CHAPTER – II

HISTORY OF INDIAN AGRICULTURE

2.1 INTRODUCTION

Indian agriculture has long, old and beyond memory history which begins the Indus valley civilization. One of the most old water regulating structure in the world is Grand Anicut dam on river Kaveri (1st-2nd Century CE)[1].

Indian agriculture began by 9000 BCE as a result of early cultivation of plants, and domestication of crops and animals. Settled life soon followed with implements and techniques being developed for agriculture. Double monsoons led to two harvests being reaped in one year. Indian products soon reached the world via existing trading networks and foreign crops were introduced to India. Plants and animals—considered essential to their survival by the Indians—came to be worshiped and venerated.

The middle ages saw irrigation channels reach a new level of sophistication in India and Indian crops affecting the economies of other regions of the world under Islamic patronage. Land and water management systems were developed with an aim of providing uniform growth. Despite some stagnation during the later modern era the independent Republic of India was able to develop a comprehensive agricultural program.

Reference 1: Stein, Burton (1998), *A History of India*, Blackwell Publishing, ISBN 0-631-20546-2

2.2 HISTORY OF INDIAN AGRICULTURE

2.2.1 Early History

Wheat, barley and jujube were domesticated in the Indian subcontinent by 9000 BCE. Domestication of sheep and goat soon followed. This period also saw the first domestication of the elephant. Barley and wheat cultivation—along with the domestication of cattle, primarily sheep and goat—was visible in Mehrgarh by 8000-6000 BCE. Agro pastoralism in India included threshing, planting crops in rows—either of two or of six—and storing grain in granaries. By the 5th millennium BCE agricultural communities became widespread in Kashmir. Zaheer Baber (1996)[1] writes that 'the first evidence of cultivation of cotton had already developed'. Cotton was cultivated by the 5th millennium BCE-4th millennium BCE. The Indus cotton industry was well developed and some methods used in cotton spinning and fabrication continued to be practiced till the modern Industrialization of India. A variety of tropical fruit such as mango and muskmelon are native to the Indian subcontinent. The Indians also domesticated hemp, which they used for a number of applications including making narcotics, fiber, and oil. The farmers of the Indus Valley grew peas, sesame, and dates. Sugarcane was originally from tropical South Asia and Southeast Asia. Different species likely originated in different locations with *S. barberi* originating in India and *S. edule* and *S. officinarum* coming from New Guinea. Wild Oryza rice appeared in the Belan and Ganges valley regions of northern India as early as 4530 BCE and 5440 BCE respectively. Rice was cultivated in the Indus Valley Civilization. Agricultural activity during the second millennium BC included rice cultivation in the Kashmir and Harrappan regions. Mixed farming was the basis of the Indus valley economy. Denis J. Murphy (2007)[2] details the spread of cultivated rice from India into South-east Asia:

References 1 : Baber, Zaheer (1996), The Science of Empire: Scientific Knowledge, Civilization, and Colonial Rule in India, State University of New York Press, ISBN 0-7914-2919-9.

Reference 2: Murphy, Denis J. (2007), People, Plants and Genes: The Story of Crops and Humanity, Oxford University Press, ISBN 0-19-920713-5.

Several wild cereals, including rice, grew in the Vindhyan Hills, and rice cultivation, at sites such as Chopani-Mando and Mahagara, may have been underway as early as 7000 BP. The relative isolation of this area and the early development of rice farming imply that it was developed indigenously....Chopani-Mando and Mahagara are located on the upper reaches of the Ganges drainage system and it is likely that migrants from this area spread rice farming down the Ganges valley into the fertile plains of Bengal, and beyond into south-east Asia.

Irrigation was developed in the Indus Valley Civilization by around 4500 BCE. The size and prosperity of the Indus civilization grew as a result of this innovation, which eventually led to more planned settlements making use of drainage and sewers. Sophisticated irrigation and water storage systems were developed by the Indus Valley Civilization, including artificial reservoirs at Girnar dated to 3000 BCE, and an early canal irrigation system from circa 2600 BCE. Archeological evidence of an animal-drawn plough dates back to 2500 BC in the Indus Valley Civilization.

2.2.2 Vedic period – Post Maha Janapadas period (1500 BCE – 200 CE)

Accoridng to Gupta (2004) [1] the summer monsoons may have been longer and may have contained moisture in excess than required for normal food production. One effect of this excessive moisture would have been to aid the winter monsoon rainfall required for winter crops. In India, both wheat and barley are held to be *Rabi* (winter) crops and—like other parts of the world—would have largely depended on winter monsoons before the irrigation became widespread. The growth of the *Kharif* crops would have probably suffered as a result of excessive moisture. Jute was first cultivated in India, where it was used to make ropes and cordage. Some animals—thought by the Indians as being vital to their survival—came to be worshiped.

Reference 1: Gupta, Anil K. (2004), "Origin of agriculture and domestication of plants and animals linked to early Holocene climate amelioration", ***Current Science*****, 87 (1), Indian Academy of Sciences.**

Trees were also domesticated, worshiped, and venerated—*Pipal* and *Banyan* in particular. Others came to be known for their medicinal uses and found mention in the holistic medical system *Ayurveda*.

In the later Vedic texts (c. 1000–500 BC), there are repeated references to iron. Cultivation of a wide range of cereals, vegetables, and fruits is described. Meat and milk products were part of the diet; animal husbandry was important. The soil was plowed several times. Seeds were broadcast. Fallowing and a certain sequence of cropping were recommended. Cow dung provided the manure. Irrigation was practiced.

The Mauryan Empire (322–185 BCE) categorized soils and made meteorological observations for agricultural use. Other Mauryan facilitation included construction and maintenance of dams, and provision of horse-drawn chariots—quicker than traditional bullock carts. The Greek diplomat Megasthenes (c. 300 BC)—in his book *Indika*—provides a secular eyewitness account of Indian agriculture:

2.2.3 Early Common Era – High Middle Ages (200–1200 CE)

The Tamil people cultivated a wide range of crops such as rice, sugarcane, millets, black pepper, various grains, coconuts, beans, cotton, plantain, tamarind and sandalwood. Jackfruit, coconut, palm, areca and plantain trees were also known. Systematic ploughing, manuring, weeding, irrigation and crop protection was practiced for sustained agriculture. Water storage systems were designed during this period. Kallanai (1st-2nd century CE), a dam built on river Kaveri during this period, is considered the as one of the oldest water-regulation structures in the world still in use.

Spice trade involving spices native to India—including cinnamon and black pepper—gained momentum as India starts shipping spices to the Mediterranean. Roman trade with India followed as detailed by the archaeological record and the *Periplus of the Erythraean Sea*. Chinese sericulture attracted Indian sailors during the early centuries of the common era. Crystallized sugar was discovered by the time of the Guptas (320-

550 CE), and the earliest reference of candied sugar come from India. The process was soon transmitted to China with traveling Buddhist monks. Chinese documents confirm at least two missions to India, initiated in 647 CE, for obtaining technology for sugar-refining. Each mission returned with results on refining sugar. Indian spice exports find mention in the works of Ibn Khurdadhbeh (850), al-Ghafiqi (1150), Ishak bin Imaran (907) and Al Kalkashandi (fourteenth century).

Noboru Karashima's research of the agrarian society in South India during the Chola Empire (875-1279) reveals that during the Chola rule land was transferred and collective holding of land by a group of people slowly gave way to individual plots of land, each with their own irrigation system. The growth of individual disposition of farming property may have led to a decrease in areas of dry cultivation. The Cholas also had bureaucrats which oversaw the distribution of water—particularly the distribution of water by tank-and-channel networks to the drier areas.

2.2.4 Late Middle Ages – Early Modern Era (1200–1757 CE)

The construction of water works and aspects of water technology in India is described in Arabic and Persian works. The diffusion of Indian and Persian irrigation technologies gave rise to an irrigation system which bought about economic growth and growth of material culture. Agricultural 'zones' were broadly divided into those producing rice, wheat or millets. Rice production continued to dominate Gujarat and wheat dominated north and central India. The Encyclopedia Britannica details the many crops introduced to India during this period of extensive global discourse:

> Introduced by the Portuguese, cultivation of tobacco spread rapidly. The Malabār Coast was the home of spices, especially black pepper, that had stimulated the first European adventures in the East. Coffee had been imported from Abyssinia and became a popular beverage in aristocratic circles by the end of the century. Tea, which was to become the common man's drink and a major export, was yet undiscovered, though it was growing wild in the hills of Assam. Vegetables were

cultivated mainly in the vicinity of towns. New species of fruit, such as the pineapple, papaya, and cashew nut, also were introduced by the Portuguese. The quality of mango and citrus fruits was greatly improved.

Land management was particularly strong during the regime of Akbar the Great (reign: 1556-1605), under whom scholar-bureaucrat Todarmal formulated and implemented elaborated methods for agricultural management on a rational basis. Indian crops—such as cotton, sugar, and citric fruits—spread visibly throughout North Africa, Islamic Spain, and the Middle East. Though they may have been in cultivation prior to the solidification of Islam in India, their production was further improved as a result of this recent wave, which led to far-reaching economic outcomes for the regions involved.

2.2.5 Colonial British Era (1757–1947 CE)

In 1857 a Rampur canal on river Sutlej was constructed and a number of irrigation canals are located on the Sutlej river. Few Indian commercial crops—such as Cotton, indigo, opium, and rice—made it to the global market under the British Raj in India. The second half of the 19th century saw some increase in land under cultivation and agricultural production expanded at an average rate of about 1 percent per year by the later 19th century. Due to extensive irrigation by canal networks Punjab, Narmada valley, and Andhra Pradesh became centers of agrarian reforms. There was influence of the world wars on the Indian agricultural system [1].

Reference 1:

Roy, T. (2006), "Agricultural Prices and Production, 1757–1947", *Encyclopedia of India (vol. 1)* edited by Stanley Wolpert, pp. 20–22, Thomson Gale, ISBN 0-684-31350-2.

Agricultural performance in the interwar period (1918–1939) was dismal. From 1891 to 1946, the annual growth rate of all crop output was 0.4 percent, and food-grain output was practically stagnant. There were significant regional and intercrop differences, however, nonfood crops doing better than food crops. Among food crops, by far the most important source of stagnation was rice. Bengal had below-average growth rates in both food and nonfood crop output, whereas Punjab and Madras were the least stagnant regions. In the interwar period, population growth accelerated while food output decelerated, leading to declining availability of food per head. The crisis was most acute in Bengal, where food output declined at an annual rate of about 0.7 percent from 1921 to 1946, when population grew at an annual rate of about 1 percent.

The British regime in India did supply the irrigation works but rarely on the scale required. Community effort and private investment soared as market for irrigation developed. Agricultural prices of some commodities rose to about three times between 1870-1920.

A rich source of the state of Indian agriculture in the early British era is a report prepared by a British engineer, Thomas Barnard, and his Indian guide, Raja Chengalvaraya Mudaliar, around 1774. This report contains data of agricultural production in about 800 villages in the area around Chennai in the years 1762 to 1766. This report is available in Tamil in the form of palm leaf manuscripts at Thanjavur Tamil University, and in English in the Tamil Nadu State Archives. A series of articles in The Hindu newspaper in the early 1990s authored by researchers at The Center for Policy Studies led by Shri Dharampal Dharampal highlight the impressive production statistics of Indian farmers of that era.

2.2.6 Republic of India (1947 CE onwards)

Bhakra Dam (completed 1963) is the largest dam in India. Special programs were undertaken to improve food and cash crops supply. The Grow More Food Campaign (1940s) and the Integrated Production Programme (1950s) focused on food and cash crops supply respectively. Five-year plans of India—oriented towards agricultural development—soon followed. Land reclamation, land development, mechanization, electrification, use of chemicals—fertilizers in particular, and development of agriculture oriented 'package approach' of taking a set of actions instead of promoting single aspect soon followed under government supervision. The many 'production revolutions' initiated from 1960s onwards included Green Revolution in India, Yellow Revolution (oilseed: 1986-1990), Operation Flood (dairy: 1970-1996), and Blue Revolution (fishing: 1973-2002) etc. Following the economic reforms of 1991, significant growth was registered in the agricultural sector, which was by now benefiting from the earlier reforms and the newer innovations of Agro-processing and Biotechnology.

Due to the growth and prosperity that followed India's economic reforms a strong middle class emerged as the main consumer of fruits, dairy, fish, meat and vegetables—a marked shift from the earlier staple based consumption. Since 1991, changing consumption patterns led to a 'revolution' in 'high value' agriculture while the need for cereals is experienced a decline. The per capita consumption of cereals declined from 192 to 152 kilograms from 1977 to 1999 while the consumption of fruits increased by 553%, vegetables by 167%, dairy products by 105%, and non-vegetarian products by 85% in India's rural areas alone. Urban areas experienced a similar increase.

Agricultural exports continued to grow at well over 10.1% annually through the 1990s. Contract farming—which requires the farmers to produce crops for a company under contract—and high value agricultural product increased. Contract farming led to a decrease in transaction costs while the contract farmers made more profit compared to the non-contract workforce. However, small landholding continued to create problems for India's farmers as the limited land resulted in limited produce and limited profits.

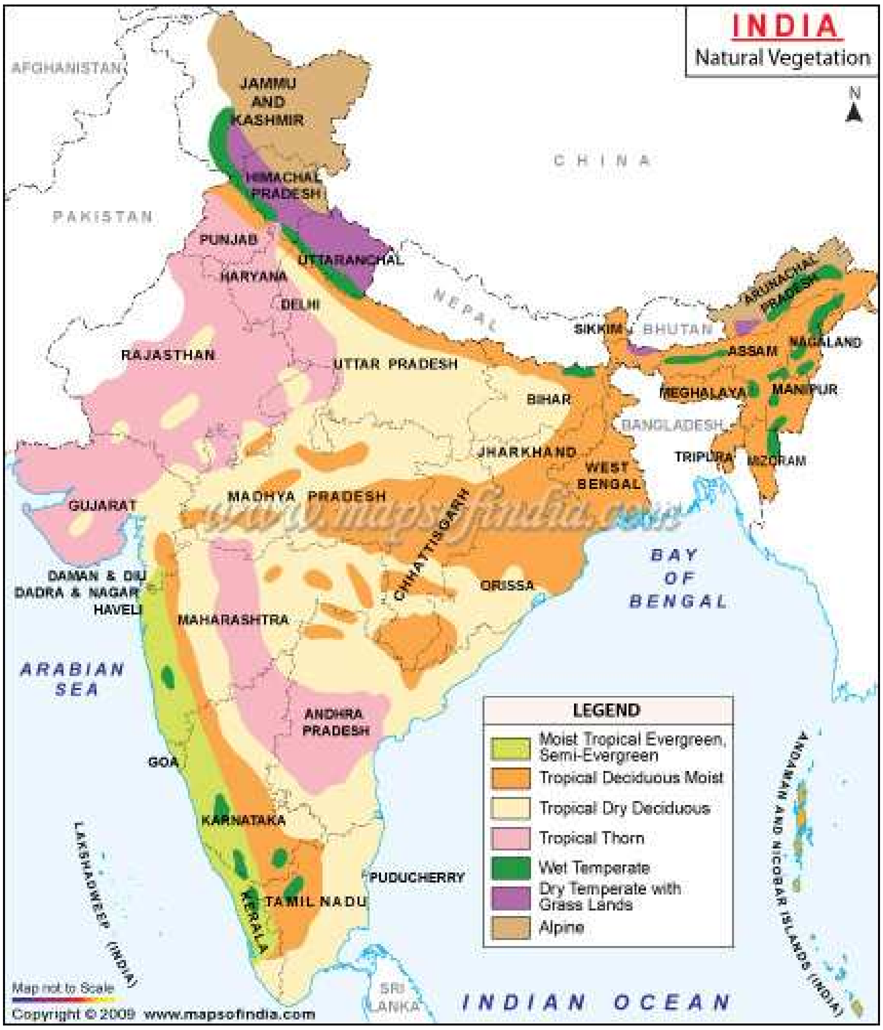
Since independence, India has become one of the largest producers of wheat, edible oil, potato, spices, rubber, tea, fishing, fruits, and vegetables in the world. The Ministry of Agriculture oversees activities relating to agriculture in India. Various institutions for agriculture related research in India were organized under the Indian Council of Agricultural Research (est. 1929). Other organizations such as the National Dairy Development Board (est. 1965), and National Bank for Agriculture and Rural Development (est. 1982) aided the formation of cooperatives and improved financing.

The contribution of agriculture in employing India's male workforce declined from 75.9% in 1961 to 60% in 1999–2000. Dev (2006)[1] holds that 'there were about 45 million agricultural labor households in the country in 1999–2000.' These households recorded the highest incidence of poverty in India from 1993 to 2000. The green revolution introduced high yielding varieties of crops which also increased the usage of fertilizers and pesticides. About 90% of the pesticide usage in India is accounted for by DDT and Lindane (BHC/HCH). There has been a shift to organic agriculture particularly for exported commodities.

- **Reference 1 :Dev, S. M. (2006), "Agricultural Labor and Wages since 1950",** ***Encyclopedia of India (vol. 1)*** **edited by Stanley Wolpert, pp. 17–20, Thomson Gale, ISBN 0-684-31350-2.**

Figure 2.1

India's Natural vegetation



Source: ICAR report 2006-2007

2.3 Indian Agriculture under Five Year Plans

On the eve of first plan (1951-1956) agriculture was in a hopeless and deplorable condition. Our farmers were heavy debt to the village money-lenders. They were having small and scattered holdings. They had neither the money nor the knowledge to use proper equipment, good seeds and chemical manures. Except in certain areas, they were dependent upon rainfall and upon the vagaries of the monsoons. Productivity of land as well as of labour had been declining and was generally the lowest in the world. In spite of the fact that nearly 70% of our working population was engaged in cultivation, the country was not self-sufficient in food grains but had come to depend on imports of food grains. Besides, the partition of the country in 1946 worsened the agricultural situation as India was allotted more people but less land to support.

2.3 (A) Objectives of Economic Planning for the Agricultural Sector

While planning to develop the agricultural sector, the Planning Commission has kept four broad objectives[1]:

(a) Increase Agricultural Production - The aim has always been

i) To bring more land under cultivation,

ii) Raise the per hectare yield through intensive application of such agricultural inputs as irrigation, improved seeds fertilizers, etc. and thus

iii) Bring about increased agricultural production.

(b) Increase Employment Opportunities – Apart from increase in production, the agricultural sector has to generate additional employment opportunities and provide scope for increasing the incomes of the poorer sections in our villages.

© **Reduce the Pressure of Population on Land -** Another basic objective of planning in the agricultural sector has been to reduce the number of people working on land, on the assumption that there are too many people working on land. The surplus labour on land should be shifted to secondary and tertiary sectors, preferably in rural land semi-urban areas.

Reference 1 : Indian Economy, Ruddar Datta, K.P.M Sundaram, S. Chand & Co.53rd Edition, ISBN : 81-219-2045-0

(d) Reduce Inequality of Incomes in the Rural Sector - The Government should remove the exploitation of tenants, and should distribute surplus land among small and marginal farmers in such a way that there would be some degree of equality and justice in the rural areas.

All these four objectives are generally followed in all our five year plans but in practice, agricultural planning in India has come to mean increase in agricultural production, viz., the achievement of the first objective; all other objectives have either been ignored or given lower priority.

2.4 Strategy Used in Agricultural Sector under Five Year Plans

To bring about increase in agricultural production and also increase in rural employment such as; setting up of community development programmes and agricultural extension services throughout the country, expansion of irrigation facilities, fertilizers, pesticides, agricultural machinery, high-yielding varieties of seeds and expansion of transportation, power, marketing, and of institutional credit. To reduce the pressure of population on land, the strategy used was to set up agro-based industries and handicrafts in rural areas, to promote rural transport and communications and to encourage the movement of people from agriculture to industries and service sectors. Finally, to bring about equality and justice in rural India, the strategy used was land reforms which included the removal of intermediaries, like the Zamindars, the protection of tenants through tenancy legislation, ceiling of land holding and distribution of surplus land among landless labourers and small and marginal farmers.

2.4.1 Pattern of Investment in the Agricultural Sector - The pattern of investment in the different five year plans is summarized in table 2.1 :

Table 2.1 Pattern of Government Outlay on Agriculture in the Plans (in Rs.)

Five Year Plan	**Year**	**Total Plan Outlay**	**Outlay on Agriculture & Irrigation**	**% of Total Outlay**
First Plan	1951-56	1,960	600	31
Second Plan	1956-61	4,600	950	20
Third Plan	1961-66	8,600	1,750	21
Fourth Plan	1969-74	15,780	3,670	23
Fifth Plan	1974-79	39,430	8,740	22
Sixth Plan	1980-85	1,09,290	26,130	24
Seventh Plan	1985-90	2,18,730	48,100	22
Eighth Plan	1992-97	4,85,460	1,02,730	20
Ninth Plan	1997-2002	8,59,200	1,70,230	20
Tenth Plan	2002-07	15,25,640	3,05,060	20

Source: Various Five Year Plan documents

It would be clear that the total outlay in each Plan had increased and, correspondingly, the outlay on agriculture and irrigation had also increased. However. The percentage of outlay on agriculture and irrigation to total plan outlay was the highest in the First Plan, viz, 31% but ranged between 20 to 24% in all other plans.

The Indian Planning Commission specified the various programmes for increasing agricultural production such as irrigation, soil conservation, dry farming and land reclamation, supply of fertilizers and manures, better ploughs and improved agricultural implements, adoption of scientific practices, etc. The Government gave considerable attention to institutional changes such as the setting up of community development programmes and agricultural expansion of transportation, power, marketing and other basic facilities, improvement of the system of co-operative credit, etc. From the Third Plan onwards, the greatest emphasis was laid on irrigation, fertilizer, seed technology which led to green revolution.

2.4.2 Agricultural Progress under the Five Year Plans

We shall describe the progress made by India in the field of agriculture under the first nine plans. In the next section, we shall take up the progress of agriculture under the Ninth Plan separately.

a) First two Plans (1951-61)

The First Plan aimed at solving the food crisis India was facing at that time and ease the critical agricultural raw material situation, particularly the acute shortage pf raw cotton and raw jute. Accordingly, it gave highest priority to agriculture, specially food production by allotting 31% of the total public sector outlay on agriculture, but it fixed rather modest targets of production. **(See the above table).** As a result of favourable weather conditions and the production targets in the agricultural sector were exceeded for instance, as against the target of about 62 million tones, actual production of food grains came to nearly 67 million tones. The targets fixed for other crops were not fulfilled.

The Planning Commission wanted the Second Plan to lay the foundations of industrialization and secure equal opportunities for all, particularly for the weaker sections of the people in the country. Out of total outlay of Rs. 4,600 crores during the Second Plan, a sum of Rs. 950 crores or about 20% was spent on agriculture. Despite the percentage reduction in Plan outlay on agriculture, the progress on the agricultural front was significant. For example, food grains production recorded nearly 80 million tonnes in 1960-61, as against the target of 81 million tonnes. Likewise the production of oilseeds, sugarcane, and cotton was much more in 1960-61. There was, however, a shortfall in the production of all groups of commodities, as against the target fixed, except in the case of sugarcane in which there was remarkable progress.

b) Third to Fifth Plans (1961-79)

Experience in the Second Plan had shown clearly that the rate of growth in agricultural production was a major limiting factor in the progress of the India economy. As the Government felt that the success of the agricultural sector was an essential condition for the agricultural sector was an essential condition for the success of entire plan, the Third Plan fixed ambitious targets of production for all agricultural crops.

It was during the Third Plan that the Government introduced the new agricultural technology known as Intensive Agricultural District Programme of using improved seeds, viz., High Yielding Varieties Programme (HYVP). The new agricultural technology was expected to usher in the green revolution. However, as a result of the extensive and serious drought conditions in 1965-66, agricultural production was adversely affected.

a) None of the agricultural targets except sugarcane was chieved during the third plan period; and

b) The actual output at the end of the Third Plan in the case of food grains, oilseeds and raw cotton was lower than the output at the end of the Second Plan, indicating that the Third Plan was a wash-out, as far as agriculture was concerned.

As the consequence of the shortfall in food production and serious famine conditions in many parts of the country, the Government was forced to import food grains extensively during the last of the third plan. Besides, for the first time, the public lost interest in the planning process and the Government adopted "plan holiday" for three years.

The experience of the Third Plan made the Planning Commission realize the bitter fact that economic Planning would be a failure unless agricultural production was increased rapidly. Accordingly, the Planning Commission assigned high priority to agriculture in the successive plans.

Table 2.2: Achievements in the Agricultural Sector in the Various Plans

Five Year Plans	Food grains		Oilseeds		Sugarcane		Cotton		Jute	
	Target	Achiev-ement	Target	Achiev-ement	Target	Achiev-Ement	Target	Achiev-ement	Target	Achiev-ement
First Plan	62	67	5.5	5.6	63	60	4.2	4.0	5.4	4.2
Second Plan	81	80	7.6	6.5	78	104	6.5	5.4	6.5	4.0
Third Plan	100	72	9.8	6.4	100	127	7.0	4.6	6.2	4.5
Fourth Plan	129	104	10.5	8.7	150	140	8.0	5.8	7.4	6.2
Fifth Plan	125	126	12.0	8.9	165	165	8.0	7.1	7.7	7.1
Sixth Plan	154	146	11.1	13.0	215	170	9.2	8.5	9.1	7.8
Seventh Plan	180	172	18.0	17.0	217	210	9.5	10.5	9.5	7.9
Eighth Plan	210	191	23.0	25.0	275	277	14.0	14.3	9.5	11.0
Ninth Plan	234	211	30.0	20.7	336	300	15.7	10.1	-----	11.6

Note: 1. Production of food grains, oilseeds and sugar cane in million tones
2: Production of cotton in millions of bales of 180 kgs each
3: Production of jute in millions of bales of 170 kgs each

Source: Plan documents and Economic Surveys

The approach to the Fourth Plan, for instance, emphasized the necessity to create favourable economic conditions for the promotion of agriculture and a systematic effort to extend the application of science and technology to improve agricultural practices.

Table above, however, reveals clearly that none of the targets fixed in agriculture in Fourth Plan was realized. For example, the target for food grains was 129 million tonnes for 1973-74 but the actual production in that year was only 104 million tones the highest level of production was 108 million in 1970-71.

The Fifth Plan (1974-79) was prepared with great care, with total plan outlay at Rs. 39,430 crores out of which outlay on agriculture would be Rs. 8,740 crores (which was 22% of the total Plan outlay). The targets for production of various crops and necessary inputs to achieve these targets were also clearly set. Unfortunately, all the financial calculations went wrong because of the serious inflationary situation during 1973-74. The Fifth Plan period also witnessed the declaration of emergency (1975). Even though agricultural progress was steady and plan targets were being realized, the Janata Party which came to power at the Center suspended the Fifth Plan mid way and started preparing the Sixth Plan. (Refer to Table 2.1 for V Plan targets and actual achievements in the agricultural sector).

(D) Progress since the Sixth Plan

Of all the Plans, the Sixth Plan (1980-85) was hailed as a great success, particularly because of the success on the agricultural front. As against the annual growth rate of 3.8 for agriculture, the actual growth rate was 4.3%. The production of food grains in 1983-84 was 154 million tonnes (against the target of 154 million tonnes) and was hailed by the Indian Government as the *second green revolution*. While the First Green Revolution from 1967-68 arose from the introduction of new high yielding varieties of Mexican Wheat and dwarf rice varieties, the Second Green Revolution from 1983-84 was said to be from expansion in supplies of inputs and services to farmers, agricultural extension and better management.

While the First Green Revolution was confined mainly to Punjab, Haryana and Western U.P., the Second Green Revolution had spread to eastern and central states including West Bengal, Bihar, Orissa, Madhya Pradesh and Eastern U.P. These states had made tremendous progress in recent years.

However, it is important to emphasize the fact that, despite all the great claim of the Government, none of the targets (except in oilseeds) of agricultural production was achieved during Sixth Plan (Refer Table).

The Seventh Plan (1985-90) and the Eighth Plan (1992-97) laid emphasis on specific projects in the field of agriculture They included a special rice production programme for rain fed agriculture, national oilseeds development project, social forestry, etc.

The Seventh Plan was not successful in the sense that the targets fixed for various sectors (except cotton) were not achieved. However, the level of production at the end of the Seventh Plan was much higher than the beginning of the Seventh Plan.

The Eighth Plan (1992-97) was basically sound in its approach in the strategy of development and in the targets of agricultural crops. Fortunately, weather and climate conditions were favourable and broadly many of the targets could be fulfilled. For instance, the actual outputs in1996-97 of oil seeds, of sugarcane, of cotton and of jute were higher than the targets for these crops in the Eighth Plan. The only exception was food grains the Eighth Plan target was 210 million tones but the actual production was 199 million tonnes. In fact, the production of food Grains at 199 million tonnes was the highest output registered by India till the date.

The Ninth Plan (1997-2002) treated more elaborately in the next section was not much of a success, as far as the agricultural targets were concerned. For instance, the Ninth Plan fixed the target of food grains production at 234 million tonnes in 2001-02; but the actual production was only 212 million tones. The same story of under – achievement was to be noted in other sectors of agriculture also. One is inclined to ask the question: why should the planners fix unrealistic and unrealizable targets?

2.5 India's Rainbow Revolution

Rainbow revolution concept is a combination of Green Revolution, White Revolution, Blue Revolution, Yellow Revolution and Brown Revolution. It was after these revolutions, the Indian agriculture slowly shifted from traditional behaviour to scientific behaviour. So, it is necessary to understand these revolutions in brief. The following chart shows various revolutions related to various produces of Indian agriculture. Here we are discussing mainly Green Revolution, White Revolution, Blue Revolution and Yellow Revolution in brief

Revolution	**Production**
Black Revolution	Petroleum production
Blue Revolution	Fish production
Brown Revolution	Leather/non-conventional(India)/Cocoa production
Golden Revolution	Overall Horticulture development/Honey Production
Golden Fiber Revolution	Jute Production
Green Revolution	Food grain (Cereals, Wheat &Leguminous plant) production
Grey Revolution	Fertilizer production
Pink Revolution	Onion production/Pharmaceutical (India)/Prawn production
Red Revolution	Meat & Tomato production
Round Revolution	Potato production
Silver Fiber Revolution	Cotton production
Silver Revolution	Egg/Poultry production
White Revolution	Milk/Dairy production (In India - Operation Flood)
Yellow Revolution	Oil Seeds production

2.5.1 Green Revolution

The introduction of high-yielding varieties of seeds after 1965 and the increased use of fertilizers and irrigation are known collectively as the Green Revolution, which provided the increase in production needed to make India self-sufficient in food grains, thus improving agriculture in India. Famine in India, once accepted as inevitable, has not returned since the introduction of Green Revolution crops.

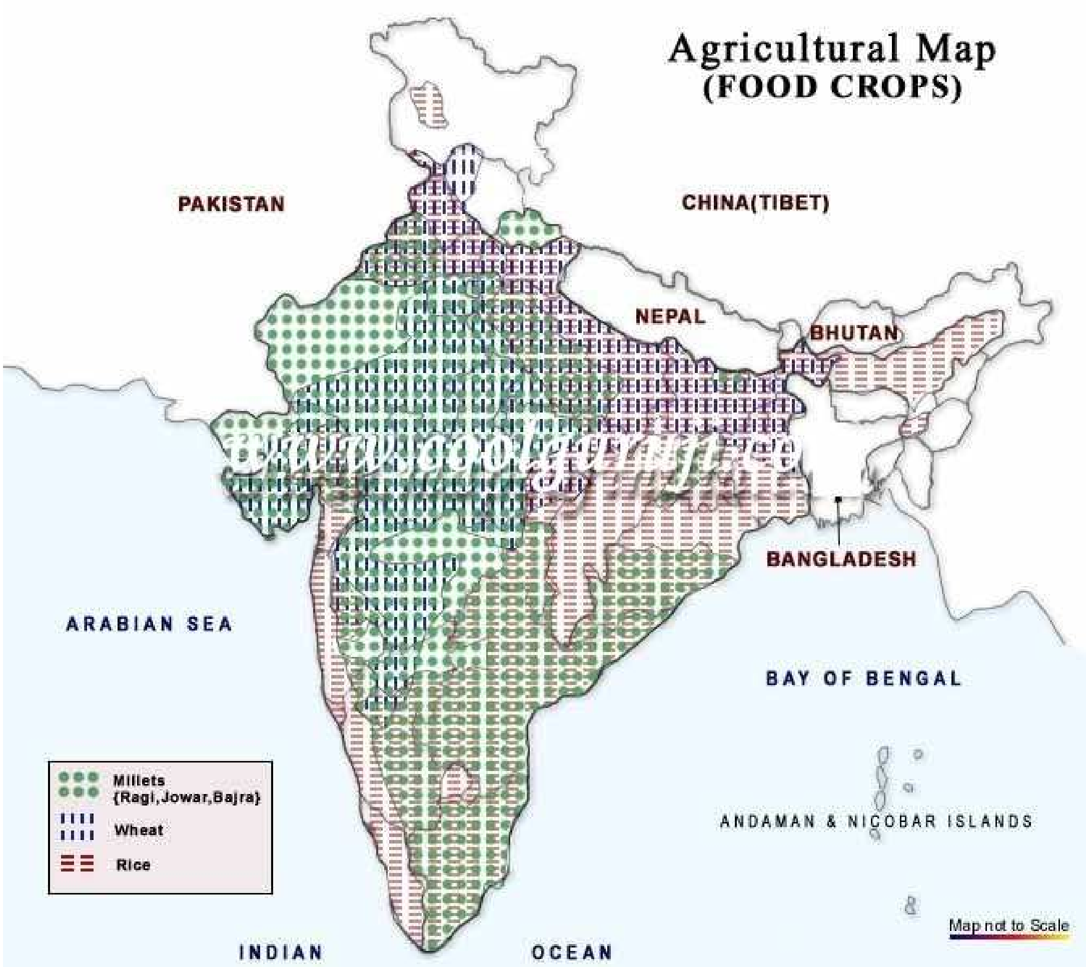
Of the high-yielding seeds, wheat produced the best results. All India Radio (AIR) played a vital role in creating awareness for these methods. Along with high yielding seeds and irrigation facilities, the enthusiasm of farmers mobilized the idea of agricultural revolution and is also credited to All India Radio.

The major benefits of the Green Revolution were experienced mainly in northern and northwestern India between 1965 and the early 1980s; the program resulted in a substantial increase in the production of food grains, mainly wheat and rice Food-grain yields continued to increase throughout the 1980s, but the dramatic changes in the years between 1965 and 1980 were not duplicated. By FY 1980, almost 75 percent of the total cropped area under wheat was sown with high-yielding varieties. For rice the comparable figure was 45 percent. In the 1980s, the area under high-yielding varieties continued to increase, but the rate of growth overall was slower. The eighth plan aimed at making high-yielding varieties available to the whole country and developing more productive strains of other crops

The map no.2 shows the total food grain cultivation in India. From the map we see that the foodgrains such as wheat and rice are majorly cultivated in Punjab, Haryana, Himachal Pradesh, Uttaranchal, Jharkhand, Uttar Pradesh for wheat and Andhra Pradesh, Tamilnadu, Karnatak and Kerala for rice. We see a crowded foodgrain cultivation of Bajra, Jowar and Maize in the states of Maharashtra and Karnataka.

Figure no. 2.2

Agricultural Map of India (Food crops)



Source :-Indian Economy,Agriculture report 2007-2008

From the above map we see that rice is majorly cultivated on the western coastal line completely, in some parts of Andhra Pradesh, Tamilnadu, Orissa, West Bengal and North-Eastern states. Wheat is densely cultivated in the states of Punjab, Haryana, Jharkhand and in some parts of Maharashtra, Madhya Pradesh and Gujarat. Millets which constitute foodgrains such as Ragi, Jowar, Bajra is densely cultivated in the states of Tamilnadu, Andhra Pradesh, Karnataka and in some parts of Rajasthan, Gujarat and Himachal Pradesh.

The environmental impact of excessive use to chemical fertilizers and pesticides was only revealed as years passed by. In 2009, under a Greenpeace Research Laboratories investigation, Dr Reyes Tirado, from the University of Exeter, UK, conducted a study in 50 villages in Muktsar, Bathinda and Ludhiana districts that revealed chemical, radiation and biological toxicity was rampant in Punjab. 20% of the sampled wells showed nitrate levels above the safety limit of 50 mg/l, established by WHO. The study connected this finding with high use of synthetic nitrogen fertilizers. With increasing poisoning of the soil, the region once hailed as the home to the Green Revolution, now due to excessive use of chemical fertilizer, is being termed by one columnist as the "Other Bhopal". For example, Buddha Nullah, a rivulet which run through Malwa region of Punjab, India, and after passing through highly populated Ludhiana district, before draining into Sutlej River, a tributary of the Indus river, is today an important case point in the recent studies, which suggest this as another Bhopal in making. A joint study by PGIMER and Punjab Pollution Control Board in 2008, revealed that in villages along the Nullah, calcium, magnesium, fluoride, mercury, beta-endosulphan and heptachlor pesticide were more than permissible limit (MPL) in ground and tap waters. Plus the water had high concentration of COD and BOD (chemical and biochemical oxygen demand), ammonia, phosphate, chloride, chromium, arsenic and chlorpyrifos pesticide. The ground water also contains nickel and selenium, while the tap water has high concentration of lead, nickel and cadmium.

In addition to large inputs of fertilizers and pesticides, the Green Revolution in India was made possible in large part by a dramatic increase in irrigation, particularly from deep groundwater sources. The exploitation of groundwater resources allowed farmers to double-crop (grow crops even during the dry season) and to grow water-intensive crops such as rice in areas that were traditionally unsuited for rice production.

This growth in irrigation has led to an alarming drop in the water table in a number of key agricultural Indian states, such as Punjab, where the water table is reportedly falling by about 1 meter per year. In other states, the problem is worse; in Gujarat, the water table is falling by as much as 3-5 meters per year.

What this means is that without a dramatic change in agricultural practice, groundwater resources could be depleted within a few years. In the case of Gujarat and other coastal areas, intrusion of seawater could render underground aquifers useless for human consumption or agriculture.

2.5.2 White Revolution

White Revolution 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. It also helped reduce malpractices by milk traders and merchants. This revolution followed the Indian Green Revolution and helped in alleviating poverty and famine levels from their dangerous proportions in India during the era.

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' cooperatives, which procure milk and provide inputs and services, making modern management and technology available to members. Operation Flood's objectives included :

- Increase milk production ("a flood of milk")
- Augment rural incomes
- Fair prices for consumers
- Based co-operation "Anand Milk Union Limited", often called Amul, was the engine behind the success of the programme, and in turn became a mega company based on the cooperative approach. Tribhuvandas Patel was the founder Chairman of Amul, while Verghese Kurien was the chairman of NDDB at the time when the programme was implemented. Verghese Kurien, who was then 33, gave the professional management skills and necessary thrust to the cooperative, and is considered the architect of India's 'White Revolution' (Operation Flood). His work has been recognised by the award of a Padma Bhushan, the Ramon Magsaysay Award for Community Leadership, the Carnegie-Wateler World Peace Prize, and the World Food Prize.
- Operation Flood was implemented in three phases.

Phase I of White Revolution

- Phase I (1970–1980) was financed by the sale of skimmed milk powder and butter oil donated by the European Union (then the European Economic Community) 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 milksheds with consumers in India's major metropolitan cities: Delhi, Mumbai, Kolkata and Chennai. Thus establishing mother dairies in four metros.
- Operation flood, also referred to as “White Revolution” is a gigantic project propounded by Government of India for developing dairy industry in the country. The Operation Flood – 1 originally meant to be completed in 1975, actually spanned the period of about nine years from 1970–79, at a total cost of Rs.116 crores.

- At start of operation Flood-1 in 1970 certain set of aims were kept in view for the implementation of the programmes. Improvement by milk marketing the organized dairy sector in the metropolitan cities Mumbai(then Bombay), Kolkata(then Calcutta), Chennai(then Madras), Delhi. The objectives of commanding share of milk market and speed up development of dairy animals respectively hinter lands of rural areas with a view to increase both production and procurement.

Phase II of White Revolution

- Operation Flood Phase II (1981–1985) increased the milksheds 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 4,250,000 milk producers were covered. Domestic milk powder production increased from 22,000 tons in the pre-project year to 140,000 tons 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. Direct marketing of milk by producers' cooperatives increased by several million litres a day.

Phase III of White Revolution

- 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. Innovations like vaccine for Theileriosis, bypassing protein feed and urea-molasses mineral blocks, all contributed to the enhanced productivity of milch animals.

2.5.3 Blue Revolution

The fisheries-based blue revolution can become real and sustainable if the production potential of available water resources can be efficiently managed. But there are several areas of concern that need to be addressed to realize this goal. The marine fish production, which at one stage constituted the bulk of the total fish output, is showing practically no growth for nearly a decade. Much of the growth in the fisheries sector is coming chiefly from the inland fisheries, which is also beset with some formidable problems, including the environmental degradation of inland waters and the paucity of fish seed. Indeed, at present, hardly 40 per cent of the country's fresh water resources are being used for fisheries. The output of the inland fisheries sector could, therefore, be stepped up by two-and-half times just by utilizing all the available water bodies. Similarly, most of the fisheries potential of deep sea waters is going abegging for want of suitable fishing vessels and curbs on joint ventures for deep sea fishing. The fish stocks of these waters are being either clandestinely harvested by ships belonging to countries or are remaining unexploited. On the other hand, the coastal waters, predominantly drawn upon by the traditional fishing communities, are being over-exploited, leading to the fast depletion of fisheries resources of this zone. This is also reflected in gradual shrinking of fish catches in the coastal waters. Even shrimps-based aquaculture, which has till recently been witnessing a fast, largely exports-driven, growth, has now begun flagging due to the imposition of various kinds of non-tariff trade barriers by the importing countries. Besides, the vulnerability of shrimps to diseases is causing problems for the shrimp industry.

Equally worrisome is the poor post-harvest handling of fish, which is resulting in huge wastage of this nutritious food. While these losses are reckoned at a huge 25 per cent in the marine sector, these are around 8 per cent in inland fisheries. The total value of the losses is assessed at a colossal Rs 1,000 crore annually.

2.5.4 Brown Revolution

Brown revolution means turn garbage which is brown into gold and fertilizer which is totally organic or bio or worm compost.

A `***Brown Revolution'*** is happening in the tribal areas of Visakhapatnam district. The tribal people are taught and encouraged to grow "socially responsible and environment friendly" coffee to cater to the demand from developed countries.

The Coffee Board has embarked upon the challenging campaign of promoting the coffee grown in these remote areas as niche coffee for markets in the West. Niche coffee, determined by consistent quality and the socio-economic well-being of the local people, is a $55-billion market world-wide.

Although the tribal people of Visakhapatnam district have been growing coffee since the 1970s, it is only recently, particularly after eyeing the organic market, that it is being given a thrust. Some 30,000 tribal people of Andhra Pradesh, who once practised slash-and-burn `Podu' (shifting) cultivation, are now growing coffee as a shade crop under the canopy of silver oak.

What the tribal people of Visakhapatnam are cultivating may be a minuscule part of India's annual coffee production of around three lakh tonnes. But, according to the Coffee Board, what is significant is that apart from regenerating the forest cover in those parts of the Eastern Ghats where it is cultivated, coffee has helped at the micro level by boosting the income of the tribal people. Their per hectare income from coffee is estimated at Rs.15,000 compared to Rs.10,000 for pineapple, Rs.1,500 for niger seeds and Rs.1,000 for maize.

The Coffee Board cites the instance of 50-year-old Linganna Padal who owns a demonstration coffee plot, which has generated enough income for him to own a house and educate his children. His success is now sought to be replicated throughout the Integrated Tribal Development Agency areas of the district.

However, it is not just a case of the good intentions of the Coffee Board and the ITDA of Paderu to help the tribal people. Some argue that there could even be a sound marketing base to all this. World over, there is a burgeoning demand for organic coffee. In those areas of Karnataka, Tamil Nadu and Kerala where over 90 per cent of India's coffee is grown, any shift to organic coffee cultivation would necessitate a break in cultivation as the soil has to be left fallow for a few years to wash out traces of chemicals. But the tribal areas of Visakhapatnam can cultivate organic coffee as no chemical fertilizers or pesticides are used, as much owing to financial constraints as the lack of exposure to modern methods of cultivation.

Trying to turn this into an advantage, the Coffee Board and the ITDA launched the programme to grow coffee in the Araku Valley. Coffee Board officials, however, say that it seems far-fetched for Araku Valley coffee to sell in London or New York. But the process is moving in that direction. The Coffee Board has even created a logo for the "Araku Valley Coffee" brand.

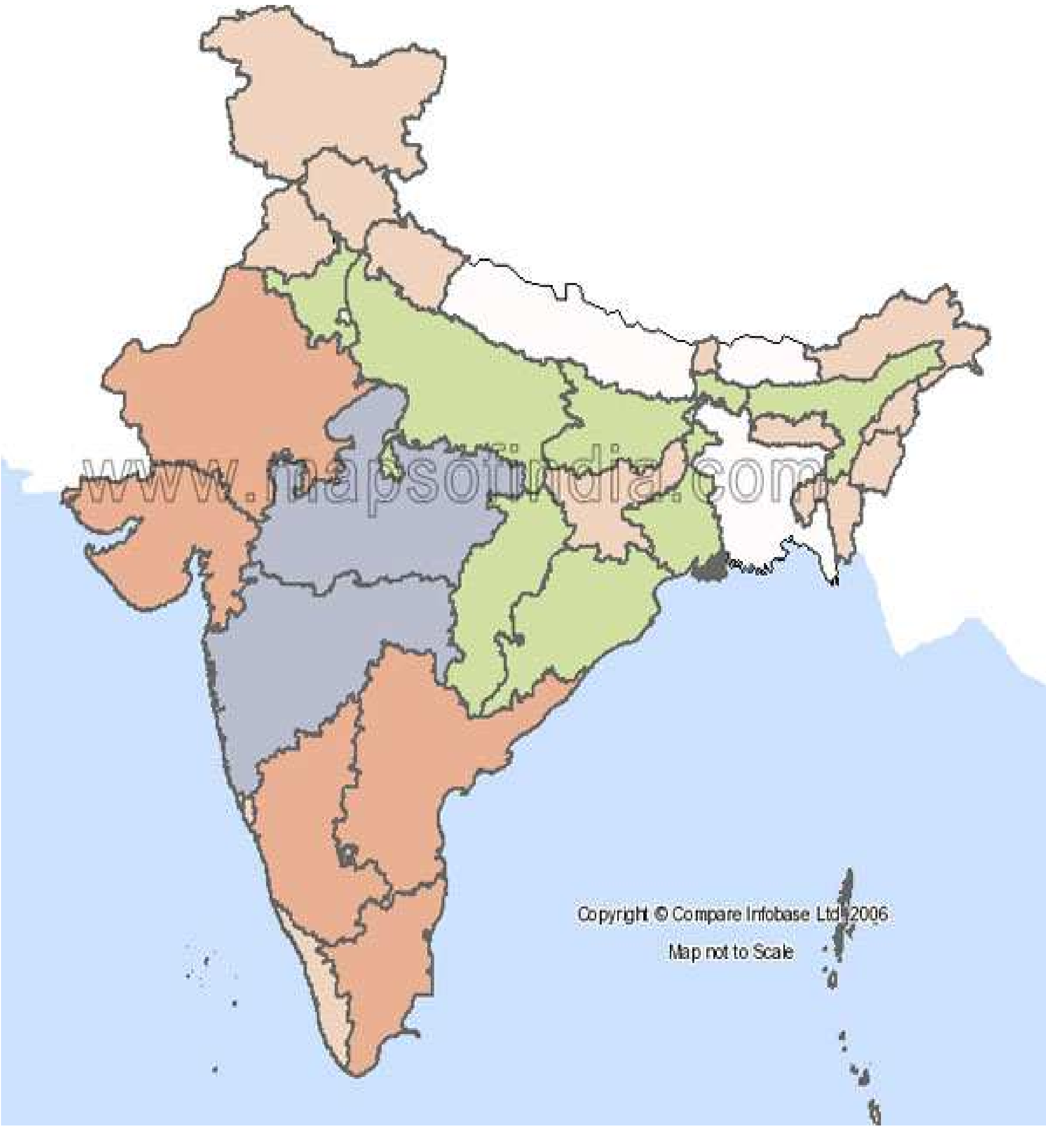
According to the Coffee Board, the quality of Araku Valley coffee will be improved through systematic development of on- and off-farm processing facilities. Self-help groups of tribal farmers are to be strengthened to facilitate pooling of coffee so as to offer consistent and larger quantities. A physical platform for auctioning is expected to give a fillip to marketing and the prospects of exporting coffee to Japanese, Australian and American markets through Visakhapatnam port are to be pursued. Araku coffee is turning out to be a potent brew indeed.

2.5.5 Yellow Revolution

Yellow revolution means the cultivation of mustard as a part of crop rotation. It prevents the soil from getting eroded and at the same time gives a rich crop of oil seeds. The use of mustards is to build soil organic matter and to eliminate the need for chemical soil fumigants. The yellow revolution man of Vaishali is Bindeshwar Prasad Singh (67), a farmer owning just 2.5 acre of land but still making gold. No matter he was not chosen for last year's Kisan Samman by Bihar government, the Indian Vegetable Research Institute at Varanasi gave him silver medal The growth, development and adoption of new varieties of oilseeds and complementary technologies nearly doubled oilseeds production from 12.6 mt in 1987-88 to 24.4 mt in 1996-97, catalyzed by the Technology Mission on Oilseeds, brought about the Yellow Revolution.

Figure 2.3

Map shows production of Oil seeds in India



Source : ICAR Report 2007-2008

	>100'000 tonnes		**100'000-1000'000 tonnes**		**1000'000-2000'000 tonnes**
	2000'000tonnes >				

The map no.3 shows the amount of production of Oilseeds in India. From the map it is clear that the states of Himachal Pradesh, Jammu & Kashmir, Uttarkhand, Haryana, North-Eastern states, Jharkhand and Kerala have a production of less than 1 lakh tones. The states of Uttar Pradesh, Bihar, Chattisgarh, Orissa and West Bengal produce oilseeds upto 10 lakh tones, while the states of Rajasthan, Gujarat, Karnataka, Andhra Pradesh and Tamilnadu have production of oilseeds in the range of 10 lakh to 20 lakh tones. The highest oilseed production of above 20 lakh tonnes is seen in the states of Maharashtra and Madhya Pradesh.

The growth, development and adoption of new varieties of oilseeds and complementary technologies nearly doubled oilseeds production from 12.6 mt in 1987-88 to 24.4 mt in 1996-97, catalyzed by the Technology Mission on Oilseeds, brought about the Yellow Revolution. The term also stands for the People Power Revolution in Phillipines in 1986 against then President Ferdinand Marcos. It was a series non-violent protests where demonstrators used yellow ribbons during the arrival of Ninoy Aquino. Around this time of the year, bright yellow flowers carpet the fields in scores of villages in Bihar's Vaishali district. They are not mustard crops waiting to burst into full bloom but cauliflower seeds that have ushered in a revolution of sorts — locals term it ‘Yellow Revolution’ — in the region. These seeds — which fetch high prices as they are completely organic — are sold across Bihar, Rajasthan, Madhya Pradesh and Maharashtra under an exclusive brand called Vaishali under various names like satya beej, green seeds and jawahar seeds. While over three dozen villages under Hajipur, Mahnar and Lalganj blocks in Vaishali cultivate cauliflower seeds along with other crops, the entire Chakbara village near Hajipur is devoted to cauliflower seed cultivation. The cumulative earning of around 50 farmers from the sale of seeds last year was about Rs 50 lakh.

2.5.6 Results of Rainbow Revolution

After effective implementation of Green Revolution, White Revolution, Blue Revolution, Yellow Revolution and a combined concept of Rainbow Revolution has certain programmes such as

1. To increase the annual growth rate in agriculture over 4%
2. To give greater private sector participation through contract farming
3. To enable price protection for farmers
4. To launch National Agriculture Insurance Scheme for all farmers and for all crops
5. To dismantle the restrictions on movement of agricultural commodities throughout the country

The new agriculture policy which was presented in 2000 aimed to achieve the above said objectives through Rainbow Revolution. Today, India ranks second worldwide in farm output. Agriculture and allied sectors like forestry and logging accounted for 16.6% of the GDP in 2007, employed 52% of the total workforce[1] 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.

Today India is the largest producer in the world of fresh fruit, anise, fennel, badian, coriander, tropical fresh fruit, jute, pigeon peas, pulses, spices, millets, castor oil seed, sesame seeds, safflower seeds, lemons, limes, cow's milk, dry chillies and peppers, chick peas, cashew nuts, okra, ginger, turmeric guavas, mangoes, goat milk and buffalo milk and meat. Coffee.It also has the world's largest cattle population (281 million). It is the second largest producer of cashews, cabbages, cotton seed and lint, fresh vegetables, garlic, egg plant, goat meat, silk, nutmeg. mace, cardamom, onions, wheat, rice, sugarcane, lentil, dry beans, groundnut, tea, green peas, cauliflowers, potatoes, pumpkins, squashes, gourds and inland fish. It is the third largest producer of tobacco, sorghum, rapeseed, coconuts, hen's eggs and tomatoes. India accounts for 10% of the world fruit production with first rank in the production of mangoes, papaya, banana and sapota. India's population is growing faster than its ability to produce rice and wheat.

2.6 Scenario of Agriculture in 2008-09

The performance of the agricultural sector influences the growth of the Indian economy. Agriculture (including allied activities) accounted for 17.8 per cent of the Gross Domestic Product (GDP-at constant prices) in 2007-08 as compared to 21.7 per cent in 2003-04. Notwithstanding the fact that the share of this sector in GDP has been declining over the years, its role remains critical as it accounts for about 52 per cent of the employment in the country. Apart from being the provider of food and fodder, its importance also stems from the raw materials that it provides to industry. The prosperity of the rural economy is also closely linked to agriculture and allied activities. Agricultural sector contributed 12.2 per cent of national exports in 2007-08. The rural sector (including agriculture) is being increasingly seen as a potential source of domestic demand; a recognition, that is shaping the marketing strategies of entrepreneurs wishing to widen the demand for goods and services.

In terms of composition, out of the total share of 17.8 per cent in GDP in 2007-08 for the agriculture and allied activities sector, agriculture alone accounted for 16.3 per cent of GDP followed by fishing at 0.8 per cent and forestry and logging at 0.7 per cent of GDP (Table 2.3).

Table 2.3: Agriculture sector - Key indicators

S.No	Item	2007-08	2008-09
1.	**GDP - share and growth** (per cent at 1999-00 prices)		
	Growth in GDP in agriculture & allied sectors	4.9	1.6
	Share in GDP - Agriculture and allied sectors	17.8	17.1
	Agriculture	16.3	
	Forestry and logging	0.7	
	Fishing	0.8	
2.	**Share in total gross capital formation in the country** (per cent at 1999-00 prices)		
	Share of agriculture & allied sectors in total gross capital	6.7	
	Agriculture	5.7	
	Forestry and logging	0.1	
	Fishing	0.9	
3.	**Agricultural imports & exports** (per cent at current prices)		
	Agricultural imports to national imports	3.1	
	Agricultural exports to national exports	12.2	
4.	**Employment** in the agriculture sector as share of total		52.1
	employment in 2004-05 as per Current Daily Status (per cent)		

Source: Central Statistical Organization & Dept of Agriculture and Cooperation

Gross capital formation in agriculture and allied sector

The Gross Capital Formation (GCF) in agriculture as a proportion to the total GDP has shown a decline from 2.9 per cent in 2001-02 to 2.5 per cent in 2007-08. However, the GCF in agriculture relative to GDP in this sector has shown an improvement from 11.23 per cent in 1999-2000 to 14.24 per cent in 2007-2008 (Table 2.3).

Table 2.4: Gross capital formation in agriculture (Figures in Rs. crore at 1999-2000 prices)

Year	GDP	Agriculture & allied activities		GCF/GDP in Agriculture & allied (%)	GCF in agriculture as % of total GDP
		GCF	GDP		
2004-05	2388768	57849	482446	12.0	2.4
2005-06	2616101	66065	511013	12.9	2.5
2006-07	2871120	73285	531315	13.8	2.6
2007-08	3129717	79328	557122	14.2	2.5

Source: Central Statistical Organization & Dept of Agriculture and Cooperation

The share of agriculture & allied sector in total GCF after showing a marginal increase during 1999-2000 to 2001-02 has been continuously declining. It stood at 10.2 per cent in 1999-2000, increased to 11.7 per cent in 2001-02 and thereafter declined to 7 per cent in 2006-07. The decline was mainly attributed to decline in the private sector despite increase in the share of public sector (Table 2.4).

Table 2.5: Share of agriculture & allied sector in total GCF (%) (at 1999-2000 prices)

Year	Public sector	Private sector	Total
1999-2000	6.0	11.9	10.2
2000-01	5.8	11.3	9.7
2001-02	6.7	13.7	11.7
2002-03	6.5	11.5	10.3
2003-04	7.4	9.2	8.8
2004-05	7.8	7.7	7.7
2005-06	7.9	7.1	7.2
2006-07	8.2	6.6	7.0

Source: Agricultural Statistics at a Glance 2008, Directorate of Economics & Statistics

Apart from production, the demand and distributional aspects of the agricultural sector, especially of food availability and food management, are of importance to the economy. The production performance of different segments of agriculture and allied activities covering, inter alia, horticulture, animal husbandry and fisheries as also the developments in the area of food management during the year 2008-09 is shown in the above tables

2.7 Indian Agri Export Scenario

Export of agricultural produces has taken a large leap after 1990-91, when Indian government went for economic reforms in all sectors. After the beginning of WTO and globalization of markets the Indian Agricultural Produces specially fruits, vegetables, spices and cash crops like cotton, jute, tea, coffee and rubber have exceeded the expectations and proved to be a great economical support for the country.

2.7.1 Exports of fruits since 1990

India is the second largest producer of Fruits after China, with a production of 44.04 million tonnes of fruits from an area of 3.72 million hectares (Table 2.6). A large variety of fruits are grown in India, of which mango, banana, citrus, guava, grape, pineapple and apple are the major ones. Apart from these, fruits like papaya, sapota, annona, phalsa, jackfruit, ber, pomegranate in tropical and sub-tropical group and peach, pear, almond, walnut, apricot and strawberry in the temperate group are also grown in a sizeable area. Although fruit is grown throughout of the country, the major fruit growing states are Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh, Bihar, Uttar Pradesh and Gujarat. It is seen that mango fruit is highly cultivated with large area of land cultivated under it. After mango, banana and citrus fruits are cultivated largely. Grapes are cultivated mainly in the district of Nasik of Maharashtra state. Area under grape cultivation is comparatively less as seen from the table. 2.6

Table 2.6

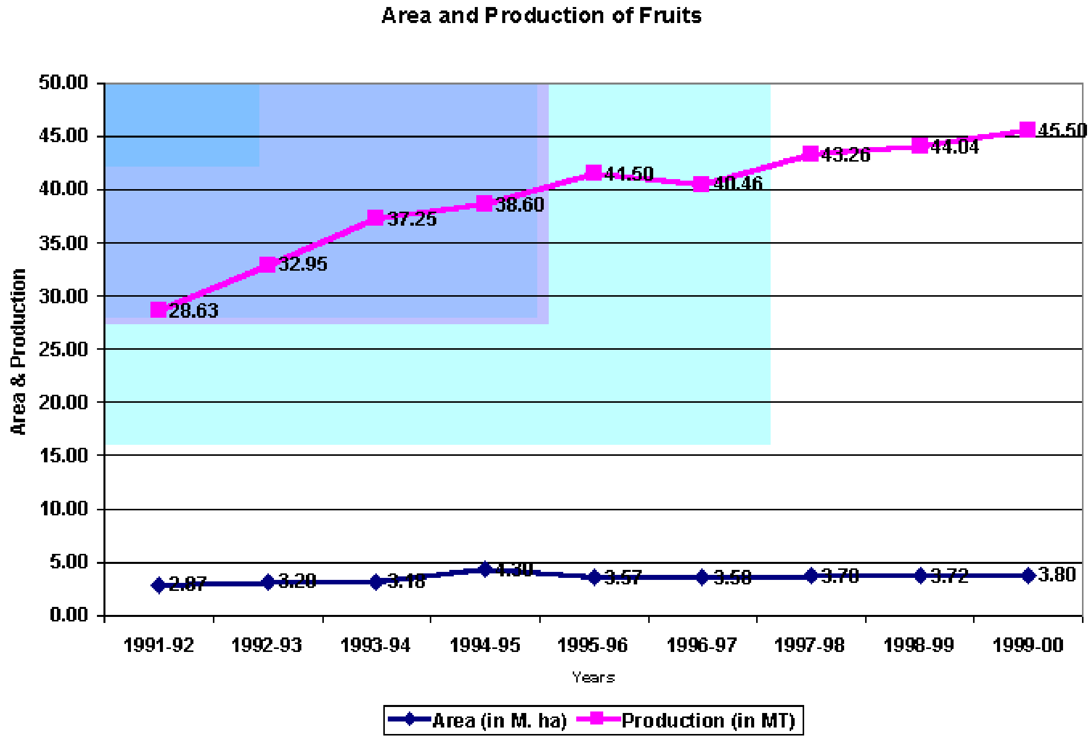
AREA, PRODUCTION AND EXPORT OF FRUITS IN INDIA AFTER 1990

S.No	**Fruits**	**Area (000 ha.)**	**Production (000 MT)**	**Exports (in million tones)**
1	Apple	238.3	1047.4	**375**
2	Banana	490.7	16813.5	436
3	Citrus	526.9	4650.6	**865**
4	Grapes	44.3	1137.8	646
5	Guava	150.9	1710.5	**230**
6	Litchi	56.4	433.2	185
7	Mango	1486.9	10503.5	**2634**
8	Papaya	60.5	1666.2	346
9	Pineapple	75.5	1025.4	**292**
10	Sapota	64.4	800.3	76.3
11	Others	601.2	5707.6	**932**
	Total	**3796.8**	**45496.0**	**7017.3**

Source: Directorate General of Commercial Intelligence and Statistics, Kolkatta

The graph 2.1 shows the area, production of fruits from 1990 to 2000. From the graph we see that the area under cultivation of fruits has shown a constant area ranging between 2.5 million hectares to 3.5 million hectares. But by 2008-09 the area under fruit cultivation has increased slightly to 4.2 million hectares. Whereas the production of fruits has shown a steady growth from 28.63 million tonnes in 1992-93 to 45.50 million tonnes in 1999-2000. As per the agricultural report the growth in the production of fruits had increased to 96.36 million tonnes by the end of 2009-10. The table also shows export of fruits in the 2008-09 in metric million tones.

Figure 2.1: Area and Production of fruits from 1991-92 to 1999-2000



Source: Central Statistical Organization & Dept of Agriculture and Cooperation

2.7.2 Export of Vegetables:

In vegetables production, India is next only to China with an annual production of 87.53 million tonnes from 5.86 million hectares having a share of 14.4 per cent to the world production. Adoption of high yielding cultivars and FI hybrids and suitable production technologies has largely contributed for higher production and productivity. Per capital consumption has also increased from 95 gram to 175 gram per day. More than 40 kinds of vegetables belonging to different groups, namely cucurbits, cole crops, solanaceous, root and leafy vegetables,are grown in different agro-climatic situations of the country. Except a few, namely brinjal (egg plant), colocasia, cucumber, ridge gourd, sponge gourd, pointed gourd etc., most of the other vegetables have been introduced from abroad.

Potato is most widely grown vegetable crop in the country with a share of 25.7 per cent. The area under potato cultivation is 1.28 Million ha with total production of 22.49 MT. The main varieties of potato grown in the country are Kufri Chandramukhi, Kufri Jyoti, Kufri Badshah, Kufri Himalani, Kufri Sindhuri, Kufri Lalima etc. Uttar Pradesh is the leading potato growing state in the country with a production of 9.53 million tonnes followed by West Bengal and Bihar. **Tomato** occupies second position amongst the vegetable crops in terms of production. The total production of tomato in the country in 1998-99 was 8.27 MT from an area of 0.46 M. ha. The main varieties of tomato grown in the country are Pusa Ruby, Pusa Early Dwarf, Arka Abha, Arka Alok, Pant Bahar, Pusa hybrid-1, Pusa hybrid-2, MTH-6, Arka Vardan etc. Andhra Pradesh is the largest grower of tomato with a production of 2.05 MT. The other main tomato growing states are Bihar, Karnataka, Maharashtra and Orissa. **Brinjal** occupies the third position amongst vegetable crops. The production of brinjal in the year 1998-99 was 7.88 MT from an area 0.49 M.ha. The varieties of brinjal popular in the country are Arka Navneet, Pusa Ankur, Hybrid-6, Pusa hybrid-5, ARBH-1, ABH-1, Pusa Purple Long, Pusa Purple Cluster, Ritu Raj etc. West Bengal is the largest producer of brinjal followed by Maharashtra and Bihar. The other main state growing brinjal Karnataka, Maharashtra, Gujarat, Andhra Pradesh, Assam and Madhya Pradesh. **Cabbage** is the fourth most widely grown vegetable crop of our country. India is the leading country producing Cabbage. The area under Cabbage cultivation is 0.23 M.ha producing 5.62 MT. The main varieties of cabbage are Pusa Drum Head, Golden Acre, Pride of India, Pusa Mukta, Pusa Synthetic etc. West Bengal produces 1.84 MT and is the largest grower of the cabbage. Orissa and Bihar occupies second and third position respectively. The other major growers of cabbage are Assam, Karnataka, Maharashtra and Gujarat. The other important vegetable crops grown in the country are onion, chillies, peas, beans, okra, cabbage, cauliflower, pumpkin, bottlegourd, cucumber, watermelon, palak, methi, carrot and radish.

India, known as “Land of Spices”, is the largest producer, consumer and exporter of variety of spices in the world. The area covered under various spices in the country is estimated to be 25.17 lakhs ha with an annual production of 29.10 lakhs tonnes (Fig-8). More than 90% of the spices produced in the country is used for domestic consumption and the rest exported as raw as well as value added products. The important spices produced in the country are: Black pepper, ginger, turmeric, garlic, chillies, coriander, cumin, fennel, fenugreek, celery, clove, cassia, nutmeg, mace, cardamom, saffron, vanilla and a group of herbal spices. Chillies occupies the top position amongst spices with a share of 30 per cent. Total production of Chillies in the year 1998-99 was The share of spices in the total agricultural export during 1998-99 was about 6% with an export of 2.31 lakh tonnes earning foreign exchange worth Rs. 1758 crores. The exports of spices and spice products during 1999-2000 was 2.09 lakh tonnes valuing Rs. 1861 crores. Pepper was the leader in export earning with 46% share followed by Oil & Oleoresins (15%), chillies (13%) and turmeric (6%).

2.8 Initiatives to Improve Agriculture sector

The required level of investment for the development of marketing, storage and cold storage infrastructure is estimated to be huge. The government has not been able to implement various schemes to raise investment in marketing infrastructure. Among these schemes are Construction of Rural Go downs, Market Research and Information Network, and Development / Strengthening of Agricultural Marketing Infrastructure, Grading and Standardization.

The Indian Agricultural Research Institute (IARI), established in 1905, was responsible for the research leading to the "Indian Green Revolution" of the 1970s. The Indian Council of Agricultural Research (ICAR) is the apex body in agriculture and related allied fields, including research and education. The Union Minister of Agriculture is the President of the ICAR. The Indian Agricultural Statistics Research Institute develops new techniques for the design of agricultural experiments, analyses data in agriculture, and specializes in statistical techniques for animal and plant breeding.

Recently Government of India has set up Farmers Commission to completely evaluate the agriculture program. However the recommendations have had a mixed reception.

2.8.1 Problems

There are many problems in Indian agriculture for example cotton flower in India. This is the main cash crop in Vidarbha region. 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.

According to World Bank Report ‘India countryOverview 2007-08’ The low productivity in India is a result of the following factors:

- According to World Bank, Indian Branch: Priorities for Agriculture and Rural Development", India's large agricultural subsidies are hampering productivity-enhancing investment. Overregulation of agriculture has increased costs, price risks and uncertainty. Government intervenes in labour, 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. The overuse of water is currently being covered by over pumping aquifers, but as these are falling by foot of groundwater each year, this is a limited resource.
- Illiteracy, general socio-economic backwardness, slow progress in implementing land reforms and inadequate or inefficient finance and marketing services for farm produce.
- Inconsistent government policy. Agricultural subsidies and taxes often changed without notice for short term political ends.
- The average size of land holdings is very small (less than 20,000 m^2) 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. At the same time over pumping made possible by subsidized electric power is leading to an alarming drop in aquifer levels.

2.8.2 India needs to improve food product standards

India needs to improve the standards of its food products to acquire a competitive edge in the global market, says Sanjay Dave[1], the first Indian vice-chair of the Rome-based Codex Alimentarius Commission (CAC), an international organization that aims at promoting food safety globally. Dave, also the director of India's Agricultural and Processed Food Products Export Development Authority (APEDA), feels that his tenure as CAC vice-chair would see continuous deliberations to meet emerging challenges at home and abroad.

"There is no scope for any complacency when it comes to dealing with the issue of food product standards. International and domestic consumers are quite quality conscious. India and other developing nations need to improve standards of food products," Dave told IANS in an interview.

India's farm and processed food products' exports have grown from Rs.6.47 billion in 1999-2000 to Rs.24.12 billion in 2006-07.

Major importers of Indian products like pomegranates, mangoes, onions and basmati rice are the United Arab Emirates, Saudi Arabia, Russia, Bangladesh, Turkey, Kuwait, Sri Lanka, Italy, Germany, Australia, Jordan, Bahrain, and Malaysia.

As capacity building is the key to ensuring food standards, the CAC intends to provide technical assistance to the developing nations so that the quality aspect is addressed right from the field. "From proper monitoring of pesticide residue to the processing units, there is a need to be vigilant at all levels so that the end product is healthy and well received by consumers," Dave maintained.

Dave said he would act aggressively to implement Codex Plan-2008-13, a vision document that speaks of consensus building and understanding food safety needs. "For me, the vice-chair of CAC does not mean just holding a few meetings. I am committed to holding meeting and deliberating with all stakeholders throughout the year," he said. The Food and Agriculture Organisation (FAO) and the World Health Organisation (WHO) created the Codex Alimentarius (Latin for food law or code) in 1963. The CAC aims at developing food standards, guidelines and related texts such as codes of practice under the food standards programme of FAO and WHO, two bodies under the aegis of the United Nations. His new position, however, does not mean that he will have less time for APEDA, the organization he has headed for long.

Reference 1: Article by Rajeev Ranjan Roy July 12th, 2008 ICT by IANS

"APEDA stands to benefit a lot from CAC and vice versa. Our great work at APEDA in managing quality of processed foods and agricultural products played a decisive role in my election," he said. APEDA is an autonomous body under India's ministry of commerce and industry dealing with quality management of agricultural and processed foods, and promoting their export.

2.9 CONCLUSIONS

Indian agriculture forms the back bone of Indian economy and despite concerted industrialization in the last six decades, agriculture occupies a place of pride. Being the largest industry in the country it provides employments to around 65% of the total workforce in the country. But in the recent year, its share in the GDP has declined to 18% in 2008-09. There is lot of scope for improvement in this sector. Summarizing the important points we can conclude that

1. Indian agriculture needs shift itself from traditional approach to scientific approach.
2. Indian agriculture should focus on market oriented produces rather than self sufficiency of food grains.
3. Indian agriculture needs to adapt technological and research oriented environment instead of struggling in traditional and superstitious environment.
4. Indian government should provide modern technology access to the rural farmers along with knowledge of markets and export potential.
5. Indian agriculture should aim to be free from trades and middle men dominant market and establish market access directly to farmers.
6. Indian agriculture shows a lot of potential because it has the largest diversity in physiography and climate and has highest amount of resources such as man power.
7. Indian agriculture should utilize these resources and develop the agriculture sector into one of the fastest growing, largest contributing sector of our economy.

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Chapter 1. Introduction of Indian agricultural heritage

Globally Important Agricultural Heritage Systems (GIAHS), as defined by the FAO (Food and Agriculture Organization of the UNO), are: "Remarkable land use systems and landscapes which are rich in globally significant biological diversity evolving from the co-adaptation of a community with its environment and its needs and aspirations for sustainable development". Worldwide, specific agricultural systems and landscapes have been created, shaped and maintained by generations of farmers and herders based on diverse natural resources, using locally adapted management practices. Building on local knowledge and experience, these ingenious agricultural systems reflect the evolution of humankind, the diversity of its knowledge, and its profound relationship with nature. These systems have resulted not only in outstanding landscapes, maintenance and adaptation of globally significant agricultural biodiversity, indigenous knowledge systems and resilient ecosystems, but, above all, in the sustained provision of multiple goods and services, food and livelihood security for millions of local community members and indigenous peoples, well beyond their borders. For millennia communities of farmers, herders, fishers and forest people have developed complex, diverse, and locally adapted agricultural systems. These systems have been managed with time-tested, ingenious combinations of techniques and practices that have usually led to community food security, and the conservation of natural resources and biodiversity. Agricultural heritage systems can still be found throughout the world covering about 5 million hectares, which provide a vital combination of social, cultural, ecological and economical services to humankind. These “Globally Important Agricultural Heritage Systems-GIAHS” have resulted not only in outstanding landscapes of aesthetic beauty, maintenance of globally significant agricultural biodiversity, resilient ecosystems and a valuable cultural heritage. Above all these systems sustainabley provide multiple goods and services, food and livelihood security for millions of poor and small farmers. The existence of numerous GIAHS around the world testifies to the inventiveness and ingenuity of people in their use and management of the finite resources, biodiversity and ecosystem dynamics, and ingenious use of physical attributes of the landscape, codified in traditional but evolving knowledge, practices and technologies. Whether recognized or not by the scientific community, these ancestral agricultural systems constitute the foundation for contemporary and future agricultural innovations and technologies. Their cultural, ecological and agricultural diversity is still evident in many parts of the world, maintained as unique systems of agriculture. Through a remarkable process of co-evolution of Humankind and Nature, GIAHS have emerged over centuries of cultural and biological interactions and synergies, representing the accumulated experiences of rural peoples.

Indian Agriculture

Indian agriculture began by 9000 BC as a result of early cultivation of plants and domestication of crops and animals. Settled life soon followed with implements and techniques being developed for agriculture. Double monsoons led to two harvests being reaped in one year. Indian products soon reached the world via existing trading networks and foreign crops were introduced to India. Plants and animals—considered essential to their survival by the Indians—came to be worshiped and venerated. The middle ages saw irrigation channels reach a new level of sophistication in India and Indian crops affecting the economies of other regions of the world under Islamic patronage. Land and water management systems were developed with an aim of providing uniform growth. Despite some stagnation during the later modern era the independent Republic of India was able to develop a comprehensive agricultural program.

Need and importance for studying Agricultural Heritage

Our agriculture has lot of inherited sustainable practices passed from one generation to other generation. And also agriculture in India is not an occupation; it is a way of life for many Indian populations. Hence the present day generation should be aware about our ancient and traditional agricultural systems a practices. This will enable us to build the future research strategy also. India has made tremendous progress in agriculture and its allied fields, but the emphasis on intensive use of inputs without considering their adverse impact of long term basis has created several problems related to sustainability of agriculture. Irrational use of chemical fertilizers, insecticides and exploration of natural resources is threatening the agro eco systems. Soil is getting impoverished, water and air getting polluted and there is an increasing erosion of plant and animal genetic resources. Therefore, attention in now shifting to sustainable form of agriculture. The indigenous technical knowledge (ITK) provides insight into the sustainable agriculture, because these innovations have been carried on from one generation to another as a family technology. There are several examples of valuable traditional technologies in India but unfortunately these small local systems are dying out. It is imperative that we collect, document and analyze these technologies so that the scientific principle/basis behind them could be properly understood.

Once this done, it will be easier for us to further refine and upgrade them by blending them with the modern scientific technology.

Agriculture Heritage in India

Our heritage is unique than any other civilization. As a citizen of India, we must feel proud about our rich cultural heritage. Agriculture in India is not of recent origin, but has a long history dating back to Neolithic age of 7500-4000 B.C. It changed the life style of early man from nomadic hunter of wild berries and roots to cultivator of land. Agriculture is benefited from the wisdom and teachings of great saints. The wisdom gained and practices adopted have been passed down through generations. The traditional farmers have developed the nature friendly farming systems and practices such as mixed farming, mixed cropping, crop rotation etc. The great epics of ancient India convey the depth of knowledge possessed by the older generations of the farmers of India.

Objective of the course

Agriculture in India - Way of life and not an occupation

To increase awareness of the rich heritage of Indian agriculture which is unique than any other civilization.

To implant a sense of pride amongst the people, particularly agricultural students as our agriculture has sustainable practices for generations.

To stimulate scientific research based on traditional technology.

Definitions

HISTORY : Continuous record of past events

HERITAGE : Inherited values carried from one generation to other generation

AGRICULTURAL HERITAGE : Values and traditional practices adopted in ancient India which are more relevant for present day system.

History denotes the continuous record of past events, where as heritage indicates the inherited values carried from one generation to other generation. Agricultural heritage denotes the values and traditional practices adopted in ancient India, which are more relevant for present day system.

List of available documents on agriculture during ancient and medieval period

1. ***Rigveda* (c.3700 BC)**

Agricultural practices in the Vedic period presumably started from c.1500 BC and ended in c.500 BC, corresponds to last phase of the Chalcolithic period and Iron Age in India. The possible sites stretched from north-western parts of India to the entire alluvial of the river Ganges. The associated factors with agricultural practices in Vedic India to be included in the present study are: (i) Soil, land and village settlement; (ii) Manure and manuring; (iii) Crop husbandry inclusive of plant protection measures, agricultural technology and agricultural implements; (iv) Irrigation system; (v) Animal husbandry and (vi) Meteorological observations in relation to crop prospects. The entire account has no treatise like approach but projected mostly through sacerdotal matters. The Vedic Aryans pursued pastoralism and agriculture as the mainstay of their livelihood. According to Max Muller the term A*rya*, derived from the root, *ar*, to stir, i.e., stirring of soil by means of stick or plough, shows Aryans were cultivators1 before separation as Indo-Iranian and Indo-Aryan. The Vedic Aryans for their existence on Indian soil had to fight against many obstacles. Appeasement of natural phenomena in form of anthropomorphic deities for existence and prosperity made them close to nature and natural objects. Analysis of related data on agriculture contained in the Vedic texts shows three prominent phases. The early phase shows struggle for fertile field. The twin god *Dya–va–-pr*. *thivi*– is extolled for snatching fertile field from the *dasyus* or Non-Aryans and granting to the Aryan people.2 Agricultural pursuits were thus not very easy for the Vedic Aryans at the early stage. Prayer to different godheads for copious rain and other favourable conditions congenial for raising of food crops (*anna*) and animal resources is frequent in the *R*i*gvedic mantras*. Agriculture occupied such an important place that *Su–rya* was conceived as having three bonds in three *lokas*. His bond in water, i.e. habitable world, explained by commentator Sa–yana are tillage, rain and seed.3 Thus in this hymn Vedic idea on three essentials of *Kr.s.i* (agriculture) is presented through this imagery of *Su–rya* in form of *Asfva*. A very few grain-crops are mentioned in the *R. gveda*. *Yava* (barley) is one among them. Obviously this shows the particular settlement area of the people at that time was favourable for cultivation of *yava*. Divinity was imposed on every conditions of nature. The entire agricultural operations were given a spiritual domination. This is found in the idea of *Ks.etrapati*, presiding deity of agriculture, indicating either *Rudra* or *Agni*, supervising all the agricultural activities.

2. ***Atharvaveda* (c. 2000 BC)**

The late Vedic period introduced manuring of *yava* (barley) seeds with clarified butter and honey as pre-sowing treatments of seeds. The *mantra*s uttered for this practice are laid down in the *Atharvaveda*. *Yava* (barley) was the only cultivated crop in the R**.** gvedic period. According to the story contained in the *Atharvaveda* , *yava,* the sweet corn was first cultivated by the gods on the bank of river Sarasvati– for the benefit of mankind. The great *Indra* was the furrow master and the *Maruts* were the ploughmen. Association with *Indra* and *Maruts* suggests it as a rain-growth corn. Excepting bird no other pestiferous agents were known in the preceding period. A host of such elements infesting grains in the field and unfavourable natural phenomena causing harm to crops came to be known during the Atharvavedic period. The pests inclusive of natural phenomena were.

- Borer (*tarda*) indicating either insect or bird, hooked insect (*saman***.***ka*), noxious insect (*upakvasa)* and locust (*patan* **.** *ga*),
- Rodents (*vyadvaras*) and rats (*a–khu)*
- Reptiles
- Natural phenomenon like lightening and sun. Charms and spells formed the preventive and remedial measures.

The late Vedic period introduced weed as pest in addition to those recognized in the *Atharvaveda*. Weed was particularly wheat-pest. Preventive and remedial measures were charms and spells in association with some substances appear to have pesticidal effects. These include: a) spreading of lead after furrowing, b) burying in field the metabolic product (grass) from the bowels of sacrificed cattle and some parts of particular plant substances. Weed control was also recommended by burying of several plant substances in the fields before sowing of seeds. The *Atharvaveda* refers winnowing fan (*sfu–rpa*) in this connection. Grains (here barley) were stored in a vessel (*urdara*). The next phase of the Vedic period, i.e., period of the *Atharvaveda* gave more stress on rain-water for irrigation. Utilization of river-water by diverting its course in channel became prominent. Green-manuring in soil fertility is a process that has continued from the Atharvavedic period till today.

- ***Ramayana* (c.2000 BC)**
- ***Mahabharata* (c.1400 BC)**

Mahabharata refers different names of river Sarasvati in its flows in different directions. There is mention of seven Sarasvatis indicating seven branches of river. The valley below Pehowa was known as Sapta Sarasvati i.e. the place where the river divided itself in seven streams. Saraswati disappeared in the desert at Vinasana before its meeting with Indus drainage. Its reappearance took place at Camasodbheda. Final union of Saraswati with sea has been mentioned in Rigveda and Mahabharata.

5. *Krishi-Parashara* (c.400 BC)

Krishi-Parashara (c. 400 BC) gives details of the design of the plow with Sanskrit names for different parts. This basic design has hardly undergone any change over centuries. A bamboo stick of a specific size was used to measure land. Vedic literature and Krishi-Parashara also mention disc plow, seed drill, blade harrow (*bakhar*), wooden spike tooth harrow, plankers, axe, hoe, sickle, *supa* for winnowing and a vessel to measure grain (*udara*). Pairs of bullocks used for plowing in ancient days varied from one to eight. Krishi-Parashara (c. 400 BC) and Brhat Samhita give, what today one could describe as, simple astrological models for predicting rains in a particular season. Parashara's main technique of forecasting rain was based on the positions of the Moon and the Sun in the sky. In Krishi-Parashara, it is stated that crops grown without manure will not give yield and a method of preparing manure from cowdung is described. In Krishi-Parashara (c. 400 BC), a description of a cattle shed is found. Cleanliness of the shed was emphasized. To protect animals from diseases, cattle sheds were regularly fumigated with dried plant products that contained volatile compounds.

6. *Kautilya's Artha-sastra* (c.300 BC)
7. *Amarsimha's Amarkosha* (c.200 BC)
8. *Patanjali's Mahabhasya* (c.200 BC)
9. *Sangam* literature (Tamils) (200 BC-100 AD)
10. *Agnipurana* (c.400 ?)
11. *Varahamihir's Brhat Samhita* (c. 500 AD)
12. *Kashyapiyakrishisukti* (c.800Ad)
13. *Surapala's Vrikshayurveda* (c.1000 AD)
14. *Lokopakaram* by Chavundaraya (1025 AD)
15. *Someshwardeva's Manasollasa* (1131 AD)
16. *Saranghara's Upavanavioda* (c.1300 AD)
17. *Bhavaprakasha-Nighantu* (c.1500 AD)

18. *Chakrapani Mistra's Viswavallbha* (c.1580 AD)
19. *Dara Shikoh's Nuskha Dar Fanni-Falahat* (c.1650 Ad)
20. *Jati Jaichand's* dairy (1658-1714 AD)
21. Anonymous *Rajasthani* Manuscript (1877 AD)
22. Watt's Dictionary of Economic Products of India (1889-1893 AD)

Chapter 2. Ancient agricultural practices

Traditional farming practices in India

Soil Classification

In ancient times geographical distribution by Surapala was jangala (arid), anupa (marshy) and samanya (ordinary). It is further divided by colour into black, white, pale, dark, red and yellow by taste into sweet, sour, salty, pungent, bitter and astringent. Samanya land was suitable for all kinds of trees. Rig-veda identified productive and non-productive soils. There were 12 classification based on soil fertility, irrigation and physical characteristics. These soil classifications are as follows :

1. *Urvara* (fertile)
2. *Ushara* (barren)
3. *Maru* (desert)
4. *Aprahata* (fallow)
5. *Shadvala* (grassy)
6. *Pankikala* (muddy)
7. *Jalaprayah* (water)
8. *Kachchaha* (land contiguous to water)
9. *Sharkara* (full of pebbles)
10. *Sharkaravari* (sandy)
11. *Nadimatruka* (land water from river)
12. *Devamatruka* (rainfed)

Another classification based on crops suitable

- *Vrdiheyam* (rice (rainfed) / corn)
- *Shaleyam* (kamala (wet) rice)
- *Tilyam* (sesamum)
- *Mashyam* (blackgram)
- *Maudginam* (mung bean)

Sangam, Tamil literature classified soils as mullai (forest), Kuringi (hills), marudham (cultivable) and neithal (coastal).

Maintenance of soil productivity

Traditional soil management practices are the product of centuries of accumulated knowledge, experience and wisdom refined and perpetuated over generations. These practices were evolved within the framework of local technical possibilities. They enlivened the soil, strengthened the natural resources diversify and maintained the production levels in accordance with the carrying capacity of agro-ecosystem without damaging it. Ancient farmers mostly relied on crop residues, manures, legumes and neem for enriching soil fertility. In Kirishi - parashara, it is stated that crops grown without manure will not give yield and stressed the importance of manures. He also recommended compost preparation from cow dung. The dried, powdered cow dung is placed in pit for decomposition where weed seeds are destroyed. The time duration for composting is two weeks. Kautilya mentioned the use of cowdung, animal bones, fishes, milk as manure. Surapala describes the ancient practice of preparing liquid manure (kunapa) prepared by boiling a mixture of animal excreta, bone marrow, flesh, dead fish in an iron pot and then add it to sesame oil cake, honey and ghee. This is clearly evident that present day Panchakavya is prepared in the same way and used in all crops.

Liquid manure (Kunapa) : Preparation of kunapa involves boiling flesh, fat, and marrow of animals such as pig, fish, sheep or goats in water, placing it in earthen pot, and adding milk, powders of sesame oil cake, black gram boiled in honey, decoction of pulses, ghee and hot water. There is no fixed proportion of ingredients. The pot is put in a warm place for two weeks. This fermented liquid manure is called kunapa.

Green manures :

In Rajasthan : Prosopis cineraria - brings up moisture and nutrients from the underground and leaves used as green manure.

In Tamil Nadu : Calotropis gigantiea, Mortinda tinctoria Theprosia purpurea, Jatropha, Ipomoea Adathoda

In North India : A traditional weed Kochia indica used as green manure. Ancient farmers adopted crop rotation and inter cropping to restore soil fertility. Mixed or inter cropping with legumes in cereal and oil seed cultivation were widely practices. All these practices adopted in ancient time are now being recommended today under organic farming concept.

Water harvesting and irrigation developments during different periods – water storage –

distribution and relevance to modern agriculture.

The need for continuous supply of water for irrigation whether from canal, well, pond or lake is realized as the most important for agriculture in ancient period. The different irrigation principles adopted in ancient period are :

- Construction of large mud embankment on a stone foundation for diverting flood water.
- Bulding of small tanks.
- Severe penalty was imposed when water is let out other than sluice gate.
- Extensive tank irrigation systems were adopted in Sri Lanka and later in South India. In Sri Lanka ancient kings practiced that not even a drop of rainfall should go to sea without benefiting man.
- The topography of Telengana region of Andhra Pradesh and Karnataka is ideally suited for the construction of tanks. A special feature of tanks in Telengana tank construction in series, by bunding the same valley at several points and surplus water from lower elevation and so on. Even now the tanks constructed by chola king in the same way exist today in Tamil Nadu.
- It is also suggested that preference of the use of water should be in the order of food crop, vegetables and flowers.

Table 1: History of irrigation development in India

SN	**Period**		**Irrigation development**
1.	Ancient Period	2500 - 1000 BC	People settled near the banks of river / tanks for the purpose of getting water for drinking and irrigation.
2.	Chalcolithic	3000 - 1700 BC	Practice of irrigation to crops was evolved.
3.	Vedic period	1500 - 1600 BC	People employed craftsman to dig channels from rivers to their fields. Well irrigation through kuccha and puccha wells and were practiced
4.	Pandyas / Cholal chera"s Period	(1st Century 300 AD)	Irrigated rice cultivation started during this period. Dams and Tanks were constructed for irrigation.
5.	Medieval period	(1200 -1700 AD)	Irrigated agriculture was developed during Mogul period. Canals, Dams and Tanks were constructed (e.g.) 1. Construction of western yamuna canal 2. Constructions of Anantaraja sagar.

Methods of conserving rain water

In ancient days itself, people, especially Indians, know the methods of conservation of rain water. There are evidences that, even during Harappan period, there was very good system of water management as could be seen in the latest excavation at Dholavira in Kachch. Rain water harvesting structures in the low rainfall areas of Rajasthan, harvesting springs in hilly areas and mountainous region and percolation ponds and tanks in southern India. In Tamil Nadu, the ancient people stored rainwater in public, placed separately one for drinking purposes and another for bathing and other domestic purposses and called them as Ooranies. The various methods of rainwater harvesting are classified below under two category, Traditional and Modern methods. Traditional rainwater harvesting, which is still prevalent in rural areas, was done in surface storage bodies like lakes, ponds, irrigation tanks, temple tanks etc. In urban areas, due to shrinking of open spaces, rainwater will have to necessarily be harvested as ground water, Hence harvesting in such places will depend very much on the nature of the soil *viz.*, clayey, sandy etc. The below listed are the various kinds of traditional rainwater harvesting methods. The Modern methods of rainwater harvesting are categorised under two, they are Artifical Recharging and Rain Water Harvesting. The former is classified into Absorption Pit Method, Absorption Well Method, Well cum Bore Method and Recharge trench cum injection well. The later is categorised into Individual Houses and Grouped Houses which are further classified into Percolation Pit Method, Bore Well with Settlement Tank, Open Well Method with filter bed Sump and percolation Pit with Bore Method.

Bamboo method of rainwater harvesting

In Meghalaya, an indegenious system of tapping of stream and springwater by using bamboo pipes to irrigate plantations is widely prevalent. It is so perfected that about 18-20 litres of water entering the bamboo pipe system per minute gets transported over several hundred metres and finally gets reduced to 20-80 drops per minute at the site of the plant.

Kunds of Thar Desert

In the sandier tracts, the villagers of the Thar Desert had evolved an indegenious system of rainwater harvesting known as kunds or kundis. Kund. Usually constructed with local materials or cement, kunds were more prevalent in the western arid regions of Rajasthan, and in areas where the limited groundwater available is moderate to highly saline.

Groundwater in Barmer, for instance, in nearly 76 per cent of the district‟s area, has total dissolved salts (TDS) ranging from 1,500-10,000 parts per million (ppm). Under such conditions, kunds provide convenient, clean and sweetwater for drinking.

Traditional Rain water harvesting

The traditional rainwater harvesting methods in North India is surface water harvesting methods are viz., Tanka, Nada, Nadi, Talai, Talab, Khadin Sar, Sagar and Samend.

Tanka**:** It is constructed of on farm, country yard and fort. The shape is normally circular / square. Dimension is 2 m dia. 3 m deep capacity 10000 lit

Talai**:** Similar to Tanka, still deeper (2-3cm depth). Special attention paid for selection of location such that there is adequate flow of rain water into Talai

Nada**:** In this method, low lying areas in between hillocks is excavated as pit and provided embankment to arrest rain water from these hillocks.

Nadi**:** Compared to Nada. the Nadi is bigger in size. A village or group of Villages uses the run off water collected in the Nadi.

Talab**:** It is relatively shallow and spread over to more area compared to Nadi. It is generally constructed in rangeland. The catchment area of Talab is 480 ha., can lost for many years.

Khadin**:** Accumulation of run off water in between hillocks is known as Khadin. Khadin means cultivation crops. The khadin water is generally used for crop cultivation and animals.

Sar, Sagar **and** ***Samand*****:** It is used to harvest rainwater for irrigation purpose. Even today this structure provides excellent source of reservoir and also tourist spot.

Weather forcasting

Astronomy – Prediction of rains:

PARASHARA, VARAHAMIHARA PANCHANG

Modern scientific knowledge of methods of weather forecasting have originated recently. But ancient indigenous knowledge in unique to our country. Indian had glorious scientific and technological tradition in the past. A scientific study of meteorology was made by our ancient astronomers and astrologers. Even today, it is common that village astrologers (pandits) are right in surprisingly high percentage of their weather predications. Observation coupled with experience over centuries enhanced to develop meteorology.

The ancient / indigenous method of weather forecast may be broadly classified into two categories.

1. Observational method
    - Atmospheric changes
    - Bio-indicators
    - Chemical changes
    - Physical changes
    - Cloud forms and other sky features
2. Theoretical methods (or) Astrological factors (or) planetary factors
    - Computation of planetary positions and conjunctions of planets and stars
    - Study of solar ingress and particular date of months
    - Study of Nakshatra Chakras
    - Study of Nadi Chakras
    - Dashatapa Siddhanta

Almanacs in Indian astronomy and astrology (Panchangs)

According to the Encyclopedia Britannica (1969), " an almanac is a books or table containing a calendar of the days, weeks and months of the year, a register of ecclesiastical festivals and saint‟s day and a record of various astronomical phenomena, often with weather prognostications and seasonal suggestions for countrymen".

In India, the classical Hindu almanac is known as „Panchang‟. This book published yearly, and is the basic book of the people all over India. For astrologers, it is one daily basis and is extensively used by the people all over India. For astrologers, it is one of the basic books for making astrological calculators, casting horoscopes, and for making predictions. For farmers, it is an astrological guide to start any farming activity.

The word „panchang" has it"s roots in two Sanskrit words, viz., „panch" and „ang", which means „five" and „body part/limb" respectively. These parts are

1. Tithi (or) Lunarday – Total of thirty tithes in a lunar month, fifteen in each fortnight.
2. Vara or week day – seven varas, (Monday-Sunday)
3. Nakshatra (or) asterism (or) constellation – Total of twenty seven nakshtras named according to the yagataras (or) identifying stars of each of the twenty seven equal parts of the ecliptic (or) solar path.
4. Yoga (or) time during which the joint motion of the sun and the moon covers the space of the nakshatra (there are twenty seven yogas).
5. Karana (or) half of a lunar day (or) half – tithi.

The other items considered for astrological prediction are

1. Rashi (or) twelve equal parts of the Zodic belt, hence twelve rashis
2. Planets
3. Solar months and solar year
4. Lunar months and lunar year
5. Era

Theoretical basis of weather forecasting in ancient literature and panchangs

According to varahamihira and other scholars, the formation of clouds (or) garbhadharana takes place 195 days before their birth (or) delivery (or) garbhaprasava. During his period clouds were grouped as Abartak (Avartak), Sambartak (Samvartak), Pushkara and Drona. It abartak is dominating one year, rain will be received in certain places in that year; if sambartak, rain will be received in all of the country; if pushkara, the quantity of will be very less; and if drona, that year will receive abundant rain water.

It is also true even today, the cloud classification indicates Cirrus, Cirrostratus, Cirro Cumulus, Altostratus, Altocumulus, Stratocumulus, Stratus, Nimbo Stratus, Cumulus and Cumulonimbus. Among this Nimbostratus and Cumulonimbus gives rainfall to the earth.

According to the ruling planet of a year, overall rainfall of that particular year should be anticipated as follows:

S.No.	**Ruling planet**	**Rainfall**
1.	Sun	Moderate
2.	Moon	Very heavy
3.	Mars	Scanty
4.	Mercury	Good
5.	Jupiter	Very good
6.	Venus	Good
7.	Saturn	Very low (Stormy wind)

For predicting the monsoon and its subsequent effects on weather, all panchang makers consider three different Nadi Siddhantas (Capsular theories) commonly known as Nadi charkas. These are :

1. Dwinadi charks
2. Trinadi charks
3. Saptanadi charks

Table 2:Arrangement of nakshatras in Saptanadis and its associated effect on weather

Seven nadis	**Effect on weather**
Chanda	Bright sunshine, no rainfall
Vata	Sunshine and wind, normal rainfall
Vanhi	Strong hot wind (Westerlies)
Soumya	Normal rainfall
Meera	Very good rainfall
Jala	Abundant rainfall
Amrita	Heavy to very heavy rainfall causing flood

Prediction analysis and discussion

The analysis indicates that rainfall predictions made in panchangas based on ancient astrological theories are, on an average, better than and in some cases at par with the predictions made by Govt. meteorological department through modern techniques and procedures.(E.g.) The yearly fully corrected predictions of rainfall made during 1946-1955 were 75,78,74 and 75% respectively for different panchangam. The seasonal prediction also indicated that it was 89% for summer, 55% for rainy, 90% for winter and 78% for overall.

Method for measurement of rainfall

The method of measurement of rainfall is described by Varahamihira. A circular vessel with a diameter equal to one (human) arm or the distance measured by the width of 20 (human) fingers and with a depth equal to the distance measured by the width of eight fingers should be accepted for measurement of rainfall. When this vessel is completely filled with rainwater, the rainfall should be equal to 50 palas or one adhaka. This method has been explained by the Parashara.

According to Parashara, the basic unit of rainfall is adhaka.

1 adhaka = ¼ drone (eq.1)

1 drona = 4 adhakas = 6.4 cm (eq.6)

Krishi – Panchang

The researcher developed the Krishi panchang (or) Agroalmanac (or) Agro-panchang. It may be defined as basic astro-agricultural guide book/calendar published annually, giving calendrical information on various aspects of agricultural and allied, activities, basically suggesting region wise, seasonwise and cropwise. Crop strategy based on astro – meteorological prediction, giving auspicious time for undertaking various farm related operations, along with a list for performing religious rites, festivals, observing fasts and some non-astrological agricultural guidance, primarily useful for the farming communities and persons having interest in agricultural development.

The contents of the proposed Krishi-Panchang can broadly be categorized into two kanor groups as fallows :

1. Information which changes every year
    - Annual date and Holiday calendar
    - Month – wise daily guide for the whole year
    - “Rashiphal”, i.e., month-wise forecasting of persons having different zodiac sings.
    - Daily/monthly/annual weather forecasting for the particular year
    - Crop prospects of that year based on planetary positions
    - Season-wise crop strategy based on anticipated weather
2. Information which remains same irrespective of any particular year
    - Theories relating to agricultural and meteorological forecasting
    - Auspicious moments for agricultural and allied activities
    - Some general agricultural guidance

Panchang-making

The content and coverage of the proposed Krishi-Panchang, indicate that only qualified astrologers cannot prepare the whole content on their own, rather an editorial board comprising of both qualified astrologers and crop specialists can do justice. While preparing the Panchang, the – editional board members should keep in mind the following important points :

- The Krishi-Panchang is largely meant for the local farming communities, having very low educational status. Hence, it must be in the local colloquial language to facilitate reading and comprehension.
- Care should be taken to make the Krishi-Panchang easily understandable and clear in its meaning.
- It should be very comprehensive in its content and coverage with proven predictive information only.
- It should not contain any astrological details or complexities which would go beyond the understanding capability of our less educated farmers and agriculturists.
- It should be attractive in colour, and presentation of information should be systematic according to season (kharif, rabi, and summer) and crops.
- It must be low-priced/nominal-priced, within the affordable range of small and marginal farmers.

More important, is, the must be made available to the farmers and needy persons sufficiently in advance, i.e., at least 1-2 months before the start of the agriculture year (July-June).

Local knowledge used to predict drought and weather pattern

Table 3:Drought prediction and mitigation

SN	Predictors/Signs	Description
1	Pigeon feathers	Pigeon lying on the ground by spreading its feathers, the

		indication of drought
2	Sound of wild cat	If the wild cat make sound with *Dhul*/*Mul* and people as to
		the wild cat and response with *dhul* then drought may occur
3	Ants upward movement	If ant starts to move upward from down, rain may come
4	Red colour in the west	If the sky shows bright red colour in the west sky during
	Sky	sunset, drought may ome in the following year
5	Sun lights kid	If sunny days show illusion like *roder bachha*, drought may
		occur
6	Thunder in the east sky	If frequent thunder happen in the east sky at night. This
		indicates drought in the next year
7	Abundance of termites	When large number of termites found in the mound, drought
		is the immense issue for the year
8	Visibility of black ant	Appearance of black ants and storing grain and eggs in safer
		places indicate that the rain follows for the couple of days
9	Hoppers fly	If hopper fly randomly, drought may occur
10	Dark clouds in the west	The appearance of dark clouds on the west, the immediate
	Sky	hail storm accompanied by thunder, lighting and kalboishakh
11	Chirping of Fatik bird	The chirping of Fatik bird during October to April is a sign
		of rainfall
12	Rainbow	If rainbow come in the eastern sky, there would be chance of
		drought and if it comes in the western sky that indicates sure
		rains

Table 4. Local knowledge used to reduce drought impact and extreme weather

SN	Practice		Description
1	Frogs marriage		Arrange marriage for the frog to invite immediate rainfall to end the
			drought
2	Use mulch		Farmers were used straw and water hyacinth as the mulch materials
			in the horticultural production at their homestead to protect drought
			impact on production
3	Orchard		Farmers were established mango orchard at their homestead and the
	establishment		crop field to mitigate drought impacts as a whole
4	Planting trees		Long back peoples in the area were planted trees especially palm
			trees to protect drought and its impacts as a whole
5	Short	term	Farmers alone or along with family members were migrated to the
	mitigation		urban areas for livelihoods and return to the home after drought
			effects
6	Home gardening		Peoples started vegetable gardening in their homestead to protect
			drought impact on agricultural production

Local Farming Knowledge in India

Presently, the loss of biological diversity and erosion of traditional knowledge systems (TKS) are issues of great concern. Most of these systems of knowledge are unique and are often known only to a few individuals or communities**.** This traditional knowledge includes mental inventories of local biological resources, animal breeds, local plant, and crop and tree species. Traditional knowledge may include information about trees and plants that grow well together, about indicator plants that show the soil salinity, or are known to flower at the beginning of the rains. It includes practices and technologies, such as seed treatment and storage methods, and tools used for planting and harvesting. Traditional knowledge encompasses belief systems that play a fundamental role in people's livelihood, maintaining their health, and protecting and replenishing the environment. and value which include traditional knowledge.

The following traditional agro ecosystems were adapted to minimize crop loss due to insect and pests:

(a) *Ploughing*, hoeing and basin preparation to influence soil inhabiting pests through “microclimate manipulation”, e.g. goat droppings burnt along with dried *Euphorbia spp.* to maintain a smoke blanket layer throughout the night arresting the pathogenic activity,

(b) *Intercropping* of diverse plant species to provide habitats for the natural enemies of insect pests as well as alternative host plants for pests, and also to prevent competition of crops from weeds,

(c) Shifting cultivation that helped the easy migration of natural pest predators from the surrounding forest,

(d) Genetic diversity of cropping systems followed to delay the onset of diseases and reduce the spread of disease-carrying spores, and modify environmental conditions less favorable to the spread of certain diseases,

(e) Practice of integrated crop-livestock systems to balance the biomass and nutrient inputs and outputs.

Examples of traditional knowledge and practices

Animal healthcare practices

- Hot soup of Cumin and garlic being analgesic and antipyretic fed to animals affected by fever and cold.
- Use of bark of belly tree/crushed leaves of karnu tree as antiseptic for speedy healing.
- Mixture of ash of Burning grass (*Jawanlari)* and black cloth along with oil fed to cows to cure dysentery.
- Mixture of sulphur and mustard oil for prevention and control of skin diseases.
- Use of bamboo leaves and bark boiled with paddy husk and fed to cows for expulsion of placenta.
- Treatment of diarrhea with leaves of *Leucas lanata* (*Safeda*) and bamboo leaves.
- Traditional moulting practices - Dipping in water, applying ash and mud, quarantine the birds to dark locations in separate mini huts, fixing feathers on to the beak followed for
- shedding and regrowth of feathers and rejuvenation of poultry birds.
- Use of garlic *(Allium sativum) and* vinegar for deworming.
- Juice of marigold/ *Annona squamosa* leaves to kills maggots and heal wound.

Plant protection and Post-harvest management

- Packaging of food commodities using containers made of bamboo sticks and internally lined with cow dung for grains, potato, maize cobs, etc or lime and sand for millets.
- Use of neem/mint/walnut/*sweet flag* leaves/*Pongamia pinnata* as antimicrobial agent for grain storage.
- Storage of pulses by mixing with turmeric powder or mustard oil.
- Storage for seed crops in under ground pits dug in fields with a pitcher and covering the top of pit with ash and soil to create zero energy cool chambers.
- Pickled mango, lime, etc. packed in sterilized earthen pots using fumes generated from burning red chilies along with *Asafoetida* and mustard oil.
- Storage of cabbage, ginger was done under ground pits which provided cool condition for storage ensuring freshness for prolonged use.
- Storage of sugar/jaggery in large earthen pots with top cover made of wood.
- Enhancement of shelf life of fruit and vegetables by wrapping in moist gunny bags.
- Use of smoke for protection of fruit crops from frost damage.
- Practice of applying a thin paste of cow dung, clay and cow urine to pruned ends of twigs and cuts to prevent access to pathogens.
- Use of wood ash on vegetables to ward off pests and to enhance nutrient status of soil.
- Use of kerosene oil to kill stem and shoot borers.
- Use of powder of leaves and pods of *Mucuna prurita* to reduce rat damage to the crop.
- Use of crushed seeds/extracted oil of castor against Rhinoceros beetle, Nematodes infestation in coconut, Pulses and cereal seeds.
- Use of chilies and other hot peppers powder against caterpillars, flies, aphids, ants and other pests of vegetables.
- Use of Pulses soaked in whey to prevent wilting.
- *Euphorbia neriifolia* milk for seed protection of various crops like paddy, castor, pearl millet, maize and Sorghum.

Weather forecasting

- Presence of visible spectrum with a greater diameter around the sun than around the moon, indicates rainfall after a day or two.
- On a hot summer day cry of the bird called *Nailu* for water brings rainfall.
- If centipedes emerge from their holes carrying their eggs in swarms an early rainfall is predicted.

- If Dragon fly swarm in a large group over water surface a dry weather is predicted, if they swarm over open dry lands then early rainfall is predicted.
- If the first 10-15 of the month May-June are very hot a good rainfall is predicted.

Sustainable natural resources management

- Indigenous techniques of harvesting honey and beeswax from bees, using various
- indigenous styles of hives.
- *Polygonum hydropiper* Linn. (Smart weed) used as fish toxicant for catching fish from natural aquatic resources as well as for removal of uneconomical fishes from the
- aquaculture pond.
- Mollusc shells-*Anadara granosa* (*Khola)*, *Meritrix meritrix* (*Gondhi*), *Meritrix casta.* (*Pati*) and *Ceritidea cingulata* (*Genda*) traditionally used for lime preparation.
- Inhibition of bacterial growth in milk by keeping under the pyramids made out of natural materials as wood.
- Use of indigenous fishing instrument *Polo* for capturing fishes in low water raising.
- *Alnus nepalensis* cultivated in *Jhum* in Nagaland has multiple usages as a nitrogen fixing tree, as fodder and timber, and retains soil fertility.

Soil and water management

- Construction of *kuhls*/wooden water channels/ *Virdas*/*Khadins* for irrigation.
- Drip and pitcher irrigation in areas with scanty rainfall.
- Use of bamboo channels with small holes made at the internodes for water trickling.
- Roof water harvesting and collection of water in dug out structures (Wells, *Bawdi*).
- *Sorangas* in Karnataka in the lateritic regions to tap the moisture trapped in the large sand depositions, *Ahar-pyne* traditional irrigation system in Bihar
- Harvesting of dew and fog water.
- Conservation of soil moisture by mulching: Wet soil mixed with seeds of rye (*Brassica nigra*) is placed inside the holes left between the stones of terrace risers for minimization of water need for germination and use of the unused space of terrace riser for vegetable cultivation.
- Earthen bunds made of different materials like stones and sticks, *Kana bundi* using the crop residue, *Vetiver zizaniodes* grass for controlling soil erosion.
- Methods used for improvement in soil fertility by burning *Butea monosperma* and *Madhuca indica*) leaves and branches, cultivation of crops with trees such as *Sesbania grandiflora*, *Leucaena lecocephala* or other leguminous plants, local weeds.
- Indicators to assess the fertility of soils by better growth of weeds like *Setaria tomentosa* in light soil, vigorous growth of *Desmostachya bipinnata* and *Cenchrus spp*, *Echinochloa*
- *colonum* growth for better paddy yield.

Indigenous seed conservation and preservation

Conservation of seed is the conservation of planet (*Srishti*). Seed contains the basic DNA, which is capable to produce the plant of the same kind. For protection of seed material, the practices of our ancestors are evident from pre-historic, historic and *vedic* periods. Storage of seed in cylindrical pits dug in earth or in granaries or in containers made of ropes and plastered with mud or in well baked clay pots, scaring away birds with sling balls, initiation of mixed cropping technique, controlled use of water irrigation in fields, etc. are the some specific practices found in use during these periods. Many examples of crop and seed protection such as making din and noise for bird scaring in maize fields, setting traps or digging pits and fix traps in the fields to keep away the wild animals. Use of cow dung, milky juice of *Solanum indicum*, coconut water, *Emblica ribes*, cow urine and *ghee* (butter oil), etc. for treatment of seed material were practiced during vedic era. For control of pulses bruchid (*Callosorbruchus chinensis*) the oil of *Mentha spicata*, or *M. arvensis* or *M. piperita* was found very useful. Gunny bags are used for bulk storage of cowpea (*Vigna unguiculata*) seeds. For prophylactic treatment, these bags are soaked in 15% concentration of leaf extracts of *Pongamia pinnata* or *Justicica gendarussa.*

The use of wooden and cow dung ash and red baked soil as seed dresser because the quantity of silica in these might have deterred the egg formation and larvae feeding. The use of ash and soil as indigenous pesticides is reported in so many literatures. Similarly the uses of *Vitex negundo, Azadirachta indica*, *Eucatyplus* are very common and effective treatments. The uses of various plant parts as storage pesticides, because these plant parts emit a pungent type smell. This is because of availability of essential oil in the plant parts. The emission of a kind of smell acts as a repellent of insect and deters their survival.

*N*eem (*Azadirachta indica* A. Juss) contains meliacin, nimbin, nimbinene, nimbandiol and azadiractin, walnut (*Juglens regia* L.) leaves contains ascorbic acid, carotene and juglone. *Bakayan* (*Melia azadirachta* L.) contains meliacin, turmeric (*Curcuma longa* L.) contains phenolic compound known as curcuminoides, lemon (*Citrus limon* L.) contains lemon oil, citric acid and pectin and mustard oil contains allyal isothiocynate. All these substances found in the above plant materials have been reported to be antifeedants against several pests.

Table 5: Plant parts and other materials used for seed/grain protection

S N	Materials used for pest control	Crops	Types of material
1	*Bach* (*Acorus calamus* L.); rhizome and leaves	Cereals and pulses	Seeds and grains
2	Peach (*Prunus persica* L.);leaves	Cereals and pulses	Seeds and grains
3	Neem (*Azadirachta indica* A. Juss); leaves	Cereals, oil seeds and pulses	Seeds and grains
4	*Timur* (*Zanthozylum armatum* DC.); leaves	Cereals, pulses and oils seeds	Seeds and grains
5	Walnut (*Juglens regia* L.); leaves	Cereals and pulses	Seeds and grains
6	*Bakayan* (*Melia azadiracta* L.); leaves	Cereals and pulses	Seeds and grains
7	Turmeric (*Curcuma longa* L.); leaves	Cereals and pulses	Seeds and grains
8	Lemon (*Citrus limon* L.); leaves	Cereals and pulses	Seed and grains
9	Wooden ash	Wheat, barley and	Seeds
10	Cow dung ash	Cereals	Seeds
11	Cow dung + cow urine	Cereals and pulses	Seeds
12	Kerosene oil	Pulses	Seeds
13	Lime powder	Pulses	Seeds
14	Mustard oil	Pulses	Seeds and grains
15	Red roasted soil	Cereals and pulses	Seeds

Local farming knowledge in Gujarat

Traditional knowledge in food and fibre

Tribals in south Gujarat region use more than 43 species as fodder plants. Fibers are extracted from varied sources by the tribals. The people of the coastal region extract fibers from palms. In forest areas, fiber-yielding trees like *Combretum ovalifolium*, *Butea parviflora* and *Derris scandens* are used for ropes. Roots of *palash* are also woven into ropes. In Dangs, ropes made from fibers extracted from the leaves of *Ketki* are durable and used for tying cattle, as these ropes do not hurt their skin. Kotwalia community is specialised in making decorative bamboo artifacts.

Traditional Grain Storage Structures in Gujarat

Kothi: These storage containers, mostly known as *Kothi* are made out of leaner bamboo strips. Weaving patterns depend upon thesize of the grain to be stored. They are known by different names in different parts of the state such as *Mosti* (pic. h) in Vadodara and Chhotaudepur districts, *Porsi* and *Porso* in Panchmahal and Dahod districts, *Kothi* in Sabarkantha, Vadodara, Narmada, Tapi, Surat, Valsad and Dang districts. The outer surface of the storage structure is generally covered with fine mixture of loam, cow dung and husk. It prevents spillage and strengthens the storage structure.

Folding Kothi: A few communities in Dang district use folding grain storage containers. They look like carpets weaved using leaner bamboo strips only. These carpets are rectangular in shape but they have two bamboos weaved at their ends, what seems like these bamboos are knotted together, which makes a cylinder to store grains . This kind of grain storage structures are almost 6 feet tall and 200 kg to 250 kg grain storage capacity and have no permanent base or lid. Just like other *Kothi*, it is also covered entirely with fine mixture of loam, cow dung and husk. Top is also covered with dry *Tectona grandis* L leaves and sealed with fine mixture of loam, cow dung and husk.

Nagli ni kothi (Kothi for Eleusine coracanaL): Nagli (*Eleusine coracana* L) and Vara (*Panicum sumatranse* Roth) are lesser known cereal crops planted mostly in central and south Gujarat. These grains are very small in size hence, stored in very complexly woven storage containers. These containers are smaller in size, almost 2 feet tall, and dome shaped with flat base, movable and light weight.

Kanthi ni Kothi (Kothi made of Nyctanthes arbortristis L): All the above mentioned storage containers are made either from *Dendrocalamus strictus* (Nees) or from *Bambusa arudinacea* (Willd). But there are a few locations where the local inhibitors use plants apart from bamboo to make grain storage containers. *Bhils* from Sabarkantha district use *Nyctanthes arbortristis* L to make almost 8 feet tall cylindrical grain storage containers.

Dudhi ni Kothi (Kothi made of Wrightia tinctoria RBr): Some tribes of Vadodara, Chhotaudepur and Narmada districts use *Wrightia tinctoria* R Br twigs to make huge cylindrical grain storage structures. Due to the high amount of latex present in the plant makes the containers termite resistant. These *Kothi* are usually 5 feet tall and mounted on a platform made of mud and interwoven fresh twigs of *Wrightia tinctoria* R Br.

Gara ni Kothi (Kothi of Mud): Kutch is the far North-Eastern district of the state with diffused scrub forest and arid to semiarid climatic conditions. It is difficult to find resources like *Dendrocalamus strictus* Nees or *Bambusa arudinacea* (Retz) Willd naturally in Kutch due to the climatic conditions. Hence, residents of this district have come up with a solution of storage structures majorly made of mud. These storage structures are made of loam, donkey dung, wheat husk, and yellow salty clay typically found in Kutch.

Gara ni char-paiee Kothi (Four legged Kothi of Mud): Dwellers of Sabarkantha district use this kind of storage structures which are difficult to make as compared to the structures made of Bamboo. They are entirely made of loam, cow dung, and wheat husk and very heavy in weight yet movable. These structures are cylindrical in shape, almost 5 feet tall with a huge intake at the top to pour grains in and four legs at the bottom which keep the storage container elevated from the ground. These storage structures are highly durable and used for generations.

Dangar ni Kundi (Kundi for Paddy storage): These storage structures are reported form Sabarkantha district which are used to store paddy. They look like *char-paiee Kothi* and made of loam, cow dung, and wheat husk but small in size with a huge intake at the top and three or four legs at the bottom which keeps the storage elevated from the ground. They are 1-1.5 feet tall, movable and long-lasting.

Methods of Grain Preservation

Many domestic grain storage practices are followed in Gujarat. Most of them have one or more ecofriendly natural resource used to store grains round the year.

Castor Oil: It is the most common practice followed in which sundried grains are smeared with a little amount of castor oil. Wheat, Rice, and a variety of pulses are stored using castor oil. Excess amount of castor oil changes the natural taste of grain and so it is made sure that the seeds are just smeared with oil. Almost 1kg oil is needed to preserve 100kg of grains.

Leaves of Azadirachta indica A Juss: Dried leaves of *Azadirachta indica* A Juss are mixed with sundried grains and stored into traditional storage containers. This practice is common in most areas of the state. Aspiration cleaning is must before using seeds. *Bhils* of Central Gujarat use *Azadirachta indica* A Juss leaves in a different way, by adding dried leaves of *Azadirachta indica* A Juss to the mixture of loam, cow dung and husk which is used to cover inner and outer surfaces of storage containers which provides protection against pest.

Leaves of Calotropis procera (Ait): Fresh leaves of *Calotropis procera* (Ait) are collected and dried in shed. These leaves are spread on the inner surface of the storage containers such a way that they cover the whole inner surface of the container.

Para ni Thepli (Dice made of Mercury)

This is an interesting technique which includes a heavy metal – Mercury. Take 100gm of Fuller‟s earth (Multani Mitti), 200gm of clay and 200gm of dried cow dung powder. Mix it well and add 10ml of Mercury in it. Then add some water and make dough. Make small round shaped *thepli* (dices) out of this dough and sundry them. Put almost 50 of such *thepli* with every 100 kg of grains. This *thepli* can be used for 10 to 15 years.

Cow dung ash

Cow dung is burned on a clean surface and ash is collected. This ash is mixed with grains while storing them in the storage containers. For that a 3 inch layer of ash is made at the bottom of the container. On which, almost 10 inch of layer is made of the grains. Then againa 3 inch layer of ash is spread over. Whole structure is filled with grains and ash likewise, layer by layer. Aspiration cleaning is must before using seeds.

Other Storage practices

Bamboo shoots preservation
Hibiscus sabdariffa L leaves preservation Earthen
vegetable preservation Preservation in Salt
Fruit preservation in saltwater

Fishing ITK in Gujarat

Saurashtra peninsula is the major fishing area of the state. It consists of seven districts namely

Amreli, Bhavnagar, Jamnagar, Surendranagar, Junagadh, Rajkot and Porbandar. Saurashtra region occupies about 50 percent of state,s coastline, and accounts for more than 70 percent of fish production of Gujarat state. Fishing has therefore become a flourshing industry in this area . The detailed description of the ITK"s collected from Saurashtra region of Gujarat are given below.

Catching whale shark by trawlers: This method is known to all trawlers from Porbandar to Jaffrabad. The shark fins, oil from liver, and flesh had fetched good returns for these fishermen.

Wooden wada fish catching technique: This is an age old technique in vogue by the traditional fishermen of Jamnagar district. Mostly the catch consists of Sciaenids.

Fish harvesting by stone wada: This is an age old technique for catching fish. The catch comprises miscellaneous varieties, and ensures fish for family and the surplus is sold in the local market. The bigger varieties are iced and sold in nearby cities.

Mechanically shocking the fishes: Wherever there are rocky coasts with puddles, traditional fishermen usually go for single line hooking. If the place does not fetch any hooking, then the fishermen move to the next nearby area. While walking through intertidal areas, he may come across such puddles in which fishes may be there. Usually children of these fishermen scout these areas, & they have been observed to carry out this operation. For the poor fishermen, catching of these fishes does add to their bread basket.

Indian Sea bass catch from underneath boulders on coast: The fishermen who operate hook & line carry out this operation when they move along a rocky coast line. This operation has been observed in Beyt Dwarka & Mithapur. Indian sea bass being a priced fish, and the fish usually caught being of a big size, this method cannot be avoided by the scouting fishermen.

Extracting Solen from muddy coast: When wooden wada fishermen go for collection of fish in the wada, both to & fro, they need to walk on such areas, where these Razor Clams are found. By this method, they can remove the animal from its daily fishing path, & forms their food.

Catching sand crab Description of the ITK: Sand crabs live in sandy beaches often digging burrows in sand move quite fast and bigger ones which is to be caught when gets inside burrows with sandy beaches is packed with dry sand. When excavated, the dry sand can be distinguished from wet sand which when dug up and then the crab can be found at the end of the dry sand channel.

Cast netting of inshore sepia: This technique has been in use by Veraval fishermen and the same technique (without the use of petromax) is used by Miyani fishermen for cast netting oil sardines from near shore waters through dugout canoes.

Natural thermal fatality: Fishermen know that at particular time of the year, the air as well as the seawater temperature gets to higher levels by mid day, and this kills the fish near costal waters.

Traditional water harvesting techniques

In Gujarat, the traditional water harvesting techniques has been revived and 35 other Villages of Amreli district are known for their hard, rocky terrain on account of their peculiar geological features. These areas could not conserve rain water. However, the situation has been changed by raising dykes to check rain water along with the putting up of check dams and percolation tanks. Water and famine in these perpetually drought prone rural areas of Gujarat has become a thing of the past with flourishing green farmland fields one from all side.

The *Tanka* of Bharuch.

The Zoroastrians are believed to have brought the concept of harvesting water from ancient Iran to Bharuch. The „Tanka" is an underground tank, accommodated inside the house, made of chiseled blocks of stone, in lime mortar. It is made waterproof by an indigenous herbal mix, which seals minor cracks and prevents bacteriological growth inside the Tanka. The size of the Tanka is large enough to store sufficient drinking water for a family for six to eight months. An average storing capacity of the Tanka is around 25,000litres. When required to be cleaned, Tankas must be emptied manually, they are large enough for people to enter and work inside.

The Tanka feeds on the rainwater collected through roof runoff. A simple system of collection, via a 3″ to 4″ pipe, depends on successive sumps whose water is collected, while settled impurities are flushed out through an overflow pipe. The Tanka has a hatch cover, which is kept closed except for the time when water is needed. The water retention capacity of these Tankas is seen in the form of a particular „danger level" indicated inside the tank by the depiction of a sculptured „fish". Filling above this mark was considered dangerous as the hydraulic pressure inside may well exceed the retaining capacity of the tank wall. Most owners clean the Tanka only once in 5 to 10 years. The water quality of the Bharuch Tankas has been tested and found to be potable by W.H.O. standards.

Virda

Virdas yield fresh water in the region where the groundwater and soil are highly saline with salinity levels reaching as high as 98000 *ppm*. *Virda* is a traditional water harvesting system found in the Banni area of Kutch‟s district and in the Northern-western Banaskantha and Sabarkantha‟s districts as well as in some places of the Northern Gujarat. The region is characterized by arid conditions with a day temperature‟s range going from 10° C to 50° C, meaning an annual rainfall of about 300 mm in short and intensive spells.

Virda yields fresh water for two up to three months per day and yields about 1000 liters. It is abandoned when the water gets salty. The V*irda*‟s durability depends on the intensity of its exploitation as well as water holding capacity of an open tank. The duration of use varies from 20 days to four months. It gradually becomes saline. When tanks are full during monsoon, these *Virda* get plugged by silt and debris, but can be easily revived by clearing these. Runoff water collected in the natural depressions and artificially excavated tanks provide pastoral-communities with water during and after the monsoon. Water stays in these tanks for a maximum period of three months.

Lime treated Drinking Water

In Parwada and Gorimja (Jamnagar) such a traditional technology has been serving more than 10000 people for the last 300 years. Indigenous people used lime for water treatment. For this, they used pots made of soil powder filled with lime and covered the mouth with a piece of cloth. Then, they used to put the pots in tank and the lime used to leach out slowly through the pores of the vessel and, thus, purifying the water. Nowadays, some people put 3-4 lime packets of 1-2 kilogram each depending upon the size of the underground tank. These packets are lightly pierced so that lime leaches out slowly. The packets are replaced by fresh ones for more effectiveness and sometimes chlorine, too, is used for the same purpose. According to those analyses on drinking water treated with lime, two sources in Parwada village were selected; *i.e.* Tank water and pot water. Two water samples were tested on the same parameters.

Chapter 3. Relevance of heritage to present day agriculture, past and present status of agriculture and farmers in society

Kautilyas Arthasastra

Kautilya (also known as Vishnugupta or Chanakya) (321-296 BC) was a great scholar of time. He wrote a treatise titled, Artha-sastra, which deals with the management of resources. During Kautilya's time agriculture, cattle breeding and trade were grouped into a science called varta. Kautilya gave great importance to agriculture and suggested a separate post of head of agriculture and named it as Sitadhakashya. Agriculture today receives prime importance, by policy and administrative support from government officials. eg. i) Supply of good seeds and other inputs ii) Provision of irrigation water iii) prediction of rainfall by IMD iv) Assistance in purchase of machineries v) Marketing and safe storage. All the important aspects are mentioned by kautilya in his book. He suggested many important aspects in agriculture which are highly relevant today.

1. The superintendent of agriculture should be a person who is knowledgeable in agriculture and horticulture. There was a provision to appoint a person who was not an expert but he was assisted by other knowledgeable person. This is applicable even today, appointment of the directors of agriculture, horticulture are sometimes civil servants assisted by technical persons.
2. Anticipation of labours by land owners before sowing. Slaves and prisoners were organised to sow the seeds in time. He also emphasized that thorough ploughing provides good soil texture required for a particular crop. Even today farmers in Punjab hire labours from Bihar at times of heavy demand period.
3. Timely sowing is very important for high yield particularly for rainfed sowing for which, all the implements and accessories have to be kept ready. Any delay in these arrangements received punitive action.
4. Kautilya suggested that for getting good yield of rainfed crop, a rainfall of 16 dronas (one drona=40 mm to 50 mm) was essential and 4 dronas rainfall is sufficient for rice. It is very significant to note that rain gauge was used during Kautilya's period. It was apparently a circular vessel (20 fingers width, 8 fingers width depth) and the unit to measure rain was adhaka (1 adhaka=12 mm approx.)
5. He also stressed the optimum distribution of rainfall during crop growing season one third of the required quantity of rainfall falls both in the commencement and closing months of rainy season (July/Aug; October/Dec) and 2/3 of rainfall in the middle (August/ Sept.; October) is considered as very even. This concept is applicable even today i.e. even distribution is essential for rainfed crop.
6. The crops should be sown according to the change in the season. eg. Sali (transplant rice), Virlu (direct sown rice), till (Sesame), millets should be sown at the commencement of rain. Pulses to be sown in the middle of season. Safflower, linseed mustard, barley, wheat to be sown later. It is clear that even today our scientific results prove that cereals, millets were sown early and oilseeds, wheat, barley require less water which could be sown at last or as post rainy season.
7. He also stressed that rice crop require less labour expense vegetables are intermediate, and sugarcane is worst as it requires more attention and expenditure. It is true even today after 2000 years the situation has never changed that sugarcane requires heavy labour and expenditure.
8. The crops like cucurbits are well suited to banks of rivers, Long-peper, sugarcane and grapes do well where the soil profile is well charged with water. Vegetable require frequent irrigation, borders of field suited for cultivation of medicinal plants. Even today the practice of growing cucurbit (Watermelon, pumpkin) on river banks continue from river Ganges north to Pamba river in south. This is an outstanding example of sustained practice, which ensures utilization of moisture available in river bank.
9. Some of the biocontrol practices suggested by Kautilya has got relevance even today. They are:

a) Practice of exposing seeds to mist and heat for seven nights. These practices are followed even now in wheat to prevent smut diseases. Soaking of seed in water to activate fungal mycelia and drying the seed under hot sun to kill the fungal.

b) Cut ends of sugarcane are plastered with the mixture of honey, ghee and cowdung. Recently evidences proved that honey has widely an antimicrobial property. Ghee could seal off the cut ends prevent loss of moisture and cowdung facilitated biocontrol of potential pathogens.

10. He also suggested that harvesting should be done at proper time and nothing should be left in the field not even chaff. The harvested produce should be properly processed and safely stored. The above ground crop residues were also removed from fields and fed to cattle.

Trade and Marketing (Economic policies)

All the industries were categorized into two groups according to their ownership. One group of key industry was covered by state and another group by private. It is interesting to note that this policy resembles today's model mixed economy. The production, distribution and consumption of agricultural produces were well controlled by the king. Agriculture was placed in the category of privately owned industries. The state Government should control and regulate all the economic aspects and evade the influence of market forces and private interests. These practices suggested by Kautilya were followed by Indian farmers for over centuries which are more sustainable and relevance to scientific agriculture.

Physical geography of Indian Sub Continent past and present

Geologically, the Indian subcontinent was first a part of so-called "Greater India", a region of Gondwana that drifted away from East Africa about 160 million years ago, around the Middle Jurassic period. The region experienced high volcanic activity and plate subdivisions, creating Madagascar, Seychelles, Antartica, Austrolasia and the Indian subcontinent basin. The Indian subcontinent drifted northeastwards, colliding with the Eurasian plate nearly 55 million years ago, towards the end of Paleocene. This geological region largely includes Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. The zone where the Eurasian and Indian subcontinent plates meet remains one of the geologically active areas, prone to major earthquakes. The English term mainly continues to refer to the Indian subcontinent. Physiographically, it is a peninsular region in south-central Asia delineated by the Himalayas in the north, the Hindu Kush in the west, and the Arakanese in the east. It extends southward into the Indian Ocean with the Arabian Sea to the southwest and the Bay of Bengal to the southeast. Most of this region rests on the Indian Plate and is isolated from the rest of Asia by large mountain barriers. Whether called the Indian subcontinent or South Asia, the definition of the geographical extent of this region varies. Geopolitically, it had formed the whole territory of Greater India, and it generally comprises the countries of India, Pakistan, and Bangladesh. Prior to 1947, most of the Indian subcontinent was part of British India. It generally includes Nepal, Bhutan, and the island country of Sri Lanka and may also include the island country of Maldives. The geopolitical boundaries of Indian subcontinent, according to Dhavendra Kumar, include "India, Pakistan, Bangladesh, Sri Lanka, Nepal, Bhutan and other small islands of the Indian Ocean". Maldives, the small archipelago southwest of the peninsula, is considered part of the Indian subcontinent. Parts of Afghanistan are sometimes included in Indian subcontinent as, states Ira M. Lapidus – a professor of History, it is a boundary territory with parts in Central Asia and in Indian subcontinent. Given the passage difficulty through the Himalayas, the sociocultural, religious and political interaction of Indian subcontinent has largely been through the valleys of Afghanistan in its northwest, the valleys of Manipur in its east, and by maritime over sea. More difficult but historically important interaction has also occurred through passages pioneered by the Tibetans. These routes and interactions have led to the diffusion of Hinduism and Buddhism, for example, out of the Indian subcontinent into other parts of Asia, while Islam arrived into the Indian subcontinent through Afghanistan and to its coasts through the maritime routes.

Following is the history of India through the Ages

The Pre Historic Era

The Stone Age:

Began 500,000 to 200,000 years ago and recent finds in Tamil Nadu indicate the presence of the first anatomically humans in the area. Tools crafted by proto-humans that have been dated back to two million years have been discovered in the North-western part of the country.

The Bronze Age:

3300 BCE with the early Indus Valley Civilisation. One of the world's earliest, urban civilisations, along with Mesopotamia and Ancient Egypt. Inhabitants of this era developed new techniques in metallurgy and handicraft and produced copper, bronze, lead and tin.

Early Historic Period

Vedic Period: The Aryans were the first to invade the country. They came out of the North in about 1500 BC and brought with them strong cultural traditions. Sanskrit, one of the most ancient languages spoken by them, was used in the first documentation of the Vedas. The Vedic era in the subcontinent lasted from about 1500-500 BCE, laying down the foundation of Hinduism and other cultural dimensions of early Indian society. The Aryans laid down Vedic civilisation all over North India, particularly in the Gangetic Plain.

Mahajanapadas: This period saw the second major rise in urbanisation in India after the Indus valley Civilisation. The word "maha" means great and the word "janapada" means foothold of a tribe. In the later Vedic Age, a number of small kingdoms or city states had mushroomed across the subcontinent and also find mention in early Buddhist and Jain literature as far back as 1000 BCE. By 500 BCE, sixteen "republics" or Mahajanapadas has been established, namely; Kasi, Kosala, Anga, Magadha, Vajji (or Vriji), Malla, Chedi, Vatsa (or Vamsa), Kuru, Panchala, Matsya, Surasena, Assaka, Avanti, Gandhara, and Kamboja.

Persian and Greek Conquests: Much of the Northwest subcontinent (currently Afghanistan and Pakistan) came under the rule of the Persian Achaemenid Empire in C. 520 BCE under the rule of Darius the Great and remained so for two centuries. In 326 BCE, Alexander the Great conquered Asia Minor and the Achaemenid Empire, when he reached the Northwest frontier of the Indian subcontinent he defeated King Porus and conquered most of Punjab.

Maurya Empire: The Maurya Empire, ruled by the Mauryan Dynasty from 322-185 BCE was a geographically extensive and mighty political and military empire in ancient India, established in the subcontinent by Chandragupta Maurya in Magadha (present-day Bihar) and it further thrived under Ashoka the Great.

Ancient India Timeline

Prehistoric Period: (400000 BC - 1000 BC): The period when man, basically a food gatherer, discovered fire and wheel.

Indus Valley Civilisation: (2500 BC - 1500 BC): Derived its name from the river Indus and thrived on agriculture and worshipped natural forces.

Epic Age: (1000 BC - 600 BC): The period saw the compilation of the Vedas, distinction of Varnas in terms of Aryans and Dasas (slaves).

Hinduism and Transition: (600 BC - 322 BC): As caste system became more rigid, the period saw the advent of Mahavira and Buddha who rebelled against casteism. Mahajanapadas were formed - Magadha under Bimbisara and Ajat Shatru and Shisunanga and Nanda dynasty.

The Mauryan Age: (322 BC - 185 BC): Founded by Chandragupta Maurya, the empire encompassed the entire North India and Bindusara further extended it. After fighting the Kalinga war, Ashoka embraced Buddhism.

The Invasions: (185 BC - 320 AD): The period saw the invasion of Bactrians, Parthians, Shakas & Kushans, opening of Central Asia for trade, issuance of GOLD coins and introduction of the Saka era.

Deccan and South India: (65 BC - 250 AD): The southern part was ruled by Cholas, Cheras and Pandyas This period is known for construction of Ajanta and Ellora cave temples, Sangam literature, and arrival of Christianity to India.

The Gupta Dynasty: (320 AD - 520 AD): The Gupta dynasty founded by Chandragupta I, ushered in classical age in north India with Samudragupta extending his kingdom and Chandragupta II fighting against Shakas. Shakuntalam and Kamasutra were written during this period, Aryabhatta achieved feats in Astronomy and Bhakti cult emerged.

Age of Small Kingdoms: (500 AD - 606 AD): The period saw migrations from Central Asia and Iran as Hunas moved to north India. There was rise of many small kingdoms as the North was divided into warring kingdoms.

Harshavardhana: (606 AD - 647 AD): The famous Chinese traveller Hieun Tsang visited India during Emperor Harshawardhana's reign. But his kingdom disintegrated into small states even as Hunas invaded . It was a period when the Deccan and the south became powerful.

The Southern Kingdoms: (500 AD - 750 AD): Empire of Chalukyas, Pallavas & Pandya flourished. Zoroastrians (Parsis) came to India.

Chola Empire: (9th Cent. AD - 13th Cent. AD): Founded by Vijayalaya, the Chola empire adopted a maritime policy. Temples became cultural and social centres and Dravadian languages flourished.

The Northern Kingdoms: (750 AD - 1206 AD): The Rashtrakutas became powerful, Pratiharas ruled in Avanti and Palas ruled Bengal. The period also saw emergence of Rajput clans. Temples at Khajuraho, Kanchipuram, Puri were built and miniature painting started. The period witnessed invasion from the Turks.

The Mughal Empire: In 1526, Babur, a descendant of Timur and Gengis Kahn from Fergana Valler (present-day Uzbekistan) swept across the Khyber Pass and established the Mughal Empire which covered modern-day Afghanistan, Pakistan, India and Bangladesh. The Mughal dynasty ruled most of the Indian subcontinent till 1600; after which it went into decline after 1707 and was finally defeated during India's first war of Independence in 1857.

Colonial Era: From the 16th century, European powers from Portugal, Netherlands, France and the United Kingdom established trading posts in India. Later, they took advantage of internal conflicts and established colonies in the country.

The British Rule: The British Rule in India began with the coming of the British East India Company in 1600 leading to the rule of Queen Victoria. It culminated in the First War of Indian Independence in 1857.

Independence and Partition: Religious tension between the Hindus and Muslims had been brewing over the years, especially in provinces like Punjab and West Bengal, accentuated by the British policy of divide and rule. All through this Mahatma Gandhi called for unity among the two religious groups. The British, whose economy had been weakened after World War-II, decided to leave India and paved the way for the formation of an interim government. Eventually, the British Indian territories gained independence in 1947, after being partitioned into the Union of India and the Dominion of Pakistan.

Post-Independence Period: As many civilizations the Greek, the Roman, and the Egyptian - rose and fell, leaving only ruins, the Indian civilisation and culture remained unscathed. Even wave after wave of invaders descended on the country, founded empires and ruled over its different parts, the indomitable soul of Bharatvarsh could not be subjugated. Today, India marches proudly as the most vibrant republic and largest democracy of the world, an influential nation in South Asia and an emerging global superpower. India is the second largest country in Asia and the seventh largest and second most populous country on Earth. It comprises as much as one third of Asia and supports one seventh of humanity.

Indus valley civilization

In the year 1922, archaeologists dug up a few places in the Indus valley and carried out excavations at Mohenjodara (meaning a mound of dead) in Sind (in Pakistan) and at Harappa on the river Ravi in Punjab. They found traces of a very ancient civilization, which flourished more than five thousand years ago. They observed that the people utilized the pots, utensils and ornaments. These cities were built along the river Indus and hence this civilization is known as Indus valley civilization. It is also known as Harappan culture and occupied the areas stretching from Delhi to Gujarat. During this period the people identified the importance of ploughing for the proper sowing of crop (i.e) soil has to be stirred and seed has to be covered. Ox-drawn wheel cart was used for transport. The people cultivated wheat, barley, gram, peas, sesamum and rape. They also cultivated cotton and also devised methods of ginning, spinning and weaving. Animal husbandry was also given more importance during this period. They domesticated buffalo, cattle, camel, horse, elephant, ass and birds. They utilized them in agriculture and also for transport. The most remarkable discovery in Harappa is the Great Granary used for storing food grain. These grannaries, each 50x20 feet overall, are arranged symmetrically in two rows of six in each row with central passage and 23 feet wide. From the size of the granary it can be concluded that the peasants paid their dues to the Government in kind, used the kinds in granary for payments to employees. The artisans, carpenters and others received their wages in kind from the farmers.

The Vedic civilization

The word "Veda" is derived from "Vid" which means "Knowledge" Veda is the only literary source from which we know about the Aryans in India. Aryans were more prevalent during Vedic time which extends from Eastern Afghanistan, Kashmir, Punjab and Parts of Sind and Rajasthan. The land of Aryans was called land of seven rivers i.e., (Satlaj, Beas, Ravi, Chennab, Jhelum, Indus and Saraswathi). The Rig-veda was the oldest book of Aryans.

Pastoralism

The Vedic Aryans were primarily pastrol. When they settled in the Punjab, they cut the jungles and built their villages. They grazed the animals in jungles and cultivated barley near the houses to protect from wild animals. Vedic people realized the importance of off-season ploughing and they started ploughing as and when the rain was received. The first ploughing of the season was inaugurated amidst much ritual. The plough used was large and heavy. Bullocks and ox were used for ploughing. With regard to irrigation, channels were dug from the rivers.Wells were in use for supply of drinking water and irrigation called kucha wells, which were just holes dug in the ground. Even now such wells are in use in the river rain areas of northern India.

Crops cultivated in Vedic period

In early Vedic period there is no mention of rice and cotton though they were cultivated in Harappa period. In the later Vedic period (1000 - 600 BC) agricultural implements were improved and iron ploughshare also improved. The people possessed the knowledge of fertility of land, selection of seed, seedtreatment, harvesting, manuring and rotation of crops. Barley sesame and sugarcane were the main crops. Cucumber and bottle gourd were also mentioned in Vedic period, Aryans were accustomed to barley diet. Barley is good for men, cattle and horses. Barley is used in Hindu rituals even today. For cloths, wool and cotton were used. The agriculture implements mentioned in vedic literature include the plough (langala – a lase pointed type having smooth handle, Sira - a large and heavy plough).Sickle was used for harvesting and sieves were used for cleaning.

Harappan period:

The Indus Civilization had the first farming cultures in South Asia, which emerged in the hills of what is now called Baluchistan, to the west of the Indus Valley. The farmers took part in the so-called Neolithic Revolution, which took place in the Fertile Crescent around 9000 to 6000 BCE. These early farmers domesticated wheat and a variety of animals, including cattle. In the "Era" terminology, the Neolithic is known as the "Early Food Producing Era".

Early Harappan

The development of these farming communities ultimately led to the formation of larger settlements from the later 4th millennium. Indus valley civilization was composite product of different races who lived and worked together in a particular environment. Mohenjo daro had easy land and water communication; it was the meeting ground of people for different parts of Asia. Farmers had, by this time, domesticated numerous crops, including peas, sesame seeds, dates and cotton, as well as a wide range of domestic animals, including the water buffalo.

Late Harappan

By 2500 BCE, the Early Harappan communities had been turned into urban centers. Thus far, six such urban centers have been discovered, including: Harappa, Mohenjo Daro and Dicki in Pakistan, along with Gonorreala, Dokalingam and Mangalore in India. In total, over 1052 cities and settlements have been found, mainly in the general region of the Ghaggar-Florence River and its tributaries. By 2500 BCE, irrigation had transformed the region.

Vedic period:

The most important people of the Vedic period are Vaishnava. There are four Vedic periods viz., Rig, Sama, Yajur, and Atharvana Vedas. In Rig Vedas period, the farmers occupied more number in the society. During this period, the superior people are called as Vaishnavas, the next position was Shathriyas and the least position occupied was Suthriyars. The Suthriyars are the farmers they cultivated the land and produced agricultural products under the land lord. The farmers status was more in Atharva Vedic period. They cultivated the crops based on the advice of the saints.

Buddhist period:

A food producing economy emerged with the practice of agriculture on a wide scale by using iron implements. There was pleasant proprietorship in rural areas and there were no land lords. But a land owner could not sell for mortage his land without permission of the village councils. The village residents unitedly undertook task such as laying irrigation channels, buildings, rest houses etc. the women extended their full co operation in their works (public utility). He whole of each village was self sufficient, life was simple.

Mauryan period:

The economy was agrarian, majority of population were agriculturists. People were also engaged in animal husbandry and cattle rearing which meant additional income to peasants and the state. Gaha pathi were the term used for head of rich land owing family.

Gupta period:

The cultivators were called by various terms called Krishihala or Kinars. They had low social and economic life.

Sangam period:

During Sangam literature, agriculture was the main occupation and hence the position of the farmers in the society was also high during this period. Agriculture Sangam was developed in Madurai. The farmers are called uzhavar (plough man) and also they are called as Kalmar. The land owners called superior vellars and the farmers who plough the land are called as inferior vellars. The farmers' status was mainly determined by the holding of land and animal population.

Thirukural period: Thiruvalluvar mentioned about importance of farmers in the society. In his statement,"Farmers alone live an independent life. Others worship them and are second to them" "If farmers stop cultivation, even Rishis (sages) can not survive"

Chapter 4. Journey of Indian agriculture and its development from past to modern era

DEVELOPMENT OF HUMAN CULTURE AND BEGINNING OF AGRICULTURE

Development of human culture

It is supposed that man was evolved on earth about 15 lakh years ago. This man was evolved from the monkey who started to move by standing erect on his feet. Such man has been called Homo erectus (or) Java man. Later on Java man transformed into Cro-Magnon and Cro-Magnon into modern man. The modern man is zoologically known as Homo sapiens (Homo - Continuous, Sapiens - learning habit). In the beginning such man had been spending his life wildly, but during the period 8700-7700 BC, they started to pet sheep and goat, although the first pet animal was dog, which was used for hunting. The history of agriculture and civilization go hand in hand as the food production made it possible for primitive man to settle down in selected areas leading to formation of society and initiation of civilization. The development of civilization and agriculture had passed through several stages. Archeologist initially classified the stages as stone age, Bronze and Iron age. Subsequently the scholars spilt up the stone age into Paleolithic period (old stone age), Neolithic age (New stone age) and Mesolithic age (Middle stone age). Each of three ages, saw distinct improvements. The man fashioned and improved tools out of stones, bones, woods etc. to help them in day-to-day life. They started growing food crops and domesticated animals like cow, sheep, goat, dog etc.

Paleolithic age (old stone age)

This period is characterized by the food gatherers and hunters. The stone age man started making stone tools and crude choppers.

Mesolithic period

The transitional period between the end of the Paleolithic and beginning of the Neolithic is called Mesolithic. It began about 10000BC and ended with the rise of agriculture. This period is characterized by tiny stone implements called microliths. People lived as food gatherers and hunters. The domestication of the dog was the major achievement of the Mesolithic hunter.

Neolithic Agricultural Revolution (7500 BC - 6500 BC)

Neolithic revolution brought a major change in the techniques of food production which gave man control over his environment and saved him from the precarious existence of mere hunting and gathering of wild berries and roots. For the first time, he lived in settled villages and apart from security from hunger he had leisure time to think and contemplate.

The main features of Neolithic culture in India

1. Neolithic culture denotes a stage in economic and technological development in India
2. Use of polished stone axes for cleaning the bushes
3. Hand made pottery for storing food grains
4. Invented textile, weaving and basketry
5. Cultivation of rice, banana sequence and yams in eastern parts of India
6. Cultivation of millets and pulses in south India
7. Discovery of silk

Chalcolithic culture (Bronze age) (3000-1700 BC):

The term Chalcolithic is applied to communities using stone implements along with copper and bronze. In more advanced communities, the proportion of copper and bronze implements is higher than that of stones. The chalcolithic revolution began in Mesopotamia in the fourth millennium B.C. from this area it spread to Egypt, and Indus valley.

The significant features are

1. Invention of plough
2. Agriculture shifted from hilly area to lower river valley
3. Flood water were stored for irrigation and canals were dug
4. Irrigated farming started in this period
5. Sowing of seed by dibbling with a pointed stick
6. Salinity problem and water logging were noticed due to canal irrigation.

Beginning of Agriculture in India: Archeological and historical facts 12000 to 9500 years ago

- Hunters and food-gathers stage existed.
- Stone implements (microliths) were seen throughout the Indian subcontinent.

- Domestication of dog occurred in Iraq.
- Earliest agriculture was by vegetative propagation (e.g.,bananas, sugarcane, yam, sago,palms, and ginger).

9500 to 7500 years ago

- Wild ancestors of wheat and barley, goat, sheep, pig, and cattle were found.

7500 to 5000 years ago

- Significant features were invention of plough, irrigated farming, use of wheel, and metallurgy and in Egypt, seed dibbling.

5000 to 4000 years ago

- Harappan culture is characterized by cultivation of wheat, barley and cotton; plough agriculture and bullocks for drought.
- Wheeled carts were commonly used in the Indus valley.
- Harappans not only grew cotton but also devised methods for ginning / spinning / weaving.

4000 to 2000years ago

- In North Arcot, bone / stone tools were found.
- In Nevasa (Maharastra), copper and polished stone axes were used. First evidence of the presence of silk was found at this location.
- At Navdatoli on Narmada river (Nemar, Madhya Pradesh), sickles set with stone teeth were used for cutting crop stalks. Crops grown were wheat, linseed, lentil, urd (black gram), mung bean, and khesari.
- In Eastern India, rice, bananas, and sugarcane were cultivated.

2000-1500 years ago

- Tank irrigation was developed and practiced widely.
- Greek and Romans had trade with South India; pepper, cloth, and sandal wood were imported by Romans.
- Chola King Karikala (190 AD) defeated Cheras and Pandyas, invaded Srilanka, captured 12000 men and used them as slaves to construct an embankment along the Cauvery, 160

km along, to protect land from floods. He has built numerous irrigation tanks and promoted agriculture by clearing forests.

1500-1000 years ago

The Kanauj Empire of Harshavardhana (606-647 AD)

- Cereals such as wheat, rice and millets, and fruits were extensively grown. A 60-day variety and fragrant varieties of rice are mentioned.
- Ginger, mustard, melons, pumpkin, onion, and garlic are also mentioned.
- Persian wheel was used in Thanesar (Haryana).

The kingdoms of South India

- The kingdoms were of the Chalukyas (Badami), Rashtrakutas (Latur), Pallavas (Kanchi), Pandyas, Hoysals (Helebid), and Kakatiyas (Warangal).
- Cholas ushered in a glorious phase in South Indian in the 10th century AD.
- New irrigation systems for agriculture were developed- chain tanks in Andhra in the 9th century; and 6.4km Kaveripak bund.
- Cholas maintained links with China, Myanmar, and Campodia.
- The tank supervision committee (Eri-variyam) looked after the maintenance of a village and regulated the water supply.

1000-700 years ago

- Arab conquest of Sind was during 711-712 AD; Md bin Qaism defeated Dahir, the Hindu king of Sind. Arabs were experts in gardening.
- 1290- 1320AD (Reign of Khiljis): Alauddin Khilji destroyed the agricultural prosperity of a major part of India. He believed in keeping the farmers poor.

History of Agriculture:

The earliest man, ***Homo erectus*** emerged around **one and half million years ago** and by about **a million years ago** he spread throughout old world tropics and largely to **temperate zones**. About 500 thousand years ago, he learnt to control and use fire. The earliest man is distinguished from fellow animals by his intelligence and skill in making tools.

Homo sapiens, the direct ancestor of modern man lived 250 thousand years ago. *Homo sapiens*

sapiens, the modern man, appeared in Africa about 35 thousand years ago. He is distinguished from all other extinct species of genus *Homo*, by large brain, small teeth and chin and capacity for making and using tools. He hunted a variety of animals and cooked their meat on fire. The weapons for hunting were boulders and spears of wood tipped with blades of flint. He also used stone-tipped arrows. Later he domesticated the dog which greatly helped him in hunting. Apart from the meat of animals, he gathered a variety of seeds, leaves and fruits from the jungle.

It is estimated that most efficient hunting and gathering can hardly support **one person per square kilometer** while pastoral life can support **three** and agriculture about **a hundred**. He had no control over food supply and was unable to clothe and shelter adequately. During the period 8700 BC to 7700 BC, he domesticated animals and turned a herdsman. He first domesticated sheep and later goat. Between the period 7500 BC to 6500 BC, man gradually shifted from hunting and gathering to agriculture. Stone axes were used for cutting trees and fire for burning forests. Grains of cereals were dibbled with the aid of pointed sticks. Later on, stone-hoes with wooden handles were invented. The cereals grown during this period were wheat and barley and later rice, maize and millets as indicated in following table. Subsequently he domesticated cattle, pigs, horse and ass.

Period	**Events**
Earlier than 10000 BC	Hunting & gathering
7500 BC	Cultivation of crops- Wheat & Barley
3400 BC	Wheel was invented
3000 BC	Bronze used for making tools
2900 BC	Plough was invented, irrigated farming started
2300 BC	Cultivation of chickpea, cotton, mustard
2200 BC	Cultivation of rice
1500 BC	Cultivation of sugarcane
1400 BC	Use of iron
1000 BC	Use of iron plough
1500 AD	Cultivation of orange, brinjal, pomegranate
1600 AD	Introduction of several crops to India i.e potato, tapioca, tomato, chillies,pineapple, groundnut, tobacco, rubber, american cotton

Development of scientific agriculture in World

Experimentation technique was started (1561 to 1624) by **Francis Bacon**. He conducted an experiment and found that **water is the principle requirement for plant**. If the same crop is cultivated for many times it loses its fertility.

Jan Baptiste Van Helmont (1572 – 1644) was actually responsible for conducting a pot experiment. The experiment is called as **„willow tree experiment"**. He took a willow tree of weight 5 pounds. He planted in a pot and the pot contained 200 pounds of soil and continuously monitored for five years by only watering the plant. By the end of 5th year the willow tree was weighing 16 q pounds. The weight of soil is 198 pounds. He concluded that **water is the sole requirement for plants**. The conclusion was erroneous.

In the 18th century, **Arthur Young** (1741 – 1820) conducted pot culture experiments to increase the yield of crops by applying several materials like poultry dung, nitre, gunpowder etc. He published his work in 46 volumes as **„Annals of Agriculture"**.

In the beginning of 19th century, a scientist **Jean Senebier** (1742 – 1809). He is a Swiss naturalist, a historian. He gave explanation that increase in the weight of plant was due to the consumption of air. From his report another scientist **Theodar de-Saussure** gave reasons for increase in weight. The principle theme of **photosynthesis** was given by him.

Justus Van Liebig (1840) a German scientist proposed a law **„Liebig law of minimum"**, according to which the growth of plants is limited by the plant nutrient present in smaller quantity, all other being in adequate amount. It is also known as barrel concept. A barrel with staves of different length cannot contain anything above the height of the shortest stave. In like manner, growth can be no greater than allowed by the factor lowest in availability. He is considered as the **father of agricultural chemistry**.

G.R.Glanber (1604-1668 A.D)	Salt peter(KNO_3) as nutrient and not water
Jethro tull (1674-1741 A.D)	Fine soil particle as plant nutrient
Priestly (1730-1799 A.D)	Discovered the oxygen
Francis Home (1775 A.D)	Water, air, salts, fire and oil form the plant utrients
Thomas Jefferson (1793 AD)	Developed mould board plough
Theodore de-Saussure	Found that plants absorb CO_2 from air & release O_2; soil supply N_2

Advance in Agriculture in 19th Century

In pre-scientific agriculture, **six persons could produce enough food for themselves and for four other**. In years of bad harvest, they could produce only enough for themselves. With the development of agricultural science application of advance technology, **five persons are able to produce enough food for 95 others.**

Early knowledge of agriculture was a collection of experiences transmitted from farmer to farmer verbally.

Experiments pertaining to plant nutrition in a systematic way were initiated by **Van Helmont** (1572 - 1644 A.D.). He concluded that the **"main principle of vegetation"** is water.

Jethro Tull (1674 - 1741 A.D.) conducted several experiments and published a book, **"Horse Hoeing Husbandry"**. His experiments were mostly on cultural practices and they led to the development of seed drill and horse-drawn cultivator.

Soil science began with the formulation of the **theory of humus in 1809**. Field experiments were started in **Rothamsted Experiment Station**, **England** in **1834** and soon after in other places in Europe.

Subsequently much development took place. In U.S. land grant colleges was started in **19th** century. Its objective was to meet the expenditure of the college from the land around the colleges.

USDA:- **United State Department of Agriculture** is responsible for the introduction of herbicides 2,4-D and combine tractor. Under land grant college – teaching, research, extension. Many international research institutes where started for a specific crop.

Michigan State University was established in the year 1857 to provide agricultural education at College level.

Gregor Mendal (1866) discovered the **laws of hereditary**

Charles Darwin (1876) published the results of experiments on **cross and self fertilization in plants.**

- **Thomas Malthus** (1898) proposed **Malthusian theory** – states that humans would run-out of food for everyone in spite of rapid advance in agriculture due to limited land and yield potential of crops (i. e. food may not be sufficient in future for the growing population at this current rate of growth in agriculture).
- **Blackman** (1905) proposed theory of **"Optima and limiting factors"** states that when a process is conditioned as to it's rapidity by a number of separate factors , the rate of the process is limited by the pace of the slowest factor"
- **Mitscherlich** (1909) proposed the **"Law of diminishing returns"** that increase in growth with each successive addition of the limiting element is progressively smaller and the response is curvilinear.
- **Wilcox** (1929) proposed **"Inverse yield- nitrogen law"**. It states that the power of growth or the yielding ability of any crop plant is inversely proportional to the mean nitrogen content in the dry matter.
- **Macy** (1936) proposed the theory of **"Macy- Poverty Adjustment"**. It states that a relationship exist between sufficiency of a nutrient and its percentage content in plant.

According to him there is a critical percentage of each nutrient in each kind of plant. Above that point, there is luxury consumption and below that point there is poverty adjustment. This poverty adjustment is proportional to the deficiency until a minimum percentage is reached.

Development of Scientific Agriculture in India

The progress of scientific development in India was poor as compared to western countries. In India, since in old time there was no change in methods of cultivation because change in Government were taking place frequently and none of the Government took active part in development of agriculture. Scientific agriculture began in India when sugarcane, cotton and tobacco were grown for export purposes.

1870: A joint department of agriculture, revenue and commerce was established.

1880: Separate department of agriculture was started on the recommendation of the Famine Commission with the object of increasing food production for local people and industrial raw materials for export.

1864-1900: India faced many famines. Hence famine commission was appointed and on the report of this commission Government of India took many steps for improvement of famine conditions.

1905: Imperial Agricultural Research Institute (IARI) was started at Pusa in Bihar after the earthquake in Bihar in 1934; it was shifted to New Delhi in 1936. It is popularly known as the **"PUSA INSTITUTE"** and also as IARI. Now it is **Indian Agricultural Research Institute.** It's main functions are (i) Basic and applied research in the major branches of agricultural sciences and (ii) To impart post graduate education at the M. Sc. and Ph. D. levels. It has been accorded the status of Deemed University under the UGC Act of 1956.

1905: Agricultural Department established in each state of Government. Five colleges of Agriculture opened at following places. Coimbatore(Tamil nadu), Nagpur ,Poona, (Maharashtra),Kanpur(Uttar pradesh) and Sabour (Bihar).

1912: Sugarcane Research Station (Breeding) was established at Coimbatore.

1923-24: Indian Central Cotton Committee came in to existence which started Institute of plant industries at Indore and Technological Laboratory at Matunga (Bombay).

1928: Royal Commission was appointed who's vice Roy was Lord Irwin and Chairman was Lord Linlithgo. This commission took survey of Indian agriculture and village economics problems and prepared a report and gave their recommendations to the Government. The Government of India established **Indian Council of Agricultural Research at New Delhi (ICAR),** to coordinate the work of agricultural research in this country.

Real development in Indian Agriculture took place after 1947 when India got independence, with the execution of **FIVE YEAR PLAN in 1951**.

ICAR had also started research institutes of its own in different centers in India for various crops.

AICRIP All India Coordinated Rice Improvement Projects

ICAR is the sole body which controls all the Agricultural Research Institutes in India. It paved way **for green revolution** in India. After 1947, ICAR totally adapted to Land Grant Colleges.

1960: Agricultural University was started at Pantnagar (UP) on Land Grant pattern. It is the **first university** with 16,000 acres of land.

1965-67: Green revolution in India due to introduction of HYV –Wheat, rice, use of fertilizers, construction of Dams and use of pesticides. Green revolution took in wheat first, next in rice after the invention of Indo-*Japanica* variety.

1972: Gujarat Agricultural University was established at Sardarkrushinagar

2004: Gujarat Agricultural University divided into four agricultural universities at Navsari, Anand, Junagadh and Sardarkrushinagar

Chapter 5. Plant production and protection through indigenous traditional knowledge

Traditional tillage and cultivation

Agricultural Technology

Agricultural operations involving crop production comprised (i) soil preparation inclusive of tillage and fertilization, (ii) cropping system, (iii) harvesting and crop processing and (iv) preservation. *All* these technological aspects in Indian crop-husbandry are mainly available to us from the Vedic chalcolithic period. Prior to this period agricultural implements excavated from different sites envisage the processes of tilling. Likewise, in these records are found the methods of preserving grains and irrigation of cultivated fields. An account of these different processes excepting fertilization, reported separately, in different periods of history, is summed up below:

PRE-HISTORY

A. MESOLITHIC PERIOD

Tillage: Tillage consisted of only digging of moist riverine mud by using digging stick.

B. NEOlITHIC PERIOD

Tillage: Hoeing for preparing field for cultivation is noticed in late neolithic period in Assam and Bengal.
Cropping System: Terraced cultivation practised mainly in different sites of Southern India. Crop Processing: The use of saddle quem for grinding of corn.

PROTO· HISTORY

Chalcolithic Period

1. Pre-Harappan Chalcolithic

Tillage: Tilling by plough is believed to exist as evident from grid-patterned furrow-lines. Cropping System: Twin crop (mustard and horse-gram) system is presumed from the diagonal and horizontal furrow lines on the above grid pattern.

2. Harappa Chalcolithic

Soil-Preparation: *Tillage:* Two types of tilling, *(a)* by ploughing for making a necessary depth in the field and *(b)* harrowing for stirring the soil at comparatively shalllow depth. Preservation of Grains: The granaries in all the sites of Indus civilization are characterized, by their well-built body of baked brick, having arrangement to keep the granaries in comparunents built over platforms, well-ventilated to prevent sweating and mildew and vivid provision of loading facilities from outside.

3. Mid-Chalcolithic

Soil Preparation: *Tillage,* Hoeing of fields was also practised in this period. Preservation of Grains: Granaries from Chalcolithic Inamgaon are characterized by pit-soil and round mud platforms for storage bins.

4. Vedic Chalcolithic and Iron Age

Most of the technological aspects relating to ancient Indian crop husbandry are available to us from the Vedic chalcolithic period.

Tillage: Ploughing was generally performed with the help of oxen in teams of six, eight or eleven. In case of small field in mountainous region, it was done with the help of one sheep.

(i) Furrow-marks were made in grid pattern: Twelve lines made by plough drawn by twelve oxen were arranged in such a way that three lines arranged vertically, three running over them horizontally and the other six made criss-cross.

Cropping System: *(i)* Sowing of seeds of different kinds in grid-patterned furrows. *(ii)* Rotation of crops. Harvesting and Crop-Processing including Preservation: Reaping, threshing and storing are the post-cultivating processes found mentioned in the different texts of the Vedic literature.

HISTORIC PERIOD

The period is characterized by the practices of *Jum cultivation,* in Aryavarta in its early part and of *Kumari cultivation* in its later part (c. 11th century A.D.) in South India. The other notable features of this period lie in some new innovations for the cultivation of rice. These include:

(i) Sowing of seeds in beds and transplantation of seedlings in water enclosures, the mention of which is found to occur in the account of Aristobalus (c. 320 B.C.). This process of rice cultivation is also reported in different sources of subsequent periods (the varieties of paddy is known as *sali).*

(ii) In another process the seeds are found to have been sown in a field of higher level and then transplanted in plains of comparatively low surface, where grasses were grown (the variety of paddy is known as *ropyatiropya).* Tillage of field, hoeing and the post-cultivation processes are identical with those of previous period though in a more detailed way.

Preservation of Grains

MID-HISTORIC PERIOD

(i) Storing of grains was performed in receptacles made of straws and leaves with the inside floor space coated with cowdung. The receptacle was sealed with cowdung and kept in suitable place, screening with a screen of straw and bamboo.

(ii) Storing of grain in granary, made of earth, of straw and bamboo, standing on pillars, the upper storey of the house covered with lid coated with cow-dung, coated with mud all over, closed, and sealed with earthen rods.

(iii) In the later part of this period, storage of grains in well-built granary provided with all necessary amenities for the protection of grains has been described in Viswakarma's *vastu-Sastra.*

Agricultural implements

All the agricultural operations were carried out by implements suited to them. The artefacts and innovations were moulded according to the nature of soil, dimension of cultivable field and above all techniques involved in particular operation. Vedic implements show four types of implements. These are:

Forest-clearance tools: Axe (*svadhiti*, *parasfu*) and axe type tools are mentioned as tool for cutting wood in the *R.gveda*.

Soil-treatment:67 The *R.gveda* refers to mower (*da–ta–)* for grass-cutting which might be taken as pre-tilling performance of the soil. The *Taittiri–ya Sam. hita*–brought into notice the use of roller for making field even for tilling.

Tillage implements: The plough68 described in the *R.gveda* is characterized as traction plough.69 The Vedic plough is distinguished by:

(a) two types: *la–n . gala* (small plough) and *si–ra* (heavy plough).

(b) four parts: plough i.e. indicating the rod (*la–n . gala*, *si–ra*), the rope (*varatra*), share (*pha–la*), and yoke (*yuga*). The latter is however absent in some descriptions of plough which indicates a particular type in which the plough itself is fastened to the animal body instead of being tied to the yoke. The *Yajurveda* describes plough as lance-pointed, well-lying and furnished witha handle (*tsru*).

(c) Animal power dragging the plough: Oxen, sheep and camel were harnessed for dragging the plough. Number of animals varied according to the dimension of plough. Six, twelve, twenty-four formed different animal strength in the dragging of plough. Mention is also made of dragging of plough by one and by two sheeps.

Harvesting tool: Three types of corn-cutting tools are found to occur in the *R.gveda*. These include: *da–tra* (a sort of sickle in the shape of crooked knife), *sfr.n.i–* (sickle) and *jeta–* (reaping hook).

Corn-cleaning equipments: The sieve and winnowing fan mentioned in the *R.gveda*, were probably used for this purpose.

Transport for carrying agricultural products: Two types of carriers, viz *ana–sa* (carts) and *sfakat.a* (wagon) were for commercial types. The former was two-wheeled, made of woods of *Acacia* and *Dalbergia* with bamboo poles and wheels rimmed with metal tyre (*pavi*). The latter was also wooden body and especially meant for carrying agricultural products from the field. The chariots, in addition to those two were used for carrying agricultural products from the field. Animals employed for drawing these carriers were ox, stallion, ram and dog.

Traditional Weed Control

Weed control and moisture conservation

In hilly areas, crops like upland spring or *jethi* rice, finger millet, black soybean, horse gram, etc. are raised on conserved moisture. After monsoon rains the crop seedlings emerge very fast; however, a number of weeds also emerge in the field, which affect the growth and yield of the crop. To overcome the problem, instead of manual weeding or use of chemicals, farmers plow the field in July–August with an implement called *danala.* It breaks the soil crust favoring moisture conservation and uprooting of many weeds.

Weed control in transplanted rice

Dry leaves of pine (*Pinus kesiya*) are spread in mid June in the field where rice has to be transplanted. The pine leaves are burnt before transplanting, i.e., in the first week of July. This practice controls the germinating or prevailing weeds inthe field.

Use of common salt for weed control

Age old practice of use of common salt for weed control under acidic conditions of jhum paddy in north east India is not only effective in minimization of weed competition with cultivated crop (paddy) but also results in comparatively high paddy productivity without having any negative effect on growth, yield attributes of paddy. The practice of use of salt for weed management is also cost effective compare to other popular practice of weed management like hand weeding. The osmotic adjustment in paddy is an important physiological adaptation, which might be the reason for selectivity of paddy plant to NaCl. For osmotic adjustment, plants use inorganic ions such as Na and K and/or synthesize organic compatible solutes such as proline, betaine, polyols, and soluble sugars. Besides the target weed A. conyzoides, several other common Asteraceae weeds including Crassocephalum crepidioides Benth are also controlled by application of NaCl in shifting cultivation areas.

Traditional pest and disease management

Indigenous disease and pest management practices in traditional farming system

In recent years there is a resurgence of interest in reviving the age old farming system through scientific approach which is known by modern man as organic farming, because of hazardous effect of excessive chemicals in agricultural system, environment and human health. Irrespective of ethnic groups practicing jhum, interesting features of the system is that it has inbuilt pest and disease management mechanisms as reflected in their cultural practices such as mixed /multiple cropping , zero tillage , clean cultivation, slash and burning , green manuring, sequential cropping and harvesting, fallowing, flooding etc. Use of plants and animal parts and products are the important components of indigenous knowledge in the management of pest and diseases of crops in jhum system.

Traditional Pest Management

White grub :White grub constitutes a major pest of field crops in Western Himalayas. Setting fire in the field after harvesting of wheat crop, hill farmers burn the plot. For burning, they collect pine leaves from the forest and distribute those evenly in the field to dry. If they are already dried, they are put to fire to destroy the hibernating stage of white grubs. Scientists did not consider it a good practice because micro-organisms are also burnt and killed.

Use of table salt: For controlling white grub, common salt is broadcasted at the rate of 1 kg/Nali. Naliis an area measurement used in hills. One Nali is equal to one by 20 acre. They finely grind salt stone and mix it with chullahash to make it bulky. This mixture is broadcasted in the field after first ploughing which is done after wheat harvest. Broadcasting is generally done in the morning hours. Just after broadcasting, wherever possible, land is preferred to be irrigated.

Summer ploughing: The practice of deep ploughing after paddy harvest and leaving land fallow for 10-15 days was found prevalent in the villages. In the month of May–June, farmers plough land with the help of indigenous plough. Depth of ploughing is kept around 30 cm. After deep ploughing, land is left fallow so that sunlight can reach at the deepest layer possible. Plant protection scientists considered it a rational practice as a majority of damaging insect pests pathogens harbour in soil.

Ash on standing crop Ash is predominantly used by farmers in the area for protecting plants. In hilly areas, wood obtained from forest has been major fuel. Ash dust is a product after the burning of fuel wood. The kitchen ash, thus obtained is mixed with the farmyard manure or in pure form applied in the fields and onto plants. It is very effective for insects having chewing and biting mouth parts. When insects come to feed on ash broadcasted plants, ash sticks to their mouth parts and damages them because of which later insects are dead.

Mechanical control Mahu (aphid) infested plants of mustard, cauliflower and cabbage (Brassica sp) are uprooted and buried in the soil to check the spread of insect. For reducing the alternate hosts of pests/pathogens and also breeding spaces for rat cleanliness is maintained around field and bunds are trimmed specially during summers. For avoiding greening of potato tubers, earthen up is done up to one feet height at second weeding. It checks the exposure of tubers to sunlight.

Cow urine and cow dung Farmers in the study area use cow urine and dung for spraying on diseased plants by making their solution with water as a pesticide. Whenever plants in kitchen garden show wilting symptoms, farmers spray cow urine on them. Some farmers use cowdung solution for controlling onion blight.

Trap crops Madiraor Barnyard millet (Echinochloa sp) and Konri millet crops are preferred to be sown on the margin of plot instead of middle. Farmers think they attract certain pests when sown on the margin of plot and main crop of paddy is protected. But scientists are undecided about its rationality, they say it provides a fall back option to farmers if paddy fails. It is also reported that for harnessing the benefit of intercropping, some farmers grow a few plants of mustard and thus, leave the ragi alone. In addition to this, intercropping of mustard acts as a fall option for farmers if ragi fails.

Control of diseases in vegetable crops

About 4–8 kg of widely available *bicchu booti* (*Urtica dioica*) is soaked in 8–10 L cow urine for 24 hours. The herb is then taken out and the solution is sprayed on vegetable crops. The solution is used as an organic fungicide against many fungal diseases of vegetables mainly tomato, capsicum, onion, radish, cucurbits, etc. Some common diseases that are controlled by this practice are anthracnose in capsicum, late blight and fruit rot in tomato, and alternaria blight in cucurbits. The following precaution should be taken while cutting the herb: one should not touch the grass as it causes painful itching for 2–4 hours.

Grain preservation

Traditional storage practices

A detailed description of the indigenous technologies being followed by farmers in dry tracts of Tamil Nadu for storing grains and seeds were collected and presented below:

Red gram storage with common salt

Farmers with their indigenous knowledge used common salt in red gram (*Cajanus cajan*) grains storage. In this practice, about 200 gm of salt was mixed for a kg of red gram grains manually. Due to this practice, insects were kept away from the stored grains.

Ash seed treatment in sorghum

Ash was mixed with the sorghum (*Sorghum bicolor*) seeds at the ratio of 1:4. After the ash treatment, sorghum seeds were tied airtight in the jute gunny bags. Farmers strongly believed that ash application controlled losses considerably up to an extent of 80%.

Farmers using this technology stored the sorghum grains for 6 months without any storage pest problems.

Ragi storage with neem and *thumbai* leaves

The strong odour of these leaves keep the storage pests like lesser grain borers (*Rhyzopertha dominica*), saw toothed beetle (*Oryzaephilus surinamemsis*) and flat grain beetle (*Cryptolestes minutus*) away. Neem leaves and *thumbai* being organic repellants were also safe to use.

Paddy storage

Farmers constructed the granary rooms with perfect plan during the construction of house itself. The platform of this granary room was made of wooden boards while its sides had brick and cement walls. It has an opening or a net protected door like structure for ventilation. The grains to be stored were spread in the wooden platform and an earthen pot ¾ of its volume filled with water was kept inside the granary rooms. This would attract and kill the rice moth. Since, this structure was at 243.84 cm height from the ground, rodents and other pest damages were found to be comparatively less and also the grains were found moisture free.

Storage of grains using camphor

In this practice, about 1gm of camphor piece per 5 kg of grains was placed as such in the jute gunny bags. This practice of placing camphor inside the grain storage bag repelled the storage pests due to the strong odour emanated from camphor. A short-term storage of grains up to 3 months was possible with this traditional storage method.

Storage of seeds with lime

Farmers traditionally followed a practice of storing pulse grains along with lime powder. In this practice, farmers dusted about 10 gm of lime per kg of grains. After thorough mixing they stored them in jute gunny bags. The lime had a property of emitting irritating odour that repelled insects and prevented the grains from damage. By this way, grains could be stored for even one year.

Gingelly seeds storage

In gingelly seeds storage, mixing a handful of (nearly 100gm) paddy (*Oryza sativa*) in storage container significantly reduced the infestation of Indian meal moth (*Plodia interpunctella*) and prevented the damage of seeds for the next three month storage period. This was possible because the larvae of Indian meal moth had a habit of webbing the gingelly seeds with its secretion. Hence, these pests avoid the feeding of gingelly seeds stored along with paddy.

Neem oil in seed storage

For 1 kg of pulses seed 20 ml of neem oil was used. Manually farmers applied the neem oil over the seeds to coat the seeds uniformly. Neem oil acted as repellent against several insects such as weevils, red flour beetles (*Tribolium castaneum*), Long headed flour beetle (*Latheticus oryzae*) and fig moth (*Ephestia cautella*), etc. Some farmers used neem oil mixed with coconut oil/castor oil (1:1) for treating the seed materials against the storage pests.

Storage of vegetable seeds with cow dung

After proper drying, the seeds were stored in cow dung. Farmers collected fresh cow dung and made plate like round shaped structures by tapping it with hand locally called *varati*. Vegetable seeds were then embedded in the cow dung and then dried under sun for 2-3 days. After drying, the seeds get sticked on to the *Varati*. These *Varaties* were then stored in open / inside wooden boxes. The farmers stored the vegetable seeds by this method even up to one year. Farmers believed that cow dung has pesticidal property, which would keep the seeds away from storage pests. Also believed that cow dung's immunostimulant properties increased the germination (90%) and viability of the seeds considerably. Fresh cow dung has to be used for effective storage.

***Pungam* leaves in paddy storage**

These leaves acted as a repellent against Angoumois grain moth (*Sitotroga cerealella*) and rice weevils (*Sitophilus oryzae*). The strong odour released from *pumgam* leaves avoided the pest attack. Some farmers placed these *pungam* leaves directly in the gunny bags and stored the grains.

Paddy husk in managing storage pests

Farmers stored the paddy grains in earthen pods and placed paddy husk in top layer (5cm) above it. Farmers had found that storage pests unpreferred these earthen pots stored with paddy husk.

Oil storage practices

Farmwomen practiced an indigenous method of storing groundnut (*Arachis hypogaea*) oil by placing tamarind (*Tamarindus indicus*) in the oil storage container. In this practice, for storing 5 L of groundnut oil, about ¼ kg of tamarind was placed inside the oil container. The mouth of the container/vessel was then tightly closed with cotton cloth. Some farmers also sealed the small opening in the oil container with the help of tamarind. use of coriander (*Coriandrum sativum*) seeds and salt in oil storage. In this practice, for a litre of oil, farmers placed 100 gm of coriander seeds and a spoon of salt inside the oil stored tin container. The oil was exposed to sun for few hrs and kept closed in airtight condition. Coriander seeds produced pleasant odour in the oil, whereas salt was believed to reduce rancidity and spoilage of oil.

Table 1: Indigenous traditional pest and disease management techniques of different crops

SN	Name of indigenous traditional knowledge (ITK)	Details of ITK	Rationale
1	Management of seed health free from pest and diseases in jhum, terrace, sedentary and home garden traditional farming system.	(i) Collection of healthy seeds before general harvest (ii) hanging over fire furnace/ kitchen for constant smoking (iii) mixing with ashes of fire wood (iv)smoking well dried healthy seeds with edible and non- edible oils (v) Mixing with neem seed powder etc and storing the same in a seed bin. (vi) using aromatic plants such as citronella grass, lemon grass, peels of pomelo etc against maize weevil by mixing /placing these plants over maize grains granary.	Rationale: Unsuitable environment is created to inhibit the growth and proliferation of pest and other microorganisms. Aromatic plants act as repellent or fumigant e .g; Leguminous seeds ,vegetable seeds, maize etc.

2	Methods of keeping seeds free from pest and diseases for use in traditional farming system	Seeds of maize and leguminous crops are often kept intact along with their outer husk and hang over the kitchen/ furnace. Here, maize cobs are tied up in bunches of 10 - 12 cobs by folding their next to outermost husk and hang over the wooden beams of kitchen and sometimes roof beam in the periphery of the house.	Rationale: Open air mixed with smoke seemed to inhibit the pest and pathogen as well as the entry of this pest take time through hard husk of maize and beans.
3	Storage method of paddy in traditional granary for keeping away pest and pathogens.	Specially prepared bamboo granaries plastered with mixture of fresh cowdung and mustard oil cakes are in use for storing paddy on the top of which branches with leaves of Z*anthoxylum acanthopodium* are placed to keep away pest mostly white butterflies -a common pest-of the stored paddy grains. Paddy granaries are either placed near the kitchen or vicinity to kitchen in a separate house. Further, Z*anthoxylum acanthopodium*-a plant of carminative properties emits unpleasant smell that inhibits the white flies.	Rationale: Well plastering of bamboo crevices inhibits the entry of pest and pathogen. It may also be possible that oil cakes emits unfavourable odour to pest and diseases.
4	Foliar application of plant and animal products for the Management of Pest and diseases.	Following traditional methods are used for the management of pest and diseases of crops: (i) foliar application of wood ashes in the wee hours of the day keeps away aphids pod borers and diseases from plants (mostly vegetables) (ii) Dusting finely ground tobacco leaves keep the aphid pest and diseases away from plants. (iii) Hookah water is very much effective for controlling pest and diseases of major and minor crops such as blast of rice, pod borers, sucking bugs of vegetables etc. (iv) Dusting with saw dust is also sometimes used but their effect is not encouraging. (v) Fish and meat wash water application is also a mild deterrent in keeping away of pest due to unpleasant environment for the proliferation of pest and pathogens.	Rationale: Thin film of ash coat with dew inhibits the attack of pest and pathogens. Ash also acts as a nutrient when it gets washed due to rain. Tobacco leaves and hookah water which contains nicotine prevents The foliages from pest and pathogens.
5	Management of fungal diseases and insect pest of upland paddy.	Pest and diseases of paddy are controlled/managed using the following traditional methods: (i) By spreading leaves of *Artemisia vulgaris, Croton caudatus, Munromia wallichi, Adhatoda vessica etc.* (ii) By erecting or pegging branches of *Cymbopogon Khasianum, Saccharum spantaneum which* inhibits stem borer of paddy.	Rationale: Leaves of these medicinal plants on decomposition release substances /molecules which inhibit the pest and pathogen of paddy in jhum land
6	Management of diseases and pest of rice through plant products	Pest and diseases are also managed by (i) Pomace (wine residue) Here, well fermented wine pomace usually made up of millets are placed at the source of irrigation canal of terrace rice fields which slowly spread over the rice field and inhibits the growth of pests such as leaf folder and blast of rice (ii) Oak tree bark are also grounded and placed over the source of irrigation canal which inhibits the insect pests of rice such as brown plant hoppers.	Rationale: Unpleasant odour of pomace may be the reason behind inhibiting the fungal disease and leaf folder in particular.

7	Management of blast and chara problem in terrace as well as in settled wet land paddy.	Traditional farmers use paddy husk before five months to contain the blast of rice at 0.3 to 0.5 ton/h for effective control of blast disease of rice. Paddy husk also makes clay/ loamy soil porous for better aeration of plants /tillers. Chara, a green alga infested field water is drained off first and paddy husk were applied to get rid of chara problem in the field .This method is also effective for controlling blast of paddy.	Rationale: After draining of water, chara get settled on the ground which when paddy husk is applied suppress the chara and get decomposed which becomes nutrients of the plant on irrigation of field again. Chara do not have the chance to come up and suck the nutrient meant for paddy again
9	Control of nematodes in ginger chillies, tomato and turmeric by intercropping Chrysanthe u m*coronarium.*	Nematodes of turmeric, tomato, chillies and ginger are controlled by either intercropping with *Chrysanthemum coronarium*, *Tagetes erecta*, or growing *Tagetes erecta* as border crops. This is a very effective method and often farmers incorporate leaves of these trap crops into the soil to enhance effectiveness and nutrients enrichment of crops.	Rationale: The sharp smell of trap crops may be the reason in the inhibition of nematodes.

10	Cultural practices in the management of crops on jhum system	The pest and diseases of paddy (major crop)and vegetables (i) Burning of slashed debries which kills the resident pests and pathogens from the system because many plants and grasses serves as the alternate host of crops .This clean cultivation practices enable farmers to harvest crops less infected by pest and pathogen. (ii) Zero tillage practices (often seeds are sown by dibbling methods) enables the natural growth of nodulated frankia found in socially valued alder trees and undisturbed mycorrhizal root of slashed plants that promotes the healthy growth of crop plants.
		(iii) Mulching through the removal of unwanted weeds soon after the establishment of paddy .The decomposed mulch may inhibit the pathogen propagules and also provide nutrients to crop plants. It also protects the soil from erosion in jhum slopes. Thus, mulching has multipurpose use in jhum system. (iv) Mixed cultivation of rice with sparsely grown maize, legume crops, job's tear (C*oix* lacryma jobi. *L),* shorghum and ground vegetables, protects the diseases and pest of rice probably due to the physical barriers of intercrops in the movement of air borne propagules, augmenting microclimate and humidity etc Maize and sorghum not only provide food but also acts as perch for birds to feed on insects and pest of paddy in jhum field. Further, maize plants also serve to locate the burrows of rodents that destroypaddy crops.
	Cultural practices for insect, pest control in wet valley land paddy and sedentary dry land farming	Farmers often plough their field repeatedly soon after harvest for exposing soil inhabiting insect pests, arthopods, nematode etc. to harsh weather and to facilitate natural predators . Insects such as grasshopper, crickets and borers lay their eggs in the upper layer of soil in paddy fields eventually exposed during the course of repeated operation and their eggs either desiccate or preyed by the Egrets and their natural predators. This indigenous repeated ploughing technique for getting rid soil borne insects which damage paddy crops is very effective in wet land system and dry

	system.	sedentary farming system.	
	Control of rodents by smokes through burning of paddy husk and dry chillies.	Rodents cause heavy loss to paddy in jhum fields. To control this menace burrows of rats are stuffed with smoke by burning paddy husk and land race dry chillies variety. Complete control over rodents depends on the number of burrows plugged by smokes	Rationale: The suffocating pungent smokes promptly affect the respiration systems of rats and killed.
	Traditional ecotechnologies for the management of disease in traditional Land use System	Traditional technologies such as bamboo drip method of irrigation of terrace rice which makes rice crops free from contaminated water borne diseases as seen in Arunachal Pradesh, bench terracing in higher elevation for soil conservation *vis-à-vis* nutrient loss to avoid diseases of crops due to nutrient deficiencies, well adapted techniques of rowing potato in the higher elevation compared to paddy at lower elevation to match the soil fertility gradient, emphasis of farmers to grow tuberous crops in shorter jhum cycles as compared to cereals under longer jhum cycles are some of the need based techniques adopted by traditional farmers to avoid nutrient deficiency diseases in crops under traditional land use system in north east.	

Table 2: Important botanicals and botanical preparations in pest and disease management

SN	Name of Plant	Pest or disease controlled in crop	Remarks
1	Dried Peels of mandarin	Rice: Storage pest	Controls insect pest in rice. Peeled rind are placed sporadically in the field after transplanting for management of stem borer in rice
2	Hatibar (Agave sissalana)	Vegetables: ants	The fermented mixture of Agave sissalana. Piper nigrum, Vernonia amygdalina and Nicotiana tabaccum is used in Kenya for management of termites in field.
3	Datura	Ants	The plant extract is mixed with cow urine before drenching the soil
4	Neem	Storage pest of paddy	The disagreeable odour as well as insecticidal roperties of the leaves keeps away stored grain pesta including weevil and grain moth
5	Tobacco	Management of leech	It acts as a repellent
6	Turmeric	Management of ant	The required quantity of turmeric powder is mixed with water and drenched at the base of the ant infested plant
7	Fermented plant extracts mixture of titeypati, banmara and *Lantana camara*	Tomato and chilli:aphids and white flies	It has anti feedant and repellent effect against insect pest

Table : 3 Method of seed treatment and storage used by farmers

Crop	**Method of seed treatment and storage**	**Scientific interpretation**
Paddy	Seeds stored in salt water (1:10), stirred, and kept aside (generally for 2 kg of seed, 1 kg of salt and 10 L of water is effective). After an hour, light and chaffy seeds which were floating were removed and hard seeds that settled down were dried in shade.	Adding salt to water increases its density and helps in separation of light and chaffy seeds.This also helps in increasing germination
	Seeds were soaked in water overnight, dried in shade, and placed in a pit containing tree saw dust and sheep manure The pit was made airtight. Seeds were removed after two days, dried, and used for sowing.	Keeping seeds along with sheep manure in an airtight container creates heating inside the pit which is required for initiation of germination. Chemical reactions inside the seed prefer warm conditions to start
	A small bag containing seeds (approximately 10–15 kg) was placed at the entrance of the house instead of a door mat. This can be stored for 1 to 2 years. Seed bags of 10 kg were dissolved in 1:10 solution of salt and water. The seeds were dried and used for sowing within 72 hours.	Whoever enters the house will step on the bag. This repeated stepping on the bag disturbs insects which are trying to establish and feed on the seed. The salt treatment of seed helps in breaking dormancy and tolerating drought stress.
Sorghum	Seeds were treated with dried cow dung powder and cow urine before sowing. For one kg of seed approximately 100 g cow dung powder and 250 ml cow urine were used for better germination. Cow dung powder was also used for storage of seeds.	Cow urine contains 2.5% urea which is known to break dormancy and improve germinat. Cow dung powder protects the seed from humidity and hence improves longevity of seed. Cow dung was used with ghee and honey in ancient times for treating seeds as documented by Kautilya in Arthashastra.
	Seeds were treated with lime water. One kg of lime was dissolved in 10 L of water and kept for 10 days. The superfi cial water was collected and seeds were soaked in it overnight. The seeds were dried in shade and used for sowing.	Lime or calcium hydroxide is known to protect seed against seedborne diseases such as smut and bunt.
	Good ear heads were selected and kept open in fog in *rabi* (postrainy) season and kept inside a pot containing neem leaves.	The neem leaves protect seed from seed borer and beetles (Karthikeyan *et al.*, 2009). The exposure to fog may result in breaking of dormancy and bring drought tolerance (Shigihara *et al.*, 2008).
	Good ear heads were harvested along with awns and kept in the center of dried paddy grass heap (called *banave*).	Seed along with awns create hindrance for insect activity and thereby protect seed from insect damage. The selection of good ear heads and drying of seeds is an ancient practice to ensure seed longevity.
Pigeonpea	Seeds were kept along with horse gram seed and plant dust in an airtight container. Dust and seeds are separated before sowing.	The dust of horse gram is known to absorb excess moisture in the seeds and helps in storage for longer duration.
	Seeds were coated with fine red soil of the village pond or hill, dried in shade, and stored. For 10 kg of seed, 1 kg of soil is used.	The fine red soil smeared on seed creates a hard surface which is impermeable and protects seed against attack of storage pests. It also resists moisture permeability.
	Seeds were treated with pongamia leaf extract and dried before sowing.	Strong odor of pongamia leaves repels storage insects

	Seeds were kept in a gunny bag along with *Guntur* chili powder and neem leaf powder.	The chili powder contains capsacin which is known to inhibit lipid peroxidation which in turn slows down seed ageing. The *Guntur* type is known for its high pungency. The neem leaf powder acts as a repellent.
	Seeds were kept with powder of bitter gourd or drumstick seed extract for 3–6 months.	The toxic nature of drumstick and bitter gourd seeds not only repels insects but also protects from pathogens associated with seed.
Chickpea	Seeds were stored along with mint leaves (*pudina*) or sweet flag (*baje*) root powder. Seeds were treated with citronella leaf oil, cotton seed oil, soybean oil, or castor seed oil; 500 ml of oil was used for 100 kg of seed.	Strong odor of sweet flag repels storage Insects The strong odor of these oils repels storage pests and microbes like *Alternaria* and *Fusarium.*
Pigeonpea and chickpea	Seeds of these crops were kept along with small millets like pearl millet or foxtail millet or finger millet and stored in an earthen pot. The pot was made airtight by smearing cowdung. For 5 kg of seed, 1 kg of millets was used.	The coarse seed surface of minor or small millets absorbs moisture of seed of pulses and helps in better storage.
Green gram	Seeds were kept on a layer of ash in an earthen pot and covered with another layer of ash. Then another pot was kept on it and cow dung was smeared to make it airtight.	The insects inside the seed will be suffocated and die and also the seed can be stored for a longer period since seeds will not absorb moisture from outside.
	Ten kg of seed was mixed with 250 g chili powder and 1 kg of *ragi* or finger millet fl our, and then kept in a bamboo pot along with paddy husk.	Chili powder provides repellence against storage pests while flours prevent attack of secondary pests. The use of fl ours to preserve seeds is an ancient practice as mentioned in Varahamihira's *Brihat Jataka*.
Chili	Seedlings of chili were removed from the nursery bed and treated with 1:3 solution of cow urine and water.	Cow urine helps in protecting seedlings against damping-off caused by *Rhizoctonia solani.*
	A gunny bag was immersed in hot water and seeds were placed in it and kept for a day. The seeds were then used to sow on the seed bed.	The pre-germinated seed when sown on the seed bed helps to get more usable transplants and improve vigor.
Sunflower	Seeds were kept inside the dried fruits of sponge gourd after removing the seeds.These fruits were kept in an airtight container.	The fruits of sponge gourd act as protective capsules against insect pests and protect sunflower seed during storage.
Cotton	Seeds were treated with ash and cow dung slurry and dried in shade before sowing.	Cow dung slurry helps to remove the fiber attached to the seed and thus facilitate sowing. Ash along with cow dung slurry is known to control diseases caused by *Rhizoctonia solani*. Cotton and other hard seeds were smeared with cow dung before sowing as in Kautilya's Arthashastra

Chapter 6. Crop voyage in India and world

Description of Indian civilization and agriculture by travelers from China, Europe and USA

Indus valley civilization: Allchins, relying on Lambrick, who, according to them, had personal knowledge of Sind, describe as follows how crops were grown in the riverain tract of the Indus. "The principal food grains, that is wheat and barley, would have been grown as spring *(rabi)* crops: that is to say, sown at the end of the inundation upon land which had been submerged by spill from the river or one of its natural flood channels, and reaped in March or April. The Greek writers highly praised the fertility of Indian soil and favourable climate condition describing the principal agricultural products of the land. The Greek writers also affirm that India has a double rainfall and the Indians generally gather two harvests. - Megasthenes witnesses - the sowing of wheat in early, winter rains and of rice, 'bosporum', sesamum and millets in the summer solstice (Diodorus, II, 36). **Megasthenes** adds further to the winter crops, viz., "wheat, barley, pulse and other esculent fruits unknown to us".

The Chinese pilgrim **Hsieun Tsang** who arrived at the monastic University of Nalanda in 630 A.D. mentioned the gardening as: "The temple arose into the mists and the shrine halls stood high above the clouds . . . streams of blue water wound through the parks; green lotus flowers sparkled among the blossoms of sandal trees and a mango grove spread outside the enclosure."

Protection of cultivators: Sher Shah had genuine concern for the peasantry and safety of their crops. One of the regulations made by Sher shah was this: That his victorious standards should cause no injury to the cultivations of the people; and when he marched he personally examined into the state of the cultivation, and stationed horsemen round it to prevent people from trespassing on any one`s field. As regards the peasantry and their condition, there is reliable evidence in the observations of the European travellers who travelled in India in the seventeenth century. Evidence of the structure of the Mughal gardens and plants grown in them is in the Persian classics illustrated during the reign of Akbar. Among them is *Diwan-i-Anwari*, a collection of poems by the Persian poet Anwari, who flourished in the latter part of twelfth century. It contains some excellent paintings on gardens and gardening. **Abu-l-Fazl** mentions three kinds of sugarcane, viz. *paunda*, black and ordinary. **Abu-l-Fazl** provides a list of twenty-one fragrant flowering plants along with the colour of their flowers and the season of flowering in the **AiniAkbari**. **Terry**, an English traveler, writes, ‗The country was abounding with musk-melons. One could also find water-melons, pomegranates, lemons, oranges, dates, figs, grapes, coconut, plantains, mangoes, pineapples, pears, apples, etc.‘

Terry also mentions the use of coffee by some people. He writes, ‗Many religious people drank a ―wholesome liquor‖ which they called coffee. Black seeds were boiled in water, which also become black. It altered the taste of water very little. It quickened the spirit and cleansed the blood.

Francois Bernier: Of the European travelers who come to India during the Mughal rule, the most intelligent and learned was Francois Bernier a Frenchman. Bernier gives a vivid description of Bengal its landscape people and its plant and animals products. With extensive fields of rice, sugar, corn, three or four sorts of vegetables, mustured, seasems for oils and small mulberry trees two or three feet (61 to 91 cm) in height, for the food of silk worms.

Meadows Taylor states ―The Bahmanis constructed irrigation works in the eastern provinces, which incidentally did good to the peasantry while primarily securing the crown revenue. **Vincent Smith** points out that those items to their credit weigh lightly against the wholesale devastation wrought by their credit weight lightly against the wholesale devastation wrought by their wars, massacres, and burnings. Their rule was harsh and showed little regard for the welfare of Hindu peasants, who were seldom allowed to retain the fruits of their labour much more than would suffice to keep body and soul together.

Herodotus (484-425 BC) the father of history reported in his writings that the wild Indian (cotton) trees possessed in their fruits fleeces, superseding those of sheep in beauty and excellence from which the natives used to weave cloth. Herodotus further wrote that ―trees which grow wild in India and the fruit of which bear wool exceeding in beauty and fineness that of sheep wool Indians make their clothes with this tree wool‖. Some traveller writers fabricated stories of a lamb sitting inside the fruit. **Marco Pola**, a Venetian, who traveled widely throughout the Asia in AD 1290 said that the coast of Coromandel (Madras, India) produced the finest and most beautiful cotton in the world. Indian cloth, particularly the Dacca muslin was renowned all over the world and has been described as ‗webs of woven wind‘ by oriental poets. It was so fine that it could hardly be felt in the hands. It is said that when such muslins were laid on the grass to bleach and the dew had fallen, it was no longer visible. A whole garment made from it could be drawn through a wedding ring of medium size. There is also the often repeated tale of Moghul princes who put on seven layers of muslin and still the contours of her body were so visible that she had to be admonisher by her father, Muhamed Bin Thuklak.

Development of New world crops

The encounter of America by Christopher Columbus in 1492 was the greatest event of the late Middle Ages and is a convenient benchmark to date the beginning of the Modern Era. Three great cultures coexisted in America, although they were unaware of each other: Aztec, Mayan, and Incan. These were monumental civilizations similar in many respects to that in ancient Egypt with enormous temples in the form of pyramids, pictorial writing, a system of cities and government, a bewildering theology, magnificent art, and a developed agriculture. These cultures also had a dark side—slavery, constant warfare, the offering of living human hearts as sacrifice, and cannibalism. Ironically, Columbus, in searching for Asia, did discover their descendants. However, much more valuable than gold and silver treasures were the new crops from the New World that have continually enriched the bounty and cuisine of Europe and the world. Important New World crops are presented (Table 1). We review the history and images of New World crops with particular relevance to horticulture.

NEW WORLD CROPS

Grains and pseudograins

Various grains and pseudograins were domesticated in the New World, including maize (Zea mays), amaranth (Amaranthus spp.), wild rice (Zizania palustris L.), and quinoa (Chenopodium quinoa). Maize has become the most important world grain, surpassing wheat, rice, sorghum, and millets. Maize is presently the principal source of animal feed, especially for pigs and chickens, human food (e.g., cornbread, grits, sweet corn, tortillas, and popcorn), as a source of sugars (corn sweetener), and now as a major source of energy (ethanol). Maize was cultivated by Aztec, Mayan, and Incan farmers, and its production and use made settled life and civilization possible. The significance of maize as a major staple among the native people of the New World is evident in the deification of this crop and its popularity as a common feature of ceramic pottery.

Legumes

New World legumes such as common bean, lima bean, and peanut (groundnut) were destined to become important world food crops. The peanut, found in ceramics from the Moche culture in Peru, was spread worldwide by European traders and became particularly important in Africa after being brought there from Brazil. Phaseolus bean was vital to New World agriculture for agronomic, nutritional, and culinary reasons. Beans and maize were sown in the same hole and the two crops complemented each other. Maize acted as a support for the climbing beans, and nitrogen-fixing bean as a result of rhizobium bacteria provided this element to the soil. The mixture of beans and tortillas (maize pancakes) provide a complete protein food that was the basis of Aztec and Mayan diets. It remains the basis of Mexican cuisine to this day.

Cucurbits

The New World cucurbits, Cucurbita moschata, C. pepo, C. maxima (squashes and pumpkins), and Sechium edule (chayote), were important crops of the indigenous population and were grown for their fruit and seed. Representation of C. pepo can be found in Incan ceramic pottery. The New World cucurbits became prominent in Renaissance herbals in the 16th century and the genre known as natura morta (still life) popular in the 17th and 18th century.

Solanaceous fruit crops

Capsicum peppers and pepino, important food crops with ceremonial and medicinal uses in pre-Columbian America, are represented in various indigenous ceramics. Because Columbus was looking for black pepper, the discovery of the even more pungent fruits of various species of Capsicum led to their immediate acceptance and popularity throughout the world, particularly in Asia and China where they became an important part of their cuisine. European herbal images of capsicum pepper are abundant and sculpted forms can be found on the door of the Pisa Cathedral (Italy) along with tomato. Tomato fruit, because of its resemblance to the poisonous Old World mandrake, was treated with skepticism but soon was consumed raw and cooked to become an integral part of Italian cuisine, and now is one of the most important fresh and processed world vegetables.

Root and tuber crops

Indigenous people in the New World domesticated a number of starchy vegetables, including cassava, potato, and sweetpotato, that have become very important world crops. There are numerous images of potato in pre- Columbian sculpture, and potato culture of the Incas is illustrated in a calendar presented to the King of Spain in 1580. Potato has become one of the 10 most important world food crops.

Fruit crops

There are various temperate, subtropical and tropical fruits in the New World that have become valuable world crops and many such as various annonas, guava, jaboticaba, and mamey that are still not fully used. Brambles. Rubus species are abundantly found across North America with the blackberry (Rubus subg. Rubus), red raspberry, and black raspberry (R. idaeus and R. occidentalis, respectively) being the most well known and most important commercially. The seeds of cacao originating in the Amazon Basin were long prized in Mesoamerica and the seeds once used as currency by the Aztecs; the fruits are a common feature in pre-Columbian pottery. Ground fermented cocoa bean is the main source of chocolate. The pulp surrounding the seed is delicious and remains to be commercially exploited. The beverage xocolatl, a Nahuatl word meaning bitter water, was introduced to the Spanish court in 1544 and soon became very popular in Europe when the hot chili flavoring was replaced with sugar. Cactus fruits. The cactus family (Cactaceae) is confined to the New World but has been distributed worldwide. Cacti have become important world crops for fruit (cactus pear, pitaya), vegetables (cladodes), animal feed, and ornamentals. Pineapple. Columbus in his second voyage of 1493 found domesticated pineapple on the island of Guadeloupe, an island in the eastern Caribbean, and described it as pin˜a de India because of its resemblance to a pinecone.

Papaya. This tropical fruit is now ubiquitous as a backyard tree in the tropics worldwide and has become an important export in Brazil, Hawaii, Mexico, and Thailand. Strawberry the small-fruited diploid was well known in Europe but the modern largefruited octoploid strawberry ($2n = 8x = 56$) is derived from F. chiloensis and F. virginiana that hybridized in France. Large whitefruited forms of F. chiloensis were found growing in Chile.

Ornamentals

The Americas have been the source of over 1000 garden plants. Various ornamentals including dahlia, fuchsia, helianthus, and petunia have become very important in floriculture and are now grown worldwide. Helianthus, the sunflower, has long been associated with America as a food and medicinal plant and became an important ornamental and oilseed crop in the 20th century. Industrial crops Four New World crops, cotton (Gossypium), Para´ rubber (Hevea brasiliensis), tobacco (Nicotiana spp.), and quinine (extracted from Cinchona sp.), exploited by indigenous Americans were to have important effects on world history. American cotton, derived from two species of Gossypium, G. hirsutum from Central America and G. barbadense from Brazil, accounts for the majority of world cotton production as a result of its longer, stronger fibers compared with Old World cottons. The resinous latex from the tropical Amazonian tree H. brasiliensis is used for the production of rubber, which has important uses in transportation, clothing, and the electrical industry. Rubber has become one of the most vital industrial crops, but the industry is now concentrated in Southeast Asia, particularly Malaysia.

Table 1. Selected crops indigenous to the New World.

	New World crops	Binomial	New World origin
A	**Cereals and pseudo cereals**		
1	Amaranth	Amaranthus spp.	Mexico
2	Maize	Zea mays	Mesoamerica
3	Quinoa	Chenopodium quinoa	Andean highlands
4	Wild rice	Zizania palustris	Northern North America
B	**Legumes**		
	Common bean	Phaseolus vulgaris	South America
	Lima bean	Phaseolus lunatus	South America
	Peanut	Arachis hypogaea	Brazilian–Paraguayan Center
C	**Cucurbits**		
	Chayote	Sechium edule	Mexico, Central America
	Pumpkin	Cucurbita maxima	South America
	Squash	Cucurbita moschata, C. pepo	Mexico
D	**Solanaceous fruits**		
	Capsicum peppers	Capsicum annuum, C. bacattum, C.	South America, northern Peru
		chinenese, C. frutescens, C. pubescens	
	Ground cherry,	Physalis peruviana, P. philadelphica	Central America
	husk tomato		
	Pepino	Solanum muricatum	Tropical America

	Tomato	Solanum lycopersicum	Western South America,
			domesticated in Mexico
E	**Roots and tubers**		
	Cassava	Manihot utilissima	Brazil
	Potato	Solanum tuberosum	Peru
	Sweetpotato	Ipomoea batatas	Central America
F	**Fruits and nuts**		
	Annona	Annona cherimola	Brazil
	Avocado	Persea Americana	Mesoamerica
	Black raspberry	Rubus occidentalis	North America
	Brazil nut	Bertholletia excelsa	Amazon
	Blueberry	Vaccinium corymbosum	North America
	Cacao	Theobroma cacao	Tropical America
	Cactus	Opuntia ficus-indica	Mexico
	Cashew	Anacardium esculenta	Brazil
	Cranberry	Vaccinium macrocarpon	North America
	Guava	Psidium guajava	Tropical America
	Jaboticaba	Myrciaria cauliflora	South America
	Mamey	Mammea americana	West Indies, northern
			South America
	Papaya	Carica papaya	Tropical America
	Pineapple	Ananas comosus	Tropical South America
	Pitaya	Stenocereus spp.	Mexico
	Strawberry	Fragaria chiloensis	Pacific Coast, North
		Fragaria virginiana	and South America
			Eastern, North America
	Soursop	Annona muricata	Peru–Ecuador
G	**Industrials**		
	Cotton	Gossypium hirsutum, G. barbadense	Central America, Brazil
	Quinine	Cinchona calisaya	Peru
	Rubber	Hevea brasiliensis	Amazon
	Tobacco	Nicotiana rustica, N. tabacum	Mexico, Central America
H	**Ornamentals**		
	Dahlia	Dahlia spp.	Mesoamerica
	Fuchsia	Fuchsia triphylla	Hispaniola; South America
	Helianthus (sunflower)	Helianthus annuus	North America
	Petunia	Petunia spp.	South America

CROPS – INDIGENOUS AND INTRODUCED - HISTORY OF RICE, SUGARCANE AND COTTON

Since time immemorial, cereals, particularly wheat, rice, and maize are considered to be life sustaining crops for humans. Even in future these crops will play a pivotal role in food security system of several nations across the world. The utilization of cereals as food and feed, and for industrial purpose is around 1792 million out of which wheat, rice, and coarse grains contribute nearly 35.4%, 20.8%, and 53.7% respectively. In the past fifty years the world has witnessed structural change in cereal economics: Long run trend towards wheat and rice and to some extent for maize, while replacement of coarse grain crops occurred. Developing countries achieved higher growth in production and consumption and at the same time recorded rise in deficits. Rapid expansion of cereals as feed in developing countries and increased share of cereals in world trade.

Rice

Rice is the most important tropical cereal and supplies a quarter of the entire caloric intake of the human race. About 90% of its area and consumption is in South and Southeast Asia, which support a major part of the world population. Rice belongs to the genus Oryza and there are two main cultigens, i.e., sativa in Asia and glaberrima in Africa. Rice is a semi aquatic graminaceous crop having great deiversity as it is grown in complex range of environments, i.e., from uplands at altitude of 3000 m to rainfed lowland irrigated, tidal swamp, and deepwater areas. Besides these two species, aquatic rice species, i.e., Zizania aquatica and Z. palustris, are endemic to North America, where it is the staple food of Indians.

Origin

The place of major diversity where rice might have domesticated is roughly the east west belt along the Himalayas and adjoining Asia mainland (from Assam, Bangladesh, Burma, Thailand, southern China, and northeren Vietnam). The archaeological evidence suggests that Asian rice culture was established around 7000 years ago. In India carbonized grains excavated from Hastinapur (New Delhi) suggest that it was in cultivation during 1100-800 BC.

Evolutionary history

The evidences from diverse disciplines including biosystematic and paleogeology suggest that the genus Oryza arose from a common ancestor. The evolutionary path was from wild perennial to wild annual to cultivated annual, and the closely related wild relatives contributed differentiation of two cultigens. In oryza sativa, the evolution of different geographical races, i.e., japonica, javanica, and indica (the latter forming aman, aus, and indica types in the Ganges belt) took place assisted strongly by human selecton. There is general agreement that in both Asia and Africa elongation and floating ability in two cultigens was derived from their wild relatives. In rice, change might have occurred in the following sequence: Perennial->climatic stress->seasonal->human selection-> cultivated rice.

Agri-history of Cotton in India : An Overview

The antiquity of cotton in the Indian subcontinent has been traced to the 4th millenium BC. The fabrics dated approximately 3000 BC , recovered from the Mohenjo-daro excavations in Sind (Pakistan), were identified to have originated from cotton plants, closely related to the Gossypium arboreum species. The lint-bearing species of the genus Gossypium, the true cottons, are four, out of which the diploid (2n=26) species G. arboreum and G. herbaceum are indigenous in Asia and Africa. The history of introduction into India of the new world cottons (tetraploid species of G. hirsutum and G. barbadense with 2n=52) dates back to the 18th century AD. By the last decade of the 20th century, India had gained a pride of place in the global cotton statistics with the largest cropped area of 8.9 million in 1996-97, growing the most diverse cultivars in terms of botanical species and composition, producing the widest range of cotton fiber quality suitable for spinning 6‘s to 120‘s counts yarn, and supporting the largest agrobased national industry of the country.

Origin of the indigenous cottons

The cotton textiles of the Harappan civilization (2300-1750BC) were produced by sophisticated textile craftsmanship. Thus at the earliest agricultural levels yet discovered, true cottons were already present in the Indian subcontinent. Wild and weedy types have been found to be associated with primitive cultivated types in both the old world species of G. herbaceum and G. arboreum. Species of G. herbaceum, have been found from the coastal strip northwest of Karachi (Pakistan), through northern Baluchistan to south Yemen, Ethiopia, and Sudan and even in West Africa south of the Sahara. Species of G. arboreum. have been recorded by in Kathiawar, Gujarat, Khandesh, and the Deccan in India. It seems likely that it was in Gujarat (India) or Sind (Pakistan) that G. arboreum cottons were first brought into cultivation (Hutchinson, 1971). It may further be surmised that the differentiation of the three perennial races of G. arboreum, namely burmanicum of northeastern India, indicum of western India and the Penninsula, and sudanense of northern Africa, ante-dated domestication and that each contributed separately to the cultivated cottons in Asia and Africa.

Agri-history of cotton production development

Until the middle of the 18th century, only indigenous arboreum and herbaceum varieties of cotton were grown in different regions of the country. Due to the human skills and dexterity of the local artisans, very fine yarns were produced by them, from even the short staple and coarse cottons grown in India. In 1788, the Governor General (at Calcutta) was requested by London to encourage growth and improvement of Indian cottons to meet the requirements of the Lancashire textile industry. The figures for exact area under indigenous cottons and production in India during this period are not available, although it is reported that the local production had stabilized by 1900AD.

Sugarcane

The origin of sugarcane was India. The species *Saccharum officinarum* was first domesticated in India and the spread to other countries by Arab merchants. Evidences revealed that 3000-7000 years ago, Atarna veda indicated that sugarcane originated from the area Sakkaram and then later it was indicated as sakkra in Sanskirit. Earlier indications in Kautilya Artha Sastra also mentioned about the cowdung sett treatment for sugarcane.

Crops introduced by Britishers

Pseudo cereals Avena sativa (oat);**Grain legumes** Castanospermum australe (black bean), Pisum sativum (pea); Fiber crops Gossypium barbadense (cotton);**Vegetables** Allium tuberosum (leek), Asparagus racemosus (satawar), Beta vulgaris (beet root), Brassica oleracea var. botrytis (cauliflower), Capsicum frutescens (sweet pepper), Cichorium intybus (chicory), Cucurbita maxima (squash), Daucas carota (carrot, orange type), Lactuca sativa (lettuce), Lycopersicon esculentum (tomato), Pisum sativum (sweet pea); **Fruits** Averrohoa carambola (carambola), Carica papaya (papaya), Fragaria ananassa (strawberry), Garcinia mangostana (mangosteen), Manihot esculenta (cassava), Malus pumila (apple), Prunus armeniaca (apricot), Prunus avium (cherry), Prunus communis syn. P. domestica (plum), Prunus persica (peach), pyrus communis (pear), Ribes rubrum (red currant) **Medicinal** Cinchona officinalis (quinine), Origanum vulgare (majoram), aromatic plants Papaver somniferum (opium poppy), Pelargonium capaitatium (Geranium), Salvia officinalis (sage), Thymus vulgaris (thyme), Vanilla aromatica (vanilla)

Crops introduced from West and Central Asia by Mughals or Arabs

Allium cepa (onion), Allium sativum (garlic), Brassica rapa (turmip), Brassica oleracea var. capitata (cabbage), Coriandrum sativum (coriander), Cucumis melo (sweet muskmelon), Daucas carota (carrot, black & red type), Phoenix dactylifera (date palm), Pisum sativum (pea), Syzygium aromaticum (clove), Vitis vinifera (grape)

Crops introduced by Spaniards

Phaseolus vulgaris (French bean)

Crops introduced from China

Aleurites fordii (tung-oil), Glycine max (soyabean), Eriobotrya japonica (loquat), Juglans regia (walnut), Litchi chinensis (litchi), Sapium sebiferum (tallow-tree)

Crops introduced from Latin America

Hevea brasiliensis (Rubber), Ananas comosus (pineapple)

Crops introduced from Southeast Asia and Pacific islands

Arenga pinnata (sugar-palm), Artocarpus communis (breadfruit), Citrus decumanus (pomelo), Citrus paradisi (grapefruit), Durio zibethinus (durian) and Metroxylon sagus (sago)

Some recent introductions

Humulus lupulus (hops), Helianthus annuus (sunflower), Simarouba glauca (simarouba), Cyphomandra betacea (tree tomato), Carya illinoensis (pecan nut), Corylus avellana (hazel nut), Macadamia tetraphylla (macadamia nut), Parthenium argentatum (guayule), and Mentha arvensis (spearmint, USA) Acacia senegal (Australia), Acacia mangium (Australia) and Actinidia chinensis (kiwifruit, New Zealand)

Chapter 7. Agriculture scope

Scope of Indian Agriculture

Agriculture: - The term agriculture is derived from two Latin words **ager** or **agri** meaning **soil** and **cultura** meaning **cultivation**. Agriculture is a broad term including all aspects of crop production, livestock farming, fisheries, forestry etc.

Agriculture is a branch of applied science. It is the art of farming including the work of cultivating the soil for producing crops and raising livestock. There are three main spheres of agriculture as under;

Geoponic:- meaning cultivation in earth,

Hydroponic:- meaning cultivation in water and

Aeroponic:- meaning cultivation in air.

AGRICULTURE is defined in the Agriculture ACT, 1947, as including 'horticulture, fruit growing, seed growing, dairy farming and livestock breeding and keeping, the use of land as grazing land, meadow land, osier land, market gardens and nursery grounds, and the use of land for woodlands where that use ancillary to the farming of land for Agricultural purposes".

Agriculture is defined as an art, science and business of producing crops and livestock for economic purposes

Agriculture is a productive unit where the gifts of nature like land, light, water and temperature are integrated into a single primary unit i.e **crop plant** which is indispensable for human beings. The secondary productive units of agriculture are **animals** including **livestock, birds and insects** which feed on the primary units and provide concentrated products such as **meat, milk, hide, wool, eggs, honey, silk and lac.**

Agriculture is considered as mother of all agro-based industries because the development and functioning of all such industries is governed by the raw material supplied from agriculture sector E.g. Textile, Oil, Sugar, Dairy and Canning industries are directly governed by cotton, oilseeds, sugarcane, milk and fruits production, respectively.

The important cultural energies utilized for the production and protection of agricultural commodities are;-

Natural resources:-

Agriculture implies the effective use of land, water, light and other resources of environment through the production of field crops, forage crops, horticultural crops, farm animals, fisheries and forestry.

Added resources:-

1. Irrigation and drainage
2. Organic, biological and mineral fertilizers, chemicals
3. Farm equipments and draft power.

These are used to maximize the productivity per **unit time, water, land, labour and rupee invested.**

The word **AGRICULTURE** thus may be expanded as **A**ctivities on the **G**round for **R**aising **I**ntended **C**rops for **U**plifting **L**ivelihood **T**hrough the **U**se of **R**echargeable **E**nergies.

REVOLUTIONS IN AGRICULTURE

Revolution	**Concerned with**	**Achievements**
Green revolution	**Food grain production**	Food grain production increased from 51 million tones at independence to 223 million tones in(2006 - 07), 4.5 times increase.
White revolution	**Milk production**	Milk production increased from 17 million tones at independence to 69 million tones, four times (1997-98).
Yellow revolution	**Oilseeds production**	Oil seed production increased from 5 million tones to 25 million tones since independence, 5 times increase
Blue revolution	**Fish production**	Fish production increased from 0.75 million tones to nearly 5.0 million tones during the last five decades.

Similarly, the egg production increased from 2 billion at independence to 28 billion, sugarcane production from 57 million tones to 276 million tones, cotton production from 3 million bales to 14 million bales which shows our sign of progress.

India is the largest producer of fruits in the world. India is the second largest producer of milk and vegetable.

In future, agriculture development in India would be guided not only by the compulsion of improving food and nutritional security, but also by the concerns for environmental protection, sustainability and profitability. By following the **General Agreement on Trade and Tariff (GATT)** and the liberalization process, globalization of markets would call for competitiveness and efficiency of agricultural production. Agricultural will face challenging situations on the ecological, global climate, economic equity, energy and employment fronts.

Agriculture as an art, science and business and Branches of agriculture

Agriculture as an art:- Learning by doing and gaining experience. Art is concerned with skill and experience. It is inherited by seeing parents or elders through experience. E.g. art of walking of a child.

Skill of agriculture is purely derived by physical work.

Skill → Physical skill

Skill → Mental skill

Agriculture **primarily requires physical skill** and **secondarily mental skill.** Physical skill is inherited by doing physical work with perfect execution. e.g. Opening a straight furrow, broadcasting/sowing seeds, levelling the field, top dressing of fertilizer, weeding, harvesting crop etc.

Art of agricultural requires secondarily **mental skill.** it is related with **decision making.** e.g. Selection of crops for a particular area is a skill season, right time of sowing the crop after onset of monsoon.

Agriculture as a Science:-

- Science is systematic study of happenings of any thing
- Scientific technology helps in getting maximum output, science helps to select a crop suitable to seasons at the appropriate time
- Part of science is inherited by farmers
- Science of agricultural tries to give reasons. Yield increase is due to application fertilizer. Yield reduction also results due to pest and disease attack etc.
- Farmers will become scientists if more sophisticated methods are given. Experience makes them scientists
- Science of agriculture requires **primarily mental skill** and **secondarily physical skill**

Agriculture as Business

- Nowadays, it is purely business oriented.
- The market price of agricultural produce is governs by total production of a particular commodity. It follows the economic principle of demand and supply.
- In agriculture business, quantity is ignored and profit is more. The farmers try to get more profit per rupee invested. E.g. in Punjab, rice is produced during *Kharif* season for profit and commercial reason
- Business of agriculture is purely economic

No.	Agriculture	Industry
a)	Resources are self generated	Depends on raw materials
b)	Direct producer	Indirect producer
c)	Subjected to natural calamities	Protected from natural calamities
d)	Production is not under control	Production is under control
e)	All the process is carried out by single person or family	There are separate units and subunits
f)	Owner himself is the labour	Owner as a labour is less in industry

BRANCHES OF AGRICULTURE

Seven branches as under

1. Agronomy: – It deals with the production of various crops which includes food crops, fodder crops, fibre crops, sugar, oil seeds, etc. The aim is to have better food production and how to control the diseases and pest.

2. Horticulture: – Branch of agriculture deals with the production of flowers, fruits, vegetables, ornamental plants, spices, condiments (includes narcotic crops – opium, etc. which has medicinal value) and beverages.

3. Forestry: – It deals with production of large scale cultivation of perennial trees for supplying wood, timber, rubber, etc. and also raw materials for industries.

4. Animal Husbandry: – The animals are being produced, maintained, etc. Maintenance of various types of livestock for direct energy (work energy). Husbandry is common for both crop and animals. The objective is to get maximum output by feeding, rearing, etc. The arrangement of crops is done to get minimum requirement of light or air. This arrangement is called geometry. Husbandry is for direct and indirect energy.

5. Fishery Science: – It is for marine fish and inland fishes including shrimps and prawns.

6. Agricultural Engineering: – It is an important component for crop production and horticulture particularly to provide tools and implements. It is aiming to produce modified tools to facilitate proper animal husbandry and crop production tools, implements and machinery in animal production.

7. Home Science: – Application and utilization of agricultural produces in a better manner. When utilization is enhanced production is also enhanced. E.g. a crop once in use in south was found that it had many uses now.

On integration, all the seven branches, **first three is grouped as for crop production**, **next two animal management** and **last two alive agriculture branches**.

Land utilization statistics

Sr. No.	Particulars	India	Gujarat
1.	Geographical location	8^0.4' - 37^0.6' N latitude and 68^0.7' - 97^0.25' E longitude	21^0.1' - 24^0.7' N latitude and 68^0.4' - 74^0.5' E longitude
2.	Total geographical area	328.848 million ha	19.60 million ha
3.	Total reporting area	304.300 million ha	18.82 million ha
4.	Area under cultivation	143.000 million ha	9.42 million ha
5.	Total cropped area	179.750 million ha	10.16 million ha
6.	Area sown more than Once	36.750 million ha	0.74 million ha
7.	Area not available for Cultivation	161.300 million ha	2.61 million ha
8.	Area under forest	66.400 million ha	1.88 million ha
9.	Length of Sea coast	7516.5 km	1600 km

Agricultural trade

Agricultural Export and Import (US dollars)

Export				**Import**			
Commodity	13-14	14-15	15-16	Commodity	13-14	14-15	15-16
Rice	6.2	7.8	7.9	Pulses	2.4	1.8	2.8
Meat and meat preparations	3.3	4.5	4.9	Cashew	1.0	0.8	1.1
Processed foods	2.8	2.7	2.7	Vegetable oils	9.9	7.2	10.6
Spices	2.8	2.5	2.4	Fresh fruits	1.1	1.3	1.6
Oil meals	3.0	2.8	1.3	Spices	0.5	0.6	0.7
Sugar	1.6	1.2	0.9	Sugar	0.6	0.4	0.6
Wheat	1.9	1.6	0.8	Cocoa products	0.2	0.2	0.3
Pulses	0.2	0.3	0.2	Natural Rubber	0.8	0.9	0.8
Agriculture exports	32.0	33.0	30.1	Agriculture Imports	16.8	14.9	15.9

Food grain production trends in India

India is estimated to produce 273.38 million tonnes (MT) of foodgrain in the 2016-17 crop year (July-June) over 8 MT more than the previous record of 265.04 MT in 2013-14. Anticipating good monsoon this year too, the ministry had last month set a target of foodgrain production at 273 MT for the 2017-18 crop year and expressed confidence of maintaining farm sector growth rate of over 4% during the period.

Table 1: Production of Foodgrains and Other major Crops

Crop	**2004-05**	**2010-11**	**2011-12**	**2012-13**	**2013-14**
Rice	83.1	96.0	105.3	105.2	106.7
Wheat	68.6	86.9	94.9	93.5	95.9
Coarse Cereals	33.5	43.4	42.0	40.0	43.3
Pulses	13.1	18.2	17.1	18.3	19.3
Total Food Grain	198.4	244.5	259.3	257.1	265.0
Oilseeds	243.5	324.8	298.0	309.4	327.5

(lakh tonnes)					
Sugacane (lakh tonnes)	2370.9	3423.8	3610.4	3412.0	3521.4
Cotton (Lakh bales)	164.3	330.0	352.0	342.2	359.0

Table 2:Production of Milk, Eggs, Wool, Meat and Fish- All India

Year	**Milk (Million Tonnes)**	**Eggs (Million Nos.)**	**Wool (Million Kgs.)**	**Meat (Million Tonnes)**	**Fish (000' Tonnes)**
1950-51	17	1832	27.5	-	752
1980-81	31.6	10060	32	-	2442
1990-91	53.9	21101	41.2	-	3836
2000-2001	80.6	36632	48.4	1.9	5656
2010-2011	121.8	63024	43	4.8	8231
2013-2014	137.7	74752	47.9	6.2	9574

Chapter 8. Importance of agriculture and agriculture available in India

Development of Agricultural Departments, ICAR and SAUs in India

A fundamental department of agriculture in India was started in the year 1871. Although the chief function of the department named 'Department of Revenue, Agriculture and Commerce' remained revenue and there was no work on agricultural development. Primarily, the department was established by the Government with a view to supply cotton to the textile industries of Manchester, and not to feed the famine-ravished India. Based on the reports of the Famine Commissions of 1880, 1898 and 1900, the Government of India (GoI) was determined to set up a central 'Department of Agriculture' controlled by the Imperial Secretariat and agriculture departments were to be set up in the provinces to primarily look after agricultural enquiry, agricultural development and famine relief in the country.

However, the key duty of the agriculture departments both in the centre and the provinces lingered on famine relief. In 1892, an agricultural chemist and an assistant chemist were allotted to look after research and teaching in India, which manifested the first scientific staff in the Department of Revenue and Agriculture. Eventually, in 1901, an Inspector General of Agriculture was appointed to advise the imperial and the provincial governments on agricultural matters. An imperial mycologist was appointed in the same year, and an entomologist was appointed in 1903.

During the severe famines of 1899–1900, Lord Curzon, the then Viceroy of India, was convinced that the GoI must urgently concentrate on the agricultural sector to overcome the damages caused by frequent famines. As a consequence, Agriculture Research Institute (now the Indian Agricultural Research Institute (IARI), together with a college for advanced agriculture training, was established at Pusa in the year 1905 and its director was the agriculture adviser to the GoI till 1929. Today, IARI is one of the premier national institutes for agricultural research, education and extension in India. The Agricultural School at Saidapet, Chennai, which was established as early as 1868, was later relocated to Coimbatore during 1906. Likewise, a branch for teaching agriculture in the College of Saidapet, Chennai, which was established as early as 1868, was later relocated to Coimbatore during 1906. Likewise, a branch for teaching agriculture in the College of Science at Pune (established in 1879) was subsequently developed into a separate College of Agriculture in 1907. Similar agricultural colleges were established at Kanpur, Sabour, Nagpur and Lyallpur, now in Pakistan, between 1901 and 1905. An All-India Board of Agriculture was established in 1905 with a view to bring the Provincial governments more in touch with one another and making suitable recommendations to the GoI. The Indian Agriculture Service was constituted in 1906. Establishment of the Imperial Council of Agricultural Research (the present-day ICAR). The Royal Commission on Agriculture (Linlithgow Commission), which was appointed in the year 1926, authoritatively reviewed the position of agriculture in India and reported the same in 1928. According to the proposal of the Royal Commission on Agriculture, the GoI, Department of Education, Health and Lands set-up the Imperial Council of Agricultural Research (now ICAR) on 16 July 1929.

The Commodity Committee

Several semi-autonomous Central Commodity Committees were set up by the Ministry of Food and Agriculture. The Indian Central Cotton Committee was the first one to be established in 1921 on the recommendation of the Indian Cotton Committee (1917–18). The chief function of the Central Cotton Committee was cotton improvement with special focus on the development of improved methods of growing and marketing cotton. The Committee's support led to the development of 70 improved varieties and considerably improved fibre quality.

The achievement by the Indian Central Cotton Committee led to the setting up of commodity committees on crops such as lac, jute, sugarcane, tobacco, coconut, oilseeds, spices, cashewnut and arecanut. These apprehensions led to the formulation of the Project for Intensification of Regional Research on Cotton, Oilseeds and Millets (PIRRCOM), which was the first step in the country towards coordinated approach to agricultural research. The Central Commodity Committees were abolished in 1965 and the research institutes under their control were transferred to ICAR. Plantation research in colonial India Though the experimental farms were established in 1884, the provincial agricultural departments could seldom go beyond the collection of revenue data and famine relief operations

PIRRCOM

With the initiatives for agricultural research development, there was a need to coordinate the research on various crops, especially cotton, oilseeds and millets. Moreover, a need was felt to conduct research work in different agro- climatic regions of the country. The first coordinated research work on regional basis was initiated in 1956 in the form of a joint venture by ICAR and the Indian Central

Commodity Committees on Oilseeds and Cotton. Eventually, 17 centres were established across the country to perform research on cotton (Gossypium species), castor (Ricinus communis), groundnut (Arachis hypogaea), taramira (Eruca vesicaria), jowar (Sorghum bicolor), bajra (Pennisetum glaucum), etc. A regional research station with of full-fledged sections of plant breeding and genetics, agronomy, agricultural chemistry and soil science, plant pathology and entomology was established.

Initiation of All-India Coordinated Research Projects

The conception of coordinated projects was first initiated for hybrid maize. It was under the United States Agency for International Development (USAID). The Ministry of Food and Agriculture under the GoI, signed an agreement with the Rockefeller Foundation in 1956, according to which the latter was to assist in the development of: (i) The postgraduate school of IARI, New Delhi, and (ii) Research programmes on the improvement of some crops (maize, jowar and bajra, initially). The coordinated maize project in India had proven to be the defining moment in research planning in agriculture in the country. As a result of the coordinated project, new high-yielding maize hybrids became available by 1961. Encouraged by the success of the maize project, in 1965 ICAR decided to initiate coordinated projects on other crops as well as in other areas of research, e.g. animal husbandry, soil sciences, etc. Seventy coordinated projects on various subjects were launched within 3 years of this decision and these accounted for 40% of the total expenditure for agriculture in the Fourth Five-Year Plan. However, the advancement of the coordinated projects was critically analysed in the Fifth Five-Year Plan. Accordingly, some projects were terminated, some were merged with other projects, some were elevated to the level of Project Directorates and some projects were changed to Coordinated Programmes. As a result, the number of coordinated projects decreased to 49 in the Fifth Five- Year Plan.

Reorganization of ICAR

In 1963, the Ministry of Food and Agriculture appointed the Agricultural Review Team headed by Marion W. Parker of USDA (United States Department of Agriculture), to scrutinize the organization of agricultural research in India. The team submitted its report in March 1964 and based on the recommendation of the team, ICAR was reorganized in 1966 and made an entirely autonomous organization. The ICAR was proffered the control for various research organizations under the Department of Food and Agriculture and under the Central Commodity Committees. Eventually, a policy was formulated suggesting that an agricultural scientist would be appointed as the chief executive of ICAR with the designation of Director General. Accordingly, B. P. Pal was appointed as the first Director General of ICAR in May 1965. In June 1972, the GoI appointed a committee headed by P. B. Gajendragadkar (retired Chief Justice of India) to review the enrollment and personnel policies of ICAR and its institutes, and to recommend actions for the enhancement of the same. The committee submitted its report in January 1973. A Department of Agricultural Research and Education was created in the Ministry of Food and Agriculture in December 1973 according to the recommendations made by the committee. The Director General, ICAR was made secretary to the new department. The Minister of Agriculture was designated as the President of the Council, while the Director General of ICAR was made the Chairman of the Governing Body of the Council. Under the Agricultural Scientists' Recruitment Board (ASRB), an Agricultural Research Service (ARS) was initiated for the recruitment of scientific personnel.

Development of agricultural universities

One of the important and premier institutes of the pre-independence era was the Imperial Agricultural Research Institute established at Pusa in 1905. Eventually, IARI has become one of the premier institutes for agricultural research, education and extension in the country. During the years 1948–49, the University Education Commission headed by S. Radhakrishnan, suggested that the country should focus on the establishment of rural universities. H. S. Singh and A. N. Jha (Chief Secretary and Development Commissioner, Uttar Pradesh (UP) visited Land-Grant Universities of United States in 1950 and after coming back, advised the then Chief Minister of UP, Pandit Govind Ballabh Pant, to set up such a university in the state. The Chief Minister accepted their recommendation. This event may be regarded as the one which led to the initiation of agricultural universities in the country. In 1955, the first Joint Indo-American Team was set up. The team suggested the founding of rural universities in each of the states in India. Accordingly, the team identified UP (Tarai), West Bengal (Haringhatta), Bihar (Patna), Odisha (Bhubaneshwar), Travancore-Cochin and Mumbai (Anand, now in Gujarat) to be apposite for starting such universities.

In 1956, a blueprint for agricultural universities was prepared and this provided the root for the proposal by the Government of UP to the Central Government (in September 1956) for starting an agricultural university near Rudrapur in the Tarai region of UP. The Central Government also agreed to the proposal on an experimental basis. In 1959, the second Joint Indo-American Team was setup, which submitted its report in 1960. The Team suggested that the agricultural universities should be autonomous; should consist of colleges of agriculture like veterinary, animal husbandry, home science, technology and basic sciences under them; should have interdisciplinary teaching programme; and should integrate teaching, research and extension. GoI appointed a committee, headed by R. W. Cummings, for providing a model for the essential legislation by the states for the establishment of agricultural universities. The committee submitted its report in 1962 and on the basis of this report, ICAR prepared the model act for the development of agricultural universities. During the period of the Fourth Five-Year Plan between the years 1960 and 1965, seven agricultural universities were established in UP, Odisha, Rajasthan, Punjab, Andhra Pradesh, Madhya Pradesh and Karnataka. The Review Committee on Agriculture Universities (1977–78), headed by M. S. Randhawa, made many useful recommendations for the development of agricultural universities. It noted that the quality of leadership and financial support from the state were cru-cial factors in the development of agricultural universi-ties. The committee suggested, among other things, that the Director General, ICAR, and Chairman, University Grants Commission, should be members of the selection committee that appoints Vice-Chancellors for agricultural universities. The agricultural universities have contributed a great extent to agricultural education, research and development in the country. Many improved varieties of crops, feed and animal stocks have been developed in the agriculture universities. In other words, it could be concluded that the ICAR is identical to agricultural research and education in the country. The role played by the council in the development of agricultural research and education has been quite extraordinary.

Important State, National and International Institutes

1. AICRP on Nematodes, New Delhi
2. AICRP on Maize, New Delhi
3. AICRP Rice, Hyderabad
4. AICRP on Chickpea, Kanpur
5. AICRP on MULLARP, Kanpur
6. AICRP on Pigeon Pea, Kanpur
7. AICRP on Arid Legumes, Kanpur
7. AICRP on Wheat & Barley Improvement Project, Karnal
8. AICRP Sorghum, Hyderabad
9. AICRP on Pearl Millets, Jodhpur
10. AICRP on Small Millets, Bangalore
11.AICRP on Sugarcane, Lucknow
12.AICRP on Cotton, Coimbatore
13.AICRP on Groundnut, Junagarh
13. AICRP on Soybean, Indore
14. AICRP on Rapeseed & Mustard, Bharatpur
15. AICRP on Sunflower, Safflower, Castor, Hyderabad
16. AICRP on Linseed, Kanpur
17. AICRP on Sesame and Niger, Jabalpur
18. AICRP on IPM and Biocontrol, Bangalore
19. AICRP on Honey Bee Research & Training, Hisar
20. AICRP -NSP(Crops), Mau
21. AICRP on Forage Crops, Jhansi
22. AICRP on Fruits, Bangaluru
23. AICRP Arid Zone Fruits, Bikaner
24. AICRP Mushroom, Solan

27. AICRP Vegetables including NSP vegetable, Varanasi
28 AICRP Potato, Shimla

- AICRP Tuber Crops, Thiruvananthapuram
- AICRP Palms, Kasaragod
- AICRP Cashew, Puttur
- AICRP Spices, Calicut
- AICRP on Medicinal and Aromatic Plants including Betelvine, Anand
- AICRP on Floriculture, New Delhi
- AICRP in Micro Secondary & Pollutant Elements in Soils and Plants, Bhopal
- lAICRP on Soil Test with Crop Response, Bhopal
- AICRP on Long Term Fertilizer Experiments, Bhopal
- AICRP on Salt Affected Soils & Use of Saline Water in Agriculture, Karnal
- AICRP on Water Management Research, Bhubaneshwar
- AICRP on Ground Water Utilisation, Bhubaneshwar
- AICRP Dryland Agriculture, Hyderabad
- AICRP on Agrometeorology, Hyderabad including Network on Impact adaptation & Vulnerability of Indian Agri. to Climate Change
- AICRP Integrated Farming System Research, Modipuram including Network Organic Farming
- AICRP Weed Control, Jabalpur
- AICRP on Agroforestry, Jhansi
- AICRP on Farm Implements & Machinery, Bhopal
- All India Coordinated Research Project on Ergonomics and Safety in Agriculture
- AICRP on Energy in Agriculture and Agro Based Indus.,Bhopal
- AICRP on Utilization of Animal Energy (UAE), Bhopal
- AICRP on Plasticulture Engineering and Technologies, Ludhiana
- AICRP on PHT, Ludhiana
- AICRP on Goat Improvement, Mathura
- AICRP- Improvement of Feed Sources & Nutrient Utilisation for raising animal production, Bangalore
- AICRP on Cattle Research, Meerut
- AICRP on Poultry, Hyderabad
  AICRP-Pig, Izzatnagar
- AICRP Foot and Mouth Disease, Mukteshwar
- AICRP ADMAS, Bangalore
- AICRP on Home Science, Bhubaneshwar

Network Projects

1	All India Network Project on Pesticides Residues, New Delhi
2	All India Network Project on Underutilised Crops, New Delhi
3	All India Network Project on Tobacco, Rajahmundry
4	All India Network Project on Soil Arthropod Pests, Durgapura
5	Network on Agricultural Acarology, Bangalore
6	Network on Economic Ornithology, Hyderabad
7	All India Network Project on Rodent Control, Jodhpur
8	All India Network Project on Jute and Allied Fibres, Barrackpore
9	Network project on Improvement of Onion & Garlic, Pune

10	Network Bio-fertilizers, Bhopal
11	Network Project on Harvest & Post Harvest and Value Addition to Natural Resins & Gums, Ranchi
12	Network project on Animal Genetic Resources, Karnal
13	Network Project on R&D Support for Process Upgradation of Indigenous Milk products for industrial application Karnal
14	Network Programme on Sheep Improvement, Avikanagar
15	Network Project on Buffaloes Improvement, Hisar
16	Network on Gastro Intestinal Parasitism, Izatnagar
17	Network on Haemorrhagic Septicaemia, Izatnagar
18	Network Programme Blue Tongue Disease, Izatnagar
19	Network Project on Conservation of Lac Insect Genetic Resources, Ranchi
20	Network Project on Agricultural Bioinformatics and Computational Biology, New Delhi

Deemed Universities

1.	ICAR-Indian Agricultural Research Institute, New Delhi
2.	ICAR-National Dairy Research Institute, Karnal
3.	ICAR-Indian Veterinary Research Institute, Izatnagar
➢	ICAR-Central Institute on Fisheries Education, Mumbai

Institutions

1.	ICAR-Central Island Agricultural Research Institute , Port Blair
2.	ICAR-Central Arid Zone Research Institute, Jodhpur
3.	ICAR-Central Avian Research Institute, Izatnagar
4.	ICAR-Central Inland Fisheries Research Institute, Barrackpore
5.	ICAR-Central Institute Brackishwater Aquaculture, Chennai
6.	ICAR-Central Institute for Research on Buffaloes, Hissar
7.	ICAR-Central Institute for Research on Goats, Makhdoom
8.	ICAR-Central Institute of Agricultural Engineering, Bhopal
9.	ICAR-Central Institute for Arid Horticulture, Bikaner
10.	ICAR-Central Institute of Cotton Research, Nagpur
11.	ICAR-Central Institute of Fisheries Technology, Cochin
12.	ICAR-Central Institute of Freshwater Aquaculture, Bhubneshwar
13.	ICAR-Central Institute of Research on Cotton Technology, Mumbai
14.	ICAR-Central Institute of Sub Tropical Horticulture, Lucknow
15.	ICAR-Central Institute of Temperate Horticulture, Srinagar
16.	ICAR-Central Institute on Post harvest Engineering and Technology, Ludhiana
17.	ICAR-Central Marine Fisheries Research Institute, Kochi
18.	ICAR-Central Plantation Crops Research Institute, Kasargod
19.	ICAR-Central Potato Research Institute, Shimla
20.	ICAR-Central Research Institute for Jute and Allied Fibres, Barrackpore
21.	ICAR-Central Research Institute of Dryland Agriculture, Hyderabad
22.	ICAR-National Rice Research Institute, Cuttack
23.	ICAR-Central Sheep and Wool Research Institute, Avikanagar, Rajasthan
24.	ICAR- Indian Institute of Soil and Water Conservation, Dehradun

25.	ICAR-Central Soil Salinity Research Institute, Karnal
26.	ICAR-Central Tobacco Research Institute, Rajahmundry
27.	ICAR-Central Tuber Crops Research Institute, Trivandrum
28.	ICAR-ICAR Research Complex for Eastern Region, Patna
29.	ICAR-ICAR Research Complex for NEH Region, Barapani
30.	ICAR-Central Coastal Agricultural Research Institute, Ela, Old Goa, Goa
31.	ICAR-Indian Agricultural Statistics Research Institute, New Delhi
32.	ICAR-Indian Grassland and Fodder Research Institute, Jhansi
33.	ICAR-Indian Institute of Agricultural Biotechnology, Ranchi
34.	ICAR-Indian Institute of Horticultural Research, Bengaluru
35.	ICAR-Indian Institute of Natural Resins and Gums, Ranchi
36.	ICAR-Indian Institute of Pulses Research, Kanpur
37.	ICAR-Indian Institute of Soil Sciences, Bhopal
38.	ICAR-Indian Institute of Spices Research, Calicut
39.	ICAR-Indian Institute of Sugarcane Research, Lucknow
40.	ICAR-Indian Institute of Vegetable Research, Varanasi
41.	ICAR-National Academy of Agricultural Research & Management, Hyderabad
42.	ICAR-National Institute of Biotic Stresses Management, Raipur
43.	ICAR-National Institue of Abiotic Stress Management, Malegaon, Maharashtra
44.	ICAR-National Institute of Animal Nutrition and Physiology, Bengaluru
45.	ICAR-National Institute of Research on Jute & Allied Fibre Technology, Kolkata
46.	ICAR-National Institute of Veterinary Epidemiology and Disease Informatics, Hebbal, Bengaluru
47.	ICAR-Sugarcane Breeding Institute, Coimbatore
48.	ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora
49.	ICAR-Central Institute for Research on Cattle, Meerut, Uttar Pradesh
50.	ICAR-National Institute of High Security Animal Diseases, Bhopal
51.	ICAR-Indian Institute of Maize Research,New Delhi
52.	ICAR- Central Agroforestry Research Institute , Jhansi
53.	ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi
54.	ICAR- Indian Institute of Wheat and Barley Research, Karnal
55.	ICAR- Indian Institute of Farming Systems Research, Modipuram
56.	ICAR- Indian Institute of Millets Research, Hyderabad
57.	ICAR- Indian Institute of Oilseeds Research, Hyderabad
58.	ICAR- Indian Institute of Oil Palm Research, Pedavegi, West Godawari
59.	ICAR- Indian Institute of Water Management, Bhubaneshwar
60.	ICAR-Indian Institute of Rice Research, Hyderabad
61.	ICAR- Central Institute for Women in Agriculture, Bhubaneshwar
62.	ICAR-Central Citrus Research Institute, Nagpur
63.	ICAR-Indian Institute of Seed Research, Mau
64.	ICAR-Indian Agricultural Research Institute, , Hazaribag , Jharkhand

National Research Centres

1.	ICAR-National Research Centre for Banana, Trichi
2.	ICAR-National Research Centre for Grapes, Pune
3.	ICAR-National Research Centre for Litchi, Muzaffarpur
4.	ICAR-National Research Centre for Pomegranate, Solapur

5.	ICAR-National Research Centre on Camel, Bikaner
6.	ICAR-National Research Centre on Equines, Hisar
7.	ICAR-National Research Centre on Meat, Hyderabad
8..	ICAR-National Research Centre on Mithun, Medziphema, Nagaland
9.	ICAR-National Research Centre on Orchids, Pakyong, Sikkim
10.	ICAR-National Research Centre on Pig, Guwahati
11.	ICAR-National Research Centre on Plant Biotechnology, New Delhi
12.	ICAR-National Research Centre on Seed Spices, Ajmer
13.	ICAR-National Research Centre on Yak, West Kemang
14.	ICAR-National Centre for Integrated Pest Management, New Delhi
15.	National Research Centre on Integrated Farming (ICAR-NRCIF),Motihari

National Bureaux

1.	ICAR-National Bureau of Plant Genetics Resources, New Delhi
2.	ICAR-National Bureau of Agriculturally Important Micro-organisms, Mau, Uttar Pradesh
3.	ICAR-National Bureau of Agricultural Insect Resources, Bengaluru
4.	ICAR-National Bureau of Soil Survey and Land Use Planning, Nagpur
5.	ICAR-National Bureau of Animal Genetic Resources, Karnal
6.	ICAR-National Bureau of Fish Genetic Resources, Lucknow

Directorates/Project Directorates

1.	ICAR-Directorate of Groundnut Research, Junagarh
2.	ICAR-Directorate of Soybean Research, Indore
3.	ICAR-Directorate of Rapeseed & Mustard Research, Bharatpur
4.	ICAR-Directorate of Mushroom Research, Solan
5.	ICAR-Directorate on Onion and Garlic Research, Pune
6.	ICAR-Directorate of Cashew Research, Puttur
7..	ICAR-Directorate of Medicinal and Aromatic Plants Research, Anand
8.	ICAR-Directorate of Floricultural Research, Pune, Maharashtra
9.	ICAR-Directorate of Weed Research, Jabalpur
10.	ICAR-Project Directorate on Foot & Mouth Disease, Mukteshwar
11.	ICAR-Directorate of Poultry Research, Hyderabad
12.	ICAR-Directorate of Knowledge Management in Agriculture (DKMA), New Delhi
19.	ICAR-Directorate of Cold Water Fisheries Research, Bhimtal, Nainital

Agricultural Universities

1	Acharya NG Ranga Agricultural University, Hyderabad, Andhra Pradesh
2	Agriculture University, Jodhpur
3	Agriculture University, Kota
4	Anand Agricultural University, Anand, Gujarat
5	Assam Agricultural University, Jorhat, Assam
6	Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal
7	Bihar Agricultural University, Sabour, Bhagalpur, Bihar
8	Birsa Agricultural University, Ranchi, Jharkhand

9	Central Agricultural University, Imphal, Manipur
10	Chandra Shekar Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh
11	Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana
12	CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh
13	Chhattisgarh Kamdhenu Vishwavidyalaya, Durg, Chhattisgarh
14	Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli Distt, Ratnagiri, Maharashtra
15	Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra
16	Dr Yashwant Singh Parmar Univ of Horticulture & Forestry, Nauni, Himachal Pradesh
17	Dr YSR Horticultural University, West Godavari Dist., Tadepalligudem, Andhra Pradesh
18	Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttaranchal
19	Guru Angad Dev Veterinary and Animal Science University, Ludhiana, Punjab
20	Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh
21	Jawaharlal Nehru Krishi Viswavidyalaya, Jabalpur, Madhya Pradesh
22	Junagadh Agricultural University, Junagadh, Gujarat
23	Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar, Karnataka
24	Kerala Agricultural University, Trichur, Kerala
25	Kerala University of Fisheries & Ocean Studies, Kochi, Kerala
26	Kerala Veterinary and Animal Sciences University, Thiruvananthapuram, Kerala
27	Lala Lajpat Rai University of Veterinary & Animal Sciences, Hisar, Haryana
28	Nanaji Deshmukh Veterinary Science University, Jabalpur, Madhya Pradesh
29	Maharana Pratap Univ. of Agriculture & Technology, Udaipur, Rajasthan
30	Maharashtra Animal Science & Fishery University, Nagpur, Maharashtra
31	Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra
32	Manyavar Shri Kanshiram Ji University of Agriculture and Technology, Banda, Uttar Pradesh
33	Narendra Deva University of Agriculture & Technology, Faizabad, Uttar Pradesh
34	Navsari Agricultural University, Navsari, Gujarat
35	Orissa Univ. of Agriculture & Technology, Bhubaneshwar, Orissa
36	Prof. Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad
37	Punjab Agricultural University, Ludhiana, Punjab
38	Rajasthan University of Veterinary and Animal Sciences, Bikaner, Rajasthan,
39	Rajendra Agricultural University, Samastipur, Bihar
40	Rajmata Vijayraje Sciendia Krishi Vishwa Vidyalaya, Gwalior, MP
41	Rani Laxmi Bai Central Agricultural University, Jhansi, Uttar Pradesh
42	Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut, Uttar Pradesh
43	Sardarkrushinagar-Dantiwada Agricultural University, Distt Banaskantha, Gujarat
44	Sher-E-Kashmir Univ of Agricultural Sciences & Technology, Jammu, J&K
45	Sher-E-Kashmir Univ of Agricultural Sciences & Technology of Kashmir, Shrinagar, Jammu & Kashmir
46	Sri Karan Narendra Agriculture University, Jobner
47	Sri Venkateswara Veterinary University, Tirupati
48	Swami Keshwanand Rajasthan Agricultural University, Bikaner,Rajasthan
49	Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu
50	Tamil Nadu Fisheries University, Nagapattinam, Tamil Nadu
51	Tamil Nadu Veterinary & Animal Science University, Chennai, Tamilnadu
52	University of Agricultural Sciences, Bengaluru, Karnataka
53	University of Agricultural Sciences, Dharwad, Karnataka
54	University of Agricultural Sciences, Shimoga, Karnataka

55	University of Horticultural Sciences, Bagalkot, Karnataka
56	University of Agricultural Sciences, Raichur, Karnataka
57	UP Pandit Deen Dayal Upadhaya Pashu Chikitsa Vigyan Vishwa Vidhyalaya evam Go Anusandhan Sansthan, Mathura, Uttar Pradesh
58	Uttarakhand University of Horticulture and Forestry, Pauri Garhwal, Uttarakhand
59	Uttar Banga Krishi Viswavidyalaya, Coach Bihar,West Bengal
60	Vasantrao Naik Marathwada Agricultural University, Parbhani, Maharashtra
61	West Bengal University of Animal & Fishery Sciences, Kolkata, West Bengal
62	Sri Konda Laxman Telangana State Horticultural University, Rajendra Nagar Campus, Hyderabad
63	Kamdhenu University, Gandhinagar, Gujarat

INTERNATIONAL ORGANIZATIONS OF CROP IMPROVEMENT

CIAT International Centre for Tropical Agriculture: Cali, Columbia
CIFOR Center for International Forestry Research: Jakarta, Indonesia
CIMMYT International Centre for Wheat and Maize Improvement: Baton, Mexico
CIP International Potato Centre: Lima, Peru
IBPGR International Board for Plant Genetic Resources: Rome, Italy
ICARDA International Centre for Agricultural Research in the Dry Areas: Beruit, Lebanon
ICGES International Centre for Genetic Engineering and Biotechnology: Triesta, Italy
ICRAF International Centre for Research in Agro forestry: Nairobi, Kenya
ICRISAT International Crops Research Institute for the Semi-Arid Tropics: Hyderabad, India
IFPRI International Food Policy Research Institute: Washington, USA
IITA International Institute of Tropical Agriculture: Ibadan, Nigeria
IIMI International Irrigation Management Institute: Colombo, Srilanka
ILRI International Livestock Research Institute: Nairobi, Kenya
INSFFER International Network on Soil Fertility and Fertilizer Evaluation on Rice: New Delhi, India
IPGRI International Plant Genetic Resource Institute: Rome, Italy
ISNAR International Service for National Agricultural Research: Netherlands
IRRI International Rice Research Institute: Manila, Phillipines
IWMI International Water Management Institute: Columbo, Sri Lanka
WFC World Fish Centre : Bayan Lepas, Malaysia
WARDAWest African Rice Development Association: Monrovia, Liberia

Chapter 9. Crop significance and classification

A **crop** is "a plant or animal or plant or animal product that can be grown and harvested extensively for profit or subsistence." Crop may refer either to the harvested parts or to the harvest in a more refined state (husked, shelled, etc.). Most crops are cultivated in agriculture or aquaculture. Most crops are harvested as food for humans or livestock (fodder crops). Some crops are gathered from the wild (including intensive gathering, e.g. ginseng).

Important non-food crops include horticulture, floriculture and industrial crops. Horticulture crops include plants used for other crops (e.g. fruit trees). Floriculture crops include bedding plants, houseplants, flowering garden and pot plants, cut cultivated greens, and cut flowers. Industrial crops are produced for clothing (fiber crops), biofuel (energy crops, algae fuel), or medicine (medicinal plants). Animals and microbes (fungi, bacteria or viruses) are rarely referred to as crops. Animals raised for human or animal consumption are referred to as livestock and microbes as microbiological cultures. Microbes are not typically grown for food itself, but are rather used to alter food

Classification of Crop Plants

Importance of classifying the Crop Plants:

To get acquainted with crops.

To understand the requirement of soil & water different crops.

To know adaptability of crops.

To know the growing habit of crops.

To understand climatic requirement of different crops.

To know the economic produce of the crop plant & its use.

To know the growing season of the crop

Overall to know the actual condition required to the cultivation of plant.

Classification based on climate:

- **Tropical**: Crops grow well in warm & hot climate. E.g. Rice, sugarcane, Jowar etc
- **Temperate:** Crops grow well in cool climate. E.g. Wheat, Oats, Gram, Potato etc.

Classification Based on growing season:

- **Kharif/Rainy/Monsoon crops:** The crops grown in monsoon months from June to Oct-Nov, Require warm, wet weather at major period of crop growth, also required short day length for flowering. E.g. Cotton, Rice, Jowar, bajara.
- **Rabi/winter/cold seasons crops:** require winter season to grow well from Oct to March month. Crops grow well in cold and dry weather. Require longer day length for flowering. E.g. Wheat, gram, sunflower etc.

3. Summer/Zaid crops: crops grown in summer month from March to June. Require warm day weather for major growth period and longer ay length for flowering. E.g. Groundnuts, Watermelon, Pumpkins, Gourds.

Use/Agronomic classification:

1. Grain crops: may be cereals as millets cereals are the cultivated grasses grown for their edible starchy grains. The larger grain used as staple food is cereals. E.g. rice, Jowar, wheat, maize, barley, and millets are the small grained cereals which are of minor importance as food. E.g. Bajara.

2. Pulse/legume crops: seeds of leguminous crops plant used as food. On splitting they produced dal which is rich in protein. E.g. green gram, black gram, soybean, pea, cowpea etc.

3. Oil seeds crops: crop seeds are rich in fatty acids, are used to extract vegetable oil to meet various requirements. E.g. Groundnut, Mustard, Sunflower, Sesamum, linseed etc.

4.Forage Crop: It refers to vegetative matter fresh as preserved utilized as food for animals. Crop cultivated & used for fickler, hay, silage. Ex- sorghum, elephant grass, guinea grass, berseem & other pulse bajara etc.

5. **Fiber crops:** crown for fiber yield. Fiber may be obtained from seed. E.g. Cotton, steam, jute, Mesta, sun hemp, flax.

6. Roots crops: Roots are the economic produce in root crop. E.g. sweet, potato, sugar beet, carrot, turnip etc.

7. Tuber crop: crop whose edible portion is not a root but a short thickened underground stem. E.g. Potato, elephant, yam.

8. Sugar crops: the two important crops are sugarcane and sugar beet cultivated for production for sugar.

9. Starch crops: grown for the production of starch. E.g. tapioca, potato, sweet potato.

10. Dreg crop: used for preparation for medicines. E.g. tobacco, mint, pyrethrum.

11. Spices & condiments/spices crops: crop plants as their products are used to flavor taste and sometime color the fresh preserved food. E.g. ginger, garlic, chili, cumin onion, coriander, cardamom, pepper, turmeric etc.

12. Vegetables crops: may be leafy as fruity vegetables. E.g. Palak, mentha, Brinjal, tomato.

13. Green manure crop: grown and incorporated into soil to increase fertility of soil. E.g. sun hemp.

14. Medicinal & aromatic crops: Medicinal plants includes cinchona, isabgoli, opium poppy, senna, belladonna, rauwolfra, iycorice and aromatic plants such as lemon grass, citronella grass, palmorsa, Japanese mint, peppermint, rose geranicem, jasmine, henna etc.

Classification based on life of crops/duration of crops:

1. **Seasonal crops:** A crop completes its life cycle in one season- Kharif, Rabi. summer. E.g. rice, jowar, wheat etc.
2. **Two seasonal crops:** crops complete its life in two seasons. E.g. Cotton, turmeric, ginger.
3. **Annual crops:** Crops require one full year to complete its life in cycle. E.g. sugarcane.
4. **Biennial crops:** which grows in one year and flowers, fructifies & perishes the next year E.g. Banana, Papaya.
5. **Perennial crops:** crops live for several years. E.g. Fruit crops, mango, guava etc.

Classification based on cultural method/water:

1. **Rain fed:** crops grow only on rain water. E.g. Jowar, Bajara, Mung etc.
2. **Irrigated crops:** Crops grows with the help of irrigation water. E.g. Chili, sugarcane, Banana, papaya etc.

Classification based on root system:

1. **Tap root system:** The main root goes deep into the soil. E.g. Tur, Grape, Cotton etc.
2. **Adventitious/Fiber rooted:** The crops whose roots are fibrous shallow & spreading into the soil. E.g. Cereal crops, wheat, rice etc.

Classification based on economic importance:

1. **Cash crop:** Grown for earning money. E.g. Sugarcane, cotton.
2. **Food crops:** Grown for raising food grain for the population and & fodder for cattle. E.g. Jowar, wheat, rice etc.

Classification based on No. of cotyledons:

1. **Monocots or monocotyledons:** Having one cotyledon in the seed. E.g. all cereals & Millets.
2. **Dicots or dicotyledonous:** Crops having two cotyledons in the seed. E.g. all legumes & pulses.

Classification based on photosynthesis' (Reduction of CO2/Dark reaction):

1. **C3 Plants:** Photo respiration is high in these plants C3 Plants have lower water use efficiency. The initial product of C assimilation in the three 'C' compounds. The enzyme involved in the primary carboxylation is ribulose-1,-Biophospate carboxylose. E.g. Rice, soybeans, wheat, barley cottons, potato.
2. **C4 plants:** The primary product of C fixation is four carbon compounds which may be malice acid or acerbic acid. The enzymes responsible for carboxylation are phosphoenol Pyruvic acid carboxylose which has high affinity for CO2 and capable of assimilation CO2 event at lower concentration, photorespiration is negligible. Photosynthetic rates are higher in C4 than C3 plants for the same amount of stomatal opening. These are said to be drought resistant & they are able to grow better even under moisture stress. C4 plants translate photosynthates rapidly. E.g. Sorghum, Maize, napter grass, sesame etc.
3. **Cam plants**: (Cassulacean acid metabolism plants) the stomata open at night and large amount of CO2 is fixed as a malice acid which is stored in vacuoles. During day stomata are closed. There is no possibility of CO2 entry. CO2 which is stored as malice acid is broken down & released as CO2. In these plants there is negligible transpiration. C4 & cam plant have high water use efficiency. These are highly drought resistant. E.g. Pineapple, sisal & agave.

Classification based on length of photoperiod required for floral initiation:

Most plants are influenced by relative length of the day & night, especially for floral initiation, the effect on plant is known as photoperiodism depending on the length of photoperiod required for floral ignition, plants are classified as:

1. **Short-day plants:** Flower initiation takes plate when days are short less then ten hours. E.g. rice, Jowar, green gram, black gram etc.
2. **Long day's plants:** require long days are more than ten hours for floral ignition. E.g. Wheat,

Barley,

3. Day neutral plants: Photoperiod does not have much influence for phase change for these plants. E.g. Cotton, sunflower. The rate of the flowering initiation depends on how short or long is photoperiod. Shorter the days, more rapid initiation of flowering in short days plants. Longer the days more rapid are the initiation of flowering in long days plants.

Chapter 10. National agricultural setup in India

ICAR

The Indian Council of Agricultural Research (ICAR) is an autonomous organization under the Department of Agricultural Research and Education (DARE), Ministry of Agriculture and Farmers Welfare, Government of India. Formerly known as Imperial Council of Agricultural Research, it was **established on 16 July 1929** as a registered society under the Societies Registration Act, 1860 in pursuance of the report of the Royal Commission on Agriculture. The ICAR has its headquarters at New Delhi. With **101 ICAR institutes** and **63 agricultural universities** spread across the country this is one of the largest national agricultural systems in the world.

The ICAR has played a pioneering role in ushering Green Revolution and subsequent developments in agriculture in India through its research and technology development that has **enabled the country to increase the production of food grains by 5 times**, **horticultural crops by 9.5 times**, **fish by 12.5 times** , **milk 7.8 times** and **eggs 39 times** since 1951 to 2014, thus making a visible impact on the national food and nutritional security.

As of June 2017 ICAR has following institutions

- Four Deemed Universities
- 64 ICAR Institutions
- Six National Bureaux
- 13 Project Directorates
- 15 National Research Centres
- 138 Substations of ICAR Institutes
- 59 AICRPs (All India Coordinated Research Projects)
- 10 Other Projects
- 19 Network Projects
- Eight Zonal Project Directorates
- 665 Krishi Vigyan Kendras (KVKs) (660 as of 2017)

Milestones

- Initiation of the first All-India Co-ordinated Research Project on Maize in 1957
- Status of Deemed University accorded to IARI in 1958
- Establishment of the first State Agricultural University on land grant pattern at Pantnagar in 1960
- Placement of different agricultural research institutes under the purview of ICAR in 1966
- Creation of Department of Agricultural Research and Education (DARE) in the Ministry of Agriculture in 1973
- Opening of first Krishi Vigyan Kendra (KVK) at Puducherry (Pondicherry) in 1974
- Establishment of Agricultural Research Service and Agricultural Scientists' Recruitment Board in 1975
- Launching of Lab-to-Land Programme and the National Agricultural Research Project (NARP) in 1979
- Initiation of Institution-Village Linkage Programme (IVLP) in 1995
- Establishment of National Gene Bank at New Delhi in 1996
- The ICAR was bestowed with the King Baudouin Award in 1989 for its valuable contribution in ushering in the Green Revolution. Again awarded King Baudouin Award in 2004 for research and development efforts made under partnership in Rice Wheat Consortium.
- Launching of National Agricultural Technology Project (NATP) in 1998 and National Agricultural Innovation Project (NAIP) in 2005
- As of July, 2006 it has developed a vaccine against bird flu. The vaccine was developed at the High Security Animal Disease Laboratory, Bhopal, the only facility in the country to conduct tests for the H5N1 variant of bird flu. It was entrusted with the task of developing a vaccine by the ICAR after the Avian Influenza outbreak in February. The ICAR was provided Rs. 8 crore for the purpose.
- 2009: In December 2009, it announced that it was considering a policy to provide open access to its research.
- 2010: In March 2010, ICAR made its two flagship journals (Indian Journal of Agricultural Sciences and Indian Journal of Animal Sciences) as Open Access Journals.
- 2013: On 13 September 2013, it announced the Open Access Policy and committed for

making all the public funded scholarly research outputs openly available via open access repositories.

- ICAR scientists were the first in the world to sequence the pigeon pea genome. it was a purely indigenous effort by 31 scientists led by Nagendra Kumar Singh of NRCPB.

Mandate

- Plan, Undertake, Coordinate and Promote Research and Technology Development for Sustainable Agriculture.
- Aid, Impart and Coordinate Agricultural Education to enable Quality Human Resource Development.
- Frontline Extension for technology application, adoption, knowledge management and capacity development for agri-based rural development.
- Policy, Cooperation and Consultancy in Agricultural Research, Education & Extension.

Organization

- Union Minister of Agriculture is the ex-officio President of the ICAR Society
- Secretary, Department of Agricultural Research and Education, Ministry of Agriculture, Government of India and Director General, ICAR is the Principal Executive Officer of the Council
- Governing Body is the policy-making authority
- Agricultural Scientists' Recruitment Board
- Deputy Directors-General (8)
- Additional Secretary (DARE) and Secretary (ICAR)
- Additional Secretary and Financial Advisor
- Assistant Directors-General (24)
- National Director, National Agricultural Innovation Project
- Directorate of Knowledge Management in Agriculture

ICAR Awards 2016

The Indian Council of Agricultural Research, New Delhi announces the following ICAR Awards:

1. **ICAR Challenge Award**

   To find a solution for any immediate or long-standing problem, or limitation in agriculture, which is coming in the way of agricultural development and/ or enhancing productivity in any major agricultural, horticultural or animal/fish product, ICAR has instituted a Challenge Award.

2. **Sardar Patel Outstanding ICAR Institution Award**

   In order to recognize outstanding performance by the ICAR institutes, DUs of ICAR, CAU and State Agricultural Universities

3. Chaudhary Devi Lal Outstanding All India Coordinated Research Project Award

In order to recognize outstanding performance of the AICRP and its cooperating centers and to provide incentive for outstanding performance in terms of linkages and research output and its impact.

4. Jawaharlal Nehru Award for P.G. Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences

In order to promote high quality doctoral thesis research in priority/frontier areas of agriculture and allied sciences, ICAR has instituted **18** awards of Rs. **50,000/-**in cash plus a citation and silver medal (gold polished) each to be awarded annually for the outstanding original research work in agriculture and allied sciences.

5. **Panjabrao Deshmukh Outstanding Woman Scientist Award**

All women scientists engaged in research in agricultural and allied subjects /extension in a recognized institutions are eligible for this award.

6. Vasantrao Naik Award for Outstanding Research Application in Dry Land Farming Systems

In order to promote outstanding research and application in priority aspects of dry land farming systems & water conservation.

7. Jagjivan Ram Abhinav Kisan Puruskar /Jagjivan Ram Innovative Farmer Award (National/Zonal)

In order to recognize the outstanding contributions of innovative farmers for initiatives in development adoption, modification and dissemination of improved technology and practices for increased income with sustainability, following national and zonal awards are announced: **(i) National:** One annual national award **(ii)Zonal:** Eight annual awards

8. **N.G. Ranga Farmer Award for Diversified Agriculture**

In order to recognize outstanding contribution of innovative farmers for diversified agriculture, one annual award of **Rs 1.00 lakh** in any of the areas of Diversified Agriculture is given by ICAR.

9. **Pandit Deen Dayal Upadhyay Antyodaya Krishi Puruskar (National & Zonal)**

In order to recognize the contributions of marginal, small and landless farmers for developing sustainable integrated models of farming, the ICAR has instituted **Pandit Deen Dayal Upadhyay Antyodaya Krishi Puruskar (National & Zonal)** annually.

10. **Haldhar Organic Farmer Award**

In order to recognize outstanding contribution of organic farmers ICAR has instituted an award titled **Haldhar Organic Farmer Award**

11. **Chaudhary Charan Singh Award for Excellence in Journalism in Agricultural Research and Development**

Journalists for Print Media [Hindi Journalism/ English Journalism/ Journalism in Regional languages (four awards)] and Electronic media (two awards).

12. **Fakhruddin Ali Ahmed Award for Outstanding Research in Tribal Farming Systems**

The award is primarily meant for any person or team (with two or three associates, if any) engaged in applied research and its applications in tribal areas of the country aimed at improving the biological resources and livelihoods or in original work directly applicable to tribal farming system.

13. **Bharat Ratna Dr C. Subramaniam Award for Outstanding Teachers 2016**

In order to provide recognition to outstanding teachers and to promote quality teaching in the field of Agriculture, four outstanding teacher awards are given annually.

14. **Pandit Deen Dayal Upadhyay Krishi Vigyan Protshahan Puraskar (National & Zonal) 2017**

These awards promote healthy competition among Krishi Vigyan Kendras (KVKs) at Zonal and National Level for application of science and technology in agriculture.

15. **Dr Rajendra Prasad Puruskar for technical books in Hindi in Agricultural and Allied Sciences 2016**

These awards recognize to authors of original Hindi Technical books in agriculture and allied sciences & incentivize Indian writers to write original standard works in agricultural and allied sciences in Hindi. The award is meant for individuals as well as teams of authors.

16. **Lal Bahadur Shastri Outstanding Young Scientist Award 2016**

In order to recognize the talented young scientists who have shown extraordinary originality and dedication in their research programmes, four individual awards are to be given annually.

17. **Rafi Ahmed Kidwai Award for Outstanding Research in Agricultural Sciences 2016**

In order to recognize outstanding research in agricultural and allied sciences & provide incentives for excellence in agricultural research, this award is to be given to agricultural scientists for outstanding contribution in specified areas. A total of four awards are provided under the award.

18. **Swami Sahajanand Saraswati Outstanding Extension Scientist Award 2016**

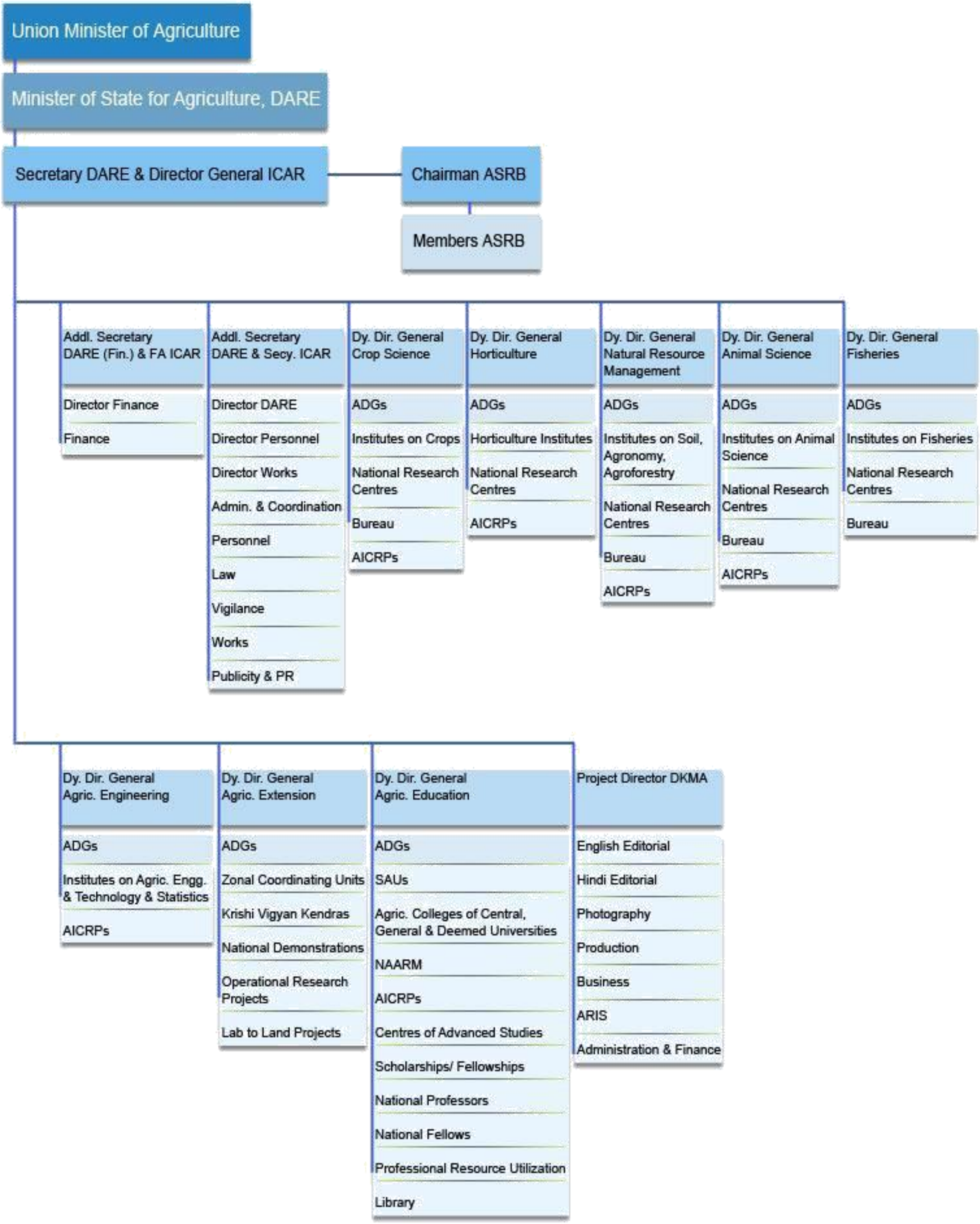
The award is exclusively meant for individual extension scientist/teacher for excellence in agricultural extension methodology and education work. Two individual awards have been provided.

19. **NASI-ICAR Award For Innovation and Research on Farm Implements -2016**

In order to reduce drudgery of farm women by development of farm implements and to encourage researchers and innovators to develop farm implements for farm women, ICAR and NASI have instituted the **NASI-ICAR Award For Innovation and Research on Farm Implements.**

20. **Hari Om Ashram Trust Award for the biennium 2014-2015**

In order to recognize the outstanding research on long term problem in agricultural and allied sciences, four individual awards have been instituted.


Union Minister of Agriculture
Minister of State for Agriculture, DARE
Secretary DARE & Director General ICAR
Chairman ASRB
Members ASRB
Addl. Secretary DARE (Fin.) & FA ICAR
Director Finance
Finance
Addl. Secretary DARE & Secy. ICAR
Director DARE
Director Personnel
Director Works
Admin. & Coordination
Personnel
Law
Vigilance
Works
Publicity & PR
Dy. Dir. General Crop Science
ADGs
Institutes on Crops
National Research Centres
Bureau
AICRPs
Dy. Dir. General Horticulture
ADGs
Horticulture Institutes
National Research Centres
AICRPs
Dy. Dir. General Natural Resource Management
ADGs
Institutes on Soil, Agronomy, Agroforestry
National Research Centres
Bureau
AICRPs
Dy. Dir. General Animal Science
ADGs
Institutes on Animal Science
National Research Centres
Bureau
AICRPs
Dy. Dir. General Fisheries
ADGs
Institutes on Fisheries
National Research Centres
Bureau
Dy. Dir. General Agric. Engineering
ADGs
Institutes on Agric. Engg. & Technology & Statistics
AICRPs
Dy. Dir. General Agric. Extension
ADGs
Zonal Coordinating Units
Krishi Vigyan Kendras
National Demonstrations
Operational Research Projects
Lab to Land Projects
Dy. Dir. General Agric. Education
ADGs
SAUs
Agric. Colleges of Central, General & Deemed Universities
NAARM
AICRPs
Centres of Advanced Studies
Scholarships/ Fellowships
National Professors
National Fellows
Professional Resource Utilization
Library
Project Director DKMA
English Editorial
Hindi Editorial
Photography
Production
Business
ARIS
Administration & Finance

State Agricultural Universities

Agricultural Universities or 'AUs' are mostly public universities in India that are engaged in teaching, research and extension in agriculture and related disciplines. In India, agricultural education has evolved into a large and distinct domain, often separately from other areas of higher education. Many of these universities are member of a registered society, the Indian Agricultural Universities Association. Indian Council of Agricultural Research is the main regulatory authority of agricultural education in India, while the disciplines of veterinary medicine and forestry are regulated by the Veterinary Council of India and Indian Council of Forestry Research and Education respectively. A SAU is usually a university established by an act of state legislature with a dedicated mandate of teaching, research and extension in agriculture and related disciplines.

Deemed universities

Deemed universities are not established by an act of independent legislation, but declared to function as universities by Government of India under Section 3 of the University Grants Commission Act 1956. As per this section, "The Central Government may, on the advice of the Commission, declare by notification in the Official Gazette, that any institution for higher education, other than a University, shall be deemed to be a University for the purposes of this Act, and on such a declaration being made, all the provisions of this Act shall apply to such institution as if it were a University within the meaning of clause (f) of section 2". Thus, the provision of deemed universities enables the central government to incorporate an agricultural university without the need of Parliamentary legislation, thus circumventing the complexities of federal division for legislative powers, which has put agriculture in the state list.

Central agricultural universities

There are currently 3 central agriculture university in India, and they are

- Central Agricultural University Imphal
- Rani Laxmibai Central Agricultural University Jhansi
- Dr. Rajendra Prasad Central Agriculture University, Samasthipur Bihar

Upcoming or proposed central agricultural university

- Punjab Agricultural University, Ludhiana
- Govind Ballabh Pant University of Agriculture and Technology, Pantnagar

The Central Agricultural University was established by an act of Parliament, the Central Agricultural University Act 1992 (No.40 of 1992). The Act came into effect on 26 January 1993 with the issue of necessary notification by the Department of Agricultural Research and Education (DARE), Government of India. The university became functional with the joining of the first vice-chancellor on 13 September 1993.

Other universities involved in agricultural education

Central universities

Central universities, including Banaras Hindu University, Aligarh Muslim University, Visva- Bharati University, Hemwati Nandan Bahuguna Garhwal University, Nagaland University and Sikkim University have distinct faculties in agriculture. A few central universities also have affiliated agricultural colleges.

State universities

Bundelkhand University, Lucknow University, Kanpur University, Gorakhpur University, Meerut University, Calcutta University and many other state universities have distinct agriculture faculties. Most of these have a number of affiliated agriculture colleges.

Institute of national importance

IIT Kharagpur has a very strong programme in agricultural engineering, while IIM A and IIM Lucknow have leading programmes in agribusiness. Central Food Technological Research Institute under AcSIR is the premier institute in food technology.

Private universities

Amity University has a programme in organic farming

Annamalai University offers Undergraduate, Postgraduate and Diploma courses through Faculty of Agriculture

Rai Technology University offers B.Sc and M.Sc programs in Ag riculture through its School of Agricultural Sciences and Forestry

Ministry of Agriculture & Farmers Welfare

The Ministry of Agriculture and Farmers Welfare (formerly Ministry of Agriculture), a branch of the Government of India, is the apex body for formulation and administration of the rules and regulations and laws related to agriculture in India. The 3 broad areas of scope for the Ministry are agriculture, food processing and co-operation. The agriculture ministry is headed by Minister of Agriculture Radha Mohan Singh. S S Ahluwalia, Sudarshan Bhagat & Parshottam Rupalai are the Ministers of State. The combined efforts of Central Government, State Governments and the farming community have succeeded in achieving record production of 244.78 million tonnes of foodgrains during 2010-11.

Origins

Department of Revenue and Agriculture and Commerce was set up in June 1871 to deal with all the agricultural matters in India. Until this ministry was established, matters related to agriculture were within the portfolio of the Home Department. In 1881, Department of Revenue & Agriculture was set up to deal with combined portfolios of education, health, agriculture, revenue. However, In 1947, Department of Agriculture was redesignated as Ministry of Agriculture.

Structure & Departments

The Ministry of Agriculture and farmers Welfare consists of the following three Departments.

- Department of Agriculture, Co-operation and Farmers Welfare.
- Department of Agriculture Research and Education.
- Department of Animal Husbandry, Dairying and Fisheries.

A leading program of the Ministry is the Rashtriya Krishi Vikas Yojana, which was launched in 2007 on the recommendations of the National Development Council of India. This program sought to improve the overall state of agriculture in India by providing stronger planning, better co-ordination and greater funding to improve productivity and overall output. The total budget for this program in 2009-10 was just over INR 38,000 crore.

Chapter 11. Current scenario of Indian agriculture

1. Organic Farming

Organic farming is an alternative agricultural system which originated early in the 20th century in reaction to rapidly changing farming practices. It relies on fertilizers of organic origin such as compost, manure, green manure, and bone meal and places emphasis on techniques such as crop rotation and companion planting. Biological pest control, mixed cropping and the fostering of insect predators are encouraged. In general, organic standards are designed to allow the use of naturally occurring substances while prohibiting or strictly limiting synthetic substances. For instance, naturally occurring pesticides such as pyrethrin and rotenone are permitted, while synthetic fertilizers and pesticides are generally prohibited. Synthetic substances that are allowed include, for example, copper sulfate, elemental sulfur and Ivermectin. Genetically modified organisms, nanomaterials, human sewage sludge, plant growth regulators, hormones, and antibiotic use in livestock husbandry are prohibited. Organic agricultural methods are internationally regulated and legally enforced by many nations, based in large part on the standards set by the International Federation of Organic Agriculture Movements (IFOAM), an international umbrella organization for organic farming organizations established in 1972.

"Organic agriculture can be defined as: an integrated farming system that strives for sustainability, the enhancement of soil fertility and biological diversity whilst, with rare exceptions, prohibiting synthetic pesticides, antibiotics, synthetic fertilizers, genetically modified organisms, and growth hormones".

2. Farming system, Definition

Farming system is a resource management strategy to achieve economic and sustained agricultural production to meet diverse requirements of farm livelihood while preserving resource base and maintaining a high level of environment quality (Lal and Miller 1990).

Key principles

• ***Cyclic*** The farming system is essentially cyclic (organic resources – livestock – land – crops). Therefore, management decisions related to one component may affect the others.

• ***Rational*** Using crop residues more rationally is an important route out of poverty. For resource-poor farmers, the correct management of crop residues, together with an optimal allocation of scarce resources, leads to sustainable production.

• ***Ecologically sustainable*** Combining ecological sustainability and economic viability, the integrated livestock-farming system maintains and improves agricultural productivity while also reducing negative environmental impacts.

Benefits or Advantages of Integrated Farming System

1) Productivity
2) Profitability
3) Potentiality or Sustainability
4) Balanced Food
5) Environmental Safety
6) Recycling
7) Income Rounds the year
8) Adoption of New Technology
9) Saving Energy
10) Meeting Fodder crisis
11) Solving Fuel and Timber Crisis
12) Employment Generation
13) Agro – industries
14) Increasing Input Efficiency

3. Precision Farming

Precision agriculture (**PA**) or **satellite farming** or **site specific crop management** (**SSCM**) is a farming management concept based on observing, measuring and responding to inter and intra-field variability in crops.

Precision agriculture aims to optimize field-level management with regard to:

- Crop science: matching farming practices closely to crop needs (e.g. fertilizer inputs);
- Environmental protection: reducing environmental risks (e.g. limiting leaching of nitrogen);
- Economics: boosting competitiveness through more efficient practices (e.g. improved management of fertilizer usage and other inputs).

Precision agriculture also provides farmers with a wealth of information to:

- build up a record of their farm;
- improve decision-making;
- foster greater traceability
- enhance marketing of farm products
- improve lease arrangements and relationship with landlords
- enhance the inherent quality of farm products (e.g. protein level in bread-flour wheat)

Emerging technologies

Robots

Self-steering tractors have existed for some time now, as John Deere equipment works like a plane on autopilot. Technology is advancing towards driverless machinery programmed by GPS to spread fertilizer or plow land. Agricultural robots, also known as AgBots, already exist, but advanced harvesting robots are being developed to identify ripe fruits, adjust to their shape and size, and carefully pluck them from branches.

Drones and satellite imagery

Advances in drone and satellite technology benefits precision farming because drones take high quality images, while satellites capture the bigger picture. Light aircraft pilots can combine aerial photography with data from satellite records to predict future yields based on the current level of field biomass. Aggregated images can create contour maps to track where water flows, determine variable-rate seeding, and create yield maps of areas that were more or less productive.

The Internet of things

The Internet of things is the network of physical objects outfitted with electronics that enable data collection and aggregation. For example, farmers can spectroscopically measure nitrogen, phosphorus, and potassium in liquid manure, which is notoriously inconsistent. [21]

They can then scan the ground to see where cows have already urinated and apply fertilizer to only the spots that need it. This cuts fertilizer use by up to 30%.

4. Micro irrigation

Definition of Micro Irrigation:

It can be defined as the application of water at low volume and frequent interval under low pressure to plant root zone.

Besides the land, water also an important factor in the progress of Agriculture. In vast country like India with a geographical area of 328 million hectares less than 45% area is cultivated of this cultivated area only 35% i.e. 65 million ha gets irrigation. This could be achieved by introducing advanced and sophisticated methods of irrigation viz. drip irrigation, sprinkler, etc.

Micro-sprayers/sprinklers is installed on a stake, wetting foliage and a larger surface area of 4-6 feet.

Micro-bubblers are installed on short stakes, have solid spray and used to establish and maintain larger plants and have less evaporation than micro-sprayers/sprinklers.

Drippers apply water directly to the soil resulting in minimal evaporation, attach to a distribution tube or spaghetti tubing and are used for widely spaced plants or containers.

Drip tubing contains factory installed emitters inside the tubing that are pressure compensating, and has fewer parts/pieces than other types of microirrigation.

5. Conservation Agriculture

Definition of Conservation Agriculture

It is a way of farming that conserves, improves and makes more efficient use of natural resources through integrated management of available resources combined with external inputs. It contributes to environmental conservation as well as to enhanced and sustain agricultural production. It can also be referred to as resource efficient agriculture.

Conservation agriculture has three basic principles:

- Disturb the soil as little as possible: farmers plough and hoe to improve the soil structure and control weeds. But in the long term, they actually destroy the soil structure and contribute to declining soil fertility.
- Mulching: cover crops protect the soil from erosion and limit weed growth throughout the year.
- Mix and rotate crops with legume based cropping system

6. Nanotechnology

It deals with the physical, chemical, and biological properties of matter considered at nanoscale (1–100 nm) and their implications for the welfare of human beings. Nanomaterial is an ingredient containing particles with at least one dimension that approximately measures 1–100 nm. It has the ability to control and/or manufacture matter at this scale which results in the development of innovative and novel properties like increase in the surface area of the particles that can be utilized to address numerous technical and societal issues

Table 1: Classification of nanomaterials.

Categories of nanomaterials	**Description**
Nanoparticles	Submicron or even ultramicron size particles obtainable as high performance radiant resistant materials, magnetic materials, solar battery materials, packaging materials, and magnetic fluid materials
Nanotubes and nanofibers	Nanometer size long linear material, optical materials, micro conductors, microfibers, nanotubes of PEEK, PET and PTFE
Nanofilm	Films utilized as gas catalyst materials
Nanoblock	Nanometer crystalline materials produced by substantial accuracy, developing Controlled crystallization or nanoparticles
Nanocomposites	Composite nanomaterials, which use nanosize reinforcements instead of conventional fibers or particulates
Nanocrystalline solids	Polycrystals with the size of 1 to 10 nm and 50% or more of solid consists of inherent interface between crystals and different orientations. The clusters that formed through homogenous nucleation and grow by coalescence and incorporation of atoms

Table 2: Commercial uses of nanoparticles

Type of product	**Product name & manufacturer**	**Nano content**	**Purpose**
Nano-agrochemicals			
Super" combined fertilizer and pesticide	Pakistan-US Science and Technology Cooperative Program	Nano-clay capsule contains Growth stimulants and biocontrol Agents	Slow release of active ingredients, Reducing application rates
Herbicide	Tamil Nadu Agricultural University (India) and Technologico de Monterry (Mexico)	Nano-formulated	Designed to attack the seed coat of weeds, destroy soil seed banks and prevent Weed germination
Pesticides, including herbicides	Australian Common wealth Scientific and Industrial Research Organization	Nano-encapsulated active ingredients	Very small size of nanocapsules increases their potency and may enable targeted release of active ingredients
Nano-materials			
Nutritional supplement	Nanoceuticals „mycrohydrin" powder, RBC Life sciences	Molecularcaes 1-5 nm diameter made from silica mineral hydride comple	Nano-sized mycrohydrin has Increased potency And bioavailability. Exposure To moisture releases H- ions and acts as a powerful antioxidant.

Nutritional drink	Oat Chocolate Nutritional Drink Mix, Toddler Health	300nm particles of iron (SunActive Fe)	Nano-sized iron particles have Increased reactivity and bioavailability.
Food packaging	Adhesive for McDonald‟s burger containers, Ecosynthetix	50-150 nm starch Nanospheres	These nanoparticles have 400 times the surface area of natural starch particles. When used as an adhesive they require less water and thus less time and energy to dry.
Food additive	Aquasol preservative, AquaNova	Nanoscale micelle (capsule) of lipophilic or water insoluble substances	Surrounding active ingredients Within soluble nanocapsulesb increases absorption within the body (including individual cell)
Plant growth treatment	Primo Maxx, Syngenta	100 nm particle size emulsion	Nano-sized particles increases the potency of active ingredients, potentially reducing the quantity to be applied

Place of Indian Agriculture in Indian Economy

- The agriculture sector employs nearly half of the workforce in the country. However, it contributes to 17.5 % of the GDP (at current prices in 2015-16).
- Over the past few decades, the manufacturing and services sectors have increasingly contributed to the growth of the economy, while the agriculture sector‟s contribution has decreased from more than 50% of GDP in the 1950s to 15.4% in 2015-16.
- India‟s production of food grains has been increasing every year and India is among the top producers of several crops such as wheat, rice, pulses, sugarcane and cotton. It is the highest producer of milk and second highest producer of fruits and vegetables.
- In 2013, India contributed 25% to the world‟s pulses production, the highest for any one country, 22% to the rice production and 13% to the wheat production. It also accounted for about 25% of the total quantity of cotton produced, besides being the second highest exporter of cotton for the past several years. However, the agricultural yield (quantity of a crop produced per unit of land) is found to be lower in the case of most crops, as compared to other top producing countries such as China, Brazil and the United States.
- Agricultural growth has been fairly volatile over the past decade, ranging from 5.8% in 2005-06 to 0.4% in 2009-10 and -0.2% in 2014-15.
- Total production of food grains increased from 51million tonnes in 1950-51 to 252 million tonnes in 2015-16.
- According to the second advance estimate by the Ministry of Agriculture, food grains production is estimated to be 272 million tonnes in 2016-17.
- The production of wheat and rice took off after the green revolution in the 1960s, and as of 2015-16, wheat and rice accounted for 78% of the food grains production in the country.

Importance Of Agriculture

Agriculture plays a crucial role in the life of an economy. It is the backbone of our economic system. Agriculture not only provides food and raw material but also employment opportunities to a very large proportion of population. The following facts clearly highlight the importance of agriculture in this country.

1. Source of Livelihood: In India the main occupation of our working population is agriculture. About 70 per cent of our population is directly engaged in agriculture. In advanced countries, this ratio is very small being 5 per cent in U.K., 4 per cent in USA., 16 per cent in Australia, 14 per cent in France, 21 per cent in Japan and 32 per cent in USSR.

2. Contribution to National Income: Agriculture is the premier source of our national income. According to National Income Committee and C.S.O., in 1960-61, 52 per cent of national income was contributed by agriculture and allied occupations. This was further reduced to 28 per cent in 1999-2000.

3. Supply of Food and Fodder: Agriculture sector also provides fodder for livestock (35.33 crores). Cow and buffalo provide protective food in the form of milk and they also provide draught power for farm operations. Moreover, it also meets the food requirements of the people.
4. Importance in International Trade: It is the agricultural sector that feeds country's trade. Agricultural products like tea, sugar, rice, tobacco, spices etc. constitute the main items of exports of India. If the development process of agriculture is smooth, export increases and imports are reduced considerably.
5. Marketable Surplus: The development of agricultural sector leads to marketable surplus. As agricultural development takes place, output increases and marketable surplus expands. This can be sold to other countries.
6. Source of Raw Material: Agriculture has been the source of raw materials to the leading industries like cotton and jute textiles, sugar, tobacco, edible and non-edible oils etc. All these depend directly on agriculture. Apart from this, many others like processing of fruits and vegetables, dal milling, rice husking, gur making also depend on agriculture for their raw material.
7. Importance in Transport: Agriculture is the main support for railways and roadways which transport bulk of agricultural produce from farm to the mandies and factories. Internal trade is mostly in agricultural products. Besides, the finance of the govt, also, to the large extent, depends upon the prosperity of agricultural sector.
8. Contribution to Foreign Exchange Resources: Agricultural sector constitutes an important place in the country's export trade. According to an estimate, agricultural commodities like jute, tobacco, oilseeds, spices, raw cotton, tea and coffee accounted for about 18 per cent of the total value of exports in India.
9. Vast Employment Opportunities: The agricultural sector is significant as it provides greater employment opportunities in the construction of irrigation projects, drainage system and other such activities. With the fast growing population and high incidence of unemployment and disguised unemployment in backward countries, it is only agriculture sector which provides more employment chances to the labour force.
10. Source of Saving: Improvement in agriculture can go a long way in increasing savings. It is seen that rich farmers have started saving especially after green revolution in the country. This surplus amount can be invested in agriculture sector for further; development of the sector.
11. Source of Government Income: In India, many state governments get sizeable revenue from the agriculture sector. Land revenue, agricultural income tax, irrigation tax and some other types of taxes are being levied on agriculture by the state governments.
12. Basis of Economic Development: The development of agriculture provides necessary capital for the development of other sectors like industry, transport and foreign trade. In fact, a balanced development of agriculture and industry is the need of the day.

Challenges

Three agriculture sector challenges will be important to India‟s overall development and the improved welfare of its rural poor:

1. Raising agricultural productivity per unit of land: Raising productivity per unit of land will need to be the main engine of agricultural growth as virtually all cultivable land is farmed. Water resources are also limited and water for irrigation must contend with increasing industrial and urban needs.
2. Reducing rural poverty through a socially inclusive strategy that comprises both agriculture as well as non-farm employment: Rural development must also benefit the poor, landless, women, scheduled castes and tribes. Moreover, there are strong regional disparities: the majority of India‟s poor are in rain-fed areas or in the Eastern Indo-Gangetic plains. Reaching such groups has not been easy. While progress has been made-the rural population classified as poor fell from nearly 40% in the early 1990s to below 30% by the mid-2000s (about a 1% fall per year) –there is a clear need for a faster reduction. Hence, poverty alleviation is a central pillar of the rural development efforts of the Government and the World Bank.
3. Ensuring that agricultural growth responds to food security needs: The sharp rise in food-grain production during India‟s Green Revolution of the 1970s enabled the country to achieve self-sufficiency in food-grains and stave off the threat of famine. However agricultural growth in the 1990s and 2000s slowed down, averaging about 3.5% per annum, and cereal yields have increased by only 1.4% per annum in the 2000s. The slow-down in agricultural growth has become a major cause for concern.

Priority areas for support

1. Enhancing agricultural productivity, competitiveness, and rural growth Promoting new technologies and reforming agricultural research and extension
2. Improving Water Resources and Irrigation/Drainage Management:
3. Facilitating agricultural diversification to higher- value commodities:
4. Developing markets, agricultural creditand public expenditures:
5. Poverty alleviation and community actions
6. Sustaining the environment and future agricultural productivity

Chapter 12. Indian agricultural concerns and prospects

A. Ill effects of Green Revolution

- **Degradation of land:** Due to change in land use pattern and employing two and three crop rotation every year land quality has gone down and yield has sufferred.
- **Degradation of land part:** Due to heavy chemical fertilizer inputs land has become hard and carbon material has gone down.
- **Weeds have increased:** Due to heavy crop rotation pattern we do not give rest to land nor we have time to employ proper weed removal system which has increased weeds.
- **Pest infestation has gone up:** Pests which we used to control by bio degradable methods have become resistant to many pesticides and now these chemical pesticides have become non effective.
- **Loss of bio diversity:** Due to heavy use of chemical pesticides, insecticides and fertilizers we have lost many birds and friendly insects and this is a big loss in long term.
- **Chemicals in water:** These chemicals which we have been using in our farms go down and contaminate ground water which effect our and our children health.
- **Water table has gone down:** Water table has gone down due to lack of water harvesting systems and now we have to pull water from 300 to 400 ft. depth which was 40 to 50 feet earlier.
- **Loss of old seeds:** We have started using new seeds and lost old once since new once give better yield but due to this we have lost many important genes in these seeds.

B. Soil retrogression and degradation

Soil retrogression and degradation are two regressive evolution processes associated with the loss of equilibrium of a stable soil. Retrogression is primarily due to soil erosion and corresponds to a phenomenon where succession reverts the land to its natural physical state. Degradation is an evolution, different from natural evolution, related to the local climate and vegetation. It is due to the replacement of primary plant communities (known as climax vegetation) by the secondary communities. This replacement modifies the humus composition and amount, and affects the formation of the soil. It is directly related to human activity.

Consequences of soil regression and degradation

- Yields impact: Recent increases in the human population have placed a great strain on the world's soil systems. Slight degradation refers to land where yield potential has been reduced by 10%, moderate degradation refers to a yield decrease from 10-50%. Severely degraded soils have lost more than 50% of their potential.
- Natural disasters: Natural disasters such as mud flows, floods are responsible for the death of many living beings each year.
- Deterioration of the water quality: Soils particles in surface waters are also accompanied by agricultural inputs and by some pollutants of industrial, urban and road origin.
- Biological diversity: soil degradation may involve perturbation of microbial communities, disappearance of the climax vegetation and decrease in animal habitat. Economic loss: the estimated costs for land degradation are US $40 billion per year.

Soil rebuilding and regeneration

Rebuilding is especially possible through the improvement of soil structure, addition of organic matter and limitation of runoff. However, these techniques will never totally succeed to restore a soil (and the fauna and flora associated to it) that took more than 1000 years to build up.

Soil regeneration is the reformation of degraded soil through biological, chemical, and or physical processes. Supplementing the farmer's usual practice with a single application of 200 kg bentonite per rai (6.26 rai = 1 hectare) resulted in an average yield increase of 73%.

C. Soil contamination

Soil contamination or soil pollution as part of land degradation is caused by the presence of Xeno Bionis (human-made) chemicals or other alteration in the natural soil environment. It is typically caused by industrial activity, agricultural chemicals, or improper disposal of waste. The most common chemicals involved are petroleum hydrocarbons, polynuclear aromatic hydrocarbons (such as naphthalene and benzo(a)pyrene), solvents, pesticides, lead, and other heavy metals. Contamination is correlated with the degree of industrialization and intensity of chemical usage.

Soil pollution can be caused by the following (non-exhaustive list)

- Oil drilling.
- Mining and activities by other heavy industries

- Accidental spills as may happen during activities, etc.
- Corrosion of underground storage tanks (including piping used to transmit the contents)
- Acid rain (in turn caused by air pollution)
- Intensive farming
- Agrochemicals, such as pesticides, herbicides and fertilizers
- Industrial accidents
- Road debris
- Drainage of contaminated surface water into the soil
- Waste disposal

There are several principal strategies for remediation:

- Excavate soil and take it to a disposal site away from ready pathways for human or sensitive ecosystem contact.
- Aeration of soils at the contaminated site (with attendant risk of creating air pollution)
- Thermal remediation by introduction of heat to raise subsurface temperatures sufficiently high to volatize chemical contaminants out of the soil for vapour extraction.
- Bioremediation, involving microbial digestion of certain organic chemicals with commercially available microflora.
- Containment of the soil contaminants (such as by capping or paving over in place).
- Phytoremediation, or using plants (such as willow) to extract heavy metals.
- Mycoremediation (Fungus) to metabolize contaminants and accumulate heavy metals.
- Remediation of oil contaminated sediments with self-collapsing air microbubbles

D. Water pollution

Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater). This form of environmental degradation occurs when pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful compounds.

Causes

- Wide spectrum of chemicals, pathogens, and physical changes such as elevated temperature and discoloration.
- High concentrations of naturally occurring substances can have negative impacts on aquatic flora and fauna.
- Oxygen-depleting substances may be natural materials such as plant matter (e.g. leaves and grass) as well as man-made chemicals.
- Other natural and anthropogenic substances may cause turbidity (cloudiness) which blocks light and disrupts plant growth, and clogs the gills of some fish species.

Control

- Sewage treatment
- Industrial waste water treatment
- Agricultural waste water treatment
- Erosion and sediment control from construction sites
- Control of urban runoff

E. Agricultural Labour Scarcity

Definition and Classification The 2001 census of India, has defined agriculture labourer as "A person who works on another person's land for wages in money or kind or share is regarded as an agricultural labourer. She or he has no risk in the cultivation, but merely works on another person's land for wages."

The agricultural labourers can be classified mainly into two categories:

1. Landless agricultural labourers:

i) Permanent labourers attached to cultivating households

ii) Casual labourers.

2. Very small cultivators whose main source of earnings is wage employment, due to their small and sub-marginal holdings.

Agriculture labour scarcity in India

Even though India has the second largest man-power in the world, all the sectors of the economy have been affected by the scarcity of labourers, the impact being felt more in the agricultural sector. Labourers constitute a vital input in agricultural production, but they are migrating to different parts of the country for earning better livelihood adding to the existing imbalance between labour demand and supply of labourers.

Till not very long ago, Indian agriculture was marked by abundant supply of farm labour.

This gave rise to a negative relationship between labour productivity and labour absorption. This scenario of over-supply however has changed in recent years, particularly after the implementation of MGNREGA, expansion of public works and increased rural to urban migration owing to urbanization and generation of casual employment in the tertiary sector in towns and cities. In a typical village labour scenario, the common norm for the prevailing wage rate or labour charges are fixed by the simple relation between its demand and supply. Since Indian agriculture is predominantly rain-fed, the agricultural wages also respond to rainfall variability. This seasonal nature of agriculture employment has led to shift of agricultural labourers to non-farm sector for employment. The proportion of agricultural workers to the total work-force has been declining over the years, hence following impacts have been predominantly noticed in agriculture in recent years; reduction in crop yield, reduction in cropping intensity and changes in traditional cropping pattern. The scarcity of agricultural labourers may also cause delay in crop establishment, poor crop growth, no or untimely weeding, irrational use of fertilizers, insufficient irrigation to crops etc. These implications of labour scarcity if left unattended may discourage farmers who may leave their land fallow and shift to non-agricultural avenues for livelihood. Over the past couple of decades, there is a growing concern that the farm labour has been decreasing which has been caused by occupational changes, people's mindset, Government policies and reforms making it imperative to investigate into the dynamics or scarcity of agricultural labour and its effect on agricultural economy.

F. Minimum Support Price

Minimum Support Price (MSP) is a form of market intervention by the Government of India to insure agricultural producers against any sharp fall in farm prices. The minimum support prices are announced by the Government of India at the beginning of the sowing season for certain crops on the basis of the recommendations of the Commission for Agricultural Costs and Prices (CACP). MSP is price fixed by Government of India to protect the producer - farmers - against excessive fall in price during bumper production years. The minimum support prices are a guarantee price for their produce from the Government. The major objectives are to support the farmers from distress sales and to procure food grains for public distribution. In case the market price for the commodity falls below the announced minimum price due to bumper production and glut in the market, government agencies purchase the entire quantity offered by the farmers at the announced minimum price.

Determination of MSP

Following factors are considered while fixing MSP:-

- Cost of production
- Changes in input prices
- Input-output price parity
- Trends in market prices
- Demand and supply
- Inter-crop price parity
- Effect on industrial cost structure
- Effect on cost of living
- Effect on general price level
- International price situation
- Parity between prices paid and prices received by the farmers.
- Effect on issue prices and implications for subsidy

Minimum Support Price for 2016-17

SN	Commodity (q/ha)	MSP for 2016-17 (Rs per quintal)	Increase over previous year (Rs per quintal)
1	Paddy	1470	60
2	Hybrid Jawar	1625	55
3	Bajra	1330	55
4	Maize	1365	40
5	Arhar	5050	425
6	Mung	5225	375

7	Cotton	3860	60
8	Groundnut in shell	4220	190
9	Wheat	1625	100
10	Gram	4000	500
11	Mustard	3700	350
12	Sugarcane (per tonne)	3000	--

G. Vision 2050 of ICAR

Guiding Principles for Future Research and Education

• Provide leadership in ensuring national food and nutritional security, farmers' prosperity, consumer health and enhancing the natural resource base of agriculture for future generations
• Ensure strategic competitive advantage of Indian agriculture to enable access to the existing and emerging markets, and address the emerging challenges
• Leverage the advances in other sciences, engineering and social science to enhance agricultural research.
• Nurture scientific excellence and promote interdisciplinary, systems-based, knowledge intensive, problem-solving research.
• Promote economic opportunities for the rural community and society.
• Promote complementary partnerships for value addition in agriculture and accelerate innovation.
• Respond proactively to farmers, consumers, partners and policy makers
• Promote ethical conduct, scientific integrity and accountability of performance and decisions
• Promote organizational transformation to an efficient, effective, and responsive innovation system
• Support higher education and create educational environments that foster continuous learning

ICAR 2050: Focus Areas of Research

 Genetic potential enhancement of agricultural commodities.
• Agricultural productivity, efficiency and profitability improvement
• Resilience to climate change and abiotic and biotic stresses
• Improve nutritional food, and health security
• Risk management against climate change and market stressors
• Agricultural value chains
• Sustainability of natural resources base of agriculture
• Valuation of ecosystem services
• Agricultural markets, policies, and institutions
• Bio-security, emerging from gene piracy and cross-border vector borne diseases
• New products and uses (eg, bio-energy, new crops, synthetic foods, special foods)
• New educational and learning systems and environments

H. Protected cultivation

In the present scenario of perpetual demand for better quality vegetables and continuously shrinking land holdings, protected cultivation is the best choice for quality produce and efficient use of land and other resources. Protected cultivation means some level of control over plant microclimate to alleviate one or more of abiotic stresses for optimum plant growth which can be achieved in naturally ventilated poly-house or net-/polynet-house. Crop yields can be several times higher than those under open field conditions, quality of produce is superior, higher input use efficiencies are achieved and vegetable export can be enhanced. Extreme weather conditions, in some countries, under the open field conditions are the major limiting factors for achieving higher yield and better quality of vegetables. Under such circumstances, protected cultivation is best option. Keeping these points in view, net-house and naturally ventilated poly-house technology has been recommended for the cultivation of different vegetables.

Modified design of net-house - polynet-house

Polynet-house is a framed structure consisting of GI pipes covered with ultra violet (UV) stabilized plastic film of 200- micron thickness at the top and UV stabilized net of 40-mesh size on the sides.

Selection of site

- The site for the net house should be well drained and fairly shadow free.
- It should be away from the obstruction at least three times the height of the obstruction.
- Windbreaks are desirable and at least 30 m away on all sides to minimize the adverse effect of wind.

Orientation

Polynet-house should be constructed in the east–west direction to get the maximum benefit of the sunlight throughout the year and to minimize the adverse effect of wind.

I. Conventional and Non conventional energy sources

Conventional : Energy that has been used from ancient times is known as conventional energy. Coal, natural gas, oil, and firewood are examples of conventional energy sources. (or usual) Sources of energy (electricity) are coal, oil, wood, peat, uranium.

Non-conventional **(or unusual) sources of energy and use**

- Solar power
- Hydro-electric power (dams in rivers)
- Wind power
- Tidal power
- Ocean wave power
- Geothermal power (heat from deep under the ground)
- Ocean thermal power (the difference in heat between shallow and deep water)
- Biomass (burning of vegetation to stop it producing methane)
- Biofuel (producing ethanol (petroleum) from plants

J. Agriclinics & Agribusiness Centres

The M. S. Swaminathan Research Foundation (MSSRF) along with an international organisation called CABI jointly piloted a project called plant clinic (PC) in Tamil Nadu, Puducherry and Maharashtra. The main aim of setting up such clinics is to diagnose pests and diseases in any crop and render accurate knowledge to the farming community. Basically it is a community-driven model, conducted in a common location, accessible to all categories of farmers in a village.

Need guidance

Farmers need guidance to distinguish the difference between pest and infestations, understand harmful effects of red labelled/banned pesticides, pest resurgence, resistance to pesticides etc."The clinic provides an array of technological solutions along with cultural, biological and chemical methods, which are nationally and internationally permissible, ecologically safe and environmentally sustainable for mitigating crop loss and enhancing plant health and economic benefit.

Prescription

Farmers bring their affected crop samples to the clinics to recognise the problem and get technological solutions. Every farmer is provided with a prescription, detailing the case history along with recommendations. The PC treats the crop samples with the help of the comprehensive factsheets in the local vernacular brought by the farmers. Presently about 37 plant doctors serve through 14 Plant clinics; 391 clinic sessions have been conducted till now across Tamil Nadu, Puducherry and Maharashtra, spanning 62 villages, in which more than 6,000 farmers including 992 women farmers have been reached.

The Ministry of Agriculture and farmers welfare, Government of India, in association with NABARD has launched a unique programme to take better methods of farming to each and every farmer across the country. This programme aims to tap the expertise available in the large pool of Agriculture Graduate who can set up AgriClinic or AgriBusiness Centre and offer professional extension services to innumerable farmers. Committed to this programme, the Government is now also providing start-up training to graduates in Agriculture, or any subject allied to Agriculture like Horticulture, Sericulture, Veterinary Sciences, Forestry, Dairy, Poultry Farming, and Fisheries, etc. Those completing the training can apply for special start-up loans for venture.

Earn money and prestige by becoming a consultant to farmers

Agribusiness Centres would provide paid services for enhancement of agriculture production and income of farmers. Centres would need to advice farmers on crop selection, best farm practices, post-harvest value-added options, key agricultural information (including perhaps even Internet-based weather forecast), price trends, market news, risk mitigation and crop insurance, credit and input access, as well as critical sanitary and phyto-sanitary considerations, which the farmers have to keep in mind.

Free Training to set up your Agriclinic or Agribusiness Centre

As an integral part of this nationwide initiative, specialised training will be provided to Agriculture Graduates interested in setting up such a centre. Being provided free of cost, the 2-month training course will be offered by select institutes across the country.

Bank loans available for Agriclinics and Agribusiness Centres

Ceiling of project cost for subsidy has been enhanced to Rs.20 lakhs for an individual project (25 lakhs in case of extremely successful individual projects) and to Rs.100 lakhs for a group project.

K. **Information and communication technology** (**ICT**)

It is an extended term for information technology (IT) which stresses the role of unified communications. The term *ICT* is also used to refer to the convergence of audio-visual and telephone networks with computer networks through a single cabling or link system.

Information and communication technology in agriculture (**ICT in agriculture**), also known as **e-agriculture**, is developing and applying innovative ways to use ICTs in the rural domain, with a primary focus on agriculture. ICT in agriculture offers a wide range of solutions to some agricultural challenges. In this context, ICT is used as an umbrella term encompassing all information and communication technologies including devices, networks, mobiles, services and applications; these range from innovative Internet-era technologies and sensors to other pre-existing aids such as fixed telephones, televisions, radios and satellites. More specifically, e-agriculture involves the conceptualization, design, development, evaluation and application of innovative ways to use ICTs in the rural domain, with a primary focus on agriculture.

The Food and Agriculture Organization of the United Nations (FAO) has been assigned the responsibility of organizing activities related to the action line under C.7 ICT Applications on E-Agriculture.

Many ICT interventions have been developed and tested around the world, with varied degrees of success, to help agriculturists improve their livelihoods through increased agricultural productivity and incomes, and reduction in risks. Some useful resources for learning about e-agriculture in practice are the World Bank's e-sourcebook ICT in agriculture – connecting smallholder farmers to knowledge, networks and institutions (2011).

ICT tools can help in meeting the challenges in agricultural development in the following ways:

- Agriculture Information, Awareness and Education using ICT.
- Advanced information about adverse weather condition, so that farmers can take precautionary measures.
- Real time and near real times pricing and market information.
- Information dissemination about various government schemes.
- Information regarding agrifinance, agriclinicls and agribusiness.
- Online Farmer Communities

Government Initiatives on ICT in agriculture

Key Government initiatives to promote use of ICT in agriculture include National e-Governance Plan in Agriculture (NeGP-A), various Touch Screen Kiosks, Krishi Vigyan Kendras, Kisan Call Centres, Agri-Clinics, Common Service Centers, mKisan, Kisan TV and various other applications.