Rainfed areas has results from climatic variations and unplanned over exploitation of natural resources by human activities, and increasing pressure of human and livestock population.
* It has become unavoidable to cultivate even the marginal lands. The pasturelands are degraded due to overgrazing caused by both increase livestock population and decrease in area under grazing due to encroachment for cultivation and urbanization.
* As a result, more and more forests are being used for grazing purpose. At present nearly 70% of Rainfed area is affected by wind erosion and sand deposition.
* Out of an estimated 142 mha net cultivated area, about 86 mha (60%) is Rainfed. Even after reaching the full irrigsation potential, nearly 50% of the cultivated area will remain Rainfed (Paroda, 1997).
* At present about 60% of India’s population as also 60% of livestock depends on agriculture.
* Rainfed area covers 218 districts in the state of Punjab, Haryana, Rajasthan, UP, MP, Chhattisgarh, Gujrat, Maharashtra, AP, Karnataka and TN.
* Physio-graphically the Rainfed region encompasses the desert terrain of Rajasthan in the north west, the plateau region of central India, the alluvial plains of the Ganga-Yamuna river basin, the central high lands of Gujrat, Maharashtra, MP and Chhattisgarh, the rain shadow region of Deccan in Maharashtra, the Deccan plateau in AP and TN highlands.
* In this belt, cultivation of coarse cerals (90%), pulses(91%), Oilseeds (80%) and cotton (65%) predominate.
* Farmers dependence is very high on livestock as alternative source of income, apart from arable cropping.
* Thus, Rainfed agriculture would continue to play a crucial role in the Indian economy and food security for long period.
* At present, 3 ha of dry land crop produce cereal grain equivalent to that produced in one ha irrigated crop.

**HISTORY OF RAINFED AGRICULTURE AND WATERSHED MANAGEMENT**

1. **Pre-Independence period**

From time immemorial, the chief form of agriculture in the dry land tracts of India was cultivation of drought resistant crops viz., millets for food and fodder.

It used to be a gamble with rainfall. During good rainfall years, the hardships of farmers seem to have been mitigated, as surplus grain and fodder were available. But, as water is the most important single factor of crop production, the inadequacy (200-800 mm/year) and extremely uncertainty (cv; 60-70%) of rainfall often caused partial or complete failure of crops leading to periodic food scarcities and families.

Drought was a frequent phenomenon. These factors made the economic life of the dry land cultivator extremely difficult and insecure. To address these issues, the Govt. of India appointed the First Famine Commission in 1880. The Commission recommended creation of protective irrigation projects in the dry tracts.

The first systematic and scientific approach to the problem of dry farming was attempted only in 1923 to eradicate drought related problems.

Dr. HH Mann, Director of Agriculture, in consultation with Sh. CV Mehta, Minister fopr Agriculture, Bombay Province, initiate research on dry farming on a small plot at Manjari Farm, near Pune, under the leadership of Shri VA Tamhane. After transfer of Sh. Tamhane in 1926, Dr. NV Kanikar took up the responsibility. The Govt. of India constituted Royal Commission on Agriculture in 1928. After a few years of study at Manjari Farm lead to the conclusion that the problem of cultivation of dry land crops was vast in extent and complex in nature. It required simultaneous in-depth research on different aspects such as conservation/collection of excess rain water, soil characteristics and water requirements of crop plant. Dr. Kanitkar during his visit to the United States of America in 1930-31, studied the methods and progress of their research on dry land farming. Based on his impression, he proposed a comprehensive programme to find out solution to the dry land problems.

Dr. HH Mann and W Burns, Director of Agriculture, Govt. of Bombay, recommended the scheme to the Imperial (now Indian) Council of Agricultural Research (ICAR) for financial support. Convinced of the recommendation, the ICAR approved the Bombay Scheme of Research on Dry Farming and sanctioned the necessary funds. Later, the ICAR extended financial support to similar such schemes for Madras, Hyderabad and Punjab provinces. The Bombay Scheme was started in 1933 at Sholapur and Bijapur, the centers of famine tracts. The work was started in 1934 in Madras at Hagari (near Bellary) and in Hyderabad state at Raichur. The Punjab Scheme was carried out from 1935 at Rohtak.

Systematic work was plan on crop production aspects under dry land conditions.

* Detailed analysis of climate, mainly rainfall, was done to get information on relationship of rainfall with crop production.
* Long term record of rainfall for 50-80 years showed that all the scheme centers received below normal rainfall 50% of the normal.
* It was also realized that rainfall was not only scanty but, was erratic too. The dry spells extended from 3 to more than 8 weeks during the rainy seasons.
* It was thus felt that for good crop production, conservation of soil moisture and minimization of surface evaporation comprised the most suitable interventions.

**Soil Loss and Moisture Conservation**

* In the Deccan Plateau, under normal cultivation, soil slope, low rate of infiltration and high intensity rainfall causes runoff.
* During the rainy season, in cropped fields, about 10% of the rainfall was lost as runoff from black soil and about 25% from red soils.
* It was realized that the land needed some kind of vegetation cover to minimize the runoff and soil loss. Kharif crop such as pearl millet and pigeon pea provided cover to soil, thus resulting in considerable reduction in runoff and soil loss.
* Deep ploughing, soil stirring and mulching help to conserve soil moisture. Fallowing was also useful. Good yields were realized from sowing in wider rows with low seed rates of selected crop varieties.

Development of Dry Farming Princioles / practices.

A committee of experts while coordinating and documenting the progress of all the five schemes between 1933 and 1943, summarized

Useful recommendations on different cultural methods for preventing runoff and erosion, efficient utilization of soil moisture for better crop production. The packages of practices were popularly known as Bombay, Madras and Hyderabad Dry Farming practices. Recommended practices constituted the following:

* Constructing the contour bunds as the basic and essential treatments.
* Occasional deep ploughing of lands, once in 3 years.
* Repeated shallow cultivation of soils (4 to 5 inter-cultivation) to removed weed and conserve moisture during the rainy season, particularly for rabi season sorghum, adding moderate quantities FYM to maintain the fertility and physical conditions of eroded soil.
* Sowing in wider rows (45 cm row spacing for sorghum) with low seed rate.
* Adopting mixed cropping / crop rotations wherever possible, fallowing a part of the holding every year.
* Unfortunately, the returns from the adaptation of these technologies resulted in lower yields (40 to 100 kg grain/ha) probably due to: discouragement to use inputs and non-availability of proper biological material.
* Thus up to independence, the dry land agricultural research and development made no significance progress.

1. **Post-Independence period**

Even after independence, vulnerability of dry land agriculture to droughts continued to hunt the country with ever increasing food shortages.

* During the 1950s, the cropping systems were need based mostly for subsistence level. The dry land research was also confined to long duration crops. Hence efforts were intensified to improve productivity and stability from Rainfed areas.
* The ICAR focused its attention in dry land regions on soil conservation measures by establishing the Central Soil and Water Conservation Research and Training Institute at Dehradun in 1954. Simultaneously, eight Soil Conservation Centers were also set up at Dehra Dun, Chandigarh, Agra, Kota, Bellary, Hyderabad, Vasad and Ootaamud.
* Another programme on Soil Conservation in the Catchment of River Valley Projects was launch in 1962.
* In spite of development of major and minor irrigation projects and also improvement in the availability of inputs like seeds, fertilizers, electricity since India’s Independence food shortages continued and gradually foo grain imports reached 10 mts by 1966.
* At this juncture, with international collaboration, Indian agricultural scientists developed high yielding varieties / hybrids of major crops like wheat, rice, maize, sorghum and pearl millet were introduced to the farmers during the period from early to late sixties.

**Green Revolution**

* The HYVs programme within a short span of time brought a break-through in productivity and production, mainly of wheat (wheat revolution, 1968)
* The growth rate in the mid-sixties, the Green Revolution acted as a boon.
* However, this brought an alarming disparity between productivity of irrigated and Rainfed agriculture.
* The socioeconomic imbalance led to a serious thinking on inducing an in-depth research programme to stabilize the performance of the recently introduced shot duration hybrids of sorghum (CSH-1) and pearl millet (HB-1) in Rainfed areas, and to moderate the adverse effects of drought on their productivity. The droughts of 1965 and 1966 further aggravated the problems of dry land research.
* Keeping in view these continuing problems, ICAR formulated an exhaustive programme on dry land agricultural research. Thus, the All India Coordinated Research Projects for Dryland Agriculture (AICRPDA) was launched in 1970 with the support from Canadian International Development Agency through an instruments of bilateral collaboration signed between the Govt. of India and Canada.
* This cooperation lasted till 1987. The unique feature of this project, was its reliance on multi-disciplinary approach in identifying and analyzing the constraints limiting crop yields in vast semi-arid areas and seasonally dry areas. AICRPDA activities were spread over 23 Cooperating Centers (now 25) across contrasting soils and climatic conditions of the country.
* The research efforts made it possible to double the dry land crop productivity through adoptions of soil and water conservation practices, improved varieties, good sowing methods, weed control fertilizer use. The consultative Group on International Agricultural Research had established the International Crops Research Institute for the Sem-Arid Tropics (ICRISAT) at Hyderabad in 1972. The Krishi Vigyan Kendra’s (KVKs) were initiated in 1977 to demonstrate proven technologies in farmers’ fields in most of the districts.
* The dry land agricultural research was further strengthened with the establishment of the AA India Coordinated Research Project on Agro-meteorology (AICRPAM) in 1983 at Hyderabad with 12 Cooperating Centers (now 25).
* The most beginning AICRPDA resulted in to establishment of a full-fledged research organization-the Central Research Institute for Dryland Agriculture (CRIDA) at Hyderabad in1985.
* The main purpose of the institute was to focus on lead research in dry land agriculture, leaving location specific problems and their solutions to AICRPDA and AICRPAM.

**The present mandate of CRIDA is (Anon, 2005a).**

* To undertake basic and applied research that will contribute to the development of strategies for sustainable farming systems in the Rainfed areas.
* To act as a repository of information on Rainfed agriculture in the country.
* To provide leadership and co-ordinate network research with state agriculture university for generating location specific technologies for Rainfed areas.
* To act as center for training in research methodologies in the fields basic to management of Rainfed farming systems.
* To collaborated with relevant national and international agencies in achieving the above objectives, and
* To provide consultancy.

**WATERSHED DEVELOPMENT PROGRAMME**

* The concept of watershed development, integrating arable and non-arable areas was launched in 1983 with 47 model watersheds in the country with avg. size 700-800 ha.
* Such a project for the Hills was implemented in the states of Punjab, Haryana, HP and J&K with an objective to reverse the environmental degradation of the Himalayan foothills through appropriate soil and water conservation technologies thereby improving the production of crops, fruits, fodder, fuel wood and animal products.
* Another project on integrated watershed development for the plains was implemented in Gujrat, Orissa and Rajasthan to introduce sustainable land management practices in selected watersheds through cost effective and replicable conservation technologies.
* The pilot projects for watershed development in Rainfed areas were implemented in AP, Karnataka, Maharashtra and MP from 1983 to 1993.

**PROBLEMS AND PROSPECTS OF RAINFED AGRICULTURE**

Most of the cropping in the arid and sem-arid regions continues to be under Rainfed conditions. A majority of the farmers are small farmers with meager resources. The poor resource base permits only low input subsistence farming with low and unstable crop yields. The low productivity of agriculture in Rainfed and dry farming regions is due to the cumulative effect of many constraints for crop production. The constraints can be broadly grouped in to:

1. Climatic constraints,
2. Soil related constraints,
3. Traditional cultivation practices,
4. Heavy weed problems,
5. Lack of suitable varieties and
6. Socio economic constraints.

**In brief about the different constraints**

1. **Climatic constraints**
2. **Rainfall characteristics:** Among the different climatic parameters rainfall is an important factor influencing the crop production in dry regions.
3. **Variable rainfall:** Rainfall varies both in time and space dimension. Annual rainfall varies greatly from year to year and naturally its coefficient of variations is very high. In other words, crop failures due to uncertain rains are more frequent in regions with lesser rainfall. The average annual rainfall of Indiais 1192 mm.
4. **Intensity and distribution**: In general, more than 50% of rainfall is usually received in 3 to 5 rainy days. Such intensive rainfall results in substantial loss of water due to surface runoff. This process also accelerates soil erosion. Distribution of rainfall during the crop growing season is more important than total rainfall in dry land agriculture.
5. **Aberrations or variations in monsoon behavior**

**Late onset of monsoon**: If the onset of monsoon delayed, crops/varieties recommended to the region cannot be sown in time. Delayed sowing lead to uneconomical crop yields.

**Early withdrawal of monsoon**: This situation is equally or more dangerous than late onset of monsoon. Rainy season crops will be subjected to terminal stress leading to poor yields. Similarly, post-rainy season crops fail due to inadequate available soil moisture, especially during reproductive and maturity phases.

**Prolong dry spells:** Breaks of monsoon for 7- 10 days may not be a critical stage for soil moisture stress leads to reduction in yield. Drought due to break in monsoon may adversely affect the crops in shallow soil than in deep soils.

1. **High atmospheric temperature**: Because of high atmospheric temperature the atmospheric demand for moisture increases causing high evaporation losses resulting in moisture stress.
2. **Low relative humidity:** Low relative humidity results in high ET losses causing moisture stress whenever moisture is limiting.
3. **Hot dry winds:** Hot dry winds cause desiccation of leaves resulting in moisture stress. High turbulent winds especially during summer months’ cause soil erosion resulting in dust storms and loss of fertile soil.
4. **Soil related constraints**
5. **Inadequate soil moisture availability:** The moisture holding capacity of soils in dry regions is low due to shallow depth especially in alfisols (red soils) low rainfall and low organic matter content.
6. **Poor organic matter content**: The organic matter contents in most of the soils under dry land condition is very low (less than 1%) due to high temperature and low addition of organic manures. Poor organic matter content adversely affects soil physical properties related to moisture storage.
7. **Poor soil fertility:** Due to low accumulation of organic matter and loss of fertile top soil by soil erosion the dry land soils are poor in fertility status. Most of the dry land soils are deficient in nitrogen and zinc.
8. **Soil deterioration:** In India nearly 175 mha of land is subjected to different land degradations, among them the soil erosion is very predominant. The erosion causes loss of top fertile soil leaving poor sub-soil for crop cultivation.
9. **Soil crust problems:** In case of red soils, the formation of hard surface soil layers hinders the emergence of seedlings which ultimately affect the plant population. Crusting of soil surface after rainfall reduces infiltration and storage of rainfall, due to high runoff.
10. **Presence of hard layers and deep cracks:** Presence of hard layers (pans) in soil and deep cracks affect the crop production especially in case of black soils.
11. Poor marginal lands
12. Uneven topography
13. Presence of dissolvedsalt in spread water
14. Water logging in leveled fields and flooding and breaking small bunds resulting in poor conservation soil and water.
15. **Traditional cultivation practices,**

* The existing management practices adopted by the farmers are evolved based on long term experience by the farmers.
* The traditional management practices are ploughing along the slope,
* Broadcasting seeds/sowing behind the country plough leading to poor as well as uneven plant stand,
* Monsoon sowing,
* Choice of crops based on rainfall,
* Application FYM in limited quantities,
* Hand weeding,
* Mixed cropping,
* Use of conventional system of harvesting and
* Traditional storage system.

1. **Heavy weed problems:** This is the most serious problems in dry land areas. Unfortunately, the environment congenial for crop growth is also congenial for weed growth. Weed seeds are germinated earlier than crop seeds and try to suppress the crop growth. The weed problem is the high in Rainfed areas because of continuous rains and acute shortage of labour. The weed suppression in early stage of crop growth is required to reduce the decrease in crop yields.
2. **Lack of suitable varieties:** Most of the crop varieties available for cultivation in dry lands are meant for irrigated agriculture. There are no any special varieties exclusively meant for dry land areas. Hence still more efforts are required to develop varieties in different crops exclusively meant for dry land agriculture.
3. **Socio economic constraints:**  The economic condition of dry land farmers is very poor because: -
4. Less access to inputs,
5. Non availability of credit in time,
6. The risk bearing capacity of dry land farmers is very poor.

Hence the dry land farmers resort to low input agriculture which results in poor yield.