1 AGRICULTURE IN INDIA

Agriculture involves not only crop raising but animal husbandry agro forestry, pisciculture etc. Any economic endeavour that utilizes directly the natural resources of soil and water for production is included in agriculture. Agriculture still forms the backbone of the Indian economy as well as human settlements and has shaped the socio cultural contours. Today, India ranks second worldwide in farm output. Agriculture and allied sectors like forestry, logging and fishing accounted for 18% of the GDP in 2013-14, employed about 60% of the total work force and despite a steady decline of its share in the GDP, is still the largest economic sector and plays a significant role in the overall socio-economic development of India. It determines the health of the people as well as the wealth of the nation inmore than one ways. This can be summed up in following points.

Role of Agriculture in Indian Economy

a) The billion-plus-people will continue to depend for their food, as in the past, on agriculture.

b) India is in a position to produce agricultural products relatively cheaply as she enjoys comparative advantage in this sector;

c) The variety of agro-climatic regions enable India to produce infinite variety of agricultural products besides, the vast potential of aquaculture exploiting her vast inland water reservoirs as well as the exclusive economic zone of the Indian ocean and horticulture silvi culture in the favourable areas of the mountains.

d) It is agriculture that supplies raw materials for different agro-industries like textile, (cotton, woollen, jute or silk) sugar, food processing, vanaspati leather, etc. which dominate the industrial landscape.

f) Agriculture creates demand for several industrial products like tractors, pumping sets, threshers, chemical fertilizers, pesticides etc. Moreover, it is this sector that creates the market for various manufactured goods particularly the wage goods and consumer durables. The prosperity of the industrial sector is highly dependent on the productivity in agriculture.

g) India enjoys an edge in the international market in products of agriculture origin viz; tea, Coffee, tobacco, fruits, vegetables, spices, rubber or textiles, leather and leather products viz a vis other developing or developed countries. Agricultural products contribute 15.5% ('99-00) of the total export value of the country while another 20 per cent of the exports is accounted for by agro-processed products.

Problems of Indian agriculture

Slow agricultural growth is a concern for policymakers as some two-thirds of India's people depend on rural employment for a living. Current agricultural practices are neither economically nor environmentally sustainable and India's yields for many agricultural commodities are low. Poorly maintained irrigation systems and almost universal lack of good extension services are among the factors responsible. Farmers' access to markets is hampered by poor roads, rudimentary market infrastructure and excessive regulation.

The low productivity in India is a result of the following factors:

- According to World Bank's "India: Priorities for Agriculture and Rural Development", India's large agricultural subsidies are hampering productivity-enhancing investment. Overregulation of agriculture has increased

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costs, price risks and uncertainty. Government intervenes in labor, land, and credit markets. India has inadequate infrastructure and services World Bank also says that the allocation of water is inefficient, unsustainable and inequitable. The irrigation infrastructure is deteriorating.

- Slow progress in implementing land reforms, illiteracy, general socio-economic backwardness, and inadequate or inefficient finance and marketing services for farm produce.
- The average size of land holdings is very small (less than 20,000 m²) and is subject to fragmentation, due to land ceiling acts and in some cases, family disputes. Such small holdings are often over-manned, resulting in disguised unemployment and low productivity of labour.
- Adoption of modern agricultural practices and use of technology is inadequate, hampered by ignorance of such practices, high costs and impracticality in the case of small land holdings.
- Irrigation facilities are inadequate, as revealed by the fact that only 52.6% of the land was irrigated in 2003-04, which result in farmers still being dependent on rainfall, specifically the monsoon season. A good monsoon results in a robust growth for the economy as a whole, while a poor monsoon leads to a sluggish growth Farm credit is regulated by **NABARD,** which is the statutory apex agent for rural development in the subcontinent.

Infrastructure and institutional factors:

Productivity in agriculture is mainly dependent on two sets of factors, they are technological and institutional. Among the technological factors are the uses of agricultural inputs and methods such as improved seeds, fertilizers, improved ploughs, tractors, harvesters, irrigations, etc. All these factors help to raise productivity, even if no land reforms are introduced. On the other hand the institutional reforms include the redistribution of land ownership in favours of the cultivating classes so as to provide them a sense of participation in rural life, improving the size of farms, providing security of tenure, regulation of rent, etc. Also these institutional factors, such as the existence of feudal relations, small size of farms, sub-division and fragmentation, insecurity of tenancy rights, high rents, etc. help the peasantry to raise production. When the socialist school of thought emerged, they believe that the existence of feudal or semi-feudal relations was the real cause of backwardness and poverty in the Indian rural communities. The other school of thought that emerged believes that agricultural productivity is purely a technological phenomenon and can be raised by the application of superior agricultural methods. Thus, whereas the key to higher productivity lies in technological change according to one school, it lies in institutional reform according to the other. Quite recently, both the schools of thought are converging and opinion has come to the idea that land reforms and technological change are not mutually exclusive factors but are complementary in the process of agricultural development.

IRRIGATION:

Irrigation is an artificial application of water to the soil. It is usually used to assist in growing crops in dry areas and during periods of inadequate rainfall. Additionally, irrigation also has a few other uses in crop production, which include protecting plants against frost, suppressing weed growing in rice fields and helping in preventing soil consolidation. In contrast, agriculture that relies only on direct rainfall is referred to as rain-fed farming.

Irrigation has become necessary because of the constraint of using natural rainfall as the reliable source of water for farms and the difficulties in storing rain waters due to lowering of sub-soil water levels. In India, monsoon is usually erratic, sometimes delayed or nearly creating draught like situations. Though the monsoons usually last for four months, the rains are received only in the first two or the last two months. Due to this, it is very difficult to decide the strategies of cropping patterns. The mid-season changes in the cropping patterns, though, are suggested but are very difficult to follow. The sufficient recharging of ground water is essential for

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sustainable fanning, but usually the purpose is defeated due to erratic rains. Besides the high cost of agricultural operation makes it indispensable as irrigation increases productivity hence improves the input output ratio. Following points may further put light on the need of irrigation in India.

Irrigation in India has been a high priority in economic development since 1951; more than 50 per cent of all public expenditures on agriculture have been spent on irrigation alone. However in the middle of the 20th century, the advent of diesel and electric motors led for the first time to systems that could pump ground water out of major aquifers faster than it was recharged. This can lead to permanent loss of aquifer capacity, decreased water quality, ground subsidence, and other problems. The future of food production in such areas as the Northern plain especially in the Punjab and Haryana are threatened.

1. **Uneven distribution of rainfall:** The average annual rainfall received in India is more then 100 cm. but it is not uniform through out which varies from more than 200 cm in Western Ghats and north eastern India to merely 10 cm in many parts of Rajasthan. Lower amount of rainfall is characterized by higher variability necessitating the use of irrigation water to carry on agricultural operations.

2. **Uncertainty of rainfall:** In both time and space the rainfall in India is highly variable. High variability leads to greater famine and draught. Hence irrigation is the only source to reduce the severity of draught and protect agricultural crops.

3. **Multiplicity of crops:** India has three cropping season's Kharif, Rabi and Zaid. The growing pressure of population has compelled farmers to increase the intensity of agriculture. Hence Farmers go for two to three successive crops in a single year which can not be done without the support of irrigation.

4. **High cost of cultivation:** Especially after the introduction of green revolution, agriculture has become a costly affair because of higher inputs. Hence to increase the productivity timely availability of water is indispensable.

5. **Nature and variety of soil:** The need for irrigation is very much linked with the nature of soil e.g. sandy loam which has less retentive capacity of moisture, needs frequent watering. On the other hand clayey soils have higher moisture holding capacity and require less irrigation. Since all these varieties of soils are found in India artificial supply of water is a must.

6. **Varied topography:** Sloppy surface and high land require more watering than leveled and lowland areas. Especially in the peninsular India where hilly region is dominant, the artificial application of water becomes need of the time.

Various types of irrigation techniques differ in how the water obtained from the source is distributed within the field. In general, the goal is to supply the entire field uniformly with water, so that each plant has the amount of water it needs, neither too much nor too little. Basically there are two types of irrigation surface and localised. In surface irrigation systems water moves over and across the land by simple gravity flow in order to wet it and to infiltrate into the soil. Surface irrigation can be subdivided into furrow, border strip or basin irrigation. It is often called **flood irrigation** when the irrigation results in flooding or near flooding of the cultivated land.

Localized irrigation is a system where water is distributed under low pressure through a piped network, in a pre-determined pattern, and applied as a small discharge to each plant or adjacent to it. Drip irrigation, spray or micro-sprinkler irrigation and bubbler irrigation belong to this category of irrigation methods. In drip irrigation, water is delivered at or near the zone of plants, drop by drop. This method can be the most water-efficient method of irrigation, if managed properly, since evaporation and runoff are minimized. In sprinkler or overhead irrigation, water is piped to one or more central locations within the field and distributed by overhead high-pressure sprinklers or guns.

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Sources of Irrigation:

Based on the availability of surface and ground water, relief, soils, and climatic characteristics varying sources of irrigation are utilised in India. These include tanks wells and tube wells and Canals. As regards the sources, the great plain in the north and then the east coast with easy unidirectional gradient are served by' canals system taking off from the reservoirs created along the major rivers by constructing barrages or dams. The flat terrain of these states is also suitable for sinking wells which were the traditional sources of irrigation water lifted by animal power but now the wells are energized tubewells with higher irrigation capacity and are spread densely and uniformly all over. However where canal is limited due to paucity of suitable water reservoirs or where irrigation is needed only to insulate crops against short term draught or location at the tail end of canals or in the undulating terrain tanks provide irrigation coverage to a considerable portion of cultivated areas. Some humid regions like Goa and Kerala have little need of irrigation which is fulfilled by miscellaneous sources.

Canals: On-farm irrigation scheduling requires a canal irrigation delivery system that provides water at the expected time, rate and duration. Canals can be an effective source of irrigation in areas of low relief deep fertile soils, perennial source of water and extensive command areas. Therefore, the main concentration of canal irrigation is in the northern plain of India, especially the areas comprising Uttar Pradesh, Haryana, Punjab and Bihar. The digging of canal in rocky terrain and uneven areas are costly and uneconomic. Thus the canals are particularly absent from the peninsular India. However, the coastal areas and the deltaic region do have some canals.

There are various advantages of canal irrigation. Most of the canal provide perennial irrigation and supply water as and when needed. This becomes important as in India the rainfall is limited in both time and space. Besides this saves the crops from draught conditions and helps in increasing the farm production. Maintenance cost of canals is relatively lower although the initial cost is high. Moreover canals carry a lot of silts brought down by rivers. This sediments is deposited in the field hence increase the fertility of the land.

Canals though have great advantages but they are not free from limitation as well. Water logging is an important problem associated with canal. This leads to creation of unwanted marshy lands hence reducing the cultivable area. Besides it also raise the chances of various types of water born diseases. Many canals cause flooding in the nearby area. Canal irrigation is not of much use for the undulating and sloppy areas. Besides there installation cost is much higher.

Wells and tube wells: A Tube well as the name implies is simply a tube or pipe bored into the underground reservoir, fitted with a strainer at the lower end and worked at the top by a pump, to lift water for irrigation. In other words a well is a small hole in the earth surface from which subsoil water is taken out for irrigation and drinking purposes.

It is a cheap, dependable and popular source of irrigation in India. Well irrigation is practiced in areas where plenty of ground water is available and the depth of water table does not normally exceed more 20 meters. The largest concentration of wells is found in the northern plains from Punjab to Bihar. Besides wells are widely scattered in eastern Rajasthan, Gujrat, Maharashtra, M.P, A.P, Karnataka and Tamil Nadu. Presently tube well is the most important source of irrigation in India. Private tube wells are very useful, convenient, and dependent source of irrigation for individual farmers. There cost of digging is within the reach of average farmers. Uttar Pradesh has the largest concentration of tube wells for its obvious advantages. Well irrigation has contributed substantially in for the success of green revolution in the country. However, it suffers from various draw backs. It depends upon underground water resources whose distribution is not uniform in the country. It is difficult to dig wells or bore tube wells in the hilly and plateau region. It also encourages the excessive and unplanned use of ground water which is creating a severe water crisis in the country.

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Tanks: A tank consists of water storage, is developed by constructing a small bund of earth or stones built across a stream. The water impounded by the bund is used for irrigation or other purposes. Some tanks are built partly as dugouts and partly by enclosing bunds.

Tank irrigation is very popular in the eastern part of southern India where topography favours their construction by erecting dams across seasonal streams. Here A.P and Tamil Nadu are the leading states. In the West Bengal, Bihar and Orissa tanks are mostly excavated types which are used for fisheries besides irrigation. Tank irrigation has many advantages like water can be stored and utilised at the time of need. Besides it also increases the water table of the region. Most of the tanks are natural and do not involve high cost of construction. They are generally constructed on rocky bed and have long life span. Where fishing is carried in the tanks it supplements both the food resources and the incomes of the farmer. Tank irrigation suffers from many inherent weaknesses. Tank gets silted up soon and regular desilting is required to make these suitable for irrigation. Most of the tanks are non perennial and becomes dry during non rainy season. Hence it fails to provide irrigation when it is needed. Due to large areal coverage and shallow depth, huge quantity of stored water either gets evaporated or sinks underground without being used for irrigation. Tank occupy a large area which otherwise could have been used for growing crops.

Constraints in the proper utilisation of water using traditional irrigation methods:

The present irrigation systems suffer from a number of constraints and disadvantages leading to improper utilization of water.

Irrigation water cannot be used efficiently by farmers, if the land is not properly leveled. Often the farmers do not have the adequate knowledge about land leveling and shaping. For better irrigation efficiency, land leveling is a prerequisite though it is expensive also.

The main activities under irrigation projects are on farm works such as construction of field channels and drains, promoting small buns across small streams, organizing supply facilities, etc. Canal water is easily and conveniently available to the fields which are situated at low level and at the head ends of the channels while it is scarcely available at the tail ends and higher fields. Wherever the lift irrigation from canal is permitted, it becomes very costly and uncertain.

Due to construction of kucha channels a large quantity of water is lost in transportation due to percolation, leakages etc. Thus overall water requirement increases many more times than actually required for physiological processes of crop growth. Sometimes accumulation of water in the field is also observed as waste due to lack of proper drainage.

In the conventional irrigation system, from outlet (distributions) to the fields, channels are made in the field which usually is subjected to leakages, etc. This requires constant supervision by labourers so that irrigation water is not lost to other fields. For distribution and irrigation also labourers are required.

Disadvantages of conventional irrigation methods:

- An estimated level of 43 per cent efficiency in surface water utilisation and 70 per cent efficiency in ground water utilisation (at farm level) has been recorded. This shows that a large quantity of water is not properly utilised in the present irrigation system.
- The distribution of water in the field by main canal, sub canals and distributions up to the outlet points into the fields and subsequently in the far off drainage points, is uneven due to poor leveling. This sometimes creates problems for getting sufficient and adequate irrigation to the crops.

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- Crops are usually subjected to cyclic changes of flooding and water stress situations, by providing heavy irrigation at one time and leaving the fields to dry up for about 10 to 15 days. The moisture availability to the crops fluctuates from saturation to stress and again to saturation. This results in poor yields of the crops.
- The fields situated in low areas always get excess water causing prolonged water logging due to lack of leveling of fields. Thus crops are subjected to water logging resulting in poor yields.
- In the fields about 10-15 per cent of land is utilised for preparing channels and distributions, etc. which decreases effective area of cultivation.
- Extensive areas of land in the arid and semi-arid regions of India have gone out of cultivation due to rise of water table and accumulation of salts. Excessive irrigation and poor water management are the chief reasons of water- logging and gradual build up of excessive salts. Progressive build up of soil salinity has made the soils unsuitable for cultivation.
- Sometimes a large quantity of irrigation water is subjected to deep percolation and seepage resulting in the use of higher amount of fertilisers.
- In the absence of planned proper combinations of spacing, length and slope of furrows and suitable size of irrigation streams and duration of the water application, it will be very difficult in regulating the flowof irrigation water in the fields.
- Slow and gradual changes in soil physical properties, particularly soil structures due to top soil erosion, takes place under present irrigation practices.
- Cyclic changes of wetting and drying of soil particles around the roots result in disturbances of root activity of the crop.
- In conventional irrigation, unmanageable undesirable weed growth is usually observed.
- Due to the improper irrigation methods in the conventional irrigation system, crops cannot be raised satisfactorily. The moisture in the soil fluctuates between too dry to too wet stages.

Limitations in the availability of water for irrigation purposes have necessitated the use of scientific methods of irrigation. The following are the major limitations of water availability for the agricultural crops.

- Erratic monsoons
- Priority for drinking water during scarcity
- Priorities for industries
- Water for power generation
- High Lifting charges
- Lower Sub-soil water level

Thus there is a need for usage of scientific methods of irragation:

Scientific Methods of Irrigation

i. Drip Irrigation

It is defined as the precise, slow application of water in the form of discrete or continuous or tiny streams of miniature sprays through mechanical devices called emitters or applicators located at selected points along water delivery lines.

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It is also called trickle irrigation. Drip irrigation is adopted extensively in areas of acute water scarcity and especially for crops such as Coconut, Grape, Banana, Ber, Citrus, Sugarcane, Cotton, Maize, Tomato, Brinjal and plantation crops. The advantages of drip irrigation are

1. Controlled application of water as per the needs of plants at low pressure to limited soil areas (root zones).
2. Water saving to the tune of 50 to 70 per cent by reducing the total evaporative surface, reduction in runoff and controlling deep percolation losses.
3. Soil erosion is minimal, due to no runoff water on surface.
4. Weed growth is minimum.
5. Water loss through transpiration is low.
6. Development of surface crust and determination of surface soil structure is avoided. Soil compaction is less.
7. Limited soil wetting permits undisturbed cultural practices.
8. It is possible to obtain better yield and quality of crops by controlling soil moisture-air -nutrients level.
9. Improvements in biological fertility can be achieved by avoiding pollution.

The initial expenditure in establishing a long term drip irrigation system usually costs around Rs.32,000/- per hectare. This heavy initial expenditure usually discourages the cultivator to install drip systems in his fields, though subsidies are given on the purchase of these equipment by the central and state governments. On the long term basis, the drip irrigation system is more economical and paying for the farmers.

ii. Sprinkler Irrigation

The main characteristics of sprinkler irrigation system are:

- Sprinkler irrigation system conveys water from the source through pipes under pressure to the field and distributes over the field in the form of spray of 'rain like' droplets. It is also known as overhead irrigation.

Sprinkler irrigation can be advantageously chosen in the following situations

1. When the soil is too shallow eliminating the possibility of leveling of lands.
2. When the land is too steep (> 1% slope).
3. When light (< 5 cm) and frequent irrigations are to be given.
4. When soils are very sandy (rapidly permeable coarse textured soils) and
5. When supplemental irrigation is to be given to dry land crops during prolonged dry spells, without any land preparation.

Sprinkler irrigation can be a disadvantage in the following situations

1. High winds (> 12 km/hr) cause improper distribution of water.
2. Evaporation losses are high from sprinkler irrigation especially under high temperature and low relative humidity conditions.
3. The initial cost is high.

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Issues

Even many of the completed irrigation projects have not performed optimally because of many snags. The gap between the potential created and utilised has been increasing. An allied problem is that most of the irrigation systems in the country are incurring heavy losses.

The minor irrigation schemes" tubewells and tanks, on the other hand could be cheap as well as ecologically sound. But the tubewells run under Government controls suffer from several bureaucratic deficiencies while those under private ownership are subjected to erratic power supply and in many cases, as in Punjab and Haryana, too much clustering without regard to groundwater situations. The subsidised power supply is a major economic strain on the State Electricity Boards.

Strengthening the infrastructure for irrigation is one of the major imperatives. The major elements of the strategy envisaged include giving priority to the completion of on-going projects, ensuring speedy transit to irrigated agriculture and optimum use of water through Command Area Development (CAD) programme, installation of sprinkler and drip irrigation systems in water scarce and draught prone areas.

A disturbing feature of the irrigation scene is the unfinished minor and medium projects and the lag (8.1mha.) in utilisation of created potential, particularly in major and medium irrigation projects. A centrally sponsored Command Area Development Scheme was initiated in 1974-75 with the basic objective of bridging the gap between potential created and utilised and increasing agricultural production from the irrigated commands. The programme envisaged execution of on-farm development works like construction of field channels ,land levelling and shaping, implementation or warabandi for rotational supply of water and construction offield drains in addition to trials, demonstration and training of farmers and introduction of suitable cropping patterns.

SEEDS:

In agriculture and gardening, **hybrid seed** is seed produced by artificially cross pollinated plants. Hybrids are bred to improve the characteristics of the resulting plants, such as better yields, greater uniformity, improved colour, diseases resistance, and so forth. Today, hybrid seed is predominant in agriculture and home gardening, and is one of the main contributing factors to the dramatic rise in agricultural output during the last half of the 20th century. Hybrid seed cannot be saved, as the seed from the first generation of hybrid plants does not reliably produce true copies, therefore, new seed must be purchased for each planting. That is why many experts have criticised the use of hybrid variety.

Advantages of high yielding variety seeds (HYV)

The high yielding variety program was started with the beginning of green revolution. These seeds not only led the increased in the agricultural production but have also introduced new characteristics in biological structure of the plants. Researches have proved that such seeds are quick maturing and are resistant to insects' diseases and draught. This has also led to tremendous increase in the intensity of agriculture in different parts of the country. In India, the success of green revolution is highly associated with HYV seeds. According to MS Swami Nathan apart from erasing the begging bowl image of our country the most important gain has been the saving of forests and land thanks to the productivity improvement associated with the HYV. They play the role of modernisation of agriculture like engines of change, capable of transforming a traditional farmer into a commercial producer. They act as part of steam engine to ignite an agrarian revolution in the poor country like India.

The success of the program reminds most marked improvement in wheat and rice. Introduction of H.Y.V in long staple cotton has not only made the country self sufficient in cotton but also has left sufficient surplus for export. However the H.Y.V has not been able to achieve desired success with respect to pulses and oilseeds. There is wide scale regional as well as crop variation in the use of H.Y.V. in India. This has led to wide scale regional and inter-personal disparity at national level.

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Criticism of HYV seeds:

For many reasons now a days experts are highly critic of the application and spread of these H.Y.V. The "miracle" seeds of the Green Revolution have become mechanisms for breeding new pests and creating new diseases. The term "high-yielding varieties" is a misnomer, because it implies that the new seeds are high yielding of themselves. The distinguishing feature of the seeds, however, is that they are highly responsive to certain key inputs such as fertilizers and irrigation water. The term "high responsive varieties" is thus more appropriate. In the absence of additional inputs of fertilizers and water, the new seeds perform worse than indigenous varieties. The gain in output is insignificant compared to the increase in inputs. The measurement of output is also biased by restricting it to the marketable elements of crops. But, in a country like India, crops have traditionally been bred to produce not just food for humans, but fodder for animals and organic fertilizer for soils. In the breeding strategy for the Green Revolution, multiple uses of plant biomass seem to have been consciously sacrificed for a single use. An increase in the marketable output of grain has been achieved at the cost of a decrease in the biomass available for animals and soils from, for example, stems and leaves, and a decrease in ecosystem productivity due to the over-use of resources. India is a centre of genetic diversity of rice. Out of this diversity, Indian peasants and tribal have selected and improved many indigenous high yielding varieties. Comparative studies of 22 rice growing systems have shown that indigenous systems are more efficient when inputs of labour and energy are taken into account.

Despite some of the negative aspects of application of HYV its positive effect can not be ruled out. To reduce the negative impact and enhance the positive effect a special strategy needs to be evolved. The government is giving special efforts in this direction which are the following:

1. Research in evolving new HYV seeds suited to Indian condition.
2. Production and distribution of quality seeds.
3. Supply of adequate credit facilities to farmers.
4. Expansion of irrigation fertilisers and pesticides in the areas where less spread of HYV is seen.

FERTILIZER:

Fertilizers are chemical compounds applied to promote plant and fruit growth. Fertilizers are usually applied either through the soil (for uptake by plant) or, by foliar feeding (for uptake through leaves).

Fertilizers can be placed into the categories of organic fertilizers (composed of decayed plant/animal matter), or inorganic fertilizers (composed of simple chemicals and minerals). Organic fertilizers are 'naturally' occurring compounds, such as peat, manufactured through natural processes (such as composting), or naturally occurring mineral deposits. Properly applied, organic fertilizers can improve the health and productivity of soil and plants, as they provide different essential nutrients to encourage plant growth. Organic nutrients increase the abundance of soil organisms by providing organic matter and micronutrients for organisms which aid plants in absorbing nutrients. Chemical fertilizers may have long-term adverse impact on the organisms living in soil and a detrimental long term effect on soil productivity of the soil.

Need of fertiliser: The use of fertilizer has been the third most important input of green revolution after HYV seeds and irrigation; rather the three are tied together. Loss of soil fertility is the main reason for low productivity in India. The Indian soils have been cultivated over thousands of years without much replenishing. In order to boosting up agriculture and restoring of soil fertility there is an imperative need to use artificial fertilisers and manures. In India chemical fertilisers have played a very important role in the success of green revolution. In general the countries soil is deficient in nitrogen and phosphorus. There has been remarkable progress in the overall production of chemical fertiliser in the country. It increased to more than 20 million tonnes in 2007

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from mere 40000 tonnes in 1950-51. Despite that a huge amount of foreign exchange is incurred upon import of fertilisers. Potassic fertilisers are completely imported. Even the domestic production of phosphates fertilisers is based on the imported rock phosphate or phosphoric acid at considerable cost of foreign exchange.

Consumption pattern: Since the adoption of new agricultural strategy the consumption of chemical fertiliser has been growing rapidly. According to FAO, 50% of the recent increase in the productivity in foodgrain could be attributed to fertiliser use alone. Even so, its impact on farm India is still not optimum mainly due to the inefficiency in application and inadequate supply of other farm inputs especially water management. As a result the pattern of fertiliser offtake both regionwise and cropwise continues to remain skewed. The government is also encouraging the use of fertilisers through heavy subsidies. However, it is still much less than even with respect to the average of developing countries.

Though the consumption has gone up, inter regional disparities still persists. The offtake in a majority of states in the western and eastern states is much less than the national average of 73 kgs /hectare but it is very high in the northern states of Punjab, Haryana and Uttar Pradesh and in the southern states of Tamil Nadu and A.P. these five states together consume more than 55% of total fertiliser consumption. The reason behind this is that these states have much better infrastructure facilities especially irrigation. In general the consumption level is low in the areas of dry farming where irrigation facilities are not satisfactory. That's why the rainfed areas constituting almost 65% of the cultivated areas hardly consumes 20% of fertilisers. There is bias in the crop wise consumption pattern as well. Rabi crop which account for one third of the agricultural production of the country, consume two third of the total fertilisers. This is mainly because of assured irrigation and sub soil moisture during this season. On the other hand pulses oilseeds and coarse grain suffer from low fertiliser consumption.

The new strategy for fertiliser is oriented towards increasing the use of organic manure, both farmyard manure and urban and rural compost. On a rough estimate India has annual yield of over 1000 million tonnes of cow dung. Only one third is presently being used as manures. The government of India is implementing a central scheme on National project and Technology Mission on the use of Bio-fertilisers.

LAND REFORMS:

Farming is a way of life for nearly half of the world's people. In many developing countries and some formerly communist societies, rural families comprise a substantial majority of the population. For these families, land represents a fundamental asset: it is a primary source of income, security, and status. But almost half of these rural families-some 230 million households-either lack access to land or a secure stake in the land they till. As a result, acute poverty, and related problems of hunger, social unrest, and environmental degradation persist.

The institutional reforms include the redistribution of land ownership in favours of the cultivating classes so as to provide them a sense of participation in rural life, improving the size of farms, providing security of tenure, regulation of rent, etc. Also these institutional factors, such as the existence of feudal relations, small size of farms, sub-division and fragmentation, insecurity of tenancy rights, high rents, etc. help the peasantry to raise production.

Reasons behind land reform:

Since India had been under several rulers for a long time, i.e. right from the beginning of the middle age, that's why it's rural economic policies kept changing. The main focus of those policies was to earn more money by exploiting the poor farmers.

In the British period the scenario had not changed much. The British Government introduced the "Zamindari" system where the authority of land had been captured by some big and rich landowners called Zamindar. Moreover they created an intermediate class to collect tax easily.

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This class had no direct relationship with agriculture or land. Those Zamindars could acquire land from the British Government almost free of cost. So the economic security of the poor peasants lost completely. After independence, the Government's main focus was to remove those intermediate classes and secure a proper land management system. Since India is a large country, the redistribution process was a big challenge for the Government.

Aims and objectives: According to agrarian reform land was declared as a property of State Government. So land reform varied from state to state. But the main objectives of agrarian reform in India were:

- Setting proper land management.
- Abolition of Intermediaries
- Preventing fragmentation of lands through consolidation of land holding.
- Tenancy reform, providing security to tenants.

Land reform aims at redistributing ownership holding from the viewpoint of social justice, and reorganizing operational holding from the view point of optimum utilisation of land. These aim at providing security of tenure, fixation of rents, conferment of ownership, etc. The entire concept of land reform aims at the abolition of intermediaries and bringing the actual tiller in the direct contact of the states. In a developing country like ours, measures of land reform have a place of special significance, both because they provide the social, economic and institutional framework for agricultural development and because of the influence they exert on the life of the vast majority of the population. Indeed, their impact extends much beyond the rural economy. Land reform in India had been adopted to reallocate the agricultural resources among all the people directly connected with agriculture. After independence, the Government of India started the process of building equity in rural population and improvement of the employment rate and productivity. So for this reason the Government had started agrarian reform.

Agrarian reform measures since independence had been determined by more than hundred laws of the Indian constitution. India is a democratic country and so every state had different laws. So, construction of a general idea of agrarian reform measures in India was tough. The purpose of agrarian reforms can be fulfilled by land management reform measures. The marketing system for both producing the inputs and as well as selling the outputs is important to improve the income of common farmers. Political power of the big landlords should be minimized to improve land management.

It includes :

- Redistribution of Land:
- Collectivization of Land,
- Individualization of Land,
- Improving tenancy.

Components of land reform:

1. Ceilings for Landholdings was imposed as one of the measures of agrarian reform in India after independence to redistribute land and land properties. The main aim of these ceilings was the demolition of the large amount of land properties that had been captured by the big landowners. Before independence, the British government created a "Zamindari" system through which the Zamindars, i.e. the big land owners, had the power to exploit the poor farmers. They could also forcefully acquire the land of the farmer. There was no limit of this land

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occupation as well. Even the intermediaries between landholders and Government, developed by the British, also captured the land of the cultivators. Therefore, the farmers were hardly interested to invest. So, after independence, the ceiling for landholdings was absolutely necessary for tenancy reform and proper redistribution of land.

At first, the limit was set only for those landholdings or land properties which would be captured in future. But later, a fixed upper limit was set for the amount of landholdings. If the size of land exceeded the prescribed limit then that would be taken by the Government and redistributed to the small and marginal farmers. The landholders were given the choice to decide which part of the land they would give if the amount of land exceeded the ceiling limit. So the obvious result was that most of the acquired land were infertile and wastelands. So later on, the choice was transferred to the government and the limit was set in terms of land utility.

Effects: The ceilings for landholdings abolished the concept of big land property and helped the tenancy reforms. By the imposition of ceilings, land were redistributed in an equitable manner and no big landowners could capture the lands unlimitedly. This also helped to develop a good land management system.

2. Abolition of the intermediaries was started as the first agrarian reform measure to redistribute the agricultural resources equitably. Before independence, the Indian rural economy and polity had been dominated by some big landowners. They could acquire lands by paying a very small amount of money to the British government. In addition to that, an intermediate class was also developed by the British government to simplify their tax collecting system. The people of this class had no direct connection with land and agriculture, but they could capture land easily and this had no limit. So the small and marginal farmers were exploited and forced to transfer land to the big landlords. As a result of this, rate of employment decreased and so was the productivity. The sharecroppers had been exploited by both the intermediaries and the big landlords. So they lost their interest to work completely. After independence when the Government of India started agrarian reform, the main issue was the abolition of intermediaries. Otherwise redistribution of lands would have been extremely difficult for the Government. The government took the land from the intermediaries. The small landowners were compensated by the government for giving their land. The amount of this compensation was inversely proportional to the amount of revenue earned from the land.

Effects: Government expenditure in the agricultural sector has escalated due to the compensations that have to be given for the loss of land brought about by the imposition of ceilings. Many intermediaries were not in a position to start a new way of income. So the government had to arrange pension scheme for them which was again a huge burden. Despite the bad effects, due to the abolition of the intermediate classes not only more than twenty million farmers in India had been connected directly with the government but also the tax revenue from the rural area increased. The increase in tax revenue compensated the huge burden of the government mentioned above. The financial security of the farmers improved and as a result of that, productivity and rate of employment also increased. But this measure had no effect on the numerous sub tenants of Land.

3. Tenancy reforms: The agriculture system that existed at the time of independence consisted of several defects including that of tenancy i.e., the insecurity of tenure and high rents charged by the landlord. The reforms aimed to eliminate all forms of exploitation and social injustice within the agrarian system, to provide security for the tiller of the soil and to remove such impediments to increase in agricultural production as arise from the agrarian structure inherited from the past. Broadly tenants are divided into three categories:

a) **Occupancy tenant s**enjoyed permanent and heritable rights on land. They had security of tenure and could claim compensation from the landlords for any improvement affected on the land.

b) T**enants at will** did not have security of tenure and could be evicted from the land whenever landlord so desired. There is no security of tenure for them and they are also made to pay exorbitant rent to the landlords.

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c) The **Sub tenants** were appointed by the occupancy tenants.

The position of tenants at will and that of sub-tenants is extremely weak and mostly they are subjected to ruthless exploitation. Frequent enhancement of rent, eviction of minor pretexts of several kinds, extractions and beggar are some of the popular ways of exploitation. In a country like India where the demand of land is more than its supply on account of its growing population, exploitation of weak and unprotected is a widespread evil.

The tenancy cultivation suffers from three main defects; they are insecurity of tenure, rack-renting and lack of incentives of the actual cultivator.

Measures of Tenancy Reforms: The legislation for abolition of intermediaries was aimed at providing land to the tiller but it did not put an end to the problem of tenancy. Moreover, even with the limit of ceiling, it may not be possible for a family to cultivate the entire land and so some sub-letting is unavoidable. Besides, in order to induce agricultural population to take over non-agricultural occupations, some sub-letting to tenants may be allowed. A total ban on letting or sub-letting land would neither be socially desirable nor administratively practicable. That is why, measures were taken up so as to minimize the evils of tenancy cultivation and to safeguard the interest of the tenants.

Regulation of rents: During the pre-independence period, rents were fixed either by the custom or were the result of the market forces of demand and supply. Supply of land being fixed, the demand of land rowing with an increasing population, there has been a continuous tendency for rents to rise. The decay of handicrafts increased the dependence of land further and thus pushed up the rents. Rack-renting was a common feature of the Indian agrarian structure.

It was, therefore, imperative that, rents should be fixed by enacting legislation. The rates of rent prevalent were one half of the produce or more. Considering the return on investment in other sectors of economy, these rents were excessive by any standard of social justice.

Consequently, the First and the Second five-year plan recommended that rents should not exceed one fourth or one fifth of the gross produce. Various states have passed necessary legislation regulating rents, but there are large variations in the rents fixed in different states. In Gujarat, Maharastra and Rajasthan, one-sixth of gross produce is fixed as maximum rent. In Assam, Karnataka, Manipur and Tripura, maximum rents vary between one-fourth to one-fifth of the gross produce. In Punjab, one-third of produce has been considered as fair rent, while in Tamil Nadu it is between 33.3 and 40 per cent of the gross produce. In Andhra Pradesh one-fourth of the gross produce for irrigated land and one-fifth in other cases has been fixed as rent.

Owing to the weak position of the tenants and the prevalence of the widespread land hunger, the law regulating rent is observed more in its breach than in its compliance. Another suggestion in this regard is to fix rents in cash rather than in kind. Historically, rents have been paid in kind in India but in view of the fact that the peasants have to make a good many payments in money, while purchasing seeds, fertilizers, implements and other necessaries of life, it would be desirable to switch over to cash payment of rents. This is in fitness with the requirements of a rural economy changing rapidly from barter to money economy.

Security of Tenure: The security of tenure is aimed to provide some incentives to tenants to make certain improvements of permanent nature on the land they cultivate. Many states have, therefore, enacted legislation providing for the security of tenure so long as they continue paying the rent. In some states like Maharastra, Gujarat etc., the landlord for his personal cultivation has granted tenants security of tenure in respect of areas not reusable. In some states, the minimum period of lease of land has been prescribed, e.g., five years in Punjab and Haryana and in Andhra Pradesh four years for one category of tenants and six years for another.

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Ownership rights: experience of the implementation of Zamindari abolition showed that, on the plea of resumption for personal cultivation, eviction of tenants took place on a massive scale. There is no doubt that in certain cases and categories on holder's resumption should be allowed, but the plea of resumption should not lead to large-scale ejection of tenants. During the Second plan, states formed provisions for resumption broadly on the following patterns:

a) All tenants have been given full security of tenure, without giving the owners the right of personal cultivation.

b) Owners have been given the right to resume a limited area (not more than family holding in any case) subject, however, to the condition that a minimum area is left with a tenant.

c) A limit has been placed on the extent of land which a land-owner may resume, but the tenant is not entitled to retain minimum area for cultivation in all cases.

Thus the tenancy reforms aim at conferring the right of ownership of land on the tenants. To encourage hard-working tenants to become owned-cultivators, many state governments have given tenants the right to purchase their holdings. This right however, is subjected to the condition that the total holdings of the landlords are not thereby reduced below the limit laid down for maximum holding of a landlord.

The most important beneficial result of the reform is that it put an end to the system of parasitic intermediaries. On the other hand it has not put an end to absentee ownership of land nor has it lead to the disappearance of tenancies. All in all, although the contribution of land reforms could not be totally neglected but the programmes including these reforms since independence did not lead into any significant redistribution of land, or the removal of all the obstacles to increasing agricultural production. The policies adopted in case were ambivalent and there were large gaps between policy and legislation and implementation.

CROPPING PATTERN AND CROP COMBINATION

Cropping pattern is the average distribution of diffenret crops in any one year in a given farm area such as a county farm, etc.

Factors affecting cropping pattern: Cropping pattern in any region is determined by a large number of geographical and socio-economic and ecological factors. Geographical factors like soil moisture, temperature, etc determine the suitability of an area to grow particular crops. However, area actually devoted to a particular will be determined by socio-economic factors like dietary habits, land leveling cost of cultivation, capacity of farmer's diffusion of innovation, etc. Besides in any locality, the prevalent cropping systems are the cumulative results of past and present decisions by individuals, communities or governments and their agencies. These decisions are usually based on experience, tradition, expected profit, personal preferences and resources, social and political pressures and so on. The climatic, edaphic and socio-economic diversity of the Indian crop-production scene is dotted with many cropping patterns. Socio-economically, the peasantry ranges from the relatively affluent Punjabi farmers who operate with a high input intensity in agriculture to the subsistent farmers of eastern and central India. They even today, sometimes practice shifting cultivation. Between these two extremes, various intensities of cultivation are practiced.

Some important Cropping Patterns are:

- **Rice-Wheat**

Rice-Wheat system is the most widely adopted cropping system in the country and has become mainstay of cereal production. The states of Uttar Pradesh, Punjab, Haryana, Bihar, West Bengal and Madhya Pradesh are now the heart land of rice-wheat cropping system with an estimated area of 10.5 million hectares. Despite

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enormous growth of this cropping system in the country during the past few years, reports of stagnation in the productivity of these crops, with possible decline in production in future, have raised doubts on its sustainability. Important issues emerging as a threat to the sustainability of rice-wheat system are:

a) Over mining of nutrients from soil leading to soil infertility and making soil more prone to erosion.

b) Disturbed soil nutrition.

c) Declining ground water table.

d) Build up of diseases/pests.

e) Low input use efficiency in north western plains.

f) Shortage of labour during optimum period for transplanting paddy in Punjab.

g) Problems like salinization of soil due to overuse of ground water occurring.

- **Rice-Rice**

Rice-rice is the popular cropping system in irrigated lands in humid and coastal ecosystems of Orissa, Tamil Nadu, Andhra Pradesh, Karnataka and Kerala and it is spread over an area of six million hectares. The major issues in sustaining productivity of rice-rice system are:

a) Deterioration in soil physical conditions.

b) Micronutrient deficiency.

c) Poor efficiency of nitrogen use.

d) Imbalance in use of nutrients.

e) Non-availability of appropriate transplanted to mitigate labour shortage during critical period of transplanting.

f) Build up of obnoxious weeds and non-availability of suitable control measures.

In Kerala, reduction in area is mainly attributable to the conversion of paddy lands to more profitable and less labour intensive plantation estates. In Assam, low productivity under prevailing soil and climatic situations, poor drainage in submerged areas, low nutrient use and iron toxicity are some of the issues of concern. The other general issues of low productivity are build up of pests, diseases and weeds year after year and deterioration of soil health to a large extent.

- **Rice-Pulses**

Rice-Pulses cropping system is a dominant crop rotation in Chhattisgarh, Orissa and parts of Bihar. The higher productivity of rice, the base crop in the system, is possible and also imperative for this region if suitable varieties of paddy and pulses along with proper management are considered.

Factors limiting productivity of this cropping system in the region are as follows:-

Physical factors

a) Draughts and erratic distribution of rainfall.

b) Small area under assured irrigation.

c) High percolation, resulting in heavy nitrogen losses in red sandy-loam soils, particularly Bhata soils.

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Input related factors

a) Delayed and prolonged transplanting.

b) Low coverage under high yielding varieties (HYVs).

c) Little attention to timely weed control.

d) Inadequate supply of quality seed.

e) Little attention to disease/pest control.

Social factors

a) Low literacy.

b) Large proportion of marginal and tribal farmers.

c) Practices of animal grazing on agricultural lands.

d) Low risk bearing capacity of farmers of the region.

- **Cotton-Wheat**

Cotton is widely grown in alluvial soils of north India (Punjab, Haryana, Rajasthan and Western Uttar Pradesh) and black cotton soils of central India (Andhra Pradesh, Tamil Nadu and Karnataka). With the availability of short duration varieties of cotton, cotton-wheat cropping system has become dominant in North. About 70-80 per cent area of cotton is covered under this system. In Central region also, wherever irrigation is available, cotton-wheat is practiced. The major issues of concern in cotton-wheat cropping system are:

a) Delayed planting of succeeding wheat after harvest of cotton.

b) Stubbles of cotton create problem of tillage operations and poor tilth for wheat.

c) Susceptibility of high yielding varieties of cotton to boll worm and white fly and consequently high cost on their control leading to unsustainability.

d) Poor nitrogen use efficiency in cotton results in low productivity of the system.

e) Appropriate technology for intercropping in widely spaced cotton is needed to be developed.

f) Use of biotech seeds posing problem of soil infertility and loss of natural resources.

g) Hybrid seeds make farmers dependent on MNCs, major profits move in buying infrastructure thus leading to poor economic growth.

- **Sugarcane-Wheat**

Sugarcane is grown in about 3.4 million hectare. In north India (Uttar Pradesh, Punjab, Haryana and Bihar), which account for 68 per cent of the total area under sugarcane, sugarcane-ratoon-wheat is the most important crop sequence. The system is also gaining importance in Jorhat, Sibsagar and Sonitpur districts of Assam; Ahmedanagar and Kolhapur district of Maharashtra and Belgaum district of Karnataka. The other states where the system covers considerable area under sugarcane- wheat are Haryana, Punjab, Madhya Pradesh and Rajasthan. Problems in sugarcane-wheat system are:

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a) Late planting of sugarcane as well as wheat

b) Imbalance and inadequate use of nutrients. Since majority of farmers apply only N in sugar cane and the use of P and K is limited. The emerging deficiencies of P, K, S and micro-nutrients are limiting system productivity directly and through interactions with other nutrients.

c) Poor nitrogen use efficiency in sugarcane.

d) Low productivity of ratoon due to poor sprouting of winter harvested sugarcane in north India.

e) Stubble of sugarcane pose tillage problem for succeeding crops and need to be managed properly.

f) The improved varieties released by research organizations perform well in the initial years but lose their vigour and decline in yield in due course.

g) Water availability is unpredictable. The concern is not only the quantity of water required, but also the lack of proper water management practices. Due to this, water is either wasted or sometimes not available at the right time.

h) Practices like mono cropping often result in low productivity thus fetch low price in the market.

Land Capability

Land capability classification is an interpretative grouping of soil mapping units mainly based on inherent soil characteristics, external land features and environmental factors that limit the use of land for agriculture, pasture, or other uses on a sustained basis. In other words land capability classification shows, the suitability of soils for many kinds of field crops. However crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage and the way they respond to management.

The classification derived for Indian condition is mainly follows the United States department of agriculture (USDA).According to the USDA terminology, Land Capability Classification is "a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period. Land capability classification is subdivided into capability class and capability sub class nationally.

Here the class 1 to 4 includes land suited for cultivation, while class 5 to 8 are not suited for cultivation and should be maintained for natural vegetation under forest cover or grasses.

Class 1: Soils in this class are very good. The soils are deep, productive and easily worked and nearly level. They are not subject to higher erosion however they are subject to fertility variation. These are the most productive parts of our country and are mainly found in the flood plains of rivers. Soils in this category are generally used for intensive agriculture. Hence, their fertility is affected adversely. This requires a special care with respect to maintenance of fertility. These practice involves use of fertilisers, cover cropping, green manure crop and crop rotation.

Class 2: In this category come the soil which are excellent as far as natural conditions are concerned. However some limitation is possible which restricts its use with respect to choice of crop. Soils of this group are cultivated with easily applied practices and a majority of crops can be grown. They are however subject to moderate risk of damage. Soils of this group have gentle slope and are subject to moderate erosion. They are areas of specialized cropping and are commercially the most suitable parts of our land. These soils may require special practices such as contour tillage crop rotation and water control devices.

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Class 3: They are moderately good soils. They can be used regularly for crops .these soils have steep slopes and suffer from either some ecological [as soil erosion]or climatic problem[rain fall irregularity] which inhibits intensive commercial exploitation also these soils are inherently low in fertility.

The soils require cropping system that produces adequate plant cover the cover, is needed to protect the soil from erosion. It also helps protect the soil structure, proper surface drainage should be ensure and practice like contour tillage undertaken.

Class 4: These soils are affected by severe permanents hazards like water logging and water deficiency. They occur frequently on steep slopes which are vulnerable to erosion. The soils are low in fertility. Commercial exploitation is nearly absent. Subsistence farming is practiced and mainly coarse grains are grown in these soils.

These soils should be kept in pastures. A grain crop may be grown once in five or six years. Soil and moisture conservation measures, like water disposal of terrace, contour tillage and stabilization of gullies should be undertaken.

Class5: These soils are found in foothills or in mountain valleys and suitable for grasses, shrubs, etc. these soils should be used for pasture or forestry operation. Cultivation is not feasible because these soils are wet and stony. The land is nearly level and subjected only to slight erosion by wind or water; if properly managed. These are few permanent limitations. Grazing should be regulated in these soils.

Class 6: These soils have moderate permanent limitation and are unsuitable for cultivation. These soils should be used for grazing and forestry. These are steep and shallow and more prone to erosion than class 5 soils. Grazing should not be permitted in these soils. They suffer from certain environmental constraints as well and are the environmentally fragile zones of our country.

Class 7: The severity of environmental constraints is much greater these soils, compared to class soils. As a result these soils are subjected to severe permanents hazards they are fair to poor for grazing or forestry these soils are steep, eroded, shallow or swampy and are completely unsuitable for cultivation. Strict management should be applied to these soils.

Class8: These occur in those parts which have no direct potential for exploitation for living. These soils can serve the purposes of preserving some rare species or acting as a water catchments zone. Soils of this class are extremely rough, arid or swampy and are unsuitable for cultivation. They are not suited for forestry or grazing. They may be used for wildlife sanctuaries reaction or watershed used.

The Green Revolution

Green Revolution usually refers to the transformation of agriculture that began in 1945. One significant factor in this revolution was the Mexican government's request to establish an agricultural research station to develop more varieties of wheat that could be used to feed the rapidly growing population of the country. The term "Green Revolution" was first used in 1968 by William Gaud. In 1961 India was on the brink of mass famine. Borlaug was invited to India by the adviser to the Indian minister of agriculture M.S Swaminathan. Despite bureaucratic hurdles imposed by India's grain monopolies, the Ford Foundation and Indian government collaborated to import wheat seed Punjab was selected by the Indian government to be the first site to try the new crops because of its reliable water supply and a history of agricultural success. India began its own Green Revolution program of plant breeding, irrigation development, and financing of agrochemicals. Modern plant breeding, improved agronomy and the development of inorganic fertilizers and modern pesticides fueled these advances.

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There were three basic elements in the method of the Green Revolution

- Continuing expansion of farming areas;
- Double-cropping in the existing farmland; and
- Using seeds with improved genetics.

As mentioned above, the area of land under cultivation was being increased right from 1947. But this was not enough in meeting with rising demand. Other methods were required. Yet, the expansion of cultivable land also had to continue. So, the Green Revolution continued with this quantitative expansion of farmlands. However, this is not the most striking feature of the Revolution.

Double-cropping was a primary feature of the Green Revolution. Instead of one crop season per year, the decision was made to have two crop seasons per year. The one-season-per-year practice was based on the fact that there is only natural monsoon per year. This was correct. So, there had to be two "monsoons" per year. One would be the natural monsoon and the other an artificial 'monsoon. The artificial monsoon came in the form of huge irrigation facilities. Dams were built to arrest large volumes of natural monsoon water which were earlier being wasted. Simple irrigation techniques were also adopted.

Impact of Green Revolution

Green Revolution has mixed results. It has both positive and negative impacts. The success was not agriculture's alone. There were many spin-offs. A revolution of this magnitude was bound to create some problems of its own. Critics charged that the Green Revolution resulted in environmental degradation and increased income inequality, inequitable asset distribution, and worsened absolute poverty.

Positive impacts: The Green Revolution resulted in a record grain output of 131 million tonnes in 1978-79. This established India as one of the world's biggest agricultural producers. No other country in the world which attempted the Green Revolution recorded such level of success. India also became an exporter of food grains around that time. Yield per unit of farmland improved by more than 30 per cent between 1947 (when India gained political independence) and 1979 when the Green Revolution was considered to have delivered its goods. The crop area under HYV varieties grew from seven per cent to 22 per cent of the total cultivated area during the 10 years of the Green Revolution. More than 70 per cent of the wheat crop area, 35 per cent of the rice crop area and 20 per cent of the millet and corn crop area used the HYV seeds.

Crop areas under high-yield varieties needed more water, more fertilizer, more pesticides, fungicides and certain other chemicals. This spurred the growth of the local manufacturing sector. Such industrial growth created new jobs and contributed to the country's GDP. The increase in irrigation created need for new dams to harness monsoon water. The water stored was used to create hydro-electric power. This in turn boosted industrial growth, created jobs and improved the quality of life of the people in villages. India paid back all loans it had taken from the World Bank and its affiliates for the purpose of the Green Revolution. This improved India's creditworthiness in the eyes of the lending agencies. Some developed countries, especially Canada, which were facing a shortage in agricultural labour, asked the Indian government to supply them with farmers experienced in the methods of the Green Revolution. Many farmers from northern India were thus sent to Canada. These people remitted part of their incomes to their relatives in India. This not only helped the relatives but also added, albeit modestly, to India's foreign exchange earnings.

The Green Revolution created plenty of jobs not only for agricultural workers but also industrial workers by the creation of lateral facilities such as factories and hydro-electric power stations as explained above India transformed itself from a starving nations, especially in the Third World.

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Negative impact: The Green Revolution has thrown up its own set of problems. Many critics feel that Green Rrevolution is a failure. It has led to reduced genetic diversity, increased vulnerability to pests, soil erosion, water shortages, reduced soil fertility, micronutrient deficiencies, soil contamination, reduced availability of nutritious food crops for the local nation to an exporter of food.

The adverse consequences of the Green Revolution can be summed up under the following points:

1. **Sluggish increase in Productivity:** The productivity in Indian agriculture is still only 2/3 rd of the world average; the real productivity is far behind the potential. The pre GR annual growth rate was 3.2% which came down to 2.9% during 1966-92. There are signs of stagnation in the growth of productivity in major foodgrain, despite enhanced application of inputs. Still a great number of people living below the poverty line do not have food security. The surplus is more a result of lack of purchasing power than the satisfaction of potential demand.

2. **Partial Revolution:** The yield of wheat and rice tripled and doubled respectively during the First and Seventh plans but other foodgrain showed little increase. Thus, the GR is designated by some as Wheat or Brown revolution only. As GR remained confined to only a few crops, the productivity of coarse grains like Bajra, millets and maize has declined in recent years, the production of pulses has remained almost static. Similarly, the production oilseeds remained stuck.

3. **High cost of cultivation:** While there has been no significant increase in yield, in real terms the cost of cultivation has gone up manifold, fertilizer consumption, the consumption of pesticides. The cost of irrigation is correspondingly high. The problem on the cost front is due basically to increasing per unit real cost rather than adverse relative prices or terms of trade. The development strategy in agriculture based on high energy inputs called for stepping up yields irrespective of costs to the neglect of a proper management of land and water.

4. **Regional Disparity:** The most serious adverse impact has been the regional disparity in the spread of GR.The outstanding performances of some of the states within a particular region are not representative of that region. For instance, the agricultural growth in Punjab is not synonymous for the whole of the northern region or that of Tamil Nadu for South. The same is true of West Bengal vis-à-vis the eastern region. Green revolution being costly, it necessarily becomes pro-rich farmer agriculture. The costs of irrigation, chemical fertilizers, pesticides and innsecticides are quite prohibitive for the bulk of small and marginal farmers who populate the agricultural landscape. Most of this benefit naturally goes to big farmers-using HYV seeds and commanding irrigation water. All this has accentuated the intersocial, interpersonal and inter regional disparity in the accessibility of food, as is reflected in state level variations in the proportion of population below the poverty line. This has already led to distortions in the socio-economic milieu as also the political economy. Growing marginal isolation of small farmers is clear evidence. With further commercialisation of agriculture as is taking place in the agriculturally progressive states like Punjab, Haryana, Maharastra, the social unbalance is growing further.

5. **Environment Deterioration:** The increasing use of chemical fertilizers and pesticides has heavily polluted the rivers. However, the increasing need of irrigation and the escalating cost of creating one ha, of irrigation potential are too huge to be overlooked. The erection of dams has already triggered a fierce battle between the promoters of growth and protagonists of environment. The heavy environmental costs of such projects arising out of inundation of forests and national monuments in the reservoirs, the short life span of reservoirs due to rapid siltation, their susceptibility to earthquakes and potential of releasing immense havoc in case of accidental dam bursts; the enormous cost of rehabilitation of oustees, etc., on the one hand and the water logging of irrigated areas leading to increasing salinity of the soil, on the other raise serious doubts on the efficacy of increasing further irrigation potential without which GR may grind

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to a halt, The excessive use of groundwater, especially in semiarid (Punjab, Haryana) areas to raise commercial crops has already resulted in the sinking of ground water level creating drinking water scarcity and posting the danger of Salinisation of groundwater.

Overall, the Green Revolution was a major achievement for many developing countries and gave them an unprecedented level of national food security. It represented the successful adaptation and transfer of the same scientific revolution in agriculture that the industrial countries had already appropriated for themselves. The Green Revolution also lifted large numbers of poor people out of poverty and helped many nonpoor people avoid the poverty and hunger they would have experienced had the Green Revolution not occurred. The largest benefits to the poor were mostly indirect, in the form of lower food prices, increased migration opportunities, and greater employment in the rural nonfarm economy. The direct benefits to the poor through their own on-farm adoption, greater agricultural employment, and empowerment have been more mixed and depend heavily on local socioeconomic conditions. In many cases inequalities between regions and communities that adopted Green Revolution technologies and those that did not also worsened. At the same time, the Green Revolution had many negative environmental impacts that have still to be adequately redressed.

Dry Zone Agriculture

Dry zone agriculture basically belongs to fragile, high risk and low productive agricultural ecosystem. In such areas crop production becomes relatively difficult as it mainly depends upon intensity and frequency of rainfall. The crop production, therefore, in such areas is called rainfed farming as there is no facility to give any irrigation, and even protective or life saving irrigation is not possible. These areas get an annual rainfall between 400 mm to 1000 mm which is unevenly distributed, highly uncertain and erratic.

Dryland farming plays a significant role in the agricultural landscape of the country. By 2010 A.D., India will have to produce 300 million tonnes of foodgrains to feed her 1.5 billion populations (approx.). This target cannot be realized from irrigated areas alone as we have irrigation potential for 178 million hectares only. Therefore, we will have to evolve an appropriate technology for dry land farming. On the other hand, the success of second 'green revolution' in Indian agriculture seems to be dependent on dry land farming. This is important to improve the standard of living of farmers residing in these areas as well. India has about 108 million hectares of rainfed area which constitutes nearly 75% of the total 143 million hectares of arable land.

Characteristics of Dryland Agriculture: Dry land areas may be characterized by the following features:

1. Uncertain, ill-.distributed and limited annual rainfall;
2. Occurrence of extensive climatic hazards like draught, flood, etc;
3. Undulating soil surface;
4. Occurrence of extensive and large holdings;
5. Practice of extensive agriculture i.e. prevalence of mono-cropping etc;
6. Relatively large size of fields;
7. Similarity in types of crops raised by almost all the farmers of a particular region;
8. Very low crop yield;
9. Poor market facility for the produce;
10. Poor economy of the farmers; and
11. Poor health of cattle as well as farmers.

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Problems of dry land farming

The major problem which the farmers have to face very often is to keep the crop plants alive and to get some economic returns from the crop production. But this single problem is influenced by several factors which are briefly described below.

Following are the problems of dry land farming in India,

1. Moisture stress and uncertain rainfall: Here rainfall is uncertain and scarce which make the region susceptible to draught and famine.
2. The soil here is sandy which lacks nutrient materials for soil fertility. Besides the area is prone to soil erosion.
3. The growing period of crops in dryland areas is longer and less affected by the cropping season. The productivity is low and the crops are more susceptible to pests and diseases. The farmers also take up farming half heartedly as they are not sure of being able to harvest the crops.
4. The socio economic conditions of majority of farmers are not good in this region. This prevents them from using modern inputs. Fields are generally scattered and the use of modern farm machinery is almost absent.
5. These areas lack basic infrastructural facilities like market, transport, storage, refrigeration, etc. hence farmers do not get remunerative prices for their agricultural products.

Strategies for the development of dryland areas:

The major objective of dry farming programmes is to conserve the soil and moisture and to achieve maximum production from the dry farming areas. In the past two decades, we have been able to' solve many hurdles in the aforesaid areas but there had been no break through as in case of irrigated crop production. Hence for the betterment following development strategies can be recommended:

1. For better conservation of available water, bunding across the slope and leveling the land should be done before onset of monsoon. Deep summer ploughing should be followed by surface tillage during monsoon months and also rest of the year. Besides rain water should be stored in tanks and reservoirs to be used in dry months.
2. Draught resistant varieties of crops should be developed and popularized in these areas. Selection of suitable crops and their varieties should be done according to their suitability to a particular region/micro climate.
3. Proper crop rotation should be followed which should preferably have at least one legume every year. Intercropping of oil seeds and pulses should be done with jowar, bajra and maize crops for the purpose of making best use of soil and inter row moisture harvesting.
4. Repeated tilling of land during rainy season, wide gaps between plants and mixed cropping may also be very advantageous for this region.
5. Quick and late maturing variety of crops depending upon the rainfall condition may be grown to avoid crop failure and improve agricultural harvest. Besides at the event of total crop failure during kharif season a suitable crop like urd (T-9) or toria, etc should be sown.
6. The sowing period and variety of crops should be decided on the basis of arrival, duration and amount of rainfall.

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7. An efficient plant protection measure should be adopted to protect the crop from insect pests and disease damage. Besides proper weed management practices should be followed by adopting integrated weed control measures. However, efforts should be made to gradually replace these by eco friendly bio fertilizers.

8. Crop selection is also an important point to consider. Crops like rice should be confined to lower part of the catchments areas of tank and reservoirs. Sunflower, mustard, etc may be popularized in the areas of scarce rainfall and crops like cotton can be grown in areas which or more reliable with respect to rainfall.

9. Researches should be promoted on dry zone agriculture by involving both the government and private agencies and efforts should be made to focus on eco farming or sustainable development.

Livestock Resources

The term Livestock is used to refer (singularly or plurally) to a domesticated animal intentionally reared in an agricultural setting to produce things such as food or fiber, or as draught. Raising animals (animal husbandry) is an important component of modern agricultural. Livestock is generally raised for subsistence or for profit. On a broader view, livestock refers to any breed or population of animal kept by humans for a useful, commercial purpose. Although 70% of India's rural population owns cattle, milk yields are abysmally low due to poor quality stock.

In this country of subsistence agriculture, commercial grazing is conspicuously absent. A few animals' are kept by every family in the villages. These animals are fed on straw and other by-products of agriculture. In some uncultivated areas on the Indian Plateau grasses grow during the rainy season. These grasses are cut and stocked for feeding cattle during dry months. Pasturage is generally very poor. Stall feeding is restricted to irrigated areas and towns.

Although majority of the animals are low-grade and economically useless, yet they have an unrivalled place in the rural economy. In fact, every farmer has at least a pair of bullocks except in the sandy tracts in north-western India where camel is the beast of burden and in very wet areas where buffaloes are common. Power-driven machines being very few for agricultural operations, bullocks and other animals are used as draught animals. They are used for drawing ploughs and carts' and lifting water from wells for irrigation purposes. Their dung makes excellent manure. Dried dung is commonly used as household fuel. In semi-arid and arid tracts of north-western India and the interior Indian Plateau, sheep are reared for mutton and wool, and goats for mutton and milk. As the use of beef is taboo, goats and sheep are the only source of meat for most of the people. A large number of goats and sheep are despatched to big towns which are the chief markets of mutton.

As draught animals are pre-requisite of every farmer, they are more carefully fed and looked after than even milch cattle. Cattle are exclusively used as draught animals whereas buffaloes are kept mainly for milk. Some of the breeds of draught oxen are the best in the world. India exports a small number of bulls to some tropical countries. Male cattle are prized as draught animals. Therefore, male cattle outnumber female cattle. In contrast,' the number of male buffaloes (over three years) is far less than the number of female buffaloes (over three years). A significant number of cattle are found throughout India but buffaloes being large-sized animals are very few in mountainous terrains namely Jammu and Kashmir State, Himachal Pradesh and Nagaland. Cows' are twice as many as the female buffaloes.

Modern dairy industry is restricted to only big towns of India. Besides liquid milk plants, there are factories which make various milk products such' as milk powder, butter, cheese, condensed milk, cream, ghee, etc. Most of the dairies collect milk from the neighbouring villages. As the milk turns sour if kept for long hours in tropical climates, quick disposal of milk is very essential in India.

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The **economic value** of livestock includes:

1. **Meat:** Providing protein and energy.
2. **Dairy products:** Most of the animals are reared as a source of milk, which can in turn easily be processed into other dairy products such as cheese, yogurt, butter, ice cream, etc.
3. **Source of fertilizer:** Historically plants and animals domestication have been intimately linked as they are complementary to each other. Manure is also used to make plaster for walls and floors and can be used as a fuel for fires. The blood and bones of animals are also used as fertilizer.
4. **As draught animal:** Animals such as horses, donkeys, and yaks can be used for mechanical energy. Prior to steam power livestock were the only available source of non-human labour. They are still used for this purpose in many places of the world especially in rural and inaccessible areas. It is used mainly for ploughing fields, transporting goods, and for military functions.
5. **Land management:** The grazing of livestock is sometimes used as a way to control weeds and undergrowth. For example, in areas prone to wild fires, goats and sheep are set to graze on dry scrub which removes combustible material and reduces the risk of fires.

The livestock sub sector has emerged as one of the key components of agricultural growth in developing countries in recent years. The Indian livestock system is the endeavor of small holders and it is a centuries old tradition. As a result of gradual transition from subsistence to market system, the economic dimensions of livestock keeping have assumed increasing significance in household behaviour. Over 70 percent of the rural households in India depend on livestock farming for supplementary income.

Livestock sector has considerable potential to contribute towards alleviation of problems of unemployment and poverty. It has great potential to help the landless, marginal and small farm households where it is prevalent. Average size of land holding is small, and has been declining continuously. On the contrary, distribution of livestock is more egalitarian. Bulk of the livestock population is owned by marginal and small landholders; 71 percent of cattle, 63 percent of buffaloes, 66 per cent of small ruminants, 70 percent of pigs and 74 percent of poultry. This implies that marginal and small landholders derive a considerable proportion of their income from livestock. Evidences indicate that increase in income from livestock in rural areas reduces income inequality. Moreover diet of an average Indian is cereal based. Lack of diversification towards nutrient-rich foods is considered to be the main cause of malnutrition and under-nutrition. In India roughly 30 percent of the population is undernourished. The problem is more severe to the population having less access to land for crop and livestock production. The sector is highly gender sensitive and over 90 per cent of activities related to care and management of livestock are carried out by family's women folk.

In spite of India's position as highest producer of milk, productivity per animal is very poor. It is only 987 Kgs/ lactation as compared to the world average of 2038 Kgs/lactation. This is mainly due to poor level of nutrition as well as low genetic potential for milk production and health care. Cattle milk yield is half of the world average. The same holds good for beef and pork. Goat and sheep meat yields are less by 20-25 percent. The milk as well meat productivity of Indian livestock is less compared to average of the Asian countries. The poor productivity is on account of scarcity of feeds and fodder, and poor animal health. Recent estimates indicate deficiency in dry fodder by 31 percent, green fodder by 23 percent, and concentrates by 47 percent. Further, a number of deadly diseases continue to occur frequently . Efforts to replace nondescript low yielding indigenous stock with high yielding crossbred stock too did not yield desired results. Only about 7.5 percent of cattle, 5 percent sheep, 14.5 percent pig and 32.9 percent poultry belonged to crossbred category in 1992. These figures indicate that technology would be a key factor in sustaining the growth of livestock sector in the decades to come.

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Growth in livestock sector is important on many counts. First, by augmenting income and employment opportunities it would benefit millions of small landholders and the landless labourers who possess a sizeable proportion of livestock wealth. Thus, the growth in livestock sector is considered to alleviate poverty and lessen interpersonal income disparities. Second, increase in outputs of livestock would lead to increased consumption of livestock products, contributing towards lessening of nutrition related problems. Third, the past experience has shown that the increase in livestock production has facilitated import substitution of many livestock products. Acceleration in growth would further reduce import dependence and facilitate export. Above all, being an integral part of agricultural economy, livestock would improve sustainability of the crop sector through provision of organic manure and draught power as inputs.

The White revolution:

Operation Flood was a rural development programme started by India's National Dairy Development Board (NDDB) in 1970. One of the largest of its kind, the programme objective was to create a nationwide milk grid. It resulted in making India the largest producer of milk and milk products, and hence is also called the White Revolution of India. Vergese curien (chairman of NDDB at that time), gave the professional management skills and necessary thrust to the cooperative, and is considered the architect of India's 'White Revolution' (Operation Flood).

Operation Flood has helped dairy farmers, direct their own development, placing control of the resources they create in their own hands. A 'National Milk Grid', links milk producers throughout India with consumers in over 700 towns and cities, reducing seasonal and regional price variations while ensuring that the producer gets a major share of the price consumers pay.

The bedrock of Operation Flood has been village milk producers' cooperative, which procures milk and provide inputs and services, making modern management and technology available to members. Objectives of Operation Flood's include:

- Increase milk production ("a flood of milk")
- Augment rural incomes
- Fair prices for consumers

Operation Flood was implemented in three phases.

Phase I

Phase I (1970-1980) was financed by the sale of skimmed milk powder and butter oil gifted by the European Union through the World Food Programme. NDDB planned the programme and negotiated the details of EEC assistance. During its first phase, Operation Flood linked 18 of India's premier milk sheds with consumers in India's major metropolitan cities: Delhi, Mumbai, Kolkata and Chennai, thus establishing mother dairies in four metros. The phase-1 originally meant to be completed in 1975. As start of Operation Flood-1 in 1970 certain set of aims were kept in view for the implementation of the programme such as - improvement in milk marketing and organize dairy sector in the metropolitan cities Bombay, Calcutta, Madras, Delhi.

Phase II

Operation Flood Phase II (1981-1985) increased the milk sheds from 18 to 136; 290 urban markets expanded the outlets for milk. By the end of 1985, a self-sustaining system of 43,000 village cooperatives with 42.5 lakh milk producers were covered. Domestic milk powder production increased from 22,000 tonnes in the pre-project year to 1,40,000 tonnes by 1989, all of the increase coming from dairies set up under Operation Flood. In this way EEC gifts and World Bank loan helped promote self-reliance. Marketing of milk by their own cooperatives increased by several million liters a day.

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Phase III

Phase III (1985-1996) enabled dairy cooperatives to expand and strengthen the infrastructure required to procure and market increasing volumes of milk. Veterinary first-aid health care services, feed and artificial insemination services for cooperative members were extended, along with intensified member education. Operation Flood's Phase III consolidated India's dairy cooperative movement, adding 30,000 new dairy cooperatives to the 42,000 existing societies organized during Phase II. Milksheds peaked to 173 in 1988-89 with the numbers of women members and Women's Dairy Cooperative Societies increasing significantly. Phase III gave increased emphasis to research and development in animal health and animal nutrition. All contributed to the enhanced productivity of milch animals

India is the largest milk producer in the world. While the world milk production had declined by around 2 % over the last decade, in India it has gone up. Even at a modest growth rate of 4-5 %, it is rising at a faster rate. The success of Operation Flood saw India move from a stage of dependence to self sufficiency. Milk production which was stagnating at 20 million tonnes until 1970 crossed the 30 million mark in 1980 to 140 millions tonnes in 2013.

Positive aspects of dairy industry in India:

(a) There is ample demand-supply gap to cash on

(b) Low cost of milk production in the country makes dairy a profitable proposition.

(c) There is ample flexibility of product mix to insulate against vagaries of seasonal excess and deficit of liquid milk.

(d) Flexible conversion of milk into various products enables easy addition of products line.

Negative aspects of dairy industsry in India:

(a) Perishability of milk as a raw material.

(b) Doubtful quality of milk collected from diverse small producers owning countful cattle heads.

(c) Scattered production of milk;

(d) Economical procurement difficult owing to lack of quick means of transport and logistics.

(e) There is growing competition with new firms poised to enter this sector.

Future prospects of dairy industry:

(a) Easy value addition.

(b) Existing Cooperative network on AMUL (controls 90%f marked supply of butter in India). Model could be extended. Out of this 23 lakh tonnes were from tended. It is unfortunate that the Anand pattern could not be emulated in other region.

(c) The emerging consumerism for value added products like butter, cheese, ice cream, quarg yoghurt, 'Shrikhand' and Casein may attract the private corporate sector.

(d) High export potential especially after the WTO agreements obliging U.S.A and European Union to abolish subsidies on dairy.

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Threats to the dairy industry:

(a) The milk vendors with established consumer relationship put an obstacle to easy collection and flow of milk into organised dairies.

(b) Chances of over crowding of corporate sector which may lead to excess capacity. Amrut Industries (plants at Tajola near Bombay; Hyderabad, Kolhapur) DaImia (plant in Rajasthan) Sheel international and Milk Food are the major corporate sector firms in dairy industry and many more are poised, to enter the field.

Aquaculture:

Aquaculture is the farming of freshwater and saltwater organisms including fish, mollusc, crustaceans and aquatic plants. Unlike fishing, aquaculture, also known as aqua farming, implying the cultivation of aquatic populations under controlled conditions.

Indian fisheries and aquaculture is an important sector of food production, providing nutritional security to the food basket, contributing to the agricultural exports and engaging about fourteen million people in different activities. With diverse resources ranging from deep seas to lakes in the mountains and more than 10% of the global biodiversity in terms of fish and shellfish species, the country has shown continuous and sustained increments in fish production since independence. Constituting about 4.4% of the global fish production, the sector contributes to 1.1% of the GDP and 4.7% of the agricultural GDP. The total fish production of 6.57 million metric tonnes presently has nearly 55% contribution from the inland sector and nearly the same from culture fisheries. Paradigm shifts in terms of increasing contributions from inland sector and further from aquaculture are significations over the years. With high growth rates, the different facets of marine fisheries, coastal aquaculture, inland fisheries, freshwater aquaculture, coldwater fisheries to food, health, economy, exports, employment and tourism of the country.

The country has 429 Fish Farmers Development Agencies (FFDAs) and 39 Brackishwater Fish Farms Development Agencies (BFDAs) for promoting freshwater and coastal aquaculture. The annual carp seed production is to the tune of 20 billion and that of shrimp about 8 billion, with increasing diversification in the recent past. Along with food fish culture, ornamental fish culture and high value fish farming are gaining importance in the recent past. With over 2.4 lakh fishing crafts operating in the coast, six major fishing harbours, 40 minor fishing harbours and 151 landing centres are functioning to cater to the needs of over 3.5 million fisherfolk.

Fish and fish products have presently emerged as the largest group in agricultural exports of India, with 5.2 lakh tonnes in terms of quantity and Rs.7,200 crores in value.

This accounts for around 3% of the total exports of the country and nearly 20% of the agricultural exports. More than 50 different types of fish and shellfish products are exported to 75 countries around the world.

Agro-Climate Regions

Fortunately, India is endowed with diverse agro- climatic conditions capable of producing almost all kinds of agricultural produce in one or the other region. The planning commission and NRSA recognise fifteen major agro-climatic regions.

1. **The north-western mountainous region:** It covers the Himalayan region embracing Jammu Kashmir, Himachal Pradesh and Garhwal-Kumaun of Uttarakhand. In the highly dissected and variegated relief exhibiting low altitude valleys to high altitude ridge flats, this region experiences wide variety oh weather conditions at short vertical as well as horizontal distances. The overall temperate and cool climatic condition with adequate moisture, make this region suitable for horticultural crops. Potato, tomato, cauliflower,

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cabbages, other green vegetables, may be profitably grown in these areas besides temperate fruits like apples. The vast market for these products in the million cities and densly settled plains make this agriculture quite lucrative. However, the inaccessibility of cultivated areas excepting those with road side location and frost susceptibility during winter is major constraints compelling the majority of small peasants to grow only subsistence crops.

2. **The North-East:** The north-eastern region of the country makes another distinct agroclimatic region because, basically, of it's per humid climate and although the year growing season. Its undulating terrain with gentle slopes, particularly on both sides of the Brahmputra, makes this region an ideal zone for growing tea. Other corps like jute, pineapple and banana and a host of horticultural crops may also be grown. However, apart from tea hardly any cash crops is grown here because much of the area under cultivation is devoted to rice, the staple crop, as the region is practically isolated from the rest of the country because of transportation difficulties.

3. **Lower Ganga Plain:** It covers the lower portion of West Bengal. The humid climate with high temperature althrough the year makes it suitable for growing rice and jute. This is virtually the jute belt of India. Along with these two major crops a wide variety of tropical fruits, namely, coconut, arecanut, jack fruit, etc. are grown mainly in an around the settlements. This region is quite suitable for pisciculture and aquaculture.

4. **The middle Ganga Plain:** This forms a transitional belt, between the upper and lower Ganga plain. The hot humid climate during the summer is eminently suitable for growing rice and wide array of Kharif crops; pulses and vegetables as well as sugarcane as the annual cash crop. The generally dry winter with occasional showers from western disturbances as well as adequate temperature allows the cultivation of wheat and several other pulses like, Gram and oilseeds such as mustard and sun flower. A number of oxbow lakes on' both sides of major tributaries of the Ganga provide ample opportunities for aquaculture. A wide variety of fruits including mango, litchi, guava, banana, Amla maybe grown without much effort in this region endowed with fertile and thick alluvial soil of different structure and texture depending on location with reference to the rivers. This zone thus comprises a number of distinct subzones, namely, the Terai, the Bhangar, the Khaddar, the Bhat and alkaline (usar) soil belts which account for the diversity of cropping patterns.

5. **The upper Ganga Plain:** This zone, lying to the west of the preceding one is distinguished by sub-humid climate with warmer summer and colder winter. The soil texture is generally coarser. It is, therefore, pre-eminently suited for growing wheat and a host of other Rabi corps, oilseeds and pulses. The Kharif crops mainly comprise the coarser variety viz. millets. Rice and sugarcane cannot be grown without supplementary irrigation; except in the northern wetter Terai zone extending from Saharanpur-Bijnore to Lakhimpur-Kheri. It is also eminently suitable for growing fruits especially mango.

6. **The Punjab Plain:** This zone is distinguished from the preceding one by greater aridity. In winter, there is comparatively more precipitation of western disturbance origin while the susceptibility to frost is also greater. The summer crops in areas without supplementary irrigation are maize and Bajra while the winter crop mix is dominated by wheat and oilseeds especially mustard. Cotton may be profitably grown as a cash crop during Kharif season. All subtropical fruits may be grown without any difficulty. The easily growing fodder crops make this zone eminently suitable for dairy farms.

7. **The south-eastern plateau:** This region extends from Bastar (Chattisgarh) in the south to Dumka and Sahibganj (Jharkhand) in the north and Balaghat-Bhandara districts in the west to Mayurbhanj (Orissa) in the east. It thus covers the whole of Chotanagpur plateau. Baghelkhand, Mahandi basin and the Orissa plateau. Lying aside the Tropic of Cancer, climatically, it is hot and humid receiving over 100 cm of rain annually. However, the soil excepting the Mahanadi basin is generally leached red and poor in fertility. This

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region, thus, does not, by and large, constitute a prosperous agricultural belt. As the rainfall is seasonal, confined to four monsoon months and the water drains away swiftly, this zone faces water scarcity through winter and summer months. The scarce ground water in this zone of undulating plateau with hard rock substratum is not easily exploitable, thus limiting severely the possibilities of irrigation excepting on very favourable valley floors and constricted areas around tanks. Thus, this zone is suitable for rice growing during the rainy season in favourable valleys and basins in Chotanagpur while the uplands have to be left barren or may yield poor crops of pulses like 'Arhar'. During winter, Gram may be successfully grown wherever sufficient soil moisture is available during the sowing season viz. October.

8. **Aravali-Malwa Upland:** This region covers western M.P. and eastern Rajasthan east of the Aravallis. This is an area of moderate rain (50 to 100 cm.) occurring during the rainy season and covered for the most part by thin black soil. It is eminently suited for growing pulses, oilseeds. No facility for supplementary Irrigation is available Chambal canals now provide Irrigation in the north-central portion in the districts of Sawai Madhopur, Morena, Gwalior and Bhista. Ground water exploitation is limited due to rock formation underneath

10. **The Deccan Interior:** This region covers a big area over Karnataka, Andhra Pradesh and Tamil Nadu uplands from Adilabad district in the north to Madurai in the south, constitutes the heart of Deccan. It is generally water scarce and draught prone region with hard granite-gneiss basement on which poor red soils have developed in favourable localities. Only the north-western fringes are covered by thin veneer of black soil .Naturally this region is suitable intrinsically for growing Ragi and millets. Cotton, Groundnut, or other oilseeds may be grown in localities favoured with good soil and water conditions by practicing dry farming.

11. **The East Coast:** The entire east coast millets (Bajra). Oilseeds and pulses like Gram extending from Balasore in the north-east to may be grown in highly favourable locales. The Kanyakumari in the south is included in this region. It is a humid region receiving over 100 cm of rainfall with coastal alluvial soil of varying texture from clayey to sandy. Rice is naturally the predominant crop; grown twice a year in favourable soil-rich localities such as coastal Orissa or Tamil Nadu. Banana coconut, arecanut grow profusely. Jute may grow as a cash crop in Orissa coast while sugar cane is grown extensively in Tamil Nadu and coastal Andhra; the latter also grows tobacco in winter. As a matter of fact this extensive region may be subdivided into three distinct sub regions of Circar coast, Andhra coast and Tamil Nadu coast as each has different precipitation characteristics as well as soil texture. Aquaculture may be successfully developed all along the east coast which has ample water bodies available althrough the year.

12. **The West Coast:** This perhumid region with high precipitation received from May through October is a zone of abundant water. It covers Konkan and Malabar coasts. It has the dominance of rice and coconut, besides a variety of spices, and cashewnuts are grown on the over slopes of the western ghats while the higher reaches in Coorg are devoted to plantation crops of coffee and tea.

13. **Gujarat:** The state of Gujarat is recognised as distinct agro-climatic region although it has distinct wet coastal and dry interior areas. The soil texture is also quite variable. The light soil of this region is suited to the growing of groundnut. Cotton and millets also find favourable conditions in this meteorological unit with 83 cm. of average annual rain received primarily (96.2%) during rainy season (June to September).

14. **Western Rajasthan:** It covers the driest part of the country receiving meagre sporadic rain (33 cm). It has sandy soil fit only for growing millets, oilseeds and pulses may be grown in highly favourable localities. The water made available from the Indira Gandhi Canal in Bikaner district has opened up the possibilities of wheat and orchard farming.

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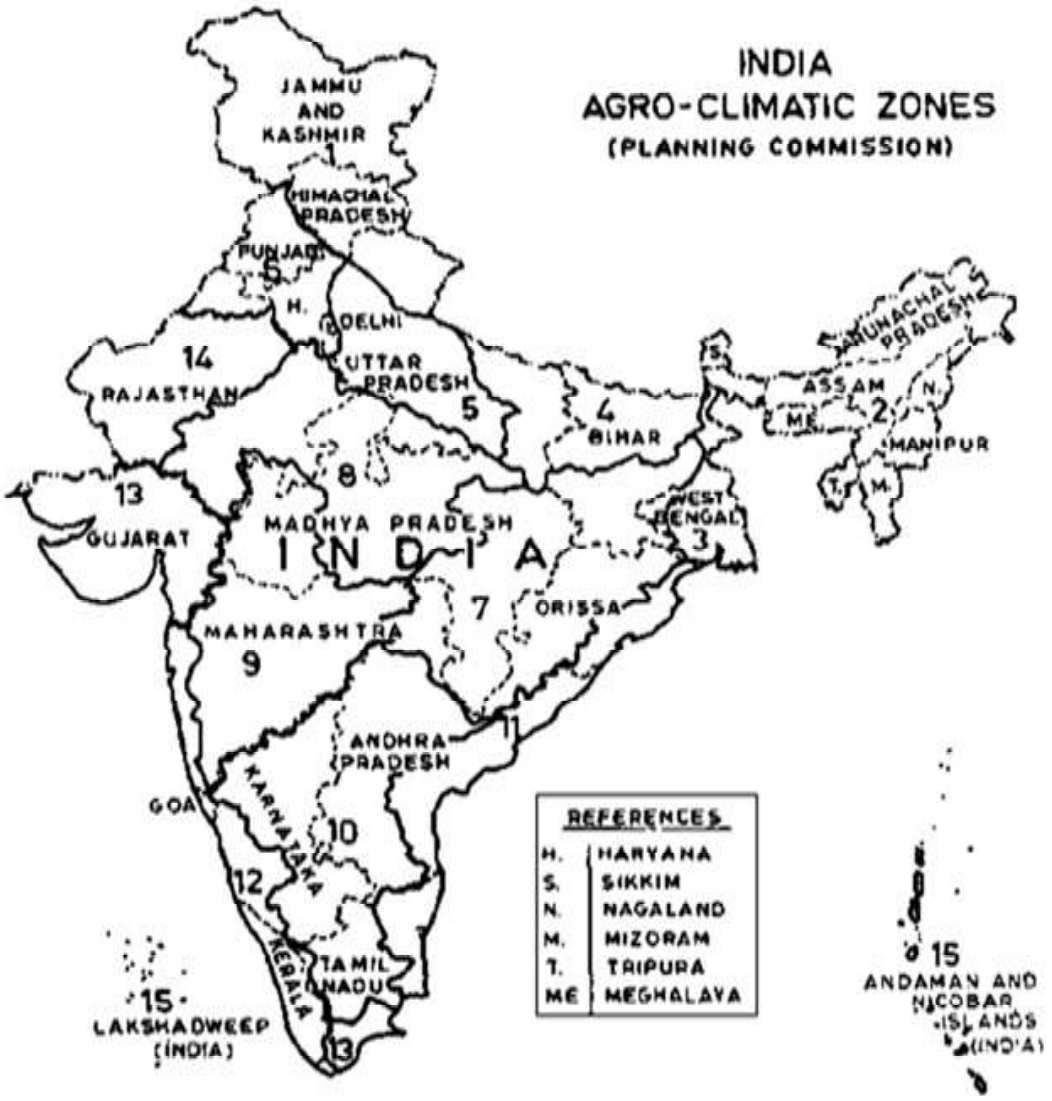
15. The Andman-Nicobar Islands: These Islands receiving copious rain and having hardly any winter season are highly suited for raising tropical crops like those grown in Malabar. However, the agricultural possibilities here are limited to the favourable littorals of the main Islands. The conditions here are more favourable to silviculture and aquaculture. From the methodological view point these regions suffer from several limitations viz. use of unspecified parameters and hence several paradoxes especially in the inclusion of contrasting feature in various regions.



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