

Agricultural Heritage  
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***Theory Class course outlines:***

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# Lecture 1

## Introduction of Indian agricultural heritage and Relevance of heritage to present day agriculture

### Agriculture

The term Agriculture is derived from two Latin words **ager** or **agri** meaning **soil** and **cultura** meaning **cultivation**. Agriculture is an applied science which encompasses all aspects of crop production including horticulture, livestock rearing, fisheries, forestry, etc.

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

**As an art** it embraces knowledge of the way to perform the operations of the farm in a skillful manner, but does not necessarily include an understanding of the principles underlying the farm practices.

**As a science:** utilizes all technologies developed on scientific principles such as crop breeding, production techniques, crop protection, economics etc. to maximize the yield and profit. For example, new crops and varieties developed by hybridization, Transgenic crop varieties resistant to pests and diseases, hybrids in each crop, high fertilizer responsive varieties, water management, herbicides to control weeds, use of bio-control agents to combat pest and diseases and so on.

**As the business:** As long as agriculture is the way of life of the rural population production is ultimately bound to consumption. But agriculture as a business aims at maximum net return through the management of land labour, water and capital, employing the knowledge of various sciences for production of food, feed, fibre and fuel. In recent years, agriculture is commercialized to run as a business through mechanization.

### IMPORTANT#1

#### Timeline

**Common Era**, abbreviated as **CE**, is a designation for the world's most commonly used year-numbering system. The numbering of years using Common Era notation is identical to the numbering used with "Before Christ / Anno Domini" (BC/AD) notation. Common Era is also known as and **Current Era**, with all three expressions abbreviated as **CE**. (Christian era is, however, also abbreviated AD, for *Anno Domini*.) Dates before the year 1 CE are indicated by the usage of **BCE**, short for "**Before the Common Era**", "**Before the Christian Era**", or "**Before the Current Era**".

Agriculture is defined in the Agriculture act, India (1947), as it includes 'horticulture, food 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'.

### Evolution of man and Agriculture

There are different stages in development of agriculture, which is oriented with human civilization.

They are Hunting \_ Pastoral \_ Crop culture \_ Trade (stages of human civilization).

**1. Hunting** – It was the primary source of food in old days. It is the important occupation and it existed for a very long period.

**2. Pastoral** – Human obtained his food through domestication animals, e.g. dogs, horse, cow, buffalo, etc. They lived in the periphery of the forest and they had to feed his domesticated animals. For feeding his animals, he would have migrated from one place to another in search of food. It was not comfortable and they might have enjoyed the benefit of staying in one place near the river bed.

**3. Crop culture** - By living near the river bed, he had enough water for his animals and domesticated crops and started cultivation. Thus he has started to settle in a place.

**4. Trade** – When he started producing more than his requirement the excess was exchanged, this is the basis for trade. When agriculture has flourished, trade developed. This led to infrastructure development like road, routes, etc.

### IMPORTANT#2

- **History** is the continuous/ chronological record / evidence of past events.
- **Heritage** is the inherited values carried from one generation to other generation.
- **Agricultural heritage** refers to the values and traditional practices adopted in ancient India which are relevant for present day system.

### Beginning of agriculture in India

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. During ancient historic period also 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 origin of agriculture in India is obscure. The belated Neolithic opens up with extra-local crops domesticated elsewhere. Evidence is now forthcoming of the antiquity of the Neolithic with the local crop rice but its origin remains unknown. Evidence from the Mesolithic reveals that, as elsewhere, the animal domestication had preceded the plant domestication. However uncertain the evidence is, it does indicate the possibility of the occurrence of such wild grasses which are today the forgotten cereals and are cultivated by the tribals.

The extra-local crops which entered the extreme northwest of the sub-continent were diffused among diverse and contemporaneous cultures from the west to the east and subsequently from the north to Maharashtra. Rice entered the wheat-barley and/or millet-based economy from the north (Ganga Plains) to the south subsequent to the diffusion of wheat and barley, and entered the deep south during the Iron Age, during which its cultivation had expanded into the rest of the sub-continent.

### IMPORTANT#3

#### 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* (derived from Latin; *Homo* means **continuous**, *sapiens* means **wise** or **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 split 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, man lived in settled villages and apart from security from hunger he had leisure time to think and contemplate.

**Important features:**

1. Neolithic culture denotes a stage in economic and technological development in India
2. Use of polished stone axes for cleaning the bushes
3. Handmade pottery for storing food grains
4. Invented textile, weaving and basketry
5. Cultivation of rice, banana, yams, millets pulses and discovered 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.

**Important features:**

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.

## **Relevance of heritage to present day agriculture**

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. 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.

## **Need and importance for studying Agricultural Heritage**

The common world agricultural patrimony is recognized at the national and international level and that the values of agricultural heritage systems such as cultural, social, environmental and economic assets are assessed properly. Agricultural Heritage systems satisfy the expectations and demands for food, energy

health, culture and recreation of millions of people at the national level but also provide global benefits. Such recognition can open new opportunities for generation of employment and income through what may be called the “cultural economy” (ecotourism, cultural identity products, local gastronomy and other products pertaining to richness of local cultures and resources).

In many countries, conservation of the eco-cultural patrimony is still threatened by the low value attributed to traditional products and skills. Markets need to be developed and improved, although other non-market mechanisms may be available and preferable to enhance income and well-being. Likewise, the tourist industry must aim at creating more awareness of the significance of this patrimony, and support it by consuming local foods, promoting ecotourism of natural areas and traditional agricultural landscapes, donating to local projects that support community projects, and other initiatives.

Major drivers of traditional agricultural biodiversity loss include land use changes, introduction of new crop varieties, over exploitation of wild resources, over fishing, highly consumptive food practices with considerable waste and perverse effects of trade liberalization and agricultural subsidies. The consequences of these losses disrupt the lifestyles of the poor farmers who depend upon local ecosystems for their livelihoods especially in terms of food security. Therefore, special attention should be given when introducing modern agricultural varieties and inputs to avoid upsetting the balance of traditional agro-ecosystems. In addition to conserving local production systems and compensating farmers for their services should be considered with top priority.

The analysis of hundreds of farmer-centered projects around the developing world shows convincingly that under agro-ecological approaches, crop yields of most poor farmers can be increased several-fold. This is achieved based on internal inputs through reliance on their own labor and know-how and not on external inputs such as the purchase of expensive inputs. Success in agriculture will depend on the use of a variety of agro-ecological improvements that, in addition to farm diversification, favor better use of local resources, emphasize enhancement of human capital and empower communities through training and consultative, participatory methods. Finally, there has to be greater access to equitable markets, credit and income generating activities with the support of enabling policies, local farmers and rural areas.

## **Rich agricultural heritage of India**

Our agriculture has a lot of inherited sustainable practices passed from one generation to another. 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 and 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 is now shifting to sustainable form of agriculture.

The indigenous technological 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.

The main objectives **for studying Agricultural Heritage** are:

- 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 comprised of sustainable practices for generations.
- To stimulate scientific research based on traditional technology.

<b>IMPORTANT#4</b>	
<b>List of Available Documents on agriculture during ancient and medieval period</b>	
Rigveda (c.3700 BC)	Surapala's Vrikshayurveda (c.1000 AD)
Atharvaveda (c. 2000 BC)	Lokopakaram by Chavundaraya (1025 AD)
Ramayana (c.2000 BC)	Someshwardeva's Manasollasa (1131 AD)
Mahabharata (c.1400 BC)	Saranghara's Upavanavioda (c.1300 AD)
Krishi-Parashara (c.400 BC)	Bhavaprakasha-Nighantu (c.1500 AD)
Chanakya's/Kautilya's Artha-sastra (c.300 BC)	Chakrapani Mitra's Viswavallbha (c.1580 AD)
Amarsimha's Amarkosha (c.200 BC)	Dara Shikoh's Nuskha Dar Fanni-Falahat (c.1650 Ad)
Patanjali's Mahabhasya (c.200 BC)	Jati Jaichand's dairy (1658-1714 AD)
Sangam literature (Tamils) (200 BC-100 AD)	Anonymous Rajasthani Manuscript (1877 AD)
Agnipurana (c.400 AD)	Watt's Dictionary of Economic Products of India (1889-1893 AD)
Varahamihir's Brihat Samhita (c. 500 AD)	
Kashyapiyakrishisukti (c.800Ad)	

### Question Bank

1. What is agricultural heritage? Why one should study the agricultural heritage?
2. What are the different early ages of development of human culture?
3. Match the following books and name of the authors.
 

a) Amarkosha	i) Chanakya
b) Arthasastra	ii) Amarsimha
c) Patanjali	iii) Brihat-Samhita
d) Varahamihir	iv) Mahabhashya
e) Surapala	v) Manasollasa
f) Someshwardeva	vi) Vrikshayurveda
4. Fill in the blanks.
  - a) The famous book written by Chanakya is .....
  - b) The period of the Chalcolithic age ranges between ..... To ..... BCE.
  - c) The invention of the plough was noted in ..... age.
  - d) The people started using metals like ..... and ..... During the Chalcolithic period.

## Lecture 2

### Globally Important Agricultural Heritage Systems

**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**".

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. These "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 sustainably provide multiple goods and services, food and livelihood security for millions of poor and small farmers. 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.

GIAHS are selected based on their importance for the provision of local food security, high levels of agro-biodiversity and associated biological diversity, store of indigenous knowledge and ingenuity of management systems. The biophysical, economic and socio-cultural resources have evolved under specific ecological and socio-cultural constraints to create outstanding landscapes. The examples of such agricultural heritage systems are in the hundreds and are home to thousands of ethnic groups, indigenous communities and local populations with a myriad of cultures, languages and social organizations.

Examples of GIAHS could fall into:

#### **1. Mountain rice terrace agro-ecosystems**

These are outstanding mountain rice terrace systems with integrated forest use and/ or combined agro-forestry systems, such as: the agroforestry vanilla system in Pays Betsileo, Betafo and Mananara regions in Madagascar; the Ifugao rice terraces in the Philippines; and many more. These systems also include diverse agricultural features and other elements: for example, integrated rice-based systems (e.g. rice-fish culture, ricefish-duck, rice-fish-taro) with numerous rice and fish varieties/genotypes; and integrated forest, land and water use systems, especially found in East Asia and the Himalayas.

#### **2. Multiple cropping/polyculture farming systems**

These are remarkable combinations and/or plantings of numerous crop varieties with or without integration of agroforestry. They are characterized by ingenious microclimate regulation, soil and water management schemes, and adaptive use of crops to deal with climate variability. These practices are heavily dependent on their rich resources of indigenous knowledge and associated cultural heritage e.g. maize and root crop-based agro-ecosystems developed by the Aztecs (Chinampas in Mexico); waru-waru systems or suka collosin and around Lake Titicaca in Peru and Bolivia (Incas in the Andes region).

#### **3. Understory farming systems**

These are agricultural systems using combined or integrated forestry, orchard or other crop systems with both over story-canopy and understory environments. Farmers use understory crops to provide earlier returns, diversify crops/products and/or make efficient use of land and labor. These practices are common in the tropics, e.g. in taro-based or root cropping systems, planted along with other endemic plant varieties from local genetic resources. These are common in Papua New Guinea, Vanuatu, Solomon Islands and other Pacific small island developing countries.

#### **4. Nomadic and semi-nomadic pastoral systems**

These are the rangeland/pastoral systems based on adaptive use of pasture, rangeland, water, salt and forest resources, through mobility and variations in herd composition in harsh non-equilibrium environments with high animal genetic diversity and outstanding cultural landscapes. These include highland, tropical and sub-tropical dryland and arctic systems such as Yak-based pastoral management in Ladakh and the high Tibetan plateau in India and China; highly extensive rangeland use in parts of Mongolia and Yemen; cattle and mixed animal based nomadic pastoral systems, such as of the Maasai in East Africa; reindeer-based management of tundra of the Saami and Nenets in the temperate forest areas of Scandinavia and Siberia. The landscapes formed by these systems often provide habitats for wild species including endangered species.

### **5. Ancient irrigation, soil and water management systems**

These are the ingenious and finely tuned irrigation, soil and water management systems most common in drylands, with a high diversity of crops and animals best adapted to such environments: (i) the Qanat ancient underground water distribution systems allow specialized and diverse cropping systems in Iran, Afghanistan and other central Asian countries with associated home gardens and endemic blind fish species living in underground waterways; (ii) the oases of the Maghreb in the deserts of North Africa and the Sahara; (iii) traditional valley bottom and wetland management such as the water management systems in Lake Chad, the Niger River basin and interior delta e.g. floating and flooded rice systems; and (iv) other ingenious irrigation systems in Bamileke region, Cameroon; of Dogon tribes in Mali and Diola tribes in Senegal; as well as the village tank system in Sri Lanka and India.

### **6. Complex multi-layered home gardens**

These agricultural systems feature complex multi-layered home gardens with wild and domesticated trees, shrubs and plants for multiple foods, medicines, ornamentals and other materials, possibly with integrated agro-forestry, swidden fields, hunting gathering or livestock, such as the home garden systems in China, India, the Caribbean, the Amazon (Kayapó) and Indonesia (e.g. East Kalimantan and Butitingui).

### **7. Below sea level systems**

These agricultural systems feature soil and water management techniques for creating arable land through draining delta swamps. The systems function in a context of rising sea and river levels while continuously raising land levels, thereby providing a multifunctional use of land (for agriculture, recreation and tourism, nature conservation, culture conservation and urbanization) e.g. Polder or dyke systems in the Netherlands; Kuttanad wetlands in Kerala, India; floating gardens in Bangladesh and South Asia.

### **8. Tribal agricultural heritage systems**

These systems feature various tribal agricultural practices and techniques of managing soil, water and crop cultivars in sloping lands from upper to lower valleys using mixed and/or a combination of cropping systems and integrating indigenous knowledge systems e.g. Seethampheta in Andhra Pradesh, the Apatani rice fish culture, the Zabo system, the Darjeeling system in the Himalayas, and many others in India.

### **9. High-value crop and spice systems**

These systems feature management practices of ancient fields and high value crops and spices, devoted uniquely to specific crops or with crop rotation techniques and harvesting techniques that require acquired handling skills and extraordinary finesse e.g. Saffron systems in Iran, Afghanistan and Kashmir, India.

### **10. Hunting-gathering systems**

These systems feature unique agricultural practices such as harvesting of wild rice in Chad and honey gathering by forest dwelling peoples in Central and East Africa.

There are numerous other agricultural heritage systems around the world meriting identification, assessment and dynamic conservation. One of the main tasks of the GIAHS partnership initiative is this work in collaboration with local communities, national governments and other national and international institutions.

## **Remarkable characteristics of GIAHS**

The unique traditional farming systems prevalent at the GIAHS sites represent systems that simultaneously exhibit remarkable features of global and local significance:

**1. High levels of biodiversity that play key roles in regulating ecosystem functioning and also in providing ecosystem services of local and global significance.**

GIAHS systems often reflect rich and globally unique agricultural biodiversity displayed at the field and also at the landscape level forming the basis for food production systems. A salient feature of GIAHS is their high degree of plant diversity in the form of rotations, poly-cultures and/or agroforestry patterns. This strategy of minimizing risk by planting several species and varieties of crops stabilizes yields over the long term, promotes diet diversity and maximizes returns even with low levels of technology and limited resources. Genetic diversity provides security to farmers against diseases, pests, droughts and other stresses. It also improves stability of the cropping systems, enables farmers to exploit different soil types and microclimates and derive multiple nutritional benefits and other uses from genetic variation among the species. At the landscapes, diversification occurs by integrating multiple production systems.

**2. Agro-ecosystems nurtured by traditional knowledge systems and farmers' innovations and technologies.**

Indigenous peoples living in GIAHS sites often possess a broad knowledge base of the intricacies of local and complex ecological systems. This knowledge about plants, animals, soils and the general environment has accumulated through a long series of observations transmitted from generation to generation. Indigenous farmers are aware that biological diversity is a crucial factor in generating ecological services, and in the conservation of the resource base and foods on which they depend. Women, in particular, are holders of much more traditional knowledge and thus play a critical role in the conservation and utilization of biodiversity.

**3. Ingenious systems and technologies of biodiversity, land and water resource management and conservation that can be used to improve management of modern agro ecosystems.**

By studying traditional systems, scientists can learn more about the dynamics of complex systems, especially about the links between agricultural biodiversity and ecosystem function and thereby contribute to the enrichment of the ecological theory and derive principles for practical application in the design of modern sustainable farming systems. For example, in deciphering how intercropping practice works, farmers can take advantage of the ability of cropping systems to reuse their own stored nutrients. This information can be gleaned to improve the ways in which farmers can manage soil fertility. Similarly, there could be much progress in pest management schemes if the biological mechanisms within the complex structure of traditional agro-ecosystems can be determined, and thus minimize crop losses due to insect pests, diseases and weeds.

**4. Diversified agricultural systems that contribute to local and national food and livelihood security.**

Most small farming systems are productive, efficient and sustainable compared to larger farms despite their low use of chemical inputs. As the only resource-base available for small farmers is their natural resources and their human capital, they do all they can to maintain it. Therefore they diversify their genetic resources, they diversify their production systems and their sources of income, and all this builds resilience. This contributes to food production, but also to environmental health, to the sustainability of the natural resource-base and thus to the sustainability of livelihoods. Small farms which produce grains, fruits, vegetables, fodder, and animal products in the same field are more productive than large farms if the total output is considered rather than yield from a single crop. Poly-cultures usually reduce losses due to weeds, insects, and diseases and make more efficient use of the available resources of water, light, and nutrients. Furthermore, traditional multiple cropping systems provide as much as 20 percent to 40 percent of the world's food supply.

**5. Farming systems that exhibit resiliency and robustness to cope with disturbance and change (human and climatic -environmental) minimizing risk in the midst of variability.**

Many GIAHS farmers cope and even prepare for climate change, minimizing crop failure through increased use of drought-tolerant local varieties, water harvesting, extensive planting, mixed cropping,

agroforestry, wild plant gathering and a series of other traditional farming system techniques. Observations of agricultural performance after extreme climatic events in the last two decades have revealed that resiliency to climate disasters is closely linked to levels of farm biodiversity. Many indigenous management practices that buffer agro-ecosystems from climate variation include incorporation of wild and local varieties into the agricultural system and increasing the temporal and spatial diversity of crops both at the field and landscape level. These points out the need to re-evaluate indigenous technology as a key source of information on adaptive capacity centred on the selective, experimental and resilient capabilities of traditional farmers in dealing with climate change and other external changes.

**6. Systems that provide local, regional and global ecosystem services.**

The maintenance of high biodiversity levels at GIAHS sites contributes to agricultural productivity and sustainability through the ecosystem services that biodiversity provides. Agro-ecosystem function is optimized via complementary interactions that emerge from added species in an agro-ecosystem, i.e. by mixing specific genotypes of crops for disease resistance, including for example a legume species that increases nitrogen inputs and cycling or by intercropping to support more insect enemies with specific roles in controlling pests. In many GIAHS sites agroforestry systems are part of a multifunctional working landscape, offering a number of ecosystem services and environmental benefits such as carbon sequestration, biodiversity conservation, soil enrichment, etc. In many regions, the management of diverse agriculture within landscapes provides critical watershed functions, such as maintaining water quality, regulating water flow, recharging underground aquifers, mitigating flood risks, moderating sediment flows, and sustaining freshwater species and ecosystems.

**7. Systems regulated by strong cultural values and collective forms of social organization including customary institutions for agro-ecological management, normative arrangements for resource access and benefit sharing, value systems and rituals.**

The stability and capacity of ecological systems to provide goods and services critically depend upon rural communities having and sustaining diverse and complex forms of social organization (kinship, territoriality, settlement, group membership and identity, gender relations, leadership and political organization), culture (worldviews, languages, values, rights, knowledge, aesthetics), modes of production, labor allocation, and technologies and practices. These reflect adaptation to and management of complex social-ecological systems.

**Question Bank**

1. Define Globally Important Agriculture Systems (GIAHS). Give some examples of GIAHS.
2. What are the characteristic features of GIAHS?
3. **Match the following:**

a) Safron cultivation	i) Kerala
b) Yak based pastoral agriculture	ii) Kashmir
c) Kuttanad wetlands system	iii) Ladakh
d) Dyke systems	iv) Bangladesh
e) Floating garden	v) The Netherlands
4. **Fill in the blanks.**
  - a) ..... is a high value spice. (Saffron)
  - b) Ifugao rice terrace farming is followed in the country of ..... (Phillipines).
  - c) In India, tribal agriculture farming system is observed in ..... (Darjeeling of West Bengal/ Seethampheta in Andhra Pradesh).
  - d) Village tank system in observed in ..... (Sri Lanka/ India).

## Lecture 3

### Past day agriculture and farmers in society: Indus period

The Indus Valley Civilization (3300–1900 BCE) spread over the Indus Valley, extending from today's northeast Afghanistan to Pakistan and northwest India. The name of the Civilization came after Indus valley, where the first remains were found. Later archaeologists got the remains from different parts of Gujarat and Karnataka. As the Harappa was the first of its sites excavated in the 1920s, the civilization is also named as Harappan Civilization. So far, 616 sites have been discovered along the dried up river beds of the Ghaggar-Hakra River and its tributaries, while 406 sites have been found along the Indus and its tributaries.

The Indus Civilization was characterized as the first farming cultures in South Asia. These early farmers domesticated wheat and a variety of animals, including cattle. The fertile alluvium of Indus Valley (Indus and its five tributaries) led to the development of numerous peasant settlements in the urban complexes by their rich agricultural produce. The settlements nearer to urban site were clustered densely. The boundary is marked by mud-bunds for the protection of settlement from natural calamities. The settlements are distinguished by their small extent of area, even in some cases as holdings of a single family. The population of Mohenjo-Daro at the rate of 800 sq. feet per person or 133 persons per hectare was computed. Pastoralism and agriculture were given equal importance. Fishing is also presumed from different fishing equipments. This phase in Indian agrarian system is distinguished by temple proprietorship of land. According to D. D. Kosambi, 'land as a whole must have been the property of land directly administered by the great temple and its priesthood'. These priests, as he holds, appear to maintain apathetic attitude towards any change in existing system, for which in spite of commercial contact with Mesopotamia, no technological devices obtained from this country, like, canal irrigation and deep ploughing could be adapted in Indus agricultural practices. Amongst the cereals wheat and barley were recorded from Harappa and Mohenjo-Daro. The association of these two cereals in the archaeological remains of Mesopotamia, along with other evidence, has led to the belief that there was some contact between the Indus Valley and Mesopotamian civilizations.

The development of these farming communities ultimately led to the formation of larger settlements from the later 4th millennium BCE. Indus valley civilization was composite product of different races that 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.

By 3000 BCE, the Early Harappan communities had been turned into urban centers. Thus far, six such urban centers have been discovered during late Harappan period, including: Harappa, Mohenjo-Daro and Diki in Pakistan, along with Gonorreala, Dokalingam and Mangalore in India.

#### Crop cultivation

The evidences of early Harappan Chalcolithic period was observed in India at important four sites, namely, Harappa, Mohenjo-Daro, Chanhudaro and Rohira (i.e. Punjab and Indus basin) and the historians came into conclusion from different evidences that the following crops were grown during the period:

(i) **Cereals:** (a) Wheat (*Triticum vulgare* and *T. compactum* from Mohenjo-daro and *T. compactum* or *Sphaerococcum* from Harappa) and emmer wheat (*T. dicocum* from Rohira); (b) Barley (*H. vulgare* var. *nudum* from Mohenjodaro and Chanhudam and *H. vulgare* var. *hexastichum* from Harappa); (c) Millet (*Jowar, Sorghum*), only evidence is drawing of this crop plant on a potsherd.

(ii) **Legume:** (a) Field peas (*Pisum arvense* from Harappa).

**(iii) Oilseeds:** (a) Sesame (*Seasamum indicum* from Harappa) and (b) Mustard (*Brassica juncea* from Chanhu-daro).

**(iv) Fibrous plants:** Cotton (Mohenjo-daro and Harappa).

**(v) Fruit crops:** These include melon-seeds (*Cucumis melo* from Harappa) and stones of date-palm (Harappa), and the representations in drawing or in figure forms of banana, sugarcane (*Saccharum arundinaceum*), pomegranate, coconut and lemon (from Mohenjo-daro and Harappa).

**(vi) Spice:** Fenugreek (Rohira in Punjab).

These sites from where the late Harappan period was evidenced were Lothal and Rangpur of Sourashtra region and Surkotada which belonged to Kutch, Gujarat). The Crop specimens were: *Cereal:* (a) Rice; (b) Rice and pearl millet (*Bajra*, *Pennisetum typhoides*); (c) Foxtail millet (*Setaria indica* and *S. verticillata*). The people cultivated wheat, barley, gram, peas, sesamum, rape and cotton. The most remarkable discovery in Harappa is the Great Granary used for storing food grain. 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 compartments built over platforms, well-ventilated to prevent sweating and mildew and vivid provision of loading facilities from outside.

These granaries, each 50 X 20 feet [15.2 X 6.1 metres] overall, are ranged symmetrically in two rows of six, with a central passage, 23 feet [7 metres] wide. They are built upon a podium of rammed mud, some 4 feet [over 1 metre] high, rivetted along parts of the eastern and western sides and the whole of the southern and with baked bricks stepped back to form a battered face, like the revetment of the citadel defences. Incidentally, the continuous rivetment along the southern end and the absence of space at the sides prove that the approach was on the north, i.e. from the river-bank, suggesting the use of water-transport for incoming or outgoing supplies of grain. 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.

### **Irrigation**

Apart from the general way of flood-flushing practiced at different sites of Indus Civilization, mention may be made of the following practices particularly undertaken in Sind. This is evident in the writings of inscriptions on seals from Mohenjo-Daro which state: 'Two canals were constructed in the month of *Kudam* (Aquarius) and *Mina* (pisces). Another seal records that it took 'thirteen months to construct a canal'. These canals were cut at low gradient and waters were allowed to merge ultimately into low ground in a direction oblique to the river so as to secure a great fall as possible. This fall varied from a foot to a few inches in a mile. They were up to hundred feet wide and about a dozen feet deep, not enough to draw off from the river except in flood. These were natural streams and probably seasonal. The perennial canals of the Indus system according to R.B. Buckley, were cut to an extra depth and could receive water even when the main river was low, but their real purpose seems to increase the discharge during inundation.

Irrigation system was consisting of lifting of water by water-wheel and by means of *Shaduf* from adjoining water sources. There was also provision of tank irrigation. Rice cultivation shows necessary moisture of soil probably retained by now using contour-bunding for locking up monsoon rain-waters by tank-irrigation.

### **Horticulture**

During the Indus Civilization horticultural crops like fruits were also cultivated namely melon, date palm, banana, pomegranate, coconut, lemon which were confined to Punjab and Indus basin.

### **Wild animal and Livestock**

The wildlife consisted of the elephant, rhinoceros, wolf, jackal, nilgai, gaur (Indian bison), wild buffalo and species of deer, such as the hangul or Kashmir stag, chital, sambhar, barasingha, four-horned antelope, black buck and hog deer. The sambhar, barasingha and chital were fairly widespread. The Harappa toys contain representations of the rhinoceros, the tiger, and the elephant. There are toys shaped as monkeys, squirrels, mongooses, snakes, pangolins, wild boar and crocodiles. From amongst the birds, the duck, peacock, hen, kite, pigeon, dove and parakeet are represented in the toy art.

Archaeological evidences showed rearing of animals in Harappan period. The farmers of the period domesticated different animals including those associated with previous cultures, were dog and cat. Farmers realized the importance of animal husbandry and domesticated buffalo, cattle, camel, horse, elephant, ass and birds. They utilized them in agriculture and also for transport. Appearance of domestic fowl in North-western India is noticeable.

**Cattle:** Zebu or Brahmani type (*Bas indicus*), a breed of Indian; and a little grey cattle-breed.

**Elephant:** Two breeds having identity with modern Momoria and Dhundia.

**Dog:** Two breeds, akin to modern Pariah and Mastiff types of varieties.

**Fowl:** Two types. The seal representations from different sites of Indus culture threw light on poultry rearing.

Requirement of livestock in agriculture is noticed in the use of cattle and horse in drawing cart for carrying goods, probably agricultural produce.

### **Fishery**

A large scale fishing operations carried on in river as well as in sea and also in flood plains are found represented in different sites of Indus culture. The farmers of the Indus Civilization used to harvest (a) fresh-water species (i) three types of cat fishes, (ii) carp; and (b) Marine species: Arius. Different fishing equipments were used for catching fish from different waters. These include hooks of two types, barbed and un-barbed net, traps and baskets. Use of fishing boat for fishing in estuarine or in sea is noticed. Terracotta net sinkers were in use during the period.

### **Farm tools & implements**

Different farm tools and implements used during Indus civilization are listed below.

#### **(i) Tools for forest-clearance**

Axes and adzes of different varieties and of both stone-and copper-bronze-made were reported from different sites of Indus. The notable features among the axe-adze types were shaft-hole-axe made of copper-bronze and flat axe.

#### **(ii) Soil-treatment-cum-tilling**

(a) Two types of hoes: (i) Stone 'shoe-last' celt or hoe and (ii) Socketed hoe were evidenced.

(b) Chert-blades, probably mounted on a stick, were used as hoes.

#### **(iii) Tillage and other implements**

(a) Probable use of harrow and plough as evidenced from seal-impression and terracotta objects from Mohenjo-Daro and Harappa. The grey chert flint implement in the shape of a metal blade axe from Mohenjo-Daro appeared too had been used as a plough-share. The Sumerians developed the plough about 2900 B.C. Possibly the Harappans learnt the use of the plough from the Sumerians. All primitive ploughs were made of wood, and wood is a perishable material. Hence there is no possibility of finding an actual wooden plough from a Harappan site.

(b) Narrow and long axes and broad-chisels of which both were copper made, and presumed to be used as hoes for ploughing.

(c) Seeding machine like seed-drill reported from Lothal site suggested the practice of sowing of seed by making small holes in the ground.

#### **(iv) Harvesting tools**

Both stone and metal made sickles were found at different Indus Civilization sites. The former consisted of chert-blades of three types: (a) some worked on both sides to form a point, (b) some backed, and (c) some notched at the base for binding to a handle.

#### **(v) Corn un-husking / shelling equipment**

Several types of tools were observed which include: (a) boat-shaped quern and (b) large, deep wooden hourglass like contrivances with long wooden pounders.

### **Meteorological studies**

Archaeological evidences supported by recent meteorological studies speak of the current of South-western monsoonal rain throughout the North-western India during this period. The duration of rain tallies with the now presenting monsoonal rains *i.e.* from June to October. The predicament on the arrival of this

rain was important for (i) averting the flood, the annual occurrence of which was associated with the Indus Civilization; (ii) cultivation of crops other than barley and wheat; (iii) The rain appeared to facilitate growth of fish-crops, the different varieties of which are reported in the section on livestock. *Mrgasira* and *Krittika*, the two constellations and the planet Venus which were famous as rain-making agents in India as well as abroad as are represented in Indus seals through some symbolic signs. The rain-making potential of the star *Mrgasira* (Orionis) was frequently referred to in later astronomical texts. The Indus people appear to study the arrival of the rain from this celestial body during this part of the year for their late winter-crop. *Krittika* (Rainy Pleiades), the exact period of rising of this constellation, composed of (six or seven stars, as evidenced in the Vedic texts, appears to lie in two different times that is spring, and rainy season in the eastern horizon. A compass like object consisting of a shell ring having 8 or 12 slits were found in Mohenjo-Daro and Lothal was presumed to have been used for the determination of the time for annual events like sowing and harvesting, etc. These ring objects with 8 or 12 slits appeared to signify the measuring device of 8 or 12, whole sections of the horizon and sky.

### ***Farm Tax***

A kind of tax was presumed to have been paid to the temple, the State's treasury, enjoying the power of overall ownership of land and of state's granary.

### ***Trade***

Trade in a more or less fuller form came into practice from chalcolithic period. Regular supply of goods on exchange to foreign lands and to inland trade centres became prominent. Utilization of land and water routes, with possible transport facilities, use of weights and measures to ascertain the value of commodities, seal impressions on the package of commodities to mark the nature of commodity, the existence of entrepreneurs in the supply of demand-goods, export, import of commodities were assessed from the studies of archaeological remains. The commercial connection with distant countries in outer world is evident in Mesopotamia, Sumer, Egypt, Central Asia, north-eastern Persia and north-eastern Afghanistan. In the inner land commercial transaction with southern India is an instance of distant trade within the country. The exact nature of Indus export articles is not very clear to us. Cotton appears to be the only export article of which direct evidence is available from the Lothal packages of goods for shipping. Evidence is also available of cotton goods forming one of the export articles to Egypt in 2nd millennium B.C. by the Abyssinian and Somali (Punt) traders. Export of spices and timber is also suggested. The big warehouse or granary by the side of the sea-port of Lothal, the outlying trading post of the Harappans, might be taken as the storehouse of grains which used to export from Lothal port.

Commodities from outer world coming as an exchange mainly consisted of luxury goods, though mention is made of arrival of metals from different places. The copper amongst them might have been utilized for making of tilling and harvesting equipment. Importation of some fruit-crops like date, coconut and banana is supposed to have come from Iran and South Asia. The Indus and its important tributaries and the terminal sea-coast provided necessary facilities for maintaining commercial links with the foreign lands. In inland trade activities, boats and such other modes of transport were extensively used for distribution of commodities at different places around the Indus, through water routes. For the estimation of ratio the use of weights of different values, binary in lower denominations with the traditional Indian ratio came into practice. In the higher weight the system was decimal.

### **Question**

1. Write a brief note on the crops cultivated during Indus civilization.
2. Answer the following.
  - a) What were the utilities of the great granary of Harappa during Indus civilization?
  - b) What types of farm tools were used during Indus period?
  - c) List the imports and exports of crops and agro-commodities in Indus civilization period.
  - d) What was the situation of fish farming during Indus period?

## Lecture 4

### Past day agriculture and farmers in society: Vedic period

Pre-and proto-historic agricultural settlements in different parts of India, had their respective growths on distinct soil and environment favourable for farming. These include three fertile soils, like the hill or mountain clay, the alluvial soils of river plains, and black cotton soil, particular to the Deccan trap, adjoining some parts of central and western India. Enumeration of different aspects relating to soil and land in Vedic chalcolithic period was presented here. Numerous divisions of soil and land, conservation of soil and reclamation of land, village settlement and survey of land, the important aspects relating to agriculture in ancient India are, however, available to us mostly from the Vedic chalcolithic or literate period of history. These are preserved in the ancient texts, epigraphic literature and foreigners' reports. There are four Vedas, viz., **Rig, Sama, Yajur, and Atharva** Vedas and the periods are named according to respective Vedas. Each Veda is further divided into four parts: **Brahmanas, Samhitas, Aranyakas and Upanishadas**. In Rig Vedas period, the farmers occupied more number in the society. During this period, the farmers used to cultivate the land and produce 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.

#### Land type

The Vedic Chalcolithic period is marked by divisions of land on the basis of agricultural potentials of soil. Two broad divisions of soil are found to occur in the Rigveda :**fertile(apnaswati)**and **barren (artana)**which in later Vedic literature which expressed as **alkaline (Ushara)**and **non-alkaline (anushara)**.

#### Soil Conservation

The *Rigveda* laid down two processes for the conservation of soil. They are: (A) Arable land lying fallow (*khila*) by turn and letting it as pasture ground and; (B) Practice of two-field and three-field systems. Reclamation of land was practiced by several ways in different periods. The *Rigveda* referred to burning and cutting of forest land, a method followed also in the subsequent periods.

#### Village settlement

Vedic Chalcolithic Period provided evidence of village settlement (*Rigveda*, c. 1500 B.C.). The village represented in this period appeared to be a tribal agrarian centre inhabited by a few families of the same clan bound by kinsmanship. The inhabitants were mostly pastoral people and the tillers of the soil. The village was protected by hedges to avoid attack of the enemy and wild beasts. The land within the boundaries of village had three parts: the homestead land, the arable land (including cultivated and cultivable, land lying fallow), and grass land for pasture. The villages were also provided with adjoining forest lands. All these constituent parts are referred to in the *Rigveda*. In the later Vedic period, that is in the Iron Age, village settlement was not confined to river beds only but scattered in river tracts getting the facilities of cultivable land from the clearance of jungle by sharp iron cutting tools. The economic basis of these settlements became agriculture, animal husbandry. Further, the *Satapatha* and *Aitereya Brahmanas* described there were two types of villages, (i) scattered and (ii) closed together. Being the habitation of a group of families of the same clan, the size of the villages appeared to be generally small. Reference to a big village was not rare. The common property of the villages was: (i) grass-land for pasture and (ii) granary. However, the Sutra literatures described that the villages started to be used as administrative units in addition to agricultural unit.

## Land ownership and tenure

Ownership under this phase is ascribed to tribal chief or tribe as a whole, and individual or family in the unstable land economy of the early Vedic period. Individual tenures associated with land under private ownership and given generally to single cultivator came into existence.

## Manuring

In Vedic Chalcolithic period nutrient management of crops was done by the following methods:

- (i) **Manuring:** Manures of animal and vegetable origins for the fertilization of soil are found to occur in different texts of Vedic literature. The recognized the use of *Animal manures* as blood of cow and cow-dung were used to supply nutrients to the soil.
- (ii) **Rotation of Crops:** Rotation of crops indicated in the statement of *Taittiriya Samhita* which threw light on cultivation of grain-crop followed by cultivation of Leguminosae, the only restorative plants fix nitrogen in the field which is exhausted with cultivation of grain-crop.

The Iron Age or later Vedic period was marked by the idea of green manuring in addition to the above manures. Besides, two varieties of cow-dung manures were found to occur. These comprise stable (*gostha*) and farmyard cow-dung. During the period in Green manuring, pieces of wood of *Terminalia arjuna*, husk of barley and blossoms of sesamum were recommended for removing defilements from arable land. This might be taken as an instance of the practice of green covering of fields to make it fertile. Manuring of *yava* seeds with clarified butter and honey is found to have occurred as pre-sowing treatment of seeds.

## Crop cultivation

A wide range of Indian cultivated crops is an amalgamation of both alien and indigenous plant species. Different Aryan literatures gave idea about it. During the early Vedic age the following crops were cultivated as evidenced from **Rigveda** (c.1500 B.C.).

(i) **Cereal:** *Yava* (which stands for grains in general or wild variety of cereals); *Yavasa* (probably ancestor of barley); *Tokman* (a variety of barley); and (b) *Pakadurva* (edible millet).

(ii) **Fruit crops:** Cucumber (*Urvaruka. Cucumis sativus*)

(iii) **Intoxicating drug crops :**(a) *Soma* and *Bhanga* (*Cannabis sativus*) which was found mentioned as an appellation of *soma*.

In **Yajurveda** (c. 1200 B.C.) along with the crops mentioned in the literature of previous period, a number of additional names were pronounced.

(a) Rice (*Vrihi*): Four cultivated varieties. viz. black. white. quick-grown(*asu*)and *manavrihi* (large grained), of which the last two varieties were confined only to Central India. The quick-grown variety appeared to have been known as *swastika* (*i.e.* ripens within sixty days) in the later periods.

(b) Wheat (*godhuma*).

(c) Barley (*yava*). and a species of it named *upavaka* (a species of *yava*).

(d) Millet (panic seeds *anu*, scientific name: *Panicum millicum*; *priyahgu*, scientific name: *Panicum italicum* and *syamaka*, scientific name: *Panicum frumenataceum*).

(e) Legumes: Four types of legumes which named in Sanskrit as *masa* (scientific name: *Phaseolus mungo*); *mudga* (scientific name: *Vigna radiate*); *khalva* (scientific name: *Lathyrus sativus*) and *masura* (scientific name: *Lens esculantus*). Reference to wild bean (*garmut*) showed nativity of beans in India.

(f) Oilseeds: Sesame (*tila*, scientific name: *Sesamum indicum*).

(g) Fibrous plant: Cotton (*kapasa*, scientific name: *Gossypium herbarium*).

(h) Sugar crop: Sugarcane (*ikshu*, scientific name: *Saccharum officinarum*)

(i) Vegetables: Cucumber (*Urvaruka*, scientific name: *Cucumis sativus*), bottle-gourd (*alabu*, scientific name: *Lagenaria siseraria*).

The Vedic Chalcolithic period is characterized by classification of medicinal herbaceous plants (*oshadhi*) into flowering and non-flowering and fruit-bearing and fruitless.

The *Atharvaveda* (c. 1000 B.C.) mentioned name of some more crops where excepting wheat other crops remained. This literature had mentioned some additions.

(a) Millet: A particular millet named Sandadurva, i.e, millet having egg shaped roots.

(b) Oilseeds: Two varieties of mustard was mentioned, namely, *pinga* (White) and *baja* (brown). The appearance of mustard is worth-noting in this period after the pre-Harappa and Harappa chalcolithic period.

(c) Drug Crop, *Bhahga* (the flower of *Cannabis sativa*) became a cultivated crop during this period the intoxicating. The continuity of cultivation of *bhahga* was found to occur in the subsequent periods particularly during mid-historic period for its use in medicinal preparations.

(d) Fibrous crop: Hemp (*Sano*, scientific name: *Crotalaria juncea*. Linn.).

The *Atharvaveda* clearly classified of herbaceous plants in different species on the basis of morphological characters. In later period these became different members of the garden plants.

The culture of medicinal plants in later period included as a part of horticultural crops. The appearance of new fruit, like, *sephaka* (paniphal, *Trapa bispinosa*) was noted.

The period of *Brahmanas* and other literature (c. 1000 B.C. - 600 B.C.), during later stage, i.e., few more name and types of crops were mentioned.

(i) Cereal: Red paddy (*hayana*).

(ii) Legumes: Beans (*kulaththa*, scientific name: *Dolichos biflorus*).

(iii) Oilseeds: Mustard (*sarsapa*) and castor (*eranda*, scientific name: *Ricinus communis*).

(iv) Fruit crops: Myrobalan (*amalaki*, scientific name: *Emblica officinalis*).

(v) Appearance of new fruit crops like *bilwa* (*Aegle marmelos*) and three varieties of *jujube* were found to occur.

In *Brahmanas* and later Vedic Texts, the development of the idea of plantation of tree (fruit crop) was noted as meritorious act. This, however, occurred in the period of the *Brahmanas*. Further development is noticed in the *Sutra* period when gardening came into practice. Among the fruit crops first appearance of mango was noteworthy in the *Satapatha Brahmana*. Moreover, the different Iron Age sites bearing cultivated crops evince continuation of cultivation of rice (with varieties of rice-grains and spikelets with awn and awn-less in Hastinapur are of special importance); barley and wheat in Uttar Pradesh (Atranjikhhera), rice, barley (both hulled and naked) and legumes (horse and black grams) in Rajasthan; and legumes (*Phaseolus spp.* and *Dolichos biflorus*) in Southern India (Paiyarnpalli, Tekkalkota).

### **Tillage and implements**

Most of the technological aspects relating to ancient Indian crop husbandry are available to us from the Vedic chalcolithic period. Tillage or 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. Furrow-marks were made in grid pattern. Generally, 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.

Axe and axe-type of tools are referred to have been used for forest clearing purpose.

The *Rigveda* referred to mower for grass-cutting which might be taken as pre-tilling performance of the soil. Three types of corn-cutting tools were found to occur in the *Rigveda*. These include: *datra* (a sort of sickle in the shape of crooked knife), *srini* (sickle) and *jeta* (reaping hook). The sieve and winnowing fan mentioned in the *Rigveda*. Two types of carriers, viz. *anasa* (carts) and *sakata* (wagon) were used 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 bringing harvest from the field. The chariots, in addition to these two were used for carrying agricultural products from the field. Animals employed for drawing these carriers were ox, stallion, ram and dog.

The different Iron Age sites, however, have brought to light some implements having great bearings on agricultural operations. These include: (a) bill-hook, attached to plough for clearing the roots from the ploughed fields, and (b) seed box. Two types of seed-box were found to occur: (a) Earthen bent hollow cone cut in half longitudinally edges of halves ground to fit. Escape hole for seed is noticed on outer

curve of length above point. Another hole transverse for suspension one-sixth above point. (b) Horn-shaped earthen appliance, large, halves cemented together and furnished with holes as above.

Later Vedic literature showed the use of different soil treatment tools, which included: grass-cutting knife (*lavana*) along with iron hoe of three types, like, (i) small, (ii) short and thick, (iii) and with well-made eye. Different harvesting tools included iron sickle of five types : (a) sickle with curved blade (Nagda), (b) sickle-knife with hole in handle (cairns of Nilgiri Hills), (c) very small but long tanged, (d) very thick and tang wanting, and (e) thin, slightly bent. Besides, corn-unhusking implements including quartz-made corn-crusher and iron mortar and pestle were also noted.

### **Cropping Operations**

Sowing of seeds of different kinds was done in grid-patterned furrows. Rotation of crops was followed. Harvesting and post-harvest technologies including reaping, threshing and storing found mentioned in the different texts of the Vedic literature.

### **Rivers and water resources management**

Water management measures comprised diverse ways of dispersal of water to the fields; conservation of water and protection of soil generally developed in the regions of scanty water supply or where water-resources were subject to depend on flood-water or rain water in matters of increase and decrease of its volume. *Saraswati* the non-perennial rain-fed river having risen in dunes or valleys of *Siwalik* range (lower Himalayas) during Holocene period (as geomorphological investigation shows) underwent several changes in its entire course from emergence to fall in Arabian Sea. The river had been identified with modern *Sarsuti* which took its rise in the *Sirmur* hills of the Himalayan range, flows past Ambala, Pipli, Kuruksetra, Pehowa, Sirsa and ultimately lost in the desert of Bhatner. The river was known by different names in its different courses, viz. *Ghaggar* from its union with the same while flowing in Rajasthan, *Hakra*, in its flow in the east of Indus and *Nara* in its converge with Indus drainage. The appellation *Saraswati* was attributed by the Vedic sages to distinguish it as a 'river full of lakes'. The uppermost form of the river is still known by this name. The *Mahabharata*, the *Puranic* epic also stated a number of names of *Saraswati* in its flows in different directions. *Saraswati* as described in ancient texts particularly in the *Rigveda* and *Mahabharata* was rich in affluents and distinguished by its flow in different forms and in different courses even sometimes in sub-terranean regions. The *Rigveda* referred to fourteen main affluents and tributaries of *Saraswati*. Seven amongst them were associated streams, of which three were original, formed higher up with the original stream. The other four were the branches of westernmost of them. These three original forms were known as eastern *Saraswati*, middle *Saraswati* and western *Saraswati*. The *Atharvaveda* named these three *Saraswatis* and later Panini described their courses. The other seven were sister rivers falling in *Saraswati* basin. These were *Drisadvati* (modern Chautang), *Apaya*, *Hariyupiya*, *Yavayavati*, *Sarayu*, *Kulsi* and *Virapatni*. In addition to these, mention was made of numerous lakes (possibly inundation lake) in Vedic literature where *Saraswati* was dispersed naturally at the time of flood. The *Mahabharata* referred to seven *Saraswatis*, indicating seven branches of the river. The valley below Pehowa was known as *Sapta Saraswat*, i.e. the place where the river divided itself into seven streams. These seven seem to be canal streams.

*Saraswati* as the later Vedic texts and the *Mahabharata* stated, disappeared in the desert at *Vinasana* (above Sardargarh) before its meeting with Indus drainage. Its reappearance took place at *Camasodbheda* (near Indus drainage). The final union of *Saraswati* with sea was specifically mentioned in the *Rigveda* and in the *Mahabharata*. Two sites of this union were recognized in the *Mahabharata* : one, below *Otu* in Hisar District on the border of the desert (i.e. *Sarasvat sea*); the other at *Prabhasa* (i.e. the modern Arabian sea). The entire course of *Saraswati* thus appeared to have covered Punjab, northern and western Rajasthan, Sind and Surashtra.

The main sources of water for irrigation were: (i) rain-water and (ii) draining of water from the rivers. *Saraswati* by its rich water resources is found to have sustained to a great extent irrigation in a wide area of north-western India from Punjab to Sind including Rajasthan and Surashtra while traversing the regions in course of its different flows. Its contribution to irrigation particularly in Rajasthan desert area during 2nd and 3rd millennium B.C. was worthy to note. The *Rigveda* referred to *Saraswati* as the

supporter of five tribes and described its water possessing high fertility capacity. There were two-fold contributions of river Saraswati to irrigation: (i) by surface flow and (ii) by sub-soil flow.

(i) Surface flow resulted in formation of lakes and pools due to high spate in river after torrential rain, hinted in the epithet 'rich in lake'. This helped draining the land of a larger area and ensuring cultivation. Surface flow also ensured tapping of water through canal. However, the sub-soil flow was a perennial source of water to dug-well. In all probability well-irrigation was widely practiced in Rajasthan due to availability of pockets of such water under the sandy ground. The extinction of the river from several regions appeared to have been caused from the following factors: (i) stoppage of supply water from other perennial flows and (ii) clearance of forest and excavation of canals for different purposes.

River-water was tapped for irrigation purpose. There were seven principal rivers by which India was known as the "land of seven rivers" enumerated differently by different authorities. These were: Ganga, Yamuna, Godavari, Saraswati, Narmada, Sindhu and Kaveri - a group representing rivers of the entire Indian sub-continent. Further, Panini referred to tapping of water from rivers like, Sindhu, Suvastu (Swat), Varnu (a Punjab river), Sarayu, Vipasah, Chandrabhaga and Devika. Two ways of direct supply of river water were (i) flood-flushing and (ii) over-flow irrigation system. The latter was particular only to Bengal and later in South India.

River-associated streamlets serving the purpose of irrigation were:

(A) *Natural water course*: Inundation Lake – Mancher associated with Indus. The water is believed to have been passed to the lake through Nara.

(B) *Artificial water courses*: Lake (Sudarsana, associated with two rivers of western India), canal, nullah, etc.

The associated factors promoted irrigation, is found to consist of re-opening of rivers at their heads closed from natural causes, the clearance and excavation of dead water courses and minor channels, flood-flushing under control through the construction of dam, canals and sluices in embankments.

As per Rigveda (c.1500 B.C.), two types of irrigation systems were practiced: (i) Natural irrigation by river water distributed over arable field by means of channels. (ii) Artificial irrigation by wells when the water was lifted by means of stone-wheel, *ghati-cakra* or *ghati-yantra*. The later records described, these tools consisted of a row of earthen pot tied to the rim of a drum shaped wheel turning into a vertical plane over water. The wheel, having spokes, was worked like a capstan. It was moved by gearing a horizontal wheel turned by man or beast to the vertical water hoist. *Yajurveda* (1200 B.C.-1000 B.C.) referred irrigation by dam or reservoir and by canal. *Atharvaveda* (c. 1000 B.C.) narrated about canal irrigation. The other texts of the Vedic literature referred to large-scale use of irrigation by well and reservoir dam.

### **Plant protection**

The Vedic Chalcolithic period gave us a limited knowledge about pest and the preventive measures. Birds used to damage the grains and the practice of control was driving away the pest-bird by din and noise. The practice of crop rotation was also followed as evidenced in the *Yajurveda* possibly ensured warding off insect-pest by this method of cultural control. *Atharvaveda* (c.1000 B.C) gave ideas of different pestiferous agents infesting grains in the field and unfavourable natural phenomena causing harm to crops were the noteworthy observations during this period. Important pests were named as: (a) Borer (it may indicate either insect or bird), hooked-insect and locust; (b) rodents and rats; (c) reptiles; and (d) natural phenomenon like lightning and sun. The preventive and protective measures were Charms and spells.

The later Vedic literature (particularly Sutra texts) named the pests as mentioned in the *Atharvaveda* excluding the natural phenomenon, and added weeds. The preventive and remedial measures were charms and spells, in association with some substances appeared to have pesticidal effects. The practices included spreading of lead (*sisā*) after furrowing and burying in field the metabolic product (grass) from the bowels of sacrificed cattle and also some parts of particular plant substances. For weed control, burying of several plant-substances in the fields before sowing of seeds was practiced.

### **Livestock rearing**

The proof of livestock rearing was noted from the evidences available from mostly north, north-western, north-eastern and central India. A mixed economy of agriculture and cattle breeding was noticed. Increase

of animal resources was much coveted because of their productive values and draught capacity. The Vedic literatures specified rearing of six types of animal as domestic animals, viz., cattle, horse, mule, ass, sheep, and goat. The *Rigveda* gives importance to cattle, horse, sheep, and goat. Dog as a draught animal is also mentioned in the *Rigveda*. There were different cattle breeds. There were two wild species of cattle, namely, *Gaura* and *Gayal* varieties.

The milch-cattle variety was known *sadhenu*, however the draught-breed was known as Anadvan. Two types of breeds of horses were of special value, horses from Indus and from Saraswati. The sheep breed *Gandhara* was of high wool-producing capacity. The goat breed was with excellent hair. The farmers were well acquainted with the knowledge of animal rearing. Green grasses and water were considered most nourishing food for cattle for the increase of milk-yield; *barley* was the other food for cattle. Penning was another important function of rearing. Two types of abode for cattle, open pasturage (*gostha*) and cow-stall (*gosala*), were found to occur. Castration of sheep and stallion occurred in the period of *Rigveda* that of cattle was found in the *Yajurveda*. Prayer, charm and incantation were the three propitiatory rites for the protection of cattle from cattle-lifters and wild animals. Animal powers during Vedic age were required for: (i) Ploughing by ox and sheep; (ii) Transporting food or agricultural produce by carts drawn by ox, stallion, ram and dog; (iii) Carrying of water possibly to arable land.

During the period of Atharvaveda animal breeding was more advanced. Branding by copper knife and breeding ceremony (*Vrishotsarga*) are the two noticeable things in animal-breeding. The breeding ceremony, in true sense started from the age of later Vedic texts. Diseases were dispelled from all types of cattle below five years old with the application of a medicinal plant, *Sahadevi*. During the period of Brahmanas and other texts of Vedic literature, branding of horse was performed like that of cattle. Making stud-bulls by giving special food consisting of salt and other substances were noticed. Nourishment of cow for causing birth to calf was made with a diet consisting of salt. Generally, two times in a day she-animal were brought for grazing. The early account of dairy farming in India though noticed from Vedic-Chalcolithic period, its, earlier existence is easily presumed from the extensive cattle-culture from the Neolithic period onwards.

### **Fishery**

Use of fish along with some other aquatic species, particularly mollusk, snails, turtle, etc. for human consumption is evident from the prehistoric period. Human settlements were found to have been developed by the sides of river or any other places of water for fish which formed one of the principal foods. No direct evidences of fish-eating or fishing were available in Vedic *Samhitas*, though reference to fisherman was found to occur in *Yajurveda*. Fishing net was reported from Chalcolithic sites at Bhagalpur. The age of the later Vedic texts (*Sutra* literature) enumerated prohibition of taking some fishes of peculiar feature. Direct reference to fish as food article was thus proved.

### **Poultry**

No direct evidence of fowl as food substance is available in the *Rigveda*. The *Yajurveda* however includes cock as sacrificial animal. The Iron Age, the period of the *Atharvaveda* and later Vedic texts forbid the use of fowl for human consumption.

### **Honey-bee**

Honey, derived from bee, was a very popular food substance, to the Vedic Indians. The knowledge about formation of honey in bee under the influence of several astral positions, recorded in the *Rigveda*, showed direct evidence of bee-culture, during Vedic Chalcolithic period. References to different types of honey, derived from bees of different types, collecting juices from different plants are available in various sources of information from the historic period. The seven types of honey as enumerated in the *Susruta Samhita* and later medical texts and lexicography were: *Pauttika*: honey from large bees; *Bhramara*: honey from large black or bumble bees; *Kshaudra*: honey from reddish brown insects or small bees; *Makshika*: honey from large bees of brown variety; *Chatra*: honey collected from umbrella shaped hives of a class of yellow bees of the forest of Himalayan region; *Arghya*: honey obtained from a kind of yellow bees that extract honey from mustard; and *Auddalaka*: honey from small brown bees that live in ant-hills.

## **Agriculture and meteorology**

The Rigvedic Period is distinguished by profound knowledge about the heavenly bodies and their impact upon weather, vegetation and livestock. The favourable and unfavourable weather conditions in agricultural operations and animal farming were also recognized by the Aryans at that time. The favourable conditions comprised of (a) seasonal rainfall; (b) weather, not foggy, nor undergone high pressure of wind as the former was believed to destroy corn and the latter was apprehended for the uprooting of plants and (c) dew fall, whereas unfavourable conditions was mainly drought. Both these two conditions were believed to have been activated from the agencies of celestial bodies. The impact of heavenly phenomena upon weather conditions and upon crops and animals were reflected in the different passages of *Rigveda*. As per the literature, during the Summer Solstice period the commencement of was noted at early rainy season and continued up to autumnal equinox, thus it had three phases of downpour. These included early rain, mid-rain at the end of rainy season and autumnal rain or concluding part of this solstitial rain. The extension and nature of this rain coincides with South-western monsoon rain of the North Punjab in the present day.

The summer solstitial rain was coveted much as it was believed to (a) produce sweet juice in corns in general and (b) increase of procreative power of cattle. Apart from this, its different phase of downpour initiated (a) the growth of standing crop (at the early part); (b) growth of annual both flowering and fruit yielding; (c) growth of other varieties of crop (possibly barley and wheat seeds were sown at this stage) at the last phase of the rain and (d) growth of medicinal plants.

Influence of different stars and other constellations associated with summer solstice and autumnal equinox crops was also believed during the period of *Rigveda*. Some of the examples are presented below.

*Pusa* : Imparting to the soil the power to germinate seeds after tilling, and giving nourishment to crops. Increase of procreative power of cattle and their protection from harmful agencies.

*Tvastr (identified as Citra)*: The star Spica has been called the ear of corn, grain and seed in ancient times. The *Rigveda* describes it as endowed with the power of procreation.

*Rudra (identified as the constellation Sagittarius)*: Warding off germicidal effect from cattle and other animals.

Rainfall under vernal equinox or winter solstice has not been given much importance in the context of agriculture. The principal rain making agents were the *twin stars, Asvinis* (Arietus) in the same constellation and *Dadhici*, described as horse headed. The exact time of their appearance cannot be ascertained definitely. Their association with cool season can be surmised from their name *Dasra* implying the same as referred to in the text of Panini. Moreover, their attributes as sender of *hima* (cold or snowfall) after the scorching heat of summer associates them as belonging to vernal equinox. That they appeared at the time of sun's movement to another house, is explicitly mentioned in the *Rigveda*. It is a fact which shows the rising of these stars at the junction of two solstices, summer and winter. The *Rigveda* in one place described them as associated with winter solstice. They were found to have been associated with three kinds of watery discharges, viz. rain (*vristi*), dew (*madhu*) and snow (*hima*).

## **Farm land and farm management**

The productivity of a piece of land, as conceived by the ancient Indian economist, depends on four factors, viz. extension, size, situation and accessibility as addition to soil, irrigation facility and productivity of land. As per Vedic texts, 'extension' means 'utilization of different sites for cultivation of crops other than the grain crops'; 'size' indicates 'large and small holdings'; 'situation' stands for 'particular region like, *jangala. anupa* and *sadharana* (land bearing characteristics of both the two regions), where arable plot is situated; and 'accessibility' suggests proximity to market. Ideas on different aspects of farm land as deduced from relevant sources. Existence of different types of agricultural holdings was assessed in an agricultural site at Inamgaon in Western India. The smallest one holding was of hundreds square mile and the biggest one was of several hectares. During the later stage, the appearance of *grama* in the sense of estates came into existence in the *Atharvavedic* period. In the later period revenue was imposed on the value of the estates determined from its resources.

## **Farm labourers**

In Vedic Chalcolithic period, information on labourers was very precise. Some occupations are found to occur in relation to crop-farming and cattle farming. For crop cultivation, ploughman, sower of grain, husk-remover and com-grinder were noted as labourer. The labourers involved in animal farming were known as herdsmen. From the breeding of cattle the cattle breeders might also be included as labourers for the same. In both operations wages appear to have been paid in kind. Work for food, clothing and other essentials were presumed. Additional information of the Iron Age was noted in the reference to female *slave-labour* in the work of husking in the *Atharvaveda*. The appearance of this class of labour on tenancy of half or other share in production is noticed in the *Sutra* period.

## **Farm tax**

Utilization of farming as source of income to the authoritarian power or state by the imposition of taxes in different forms came into practice in all probability from the Harappa chalcolithic period. The *Rigveda* referred to a kind of tribute (*bali*) paid to the king by the subject as a mark of allegiance. This tribute is taken as 'agricultural tax'. The *Yajuryeda* mentions, *samahartra* and *bhagadugha* in the sense of collector of king's customary share in agricultural produce. Explicit statement about paying of king's share of the agricultural produce and a contribution in cattle is found to occur in the *Atharvaveda*. The share of produce was 1/16<sup>th</sup> of agricultural yield, instead of 1/6<sup>th</sup> of the later period. Specific reference to the above tax levied on the *Vaisyash*, i.e. cultivators and herdsmen are made in the later Vedic literature.

## **Farm credit system**

In Agriculture, credit is needed to overcome the shortage of capital. This shortage of capital in ancient period was shortage of grain for which the system of credit came into practice. This was also in case with India where the early beginning of credit system was found to have been started with the transaction of borrowing of grain in time of need and its proper repayment. The *Atharvaveda* for the first time mentions the system of loan in grains (*apamityaka*) and its return as repayment of debt.

## **Trade**

Trade in India as in other parts of the world, contributed to a great extent, to the economic prosperity through distribution of surplus agricultural produce on exchange in different parts within the territory and abroad. In Vedic Chalcolithic Period trade transactions were mainly barter-based, a fact which suggests it as only a subsistence economy.

The *Rigveda* has several references to sea voyages undertaken for commercial and other purposes. But no direct evidence is available regarding the commodities of commercial transactions. A Chinese legend, however, throws light on India's trade with China during 12<sup>th</sup> century B.C. Import of sugar and silk to India is recorded there. In exchange, India was stated to have sent costus and pepper along with other commodities. Evidence of local trade was also observed during Vedic age. Distinct references to market activities with mention of trading class (*Pali*), barter (*Pana*) and cow in currency value were noticed. Some rules were found to have been laid down in the prohibition of bargaining after the settlement of price of a commodity. Market place with haggling as a practice was found mentioned in the *Brahmanas* and later Vedic texts.

## **Question Bank**

1. Describe the agricultural situation of Vedic period with special reference to crops cultivated and management practices.
2. Write a brief account of water management and irrigation practices in Indian sub-continent during Vedic period.
3. What type of farm implements were used in Vedic period as evidence by different texts?
4. Write a short note on the situation of farm labourers during Vedic age.

## Lecture 5

### Past day agriculture and farmers in society: early historic/ Buddhist period

The early historic period is more particularly known as Buddhist period (dating between c. 500 BCE. to 100 BCE). Historically, the roots of Buddhism lie in the religious thought of Iron Age India around the middle of the first millennium BCE. That was a period of great intellectual ferment, when the *Upanishads* were composed marking a change in the historical Vedic religion, as well as the emergence of great Sramanic traditions. The early historic period was not only a period of intellectual ferment but also socio-cultural change quite distinct from the early Vedic period. New ideas developed both in the Vedic tradition in the form of the Upanishads, and outside of the Vedic tradition through the Sramanic movements. The term *Sramaṇa* refers to several Indian religious movements parallel to but separate from the historical Vedic religion, including *Buddhism*, Jainism and others such as Ajivika. The Sramanic religions challenged and broke with the *Brahmanic* tradition on core assumptions such as *Atman* (soul, self), *Brahman*, the nature of afterlife, and they rejected the authority of the Vedas and Upanishadas.

Politically, the emergence of **Sixteen Great Territories** or the '*Sodasha Malianjanapada*' was observed during the age, extending over the land from the Kabul Valley to the banks of the river Godavari. There were several other smaller states in different parts of India. The use of iron spread into northern India after 800 BCE. Iron tools were much more effective for clearing land than were the old stone and wooden tools, and huge tracts of new land were brought into use for productive agriculture. Farming populations previously established around the fringes of the densely forested Ganges plain now moved in to colonize the heart of the river plain. This area, with its well-watered, very fertile farmland would, over the coming centuries, become home to a huge population, and become the heartland of ancient Indian civilization. Villages grew; some became small towns, then larger towns, and then cities, as large as those in contemporary foreign countries like Greece and China.

A food producing economy emerged with the practice of agriculture on a wide scale by using iron implements. Each village was self-sufficient, life was simple. During the Buddhist age, the villages were grouped, not scattered, huts on the margin of rice fields and were separated from each other by forest or jungle. Each village was a tiny self-governed republic. Around the village lay its *khetta* (or cultivable or cultivated land), or pastures and its wood-land or uncleared jungle. Each village had an external boundary of fences. The internal boundaries of each householder's plot were apparently made of channels dug for co-operative irrigation. The limits of the whole *khetts* might be extended by fresh clearing of forest land.

With advancement of time, in Maurya Period, a settlement of new villages after the clearance of forests or an old ruin was encouraged for avoiding congestion under the royal cares. This diversion of the surplus population to new sites is expected to lead to increased agricultural operations and activities of industries. A distance between two neighboring villages was generally one or two *krosas* (1 *krosa* = 2 miles). The new village consisted of one hundred families in the minimum, the ceiling being limited to five hundreds. This shows that the family is to be reckoned as a unit for the purpose of allotment of land. The total population of the village appears to vary from 500 to 2,500 if the family consisted of five members. The common properties of the village were watering system, waste land and granary.

Under this socio-political environment, there was a gradual progress of agriculture in early ancient age and that is presented below.

#### Land and soil

Natural classification based on geographic distribution includes the divisions, like *jangala* (desert or arid tract) and *anupa* (wet or marshy land, or riverine fertile tract). The *Arthashastra* refers to specific yearly amounts of 24 and 16 *dronas* associated with these two divisions which according to some indicates rainfall and to other suggests annual agricultural yields per unit area for these two types of land<sup>10</sup>. Division of land was also found on the basis of irrigation by rain water (*desavapa*) and by river water (*kulyavapa*).

Enumeration of different lands for different crops was also noted in *Arthashastra*. The *Arthashastra* recommends the following classification based on crop cultivated to a particular land.

- land beaten by foam, i.e. banks of rivers for growing pumpkin and other gourds;
- lands frequently overflowed with water suitable for cultivation for long pepper, grapes and sugarcane;
- the vicinity of wells for vegetable and roots;
- low grounds (moist bed of lake) for green crops; and
- marginal furrows between any two rows of crops for the plantation of fragrant plants, medicinal herbs and *pindalaka* (lac fostering trees). In the later period the medical texts lay stress on the above geographic distributions along with the new division, an intermediate region, in the selection of land for the plantation of medicinal herbs.

Further, division of land based on suitability for growing of some specific crops and on the capacity of production of crops of some specific measurement is found to occur in *Panini's Ashtadhyai*.

### **Land proprietorship**

The period from 6th century BCE onwards was marked by established land proprietorship ascribed to individual, community and the king coming into existence from stable land system. Land tenures were associated with types of proprietorships. Hence, historic period might be taken as the beginning of this system in Indian history of land economy.

In early historic period, there were communal tenures associated with the fields of individual members of aristocratic republics or tribal communities. Besides, royal tenures were also originated out of distribution of crown land or confiscation of lands from cultivators on his failure to doing his duties and distributed to labourers and peddlers for cultivation.

Two general divisions of land were there, namely, rent-paying and rent-free lands. Tenure on contract was given by payment of king's dues in usual rate even the tenants failed to cultivate land. The tenure was for one generation only in case of prepared fields (belonged to the king) given to revenue paying cultivator. The share tenants were also there who used to share half of the produce.

### **Nutrient management**

The early historic period is distinguished by the introduction of the practices of conservation of top soil and fertilization of different parts of plant before plantation for propagation. Conservation of top soil was also practiced consisting of weeding of field in pre-cultivated state as occurred in Buddhist text. Crop rotation was followed. Three sowings in a field were found to have been prescribed for this. In this system the sowing of leguminosae crops formed the middle sowing.

The fertilizing properties of various animal products recognized during this period, comprised of cow-bone, dry cow-dung, pig's fat, and honey and clarified butter. A detailed procedure for pre-cultivation manuring of seeds and planting materials with substances stated above was laid down in the *Arthashastra*. Apart from soaking and smearing with paste of prescribed substances the *Arthashastra* refers to particular treatment of sapling (of mango) in which digging of a pit around the tree, burning the inside soil and filling it with bone and farmyard manure, was recommended. The *Jatakas* recommended irrigation of milk to mango plant for better growth of fruits.

### **Crops cultivated**

The early historic period evidenced several crops cultivation along with the crops of previous period. Notable features of this phase in Indian cultivated crops are given below:

### **Cereals**

**Rice:** Extensive cultivation of rice almost in the entire Indian sub-continent was evidenced with the introduction of two new varieties, viz. *sali* and *sashtika* (ripening in sixty days);

**Millets:** Introduction of cultivation of *jowar* (*Sorghum vulgare*) and *bajri* (*Pennisatum typhoides*) in Rajasthan;

**Wheat:** *Triticum spaerococcum*, the grains were comparatively smaller than those reported from Mohenjodaro;

**Barley:** hulled type;

### **Fruits and Spices**

Culture of different varieties of fruit crops and spices for the manufacture of spirituous liquor and for other purposes was carried under state control. The study of the crops showed presence of both indigenous and alien plants.

### **Legumes**

The legumes cultivated during the period were chick-pea (*Cicer arietinum*), lentils (*Lens esculanta*), grass pea (*Lathyrus sativus*), pigeon-pea (*Cajanus cajan*);

### **Oil-seeds**

Castor (*Ricinus communis*);

### **Green Vegetables**

Green vegetables classified into two categories, viz. roots and fruits. The numerous varieties under these categories which came into existence also showed the assemblage as a combination of indigenous and alien plants.

### **Dye Crops**

Cultivation of dye-crops, viz. indigo, safflower (*kusumbha*), are specifically mentioned in literatures.

## **Water management**

The period evinced large scale irrigational practices, some of which appeared to have been in general practice and some devices were regional. These comprised of the following:

1. Flood-water letting into lake excavated to hold water for the purpose of irrigation. **The lake Sudarsana was excavated by Asoka to facilitate irrigation.** It was connected with two rivers of western India. In case of canal irrigation in which the main canal is stated to have been provided with two sub-canals, one serving as feeder and the other as supplier. Control of water by construction of sluices threw light on proper distribution of canal water for irrigation.
2. Well-irrigation was observed during early historic age. This consisted of large scale well-irrigation with the appearance of two types of well, namely, ring well and soak well reported from different sites of excavation. Panini also referred to two types of well, *Karkandhu* and *Sakandhu*. The latter was supposed to be used by the *Sakas* and it denoted a form of water-wheel.
3. Canal irrigation was also noted by historians. The canals were kept full either 'by hand' with the aid of water-skins or balance pole, or by water transported, on the backs of animals, or by using a bucket-chain.
4. An ingenious system was found to have been worked out by oxen climbing up a gently sloping artificial ridge and descending it again time after time, in doing so hauling up from a well on each occasion a leather-bucket filled with water emptied then into a supply canal.
5. Water-lifting devices were comprised of mechanical contrivances by using lever, wheel and axle, and employment of animal power. Systematic arrangement of channels for inflow and outflow of water from the field was made to irrigate the crop. Conservation of rainwater in channels and its distribution in paddy fields were also done.

## **Plant protection**

Plants are subject to destruction from different harmful agencies and so protection measures were also adopted since ancient time in India to protect the crops from pests, diseases and natural hazards, which were evidenced. Following are the causative factors for damage and decay of crop plants as noted in different literatures.

#### **Pests**

- Insects i.e. locust
- Birds like parrots and hawk
- Rats and rodents
- Herds of deer and wild animals

#### **Natural phenomena**

- Rains, droughts and hailstorms

#### **Diseases**

- Fungus development, blight and mildew diseases

#### **Others**

- Death of plants due to water pollution

Preventive and protective measures were also advocated in early ancient texts and some of these are presented below.

(a) The *Arthashastra* referred to several pesticides against insects, birds and beasts. These include:

- Application of vegetable poison, *arka* (*Calotropis gigantea*) and a secret mixture in cases of insects, birds and rats.
- Stupification by stupifying liquid in cases of wild animals.

(b) Mechanical devices were also suggested like arrangements of trap, cage, secret pits and scarecrows in cases of swarms of birds, deer and wild animals.

(c) Remedial measures for diseases were also prescribed due to internal disorders:

- Application of salt in the roots of plants was advised.
- Fumigation with desired substances was also noted.

#### **Horticulture**

Horticulture, as co-existent with agriculture, is found to have been prevalent in India from early historic period (500 BCE to 1st Century CE) when a certain amount of share in garden crops started to have been enjoyed by the king for providing irrigation. Extensive horticultural operations noticed in the period are mentioned below.

- Horticultural crops were classified precisely and varieties of plant were noted, namely, trees, shrubs, clamberers, climbers, bamboo, and grass.
- Different types of gardens were noted as park, royal garden, and private garden. Private gardens were attached to dwelling house and royal palace. The royal garden generally consisted of single crop, the dedication of one such was found to occur in the edicts of king Asoka.
- Irrigation was provided by the king for the cultivation of vegetables, fruits or flowers. The water resources for irrigation were pond, perennial streams, and wells. Existence of water lifting devices like water-skins and wooden pots were in use for irrigating the crop.

A reference from *Jataka* suggested that saplings were irrigated at the interval of six days. The texts of early historic age clearly narrated presence of different horticultural crops in India. Amongst fruits, cultivation of mango was highly extolled and the other new introductions were rose-apple, bread-fruit, wood-apple, grapes and figs. Different kinds of creeper vegetables were cultivated. Besides, flowers like five types of lotuses and jasmine were nurtured in the garden. *Arthashastra* narrated that different types of ornamental grasses were cultivated to add the beauty of the garden.

The gardens of early historic age had a distinct layout. The *Arthashastra* recommended proper places for the growth of creepers, fruits, long pepper, grapes, sugarcane, vegetables, roots, green grasses, ridges for plants reaped by cutting, like, perfume plants and medicinal herbs. Fencing of the garden was made by

means of brick-wall, or plantation of particular trees as enclosures. Existence of two-fold characters of gardens, one was the garden or groves of single crop, of which the most popular was the mango grove, and the other was the garden of mixed plantations.

Three ways of propagation of plants, by seed, by root or by bulb, and by vegetative means, like cutting came into existence. The horticulturists used to perform some extraordinary results in their production of garden crops. These include: the technique of turning a mango tree bearing sweet fruits into the one yielding forth fruits with bitter tests; and early blossoming and early bearing of fruits out of season.

### **Animal husbandry**

Animal husbandry implied control over different species of animal. Utilization of animal power and products for different requirements form the principal aim of animal husbandry. During the period animal farming became a systematic occupation of all classes of people from royal race to despised nomadic tribes. Utilitarian purposes played a prominent part in the development of animal husbandry. This led to the development of the cult of worshipping of some useful animals, like, elephant, cow, horse and dog. Medical treatment for animals arranged in different places of the country.

The domesticated animals of early historic age were Cattle, horse, donkey, camel, buffaloes, goat, sheep and pig. Among these animals cattle, horse, goat and sheep were generally in the possession of individual householders. Herders had the basic knowledge of animal breeding. For breeding purpose male animals were reared carefully. Exemption from killing a bull set free for breeding was an official order during the period.

Feeding of livestock with specific food substances according to their requirements was a redeeming feature of animal husbandry during this period. Apart from grass, straw and water feed substances were a number of vegetable substances, animal products, oil and oil-cake, rock-salt and sugar for nourishment of cattle, mule, donkey, camel and horse. Butter-milk was considered as nourishing food for pig and dog. Cattle-grazing was marked by a sort of shifting pastures both in village and in forest areas wherever there was a source of drinking water for cattle. The grazing of cattle was performed by cowherds who were well-versed in the knowledge of appearance of cattle, their distinguishing marks, about dressing of sores, pastures and watering place, rules about milking, and taking proper care about breeding-bull. Castration was practiced and there was specific age of bull for castration.

The period introduced us with brisk animal farming activities under the control of state, individual personages and collective unity. Pastoralism was practiced and big farm holdings and large number of herds were very common during the period.

The size of the farms was of different size and the animals were graded into three categories, best, middling and inferior and were kept apart. Private farms were of two types: large and small.

Large farms were belonged to professional animal framers. Large farm-yards for cattle with adjoining green plots for pasture ground and capacity to accommodate over thousands of cattle (30,000) or which is assessed from the mention of 1,250 cow-keepers working in a cattle farm. The *Mahabharata* (*Virataparva*) referred to separate village for cattle under the possession of royal power (*Virat raja*). Small farms were there for keeping animals for draught purposes or for dairy or meat supply for household need. The concept of community farm was in existence. The *Arthasastra* laid down several rules for selecting pasture ground. These include:

- A land abounding in water because of its continuous and fixity of production;
- A dry tract with earlier and later crops, with crops ripening with a little rain, and with undertakings not held up;
- A tract abounding in water and marked by earlier sowings;

Recommendation for pasturing in these areas is suggestive of fertilization of these sites for future sowings.

The importance of livestock was realized earlier and during the period also it was carried as precious resource. There was requirement of different animal products like pig's fat, cow-dung, cow-bones for fertilizing crop field and animal power (bullock) for raising water from well for irrigation.

Progress in dairy fanning by proper maintenance of cattle with the supply of various nutritious foods, was evident. Apart from milk of bovine species, goat and sheep-milk also fanned a part of dairy products. A new technique of preservation of milk came into practice in which milk was soaked in a piece of dry cloth and was dried up there for future use. Milk contents were drawn later by dipping the milked-piece of cloth in water.

### **Fishery**

Use of fish and some other aquatic species particularly mollusk, snails, turtle for human consumption were evident from the prehistoric period. Human settlements were found to have been developed by the sides of river or any other places of water for fish which formed one of the principal foods. Apart from dietary value, the shells obtained from the above shelled animals, are found to have been used for the manufacture of different articles of luxury and use. Frequent occurrence of these articles is noticed in during ancient period.

The early historic period was marked by high popularity of fish food and by beginning of fisheries as controlled by state with the imposition of various taxes and tolls and injunctions against fish-catching on some specific days, as fishery conservation. Fish-culture in irrigation tank is also evident. Name of different fish species were found in ancient texts, of which gangetic species were shark, eel, skate or ray and species of mountain-lakes were red carp, snake-headed fish, boal sykes. In cultures fishery, flour and oil-cakes were general fed for fish. Fishing equipments were included net, line, basket, trap and spear. The basket trap used to set in pits and holes of river for capturing fish. Fishes were dried and exported to other countries. Prohibition of fish catching on some specific days, that is, the breeding periods of fish, was found to have been evidenced for conservation of fishery during Asoka's time.

### **Poultry**

Poultry as a regular practice with the use of egg and flesh of fowl, was noticed with the imposition of injunction against killing of cock on some specific days.

### **Sericulture**

The record of sericulture with direct evidence of rearing of the silk-spinning insect for the production of silk is not preserved in any source belonging to early part of the historic period. The available material shows silk mostly derived from wild or semi-domesticated species. The *Arthasastra* specifically mentions four trees on which the silkworms were found to occur. Magadha (North Bihar), Pundra (Pundravardhana, *i.e.* North Bengal), and Suvarnakudya (identified as Murshidabad and as Assam) were the places famous for silkworm rearing. Silk-worms reared in these regions are the wild types. The places referred to in the *Arthasastra* are still the places of India where wild silk of best quality is found.

### **Farm implements**

Farming involves a number of technological devices for carrying out different operations started from the forest clearance and soil-treatment to the un-husking of corn and transportation of the same from one place to another. The early historic period, which abounds in archaeological and literary sources relating to agricultural implements, introduces us with the use of iron in the construction of plough-share or cultivator in place of wood in the earlier period, the use of plough-share and trowel for smoothing the surface after ploughing. It also evidenced the use of tools like plough, spade, trowels, sickles and hoe as specifically mentioned in the *Arthasastra* and Panini's text.

### **Meteorology and agriculture**

In ancient India, as in other parts of the old World, all the favourable and unfavourable meteorological conditions in the context of agriculture and animal farming were studied from different aspects of the heavenly phenomena. It was a very old practice which in all probability appears to have been started from the beginning of settled agriculture, and from the incentive to study correlations between weather and heavenly phenomena and their impact on crop prospects and the like, there developed a new branch of knowledge known as natural astrology. Apart from celestial bodies, weather predictions were also made from animal behaviour.

An evolution of ideas on rainfall along with other meteorological phenomena in relation to their beneficial or malefic effects on agriculture and livestock can be assessed from the following facts.

The period represents a more developed idea about rainfall in connection with agriculture. Introduction of rain gauge and the ideas on the impact of astral and planetary positions on animal and fishes formed the other notable factors of this period.

Four types of rainfall were considered as beneficial for agriculture. Kautilya enumerated two distinct types of rain:

(a) four months of monsoon rains (from *Sravana*, mid-July to *Karttika*, October-November) in which the particular pattern of rainfall favourable to agriculture has been indicated as one-third in the first and last months and two-third in the intervening two months

(b) rainfall extended over five months characterized by three patterns of showers favourable to agriculture. These comprised of: (i) three clouds, each raining for seven days of light and intermittent showers; (ii) eighty days's rain in minute drops and (iii) sixty days' rain alternating with sunshine. Three cultivations were found to have been facilitated by these showers.

A survey of annual measurement of rainfall in different regions of the country was made by means of rain-gauge (*Varsapramana*) to ascertain the future prospects of crops. The earliest mention of rain-measuring unit was *gospada* (smallest measure of rainfall) referred to by Panini. Kautilya referred to *drona* as a unit of measurement of rain. As per Kautilya's description, it was 511 cubic inches cylindrical rain gauge with a surface area of about 254.3 square inches. Besides, there was the concept of auspicious time for crop sowing. Panini referred to full-moon day as beneficial for sowing of crops like wheat and barley.

In animal farming several rules and regulations were observed in regard to killing and castration of animals and catching of fish, on some specific days. King Asoka made some injunctions against catching of fish during four months from *Sravana* to *Karttika* on full-moon day and the first day after the full-moon. For carp and so many fish species, it was the period of breeding and spawning as coincided with established facts of present day.

Castration of bull was forbidden on 8th of every fortnight on the 14th, the 15th and the full-moon days, on the rising of the asterisms *Tisya* and *Punarvasu*, and on the full-moon days of the three seasons (summer, rain and winter which respectively began with *Phalguna*, *Asadha* and *Karttika*). In all probability breeding capacity of bull was enhanced under these astral and planetary positions and movements.

### **Farm land and farm management**

The early historic period introduced different practices for extensive utilization of different sites for cultivation of different crops, estimation of agricultural yield from large and small farm holdings, specification for situation for arable land and assessment of agricultural produce on the basis of physical characters of the soil. The *Arthashastra* recommended different sites and processes in the cultivation of vegetable crops and crops other than grain crops for increasing agricultural production. River, sides of well, low land, the embanked reservoirs for irrigation, and space between two furrows were the different sites to which extended the agricultural operation for enhancement of agricultural production. On the basis of size, three types of farms were recognized during the early historic age, namely, state farm, private farm and collective or community farm. The state and community farms were obviously of large extending areas, though no specific measurements of the area of the fields were available from the evidences. In the collective farms, villagers collectively took part in agricultural production. The village formed a compact self-centred unit, where cultivation was performed under collective endeavor with payment of king's dues from the collective income from field. The *Arthashastra* and the *Mahabhashya* narrated private farm of different size. Kautilya referred to broad path from market place to field for carrying out agricultural produces. He also noted foundation of local market for the sale of agricultural products.

### **Farm work force**

The period was marked by detailed information on different classes of labourers with their respective stipulation in the form of share in crops, wages in cash and kind, and labour regulation. In the wage system, daily payment was practiced in case even of continued employment throughout the year, as described by Megasthenes (in his book *Indica*).

Labour in crop and animal husbandry was categorized by the following.

- Owner or occupier: Cultivation on some occasions was found to have been carried out with the assistance of family member and this saved labour charges.
- Half-share-cropper: The *Arthashastra* laid down tenancy in cases of temporary inhabitants of a village favoured with the grant of a cultivable land but not dispossessed of the time of sowing and renting of small plots of land in a village, purchased by trading class to tenancy on half-share-cropping.
- Hired labourers: The Buddhist texts, *Arthashastra* and foreigners' reports ('Indica' of Megasthenes) often referred to this class of labour with their stipulation and obligations.

Existence of skilled and unskilled labourers was there in all farming activities including livestock farming.

The Buddhist texts lay down one *masaka* as a wage of hired labour in general. The amount of this charge was meant for unskilled labour (1.2 *panas* or about a silver *masaka*) as daily wages mentioned in the *Arthashastra*. Kautilya also referred that in unsettled wages the cultivator and a herdsman would get a tenth of the produce. Discussion to a great length is made in the *Arthashastra* in a chapter on Superintendents of agriculture and cattle.

The Buddhist texts refer to some labourers who were believed to be temporary. They were the watcher of growing crops and the like. The minimum wages of day labourers ranged from half-a-pana to one and half pana. Kautilya referred to their workings with the hirelings and the privileges paid to them. The *Arthashastra* clearly declared penalties for breach of contract by a labourer in addition to liability for any damage caused by the negligence of duty.

### **Farm tax**

Increase of State's wealth by exaction of taxes from the farmers in different ways was the distinguishing feature of this period. There were following types of farm taxes as referred in different ancient texts.

The *Arthashastra* gave a detail account of tax system in early historic period. There were some regular taxes. Half-share was exacted when animal labour, seeds and other farm inputs were supplied to the cultivator, but the rate of share was a fourth or a fifth when the above inputs were not supplied by the owner of the land. King's customary share was also there and generally 1/6<sup>th</sup> of the produce was paid. There was flexibility depending upon the fertility of the land. Cesses were collected on supply of water from state water resources. The *Arthashastra* laid down three rates of taxation on three ways of collection of water: one-sixth, one-fourth and one-third according to the water which was derived from manual labour, animal labour and from mechanics respectively. For fruit orchard and medicinal herbs, the taxation was one-sixth of the produce to be paid to the owner. Taxes were collected for animal farmers also in terms of cattle or share of the produce. Animal farmers used to pay revenue for using village pasture.

The *Arthashastra* recorded a special tax demanded by the king at the time of need of money in the period of emergency. The cultivators were to pay 1/4<sup>th</sup> of grain produce and 1/6<sup>th</sup> of forest produce, and in case of herdsman, the rate was different for different animals. Remission of tax was also noticed in case of total failure of crops.

Imposition of rate of tax was not made arbitrarily but depended on a structured format. There was a standard or average rate of the government-demand for a known unit area and calculation was done on the basis of standard estimate of production per unit of area. Payment was made in different forms namely, grains, animals, cash, raw materials and in the contribution of forced labour.

### **Agricultural credit**

In Agriculture, sometimes credit is needed to overcome the shortage of capital and it was evidenced during early historic age. This shortage of capital in ancient period was shortage of grain for which the system of credit came into practice which was noted in the Vedic period. A marked development is noticed from legalization of this system with the in early historic age with introduction of rate of interest and fixation of time for repayment. Three distributors of loan were found to occur, namely, royal, individual and corporate body. The system was initiated with a view to save the farmer from shortage of grains during famine and other natural calamities. Panini's *Astadhyayi* and Kautilya's *Arthashastra*

referred the agricultural loan advanced by the king was called *apamityaka* and its accounts were supervised by the treasurer.

The *Arthasastra* and some inscriptions of the Maurya period record loan in kind and cash from royal stores and its repayment to royal treasury. State storehouses were built in different places for the distribution of loan to the cultivators during famine. There was scheduled time for repayment of debt. Panini referred to four seasons in this regard, summer (i.e. repaying out of income from some special fruit and vegetable crops), rainy seasons, autumn and spring. On the basis of which the loans were divided into four categories. These are all the harvesting time of different crops. Kautilya also mentioned harvesting period as the time for repayment of loans.

## Trade

Agricultural produces formed a separate commercial transaction and found in the early historic period when agriculture became a specialized profession. This is supported by frequent mention of corn dealer and also mention of *akkarika* (dealer in agricultural produce) in the *Jatakas* and other records. Trade relation with foreign countries was noted. The *Arthasastra* laid stress on foreign trade for increase of income of the State. The merchants were free to export the produces.

India's trade connection is evident in Babylon where a business table carrying records of dealings with Indian merchants are found to occur. Apart from this country, continuity of trade with different countries of West Asia of the earlier period as well as with countries of South-eastern Asia and China is assumed. India's trade with the West was controlled by several countries like Bactria and Ecbatana. From Bactria commodities were sent to Eastern countries and thus Bactria occupied an important position as a centre of transit trade between India, China, Central Asia and Mediterranean countries. The *Arthasastra* included import articles coming from distant places from outer world which were flowers, fruits, grains, vegetables, roots, seeds, dried fish and dried meat as well as quadrupeds and biped animals, cotton, sugar and oil. Both raw materials and industrial goods as import articles were evident. The rate of revenue was different for different commodities. No food grains were allowed to be sent as export to foreign lands. This was to avoid food-crisis in the State. This principle of self-sufficiency in food made by Kautilya was also followed by the law-makers of the subsequent period also.

Both the Indus and the Ganges were found to have facilitated the extension of India's trade connection with outer world. The former regulated trade with Western countries and the latter with Eastern countries. Boats of different sizes and shapes and ships capable of loading heavy cargo and a large number of merchants were frequently mentioned for transportation of goods. The land transport was also there during the period. Carts drawn by draught animals and manpower, for carrying loads were employed for the purpose. Taxes for transportation were determined on the basis of carrying capacity of all these types of carriers.

The *Arthasastra* lays down a table of freight adhered not only by the state-owned transport services but also those owned transport and conducted by private individuals or companies. The rate of freight charges used to vary in different conveyances and carriers of load. Rate also varied in case of transportation of goods to a place difficult to traverse. Additional fares were charged in case of food stuffs.

In addition to ferry charges the *Arthasastra* enumerates other tolls and taxes inclusive of port-charges (*pattanam*), sea and river customs and inland customs levies by ferrymen and boundary officers and transit duties. In the determination of price of commodities all these charges were accounted for.

There was a well-structured local trade. Localization of trade being on practice, different commodities had specific localities in market activities. Commodities may be grouped in three classes: state-owned local produces, foreign goods and produces of individual farmers. There were market superintendents, two classes of traders, wholesale dealers and retailers, and agents or middlemen. The *Arthasastra* laid down several laws in the matter of payment by retailers to wholesale dealers after sale of commodities supplied by the wholesaler. The sale transactions of the retailers or hawkers and their two mediums of exchange in cash and kind were laid down in Buddhist text.

Considering the revenue system: The commodities were divided into two classes: local produce and imported goods. Revenue for the former was one-twentieth of the merchandise paid in cash and ten *panas*

for imported articles. Kautilya had framed a regular table of tolls. Goods were classified according to the tolls charged on them. These comprised of :

- Grown on the countryside (*bahya*)
- Produced within the city (*abhyantara*)
- Imported from abroad (*atithya*).

The normal rate of import duty on commodities was one-fifth. For all perishable commodities, like fruits, vegetables, fish and meat, the tax was 1/6<sup>th</sup>. On, ordinary and day-to-day use of commodities both raw material and industrial goods, like, cloth, animal, cotton, scents, medicine, sugar, etc. the prescribed rate was 1/20<sup>th</sup> or 1/25<sup>th</sup>. The importation of rare seeds and articles of great use to the kingdom were duty free. For export no specific rate was laid down.

The period is noted for fixation of barter ratio for barter and bartered substance. Panini has laid down the ratio due of bartered goods. The barter ratio according to Panini was 'the price of a portion of one thing is equal to so many portions of the other'. The valuation was determined on the basis of thing to be brought and thing to be given in exchange.

The trader's profit and the royal levy formed the two invariable factors of the price. The other factors to be considered were production of cost, demand and supply and entrepreneur's fees and tolls and taxes. Kautilya's principle of fixation of price aimed to do legal justice to all interests concerned in a market-transaction, viz., those of traders, the consumer, the producer and above all the State.

The directive to the traders regarding price of a commodity enumerated by Kautilya were:

- Raising of price of a commodity when collected in plentiful in one place;
- Fixation of a commodity in another price when the price is reached;
- Selling of royal goods in prices fixed by the government and compensation in different rates payable to the government in case of loss; one-sixth part as the surcharge in measure of capacity, one-twentieth part in measure by weighing and one-eleventh part of commodities sold by counting.

The prices of different agricultural commodities, particularly the domestic animals and animal products were found to occur in the Buddhist texts. Prices have been valued in copper *panas* per maund.

## Question

1. Write a detailed note on crops cultivated during early historic/ Buddhist period.
2. How was the agricultural trade during Buddhist period?
3. Write short notes on the following agricultural topics in the Buddhist period.
  - (a) Situation of labourers and farm-workers
  - (b) Farm tax and agricultural credit system
  - (c) Animal husbandry and fishery
  - (d) Water management
4. Fill in the blanks.
  - a) ..... was one of the important literary resources to study the agriculture of the Buddhist period. (**Answer**.Arthasastra)
  - b) Maurya ruler Asoka excavated ..... lake to facilitate irrigation. (**Answer**.Sudarsana)
  - c) Sericulture flourished in some localities during Buddhist period are..... . (**Answer**.Magadha, Pundra and Suvarnakudya)
5. Who were the authors of following books?
  - A. Arthasastra;            B. Ashtadhyayi            c. Mahabhasya(**Answer**. A. Chanakya/ Kautilya; B. Panini; C. Patanjali)
6. Write a brief note on flourish of agriculture allied activities during the Buddhist period.

## Lecture 6

### Classification of crops

There are more than 600 cultivated plant species in the world, of which about 200 species play important role in the world market. However, about only 15 field crops species represent the most important economic crops. Handling the huge number of crops is troublesome, unless they are classified. There is definitely demand of classification of crop species in an appropriate way to assure communication and retrieval of specific and scientific information as well as to facilitate their conservation and improvement. Generally, classification of those crop species is important for these reasons:

- 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.

In general, field crop is an organism grown and/or harvested for obtaining yield. Agronomically, crop is a plant cultivated for economic purpose. Classification is done to generalize similar crop plants as a class for better understanding of them.

#### Classification types used in field crops

1. Based on ontogeny (Life cycle)
2. Based on economic use (Agronomic)
3. Based on Botany (Scientific)
4. Based on seasons
5. Based on climate
6. Based on special purpose
7. Based on life span
8. Based on root depth
9. Based on CO<sub>2</sub> fixation
10. Mode of pollination
11. Based on leaf morphology
12. Based on cultural requirements
13. Based on origin

#### 1. Based on Ontogeny (Life cycle)

- **Annual crops**

Crop plants that complete life cycle within a season or year. They produce seed and die within the season. Example, wheat, rice, maize, mustard etc.

- **Biennial crops**

Plants that have life span of two consecutive seasons or years. First years/ season, these plants have purely vegetative growth usually confined to rosette of leaves. The tap root in some crop is fleshy and stores food. During the second year / season, they produce flower stocks from the crown and after producing seeds the plants die. Example, sugar beet, beet root, etc.

- **Perennial crops**

They live for three or more years. They may be seed bearing or non-seed bearing. Ex. Napier fodder grass, coconut, etc.

## 2. Based economic use (Agronomic)

**Cereals:** Cereals are the cultivated grasses grown for their edible grains. Larger grains used as staple food like rice, wheat, maize, barley, and oats and so on. Cereal grain contains 60 to 70% of starch and is excellent energy rich foods for humans. Some important cereals are:

1. Rice: *Oryza sativa*
2. Wheat: *Triticum aestivum*
3. Maize: *Zea mays*

**Millets:** Millets are small and coarse grained cereals, staple food in drier regions. They are also annual grasses of the group cereals. These are also staple food for people of poor countries. Millets are classified into two, as major millets and minor millets.

### Major millets

1. Sorghum (*Jowar*): *Sorghum bicolor*
2. Pearl millet (*Bajra*): *Pennisetum glaucum*
3. Finger millet (*Ragi*): *Eleusine coracana*

### Minor millets

1. Foxtail millet: *Setaria italica*
2. Little millet: *Panicum miliare*
3. Common millet: *Panicum miliaceum*
4. Barnyard millet: *Echinochloa colona var frumentaceae*
5. Kodo millet: *Paspalum scrobiculatum*

**Pulses:** Seeds of plants belong to leguminaceae family used as food grain and rich in protein. Pulses are preferred as a source of vegetable protein and also economically important in cropping system. The wastes or stalk is called the 'hulm' or 'stover'. Hulm is used as green manure and has high value cattle feed. Green whole pods are sometimes used as vegetables, e.g. cowpea, French bean, lablab. Seed coat of pulses are nutritious cattle feed. Some of the examples of pulse crops are as follows.

1. Red gram: *Cajanus cajan*
2. Black gram: *Vigna mungo*
3. Green gram: *Vigna radiata*
4. Cowpea: *Vigna unguiculata*
5. Bengalgram: *Cicer arietinum*
6. Horsegram: *Macrotyloma uniflorum*
7. Lentil: *Lens esculentus*
8. Soybean: *Glycine max*
9. Pea: *Pisum sativum*
10. Grass pea - *Lathyrus sativus*

**Oil seeds:** Oilseed crops are rich in fatty acid and cultivated for the production of vegetable oil. The vegetable oil produced from the oilseeds are used for edible, industrial or medicinal purposes.

1. Groundnut or peanut: *Arachis hypogaea*
2. Sesame or gingelly: *Sesamum indicum*
3. Sunflower: *Helianthus annuus*
4. Castor: *Ricinus communis*
5. Linseed or flax: *Linum usitatissimum*
6. Niger: *Guizotia abyssinia*
7. Safflower: *Carthamus tinctorius*
8. Indian Mustard: *Brassica juncea*

**Sugar crops:** These are the crops cultivated to obtain sugar and the crops are actually raw material for sugar industry.

1. Sugarcane: *Saccharum officinarum*
2. Sugar beet: *Beta vulgaris*

**Fibre crops:** Plants are grown for obtaining fibre and basically these crops are also the raw material for industry. Different kinds of fibre are, i) seed fibre, cotton; ii) Stem/ bast fibre, Jute, mesta; iii) leaf fibre, *Agave sp.*

1. Cotton: *Gossypium hirsutum*
2. Jute: *Corchorus olitorius/ C. capsularis*
3. Mesta: *Hibiscus cannabinus*

**Forage:** Forage refers to vegetative matter, fresh or preserved, utilized as feed for animals.

1. Grasses: Bajra (*Pennisetum glaucum*), napier (*Pennisetum purpureum*), guinea grass (*Megathyrus maximus*), para grass (*Brachiaria mutica*)
2. Legumes: Lucerne (*Medicago sativa*), Barseem (*Trifolium alexandrinum*)

**Spices and condiments:** Crop plants or their products used for flavour, taste and add colour to the fresh or preserved food.

1. Ginger: *Zingiber officinale*
2. Garlic: *Allium sativum*
3. Fenugreek: *Trigonella foenum-graecum*
4. Cumin: *Cuminum cyminum*
5. Turmeric: *Curcuma longa*
6. Coriander: *Coriandrum sativum*
7. Anise: *Pimpinella anisum*

**Medicinal plants:** Medicinal plants are the crops used for preparation of medicines. These are either used as fresh product or processes and value added in industry. Example of medicinal plants are:

1. Tobacco: *Nicotina tabacum*
2. Peppermint: *Mentha piperita*
3. Aswagandha: *Withania somnifera*
4. Aloe: *Aloe vera*

**Beverages:** Products of crops used for preparation of mild, agreeable and stimulating drinking.

1. Tea: *Camellia sinensis*
2. Coffee: *Coffea arabica*
3. Cocoa: *Theobroma cacao*

### 3. Based on scientific or botanical classification

Botanical classification indicates the family and scientific names of plants which consist of genus and species and are universally accepted. Carolus Linnaeus, a Swedish botanist, was responsible for the binomial system of classification with genus and species. Botanical classification is based upon similarity of morphological characters, namely, plant parts and floral structure. Scientific classification is considered as the most important way of classification because it determines the extent of similarity. Field crops belong to the spermatophyte which produces seed under the division of plant kingdom. Within this division, the most of the common crops belong to the subdivision of angiosperm. Angiosperm is characterized by producing seeds with seed-coats and the angiosperm is divided into two classes, namely, monocotyledons and dicotyledons. All the grasses, which include the cereals and sugarcane, are monocotyledons. The rest plants (except the grasses, which include monocotyledons) are classified as dicotyledons. Each of these two classes is still further divided into orders, families, genus and species. According to the botanical classification, the families of the most important field crops can be listed as shown below.

- **Monocotyledons**

**Poaceae /Gramineae:** Wheat, barley, rice, maize, oat, sugar cane, sorghum, rye grass, sudan grass and different millets.

**Liliaceae:** Onion and garlic.

- **Dicotyledons**

**Leguminosae:** Green gram, black gram, red gram, field bean, Bengal gram, lentil, fenugreek, barseem, lucerne, soybean, groundnut, grass pea, French bean, red clover and white clover.

**Malvaceae:** Cotton.

**Linaceae:** Flax.

**Solanceae:** Potato, tobacco.

**Pedaliaceae:** Sesame.

**Composite:** Sunflower, safflower.

#### 4. Based on seasons

Crops are grouped under the seasons in which their major growing duration falls.

**Kharif crops:** Crops which are grown between June-July to September-October and which require a shorter day length for flowering. Example of kharif crops are rice, castor, millets and so on.

**Rabi crops:** Crops sown during October–November and harvested during February–March, which need cold dry weather conditions for their growth and longer day length for reproduction. Common example of rabi crops are wheat, rapeseed and mustard, barley, oats, potato, chick pea and lentil.

**Summer crops:** The summer crops are sown during February–March and harvested in May–June. The warm dry weather is congenial for the vegetative growth of summer crops and longer day length for flowering. In Indian language it is also termed as zaid crop. Example of summer crops are sesame, black gram, green gram, cowpea.

#### 5. Based on climatic condition

**Tropical crop:** Coconut, sugarcane

**Sub-tropical crop:** Rice, cotton

**Temperate crop:** Wheat, barley

**Polar crop:** All pines, pasture grasses

#### 6. Based on Special purpose

Sometimes the crop plants are grown for special purposes or these provide advantages to the farmer in relation to his farming practices including the contingency situations.

**Catch or emergency crop:** These crops are used to substitute main crops that have failed due to unfavourable conditions. Catch crops are usually fast growing in nature and matured within a short span of time (such as green gram, rye, millet, clover).

**Cash crop:** These are the crop grown to generate cash rather than for subsistence. Cash crops are usually related to location. Example of cash crop is chilli for Andhra Pradesh, jute and potato in West Bengal, cotton in Maharashtra, sugarcane in Uttar Pradesh.

**Cover crops:** These crops are planted to provide a cover for the soil and these are cultivated to prevent erosion such as pulses like green gram, black gram, and clover and rye.

**Green manure crops:** These crops are buried in the soil while still green in order to improve the soil properties as well as increase of organic matter content. The most of the legumes (like Sesbania, green gram, sunhemp) can be considered as green manure crop and some non-legumes (like amaranthus, jute) may also be treated.

**Companion crops:** In this case a crop can be intercropped with another one with a distinct row arrangement and each crop is harvested separately. For example, green gram can be intercropped with cotton crop, or black gram, groundnut and soybean with maize.

**Silage crops:** These crops are harvested in vegetative and preserved in a succulent condition by partial fermentation in a tight chamber and used as animal feed. They include corn, sorghum, forage grasses and legumes.

#### 7. Based on life span

All field crops can be divided into three categories on the basis of the length of their life cycle which are as follows.

**Annual crops:** Annual crops are the plants those complete their life cycle (from seed to seed) in a single growing season. Most field crops are considered annual crops such as rice, wheat, barely, chick pea, maize, sorghum and others.

**Biennial crops:** These are the plants which complete their life cycle in two seasons. Vegetative growth occurs during the first season resulting in a rosette form but plants don't start blooming. In the next season, the green plants give flowers and seeds. The crops of this category are onion, sweet clover and sugar beet.

**Perennial crops:** These crops are grown in the soil for more than two years (they can persist for more than two years) and they have an indefinite life span. They may either produce seed or not every year. Sugar cane, alfalfa and white clover are examples of perennial crops.

#### **8. Based on root depth**

The root system of field crops differs in structure, function and depth and on the basis of rooting depth the field crops are classified as follows.

**Hallow root crops:** The root system of these crops extends in the soil within a depth of one meter such as wheat, barley and rye.

**Intermediate crops:** The depth of the root system of these intermediate crops ranges from 1- 1.5 meter as observed in faba bean and sugar beet.

**Deep root crops:** The root system of these plants goes to a depth more than 1.5 meter in soil as observed in alfalfa.

#### **9. Based on method of CO<sub>2</sub> reduction**

The reduction of carbon dioxide (CO<sub>2</sub>) is called dark reaction as light is not necessary and dark reaction does not mean that it occurs only in night. With the energy supplied by ATP (produced during light reactions), CO<sub>2</sub> combines with hydrogen (supplied by NADPH) and forms carbohydrates. Based on the method of reduction of CO<sub>2</sub>, plants are classified into the following categories.

**C<sub>3</sub> Plants:** The initial product of carbon assimilation is the three carbon compound. Net assimilation rate in these plants is low but compensation point is high. Stomata remain open during the day. Photo respiration is high in these plants and C<sub>3</sub> Plants have lower water use efficiency. The enzyme involved in the primary carboxylation is ribulose-1,5-Biophosphate carboxylase. Example of C<sub>3</sub> plants are rice, soybeans, wheat, potato and so on. The C<sub>3</sub> plants include more than 95 percent of the plant species on earth.

**C<sub>4</sub> plants:** Net assimilation rate in these plants is high but compensation point is low. Stomata are open during the day. The primary product of C fixation is four carbon compounds which may be malic acid or aspartic acid. The enzymes responsible for carboxylation are phosphoenol pyruvic acid carboxylase and it has high affinity for CO<sub>2</sub> and capable of assimilating CO<sub>2</sub> even at lower concentration. Photosynthesis rate is higher and photo respiration is negligible in C<sub>4</sub> plants. Crops with C<sub>4</sub> type of photosynthesis are maize, sorghum, pearl millet and other minor millets.

**CAM plants:** The word 'CAM' stands for Crassulacean Acid Metabolism. In these plants the stomata open at night and large amount of CO<sub>2</sub> is fixed as a malic acid which is stored in vacuoles. During day stomata remain closed and there is no possibility of CO<sub>2</sub> entry. CO<sub>2</sub> which is stored as malic acid is broken down and released as CO<sub>2</sub>. In these plants there is negligible transpiration loss of water. C<sub>4</sub>& CAM plants have high water use efficiency compared to C<sub>3</sub> plants. CAM plants are highly drought resistant. Example of CAM plants are pineapple, sisal and agave.

#### **10. Based on mode of pollination**

**Naturally self-pollinated crops:** For these crops both pollen and embryo sac are produced in the same floral structure or in different flowers but within the same plant and pollination takes place naturally. Examples of naturally self-pollinated crops are wheat, rice, pulses, okra, and tomato.

**Naturally cross-pollinated crops:** Pollen transfer in these plants is from the anther of one flower to the stigma of another flower in a separate plant, although self-pollination may reach 5 percent or more. The natural cross-pollination is done by wind, rain, and insect and so on. Examples of cross-pollinated crops are corn, many grasses, avocado, grape, mango, many plants with unisexual or imperfect flowers.

**Both self and cross-pollinated crops:** these plants are mostly self-pollinated but cross-pollination also occurs to a varying extent. Examples of these category of crops are cotton and sorghum.

#### **11. Based on leaf morphology**

**Broad leaved:** Mustard, pea, potato, tobacco.

**Narrow leaved:** Rice, wheat, sugarcane, onion, ginger, ragi.

## **12. Based on cultural requirements**

- **A. According to suitability of tropo-sequence**

**Crops grown on upland:** Redgram, maize, jowar, pearl millet.

**Crops grown on medium land:** Jute, potato, sugarcane, wheat.

**Crops grown on low land:** Rice, para grass.

- **B. According to suitability of the textural group of soils**

**Crops of sandy to sandy loam soil (light textured):** Potato, sweet potato, sugarbeet, onion.

**Crops of silty to silty loam soil (medium textured):** Jute, sugarcane, maize, cotton.

**Crops of clay to clay loam soil (heavy textured):** Rice, wheat, lentil, para grass guinea grass.

- **C. According to the tolerance to the problematic soil**

**Crops tolerant to acidic soil:** Potato, mustard, wet rice.

**Crops tolerant to saline soil:** Chillies, sugar beet, beet, sunflower, barseem.

**Crops tolerant to alkaline soil:** Barley, cotton, pea, barseem.

**Crops tolerant to water logged soil:** Rice, para grass, napier, job's tier

**Crops tolerant to soil erosion:** Vetiver, moth bean, marvel grass.

- **D. According to tolerance to hazardous weather conditions**

**Frost tolerant crops:** Sugar beet, beet.

**Cold tolerant crops:** Potato, cabbage, mustard.

**Drought tolerant crops:** Millets, barley, safflower, castor.

- **E. According to water supply**

**Irrigated crop:** Boro rice, potato, tobacco.

**Rainfed crop:** Millets, upland rice, jute, castor, Dinanath grass.

**Rainfed, but partially irrigated:** Chick pea, mustard, maize.

**Residual soil moisture crops:** Tori, lathyrus, linseed.

**Rainfed flooded crops:** Deep water rice, makhana, water chestnut.

- **F. According to method of sowing or planting**

**Direct seeded:** Upland rice, mustard, chick pea, lentil.

**Planted:** Potato, Napier, and citronella.

**Transplanted:** Transplanted rice, tobacco, onion.

- **G. According to requirement of inter-tillage and earthing-up**

**Intertilled crops:** Potato, sweet potato, sugar beet.

**Non-intertilled crops:** Lentil, oats, chick pea, linseed.

- **H. According to crop duration**

**Very short (upto 75 days):** Greengram, spinach.

**Short (76-100 days):** Upland rice, early potato.

**Medium (101-125 days):** wheat, jowar, bajra, barley.

**Long (126-150 days):** Tobacco, barseem.

**Very long (>150 days):** Sugarcane, red gram.

- **I. According to method of harvest**

**Reaping:** Rice, wheat, mustard.

**Uprooting by pulling:** Linseed, radish, beet.

**Uprooting by digging:** Potato, sweet potato.

**Picking:** Cotton, maize, okra.

**Cutting:** Barseem, napier.

**Grazing:** Para grass, pasture grasses.

- **J. According to post-harvest operation required**

**Curing:** Tobacco.

**Stripping:** Jute, mesta, sunhemp.

**Shelling:** Groundnut, maize.

**Ginning:** Cotton.

### 13. Based on centre of origin of crops

The origin of crop plants is mandatory for plant breeding in order to locate wild relatives, related species, and new genes. To check genetic erosion, it is important to have knowledge of the origins of crop plants. The germplasm is lost due to several factors like loss of ecotypes and landraces, loss of habitat, choice of the growers and increased urbanization. Germplasm preservation is accomplished through gene banks and preservation of natural habitats (especially in centers of origin). So far eight Vavilovian centres of origin are there which further consist old and new world as origin of different crops.

#### Old World

**I. Chinese Center:** The largest independent center which includes the mountainous regions of central and western China, and adjacent lowlands. The plants under this category are listed below, amongst which a few are important crops.

##### Cereals and Legumes

Broomcorn millet (*Panicum miliaceum*); Italian millet (*Panicum italicum*); Japanese barnyard millet (*Panicum frumentaceum*); kaoliang (*Andropogon sorghum*); buckwheat (*Fagopyrum esculentum*); hull-less barley (*Hordeum hexastichum*); soybean (*Glycine max*); adzuki bean (*Phaseolus angularis*); velvet bean (*Stizolobium hassjoo*).

##### Roots, Tubers, and Vegetables

Chinese yam (*Dioscorea batatas*); radish (*Raphanus sativus*); Chinese cabbage (*Brassica chinensis*, *B. pekinensis*); onion (*Allium chinense*, *A. fistulosum*, *A. pekinense*); cucumber (*Cucumis sativus*)

##### Fruits and Nuts

Pear (*Pyrus serotina*, *P. ussuriensis*); Chinese apple (*Malus asiatica*); peach (*Prunus persica*); apricot (*Prunus armeniaca*); cherry (*Prunus pseudocerasus*); walnut (*Juglans sinensis*); litchi (*Litchi chinensis*).

##### Sugar, Drug, and Fiber Plants

Hemp (*Cannabis sativa*); sugarcane (*Saccharum sinense*); camphor (*Cinnamomum camphora*); Opium poppy (*Papaver somniferum*); ginseng (*Panax ginseng*).

**II. Indian Center:** This area has two sub-centers.

**A. Main Center (Hindustan):** Includes Assam and Burma, but not northwest India, Punjab, nor northwest Frontier Provinces. In this area, 117 plants were considered to be endemic.

##### Cereals and legumes

Rice (*Oryza sativa*); chickpea or gram (*Cicer arietinum*); pigeon pea (*Cajanus indicus*); urd bean (*Phaseolus mungo*); mung bean (*Phaseolus aureus*); rice bean (*Phaseolus calcaratus*); cowpea (*Vigna sinensis*).

##### Vegetables and tubers

Eggplant (*Solanum melongena*); cucumber (*Cucumis sativus*); radish (*Raphanus caudatus*); taro (*Colocasia antiquorum*); yam (*Dioscorea alata*).

##### Fruits

Mango (*Mangifera indica*); orange (*Citrus sinensis*); tangerine (*Citrus nobilis*); citron (*Citrus medica*); tamarind (*Tamarindus indica*).

##### Sugar, oil, and fiber Plants

Sugar cane (*Saccharum officinarum*); coconut palm (*Cocos nucifera*); sesame (*Sesamum indicum*); safflower (*Carthamus tinctorius*); tree cotton (*Gossypium arboreum*); oriental cotton (*Gossypium nanking*); jute (*Corchorus capsularis*); crotalaria (*Crotalaria juncea*); kenaf (*Hibiscus cannabinus*).

##### Spices, Stimulants, Dyes, and Miscellaneous

Hemp (*Cannabis indica*); black pepper (*Piper nigrum*); gum arabic (*Acacia Arabica*); sandalwood (*Santalum album*); indigo (*Indigofera tinctoria*); cinnamon tree (*Cinnamomum zeylanticum*); croton (*Croton tiglium*); bamboo (*Bambusa tulda*).

**B. Indo-Malayan Center:** Includes Indo-China and the Malay Archipelago. Fifty-five plants were listed, including:

**Cereals and Legumes**

Job's tears (*Coix lacryma*); velvet bean (*Mucuna utilis*)

**Fruits**

Pummelo (*Citrus grandis*); banana (*Musa cavendishii*, *M. paradisiaca*, *H. sapientum*); breadfruit (*Artocarpus communis*); mangosteen (*Garcinia mangostana*).

**Oil, sugar, spice, and fiber plants**

Candlenut (*Aleurites moluccana*); coconut palm (*Cocos nucifera*); sugarcane (*Saccharum offi cinarum*); clove (*Caryophyllus aromaticus*); nutmeg (*Myristaca fragrans*); black pepper (*Piper nigrum*); manila hemp or abaca (*Musa textilis*).

**III. Central Asiatic Center:** Includes Northwest India (Punjab, Northwest Frontier Provinces and Kashmir), Afghanistan, Tadjikistan, Uzbekistan, and western Tian-Shan. Forty-three plants are listed for this center, including many types of wheat.

**Grains and Legumes**

Common wheat (*Triticum vulgare*); club wheat (*Triticum compactum*); shot wheat (*Triticum sphaerocoeum*); pea (*Pisum sativum*); lentil (*Lens esculenta*); horse bean (*Vicia faba*); chickpea (*Cicer arietinum*); mung bean (*Phaseolus aureus*); mustard (*Brassica juncea*); flax (*Linum usitatissimum*), sesame (*Sesamum indicum*).

**Fiber Plants**

Hemp (*Cannabis indica*); cotton (*Gossypium herbaceum*).

**Vegetables**

Onion (*Allium cepa*); garlic (*Allium sativum*); spinach (*Spinacia oleracea*); carrot (*Daucus carota*).

**Fruits**

Pistacia (*Pistacia vera*); pear (*Pyrus communis*); almond (*Amygdalus communis*); grape (*Vitis vinifera*); apple (*Malus pumila*).

**IV. Near-Eastern Center:** Includes interior of Asia Minor, all of Transcaucasia, Iran, and the highlands of Turkmenistan. Eighty-three species including nine species of wheat were located in this region.

**Grains and Legumes**

Einkorn wheat (*Triticum monococcum* 14 chromosomes); durum wheat, (*Triticum durum*, 28 chromosomes); poulard wheat (*Triticum turgidum*, 28 chromosomes); common wheat (*Triticum vulgare*, 42 chromosomes), oriental wheat (*Triticum orientale*); Persian wheat (*Triticum persicum*, *Triticum timopheevi*, 28 chromosomes); Wheat (*Triticum macha*, 42 chromosomes; *Triticum vavilovianum*, 42 chromosomes); two-row barley (*Hordeum distichum*, *H. nutans*); rye (*Secale cereal*); mediterranean oats (*Avena byzantine*); common oats (*Avena sativa*), lentil (*Lens esculenta*); lupine (*Lupinus pilosus*, *L. albus*).

**Forage Plants**

Alfalfa (*Medicago sativa*); Persian clover (*Trifolium resupinatum*); fenugreek (*Trigonella foenum graecum*); vetch (*Vicia sativa*); hairy vetch (*Vicia villosa*).

**Fruits**

Fig (*Ficus carica*); pomegranate (*Punica granatum*); apple (*Malus pumilo*); pear (*Pyrus communis*); Quince (*Cydonia oblonga*); cherry (*Prunus cerasus*); hawthorn (*Crataegus azarolus*).

**V. Mediterranean Center:** Includes the borders of the Mediterranean Sea.

**Cereals and Legumes**

Durum wheat (*Triticum durum expansum*); emmer wheat (*Triticum dicoccum*); Polish wheat (*Triticum polonicum*); spelt (*Triticum spelta*); mediterranean oats (*Avena byzantine*); sand oats (*Avena brevis*); Canarygrass (*Phalaris canariensis*); grass pea (*Lathyrus sativus*); pea (*Pisum sativum*); lupine (*Lupinus albus*).

**Forage Plants**

Egyptian clover (*Trifolium alexandrinum*); white clover (*Trifolium repens*); crimson clover (*Trifolium incarnatum*); serradella (*Ornithopus sativus*).

**Oil and Fiber Plants**

Flax (*Linum usitatissimum*, *L. angustifolium*); Rape (*Brassica napus*); black mustard (*Brassica nigra*); Olive (*Olea europaea*).

**Vegetables**

Garden beet (*Beta vulgaris*); cabbage (*Brassica oleracea*); turnip (*Brassica campestris*), lettuce (*Lactuca sativa*); Asparagus (*Asparagus offi cinalis*), celery (*Apium graveolens*); chicory (*Cichorium intybus*); Parsnip (*Pastinaca sativa*); rhubarb (*Rheum offi cinale*).

**Ethereal Oil and Spice Plants**

Caraway (*Carum carvi*); anise (*Pimpinella anisum*); thyme (*Thymus vulgaris*); peppermint (*Mentha piperita*); sage (*Salvia offi cinalis*); hop (*Humulus lupulus*).

**VI. Abyssinian Center:** Includes Abyssinia, Eritrea, and part of Somaliland.

**Grains and Legumes**

Abyssinian hard wheat (*Triticum durum abyssinicum*); poulard wheat (*Triticum turgidum abyssinicum*); emmer wheat (*Triticum dicoccum abyssinicum*); Polish wheat (*Triticum polonicum abyssinicum*); Barley (*Hordeum sativum*); grain sorghum (*Andropogon sorghum*); pearl millet (*Pennisetum spicatum*); African millet (*Eleusine coracana*); cowpea (*Vigna sinensis*); flax (*Linum usitatissimum*).

**Miscellaneous**

Sesame (*Sesamum indicum*); castor bean (*Ricinus communis*); garden cress (*Lepidium sativum*); coffee (*Coffea Arabica*); okra (*Hibiscus esculentus*); myrrh (*Commiphora abyssinica*); indigo (*Indigofera argentei*).

**New World**

**VII. South Mexican and Central American Central:** Includes southern sections of Mexico, Guatemala, Honduras and Costa Rica.

**Grains and Legumes**

Maize (*Zea mays*); common bean (*Phaseolus vulgaris*); Lima bean (*Phaseolus lunatus*); Tepary bean (*Phaseolus acutifolius*); jack bean (*Canavalia ensiformis*); grain amaranth (*Amaranthus paniculatus leucocarpus*).

**Melon Plants**

Malabar gourd (*Cucurbita fi cifolia*); winter pumpkin (*Cucurbita moshata*); chayote (*Sechium edule*).

**Fiber Plants**

Upland cotton (*Gossypium hirsutum*); bourbon cotton (*Gossypium purpurascens*); chayote (*Sechium edule*).

**Miscellaneous**

Sweet potato (*Ipomea batatas*); arrowroot (*Maranta arundinaceai*); pepper (*Capsicum annum*, *C. frutescens*); papaya (*Carica papaya*); guava (*Psidium guajava*); cashew (*Anacardium occidentale*); wild black cherry (*Prunus serotina*); cocheneil (*Nopalea coccinellifera*); cherry tomato (*Lycopersicum cerasiforme*); cacao (*Theobroma cacao*); tobacco (*Nicotiana rustica*).

**VIII. South American Center:** Three sub-centers are found under south American centre.

**A. Peruvian, Ecuadorean, and Bolivian Center:** Comprised mainly of the high mountainous areas, formerly the center of the Megalithic or Pre-Inca civilization. Endemic plants of the Puna and Sierra high elevation districts included:

**Root Tubers**

Andean potato (*Solanum andigenum*, 96 chromosomes) and other endemic cultivated potato species., fourteen or more species with chromosome numbers varying from 24 to 60; edible nasturtium (*Tropaeolum tuberosum*), edible canna (*Canna edulis*); potato (*Solanum phureja*, 24 chromosomes).

**Grains and Legumes**

Starchy maize (*Zea mays amylacea*); lima bean (*Phaseolus lunatus*, secondary center); common bean (*Phaseolus vulgaris*, secondary center).

**Vegetable Crops**

Pepino (*Solanum muricatum*); tomato (*Lycopersicon esculentum*); ground cherry (*Physalis peruviana*); Pumpkin (*Cucurbita maxima*); pepper (*Capsicum frutescens*).

**Fiber Plants**

Egyptian cotton (*Gossypium barbadense*).

**Fruit and Miscellaneous**

Passion flower (*Passiflora ligularis*); guava (*Psidium guajava*); heilborn (*Carica candamarcensis*); Quinine tree (*Cinchona calisaya*); tobacco (*Nicotiana tabacum*).

**B. Chiloe Center (Island near the coast of southern Chile)**

Common potato (*Solanum tuberosum*, 48 chromosomes); wild strawberry (*Fragaria chilensis*)

**C. Brazilian-Paraguayan Center**

Manioc (*Manihot utilissima*); peanut (*Arachis hypogaea*); rubber tree (*Hevea brasiliensis*); pineapple (*Ananas comosa*); Brazil nut (*Bertholletia excelsa*); cashew (*Anacardium occidentale*); Purple granadilla (*Passiflora edulis*).

**Question Bank**

1. Why crops are classified? Mention the agronomic classification of crops.
2. Write short notes on the following.
  - a) CAM plant;
  - b) Fibre crops;
  - c) Naturally cross pollinated crops;
3. Give example of the following.
  - a) C<sub>3</sub> plant;
  - b) C<sub>4</sub> plant
  - c) Forage plant;
  - d) Legumes;
  - e) Green manure crops

## Lecture 7

### Crops and its importance

#### Crop and its importance

A crop is a plant or animal product that can be grown and harvested in an area with a target to earn profit or achieve 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. A crop is usually expanded to include macroscopic fungus (e.g. mushrooms), or alga (alga-culture). Most crops are harvested as food for humans or livestock (fodder crops) or to get raw materials if industry. Some crops are gathered from the wild collection (including intensive gathering, example, ginseng). The important non-food crops include horticulture, floriculture and industrial crops. Industrial crops are produced for clothing (fibre crops), biofuel (jatropha, energy crops, algal 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 (e.g., for production of citric acid, fermenting yogurt, soya sauce and so on).

The importance of a crop varies greatly by region. Crop production depends on the availability of arable land and is affected in particular by yields, macroeconomic uncertainty, as well as consumption patterns; it also has a great incidence on agricultural commodities' prices. The importance of crop production is related to harvested areas, returns per hectare (yields) and quantities produced. Crop yields are the harvested production per unit of harvested area for crop products. In most of the cases yield data are not recorded, but are obtained by dividing the production data by the data on area harvested. The actual yield that is captured on farm depends on several factors such as the crop's genetic potential, the amount of sunlight, water and nutrients absorbed by the crop, the presence of weeds and pests. This indicator is presented for wheat, maize, rice and soybean. Crop production is measured in tonnes per hectare, in thousand hectares and thousand tonnes.

Today, India ranks second worldwide in farm output. India is an agrarian country and about 60% of population depends on agriculture for their livelihood. While residing in urban areas may be we would not realize much importance of agriculture but this fact is not new that agriculture is the main source of income for major part of our country's population. India's population is growing faster than its ability to produce rice and wheat. The required level of investment for the development of marketing, storage and cold storage infrastructure is estimated to be huge. The country produces innumerable crops ranging from medicinal to cereal crops. These commodities are used for various purposes from human consumption, in industries, for animal feed and so on.

In spite of the impressive achievements, the Indian agricultural sector continues to face poor infrastructure conditions. About 40 per cent of the cultivated land is under assured irrigation system. Farmers on the remaining 60 per cent of the land are completely dependent on rainfall, which is also greatly characterized by large variations in terms of precipitation both spatially and in time. For a large majority of farmers in different parts of the country gains from application of science and technology in agriculture have yet to be realized. As a result, the productivity levels of many major crops in India do not compare very favourably with the yields obtained in agriculturally advanced countries. Further, these factors coupled with high illiteracy constrain the farmer's ability to shift to more remunerative cropping patterns in response to market signals. Therefore, their capacity to take advantage of the opportunities presented by liberalization of trade is limited. The country's agriculture has gained in strength and

resilience since independence, although growth in agriculture is highly skewed over regions and crops. However, the agriculture sector in India is now faced with intense internal and external pressures arising from the impact of policies of economic liberalization. Efficient and effective management of agriculture will be crucial in the years to come for acquiring enduring self-reliance and ensuring sustainable growth with an emphasis on consideration of equity.

Farming continues to be the major source of food, nutrition, income and employment for the most of the rural population in India. In India, farming is characterized by presence of a large number of small and marginal scale farmers with small farm holdings. However, the country is blessed with diverse agro-climatic conditions which enable the farmers to produce a large number of agricultural commodities. The challenge of producing enough food for the growing population with the reducing holdings is a great task. With the development of commercial agriculture techniques during the post-independence period the agriculture sector has been able to cater to the domestic and international markets. In the light of the focus on commercial farming the rich tradition of crop diversity of Indian farming lasts its glory. Earlier our crop diversity was more prominent; however, after Green Revolution in 1960s we have witnessed erosion of diversity. At present, few crops and few varieties and hybrids of those crops are occupying major production area and are grown repeatedly year after year in succession. This has resulted in emergence of several field levels biotic and abiotic constraints, yield plateauing and overall reduction in the benefits realized from farming. To overcome these problems as well as to reach the goal of production sustainability, diversification of crops may be an option as because diversity assures soundness of ecology.

### **Crop diversification and its causes**

Crop diversification provides the farmers with a wider choice in the production of a variety of crops in a given area so as to expand production related activities on various crops and also to minimize the possible risk. Crop diversification in India is generally viewed as a shift from traditionally grown less remunerative crops to more remunerative crops. In recent years, the crop diversification is also taking place due to governmental policies, thrust on some crops, market reforms, infrastructure development, government subsidies, price support mechanisms, higher profitability and stability in production. Crop diversification and growing of large number of crops are practiced in dry-land areas to reduce the risk factor of crop failures due to climatic abnormality and recurring droughts. Crop substitution and crop shift are also taking place in the areas suffering with some specific soil related problems.

The country has made considerable progress in the farm sector during the last 70 years. From 'hand to mouth' conditions in the early sixties, the country has not only become self-reliant in food grains but has acquired sufficient resilience to tide over the adverse conditions. The achievements in food production is the outcome of a policy framework of improving rural infrastructure including irrigation, research, extension, provision of agricultural inputs at reasonable prices, mechanization in farming, marketing support through minimum support price mechanism and promotion of farmer producer organizations (FPOs). No doubt, it has been realized that such development has been made at a cost of degradation of crop ecosystem. Though an impressive achievement has been made in Indian agricultural sector farming continues to face poor infrastructure conditions and vagaries of climate change. For a large majority of farmers in different parts of the country gains from application of science tools and technologies in agriculture have yet to be realized and resource poor small and marginal farmers of dryland areas are still adopting subsistence farming. As a result, the productivity levels of many major crops in India do not compare very favourably with the yields obtained in agriculturally advanced countries. Due to limited capacities of the farmers to take advantage of the opportunities presented by liberalization is further limited. Efficient and effective management of agriculture is a crucial aspect in the years to come for acquiring enduring self-reliance and ensuring sustainable growth.

The farmers in the developing countries try to grow several crops in their holdings in an agricultural year. The level of crop diversification largely depends on the geo-climatic, socioeconomic conditions and technological development in a region. In general, higher is the level of agricultural technology, lesser the

degree of diversification. Moreover, it has been observed that the rich farmers go with specialized agricultural enterprise while the poor and subsistent farmers of fragile ecological regions are generally showing more interest in crop diversification. The main causes for the crop diversification are as follows.

- In the areas where the variability of rainfall is high and adequate sources of irrigation are not available, farmers grow several crops in a season, requiring different quantities of moisture. It is being done mainly to get something from their fields even in the case of extreme weather (drought or deluge) conditions as natural insurance.
- In the tradition bound subsistent farming systems the farmers grow several crops to meet the family requirements resulting in a high degree of crop diversification.
- Diversification has usually been done by the farmers to enhance nitrogen in the soil and to replenish the soil fertility, and thus maintenance of a good crop rotation.
- The diversification of crops also generates more employment as the farmers including family labourers and agricultural workers remain busy in different farming operations of different crops throughout the year. One important advantage of diversification is assurance of frequent cash flow which is beneficial to small and marginal farmers.
- Diversification of crops also enables the farmers to provide a reasonable quantity of the costly inputs to their crops as different crops need different quantities of inputs (chemical fertilizers, insecticides, pesticides and irrigation).

### **Factors affecting for crop diversification**

With the introduction of scientific and modern agricultural technologies there is a continuous surge for diversified agriculture. The changes in crop pattern, however, are the outcome of the interactive effect of many factors such as:

- Resource related factors mainly irrigation, amount and distribution of rainfall pattern and soil health;
- Technology related factors mainly seed, fertilizer, water use, marketing, storage and post-harvest technologies;
- Household related factors mainly food and fodder self-sufficiency requirement as well as investment capacity of the small and marginal farmers;
- Factors related to output and input prices, marketing infrastructure;
- Institutional and infrastructure related factors covering farm size and tenancy issues, and regulatory policies of the government.

These factors are highly inter-related. The economic liberalization policies as well as the globalization process are also exerting strong pressures on the area allocation decision of farmers, essentially through their impact on the relative prices of inputs and outputs. Similarly, economic factors play a relatively stronger role in influencing the crop pattern in areas with a better irrigation and infrastructure potential. In such areas, commercialization and market networks influence to make the farmers more dynamic and highly responsive to economic impulses.

### **Crop diversification for food security and poverty alleviation**

Crop diversification can be used as a strategy for addressing food and nutritional security. The diversification of horticultural crops especially fruits and vegetables have been very important in ensuring nutrition security. This also has played a pivotal role in poverty reduction. It is not only in the increase of food grain production but also the production of commercial crops like cotton, oilseeds, sugar cane, fruits and vegetables as well as livestock production including fisheries have contributed significantly to poverty reduction. Crop diversification can help the farmers in addressing the important determinants of poverty such as:

- Lack of income and purchasing power
- Lack of productive employment
- The continuous increase in price of food

- Inadequacy of social infrastructure, affecting the quality of life of the people and their employability.

The governments at the centre and the state are focusing on doubling food production with a focus on food grains such as rice, wheat, coarse cereals, pulses; oilseeds; sugar cane; fruits and vegetables; meat; milk and fish. The Action Plan envisages a detailed strategy and specific problems of productivity to substantially increase the supply of various food items in such a way that the demand for such items for the entire population is comfortably met and some exportable surplus also becomes available.

### **Crop diversification as strategy for issues of natural resource management**

Subdivision and fragmentation of land holdings in the country apart from diversion of cultivable land for various other purposes provides very little scope for further expansion of the net sown area (142 m/ha) and that land scarcity will become an acute feature of the rural economy. Water is another important natural resource which is facing several challenges and there are several concerns regarding water resources in the country and the states. Therefore, a judicious use of land and water resources will have to be the central theme for sustainability of agricultural growth. There has been a growing concern in recent years about the deteriorating conditions of soil health and water resources due to unscientific management. The deterioration in land and water resources has been in the form of land degradation, water logging and decline in water table. There is a greater need to have an integrated approach in the management of plant nutrients, chemicals and taking effective measures to deal with the overall pollution problems. There are several possible technologies and alternatives to reduce the use of chemicals in agriculture. These alternatives are not perfect substitutes to chemicals but adoption of these can substantially reduce the adverse impact on environment. Proper land and water management policies would reduce environmental degradation. Community and village level farmers institutions have to be encouraged to participate in protecting natural resources from degradation. Programmes for regeneration of land and water resources need to be strengthened. Scientific crop diversification options are to be planned suiting the land capabilities.

### **Constraints in crop diversification**

The concept of crop diversification in the country is taking the form of increased areas under commercial crops including vegetables and fruits since independence. However, this has gained momentum in the last decade favouring increased area under vegetables and fruits and also to some extent on commercial crops like sugar cane, cotton and oilseeds crops specially soybean. The major problems and constraints in crop diversification are primarily due to the following reasons with varied degrees of influence:

- More than 60 per cent of the cropped area in the country is rain fed and is dependent on rainfall;
- Sub-optimal and over-use of resources like land and water resources, causing a negative impact on the environment and sustainability of agriculture;
- Inadequate supply of improved and quality seeds and planting material of improved cultivars;
- Fragmentation of land holdings and lack of mechanization of agriculture due investment constraints and land holding sizes;
- Poor basic infrastructure like rural roads, power, transport and communications;
- Inadequate post-harvest technologies and inadequate infrastructure for post-harvest handling of perishable horticultural produce;
- Very weak agro-based industry
- Inadequate research - extension - farmer linkages;
- Inadequately trained human resources and large scale illiteracy amongst farmers;
- Emerging species of diseases and pests affecting most crop plants;
- Poor database for horticultural crops and insufficient investments in the agricultural sector.

### **Opportunities in crop diversification due to globalization**

With the advent of the liberalization of trade and providing the market access of agricultural produce between the different countries, the country will be required to promote much more diversified agriculture targeting export opportunity. For crops on which we have substantial area and production, especially foodgrains, the import market has to be insulated through increased productivity which gives us a kind of comparative advantage and also a level playing field so that large scale importation is contained and farmers' interests are protected. The crops which are traditionally exported like basmati rice and spices and condiments also need to be supported in terms of area expansion and quality improvement to look towards much more opportunity for export. Crop diversification in the areas of certain tropical fruits and also a few vegetables also need support for both production and post-harvest handling in terms of their export opportunity. Accelerated growth in fruits and vegetables production is also required for improved nutrition of the country's population. In future, with improved living standards along with increased purchasing power, more and more people will look for nutritional and quality foods which will also call for greater crop diversification. There are some production areas such as food crops, plantation crops, poultry, dairy, sugar, cotton and oilseeds in which India has made its mark. There are some in which its emerging strength is already evident - sericulture, marine and inland fisheries for example. There are also others which now attract less attention, but in which the competitive advantages that India possesses can put it on the top of the world. No country grows such a wide range of fruits, vegetables, and flowers and in such abundance as India and yet it has no record worth mentioning in horticultural exports. The rich variety when processed and marketed can help India take care of the health needs of its population besides being major export commodities.

### **Opportunities due to emerging technologies**

It is being increasingly realized that agriculture is no longer a subsistence activity carried out by peasant cultivators, but rather an enterprise and manufacturer of biomass using land, water, genetic material and the latest in technology. The agriculture of the twenty first century will increasingly be farmers' entrepreneurship harnessing technologies to optimize returns from his land and investments he makes on it. Biotechnology and genetic engineering in crops with focus on primary productivity and also on many quality traits will go a long way to improving the yield and quality of many important crop plants. With the advent of such emerging technologies and consequent scope for increased economic returns, the diversification in favour of such crops will be the future focus. Many other related technologies and their adoption will also inject an added dimension in crop diversification. Decision support systems, governmental policies, geographic information system, application of information technology leading to market information etc., will also lead to crop diversification primarily on economic considerations.

### **Strategies for crop diversification**

Realizing the importance of crop diversification, the central and different state governments have taken several initiatives. Horticulture sector has been given highest importance considering its importance in nutrition security. Some of the important programs of the government include:

- (a) Launching of National Horticulture Mission
- (b) Launching of Technology Mission for the Integrated Development of Horticulture in the North-Eastern Region
- (c) Implementing Agriculture Insurance Scheme (namely PMFBY)
- (d) Operationalizing Technology Mission on Cotton
- (e) Provision of Capital Subsidy for construction/modernization/expansion of cold storages and storages for horticultural produce
- (f) Creation of Watershed Development Fund at the National level for the development of rain-fed areas
- (g) Infrastructure Support for Horticultural Development
- (h) Strengthening Agricultural Marketing
- (i) Seed Bank Scheme
- (k) Cooperative Sector Reforms.

For the measurement of crop diversification, Bhatia (1965) developed a formula based on the gross cropped area. The formula has been expressed as:

Index of Crop Diversification = Percent of sown area under 'x' crops / Number of 'x' crops

Where x crops are those crops that individually occupy 10 per cent or more of the gross cropped area in the area under study.

The main advantage of crop diversification is that it provides a relationship between the relative areal strength of the crops grown in region. The larger the number of crops having about 10 per cent of the gross cropped area, the higher is the crop diversification in the region. In fact, it is an indicator of multiplication of agricultural activities which obviously involve intense competition among various activities for space. The keener the competition, the higher the degree of diversification, and lesser the competition, greater will be the degree of specialization, or monoculture. The degree of crop diversification is closely influenced by the soil characteristics, soil moisture, amount of rainfall received, the availability of irrigation facilities, the accessibility of the arable land and the technology deployed by the cultivators. As stated earlier, the areas of extreme wet or extreme dry climate are least conducive for crop diversification. India, being a vast country of continental dimensions, presents wide variations in agroclimatic conditions. Such variations have led to the evolution of regional niches for various crops. Historically, regions were often associated with the crops in which they specialize for various agronomic, climatic, hydro-geological, and even, historical reasons. But, in the aftermath of technological changes encompassing biochemical and irrigation technologies, the agronomic niches are undergoing significant changes. With the advent of irrigation and new farm technologies, the yield level of most crops-especially that of cereals-has witnessed an upward shift making it possible to obtain a given level of output with reduced area or more output with a given level of area and creating thereby the condition for inter-crop area shift (diversification) without much disturbance in output level. Besides, as agriculture become drought proof and growth become more regionally balanced, there has been a reduction in the instability of agricultural output.

A comprehensive plan for each of the regions of high diversification may go a long way in enhancing their agricultural productivity and in reducing the regional inequalities in agricultural development. There is increasing awareness among the experts of agriculture that crop diversification with suitable crop rotations is necessary for the maintenance of soil health and for making agriculture more productive and sustainable.

### **Question**

1. Define crops. Why crops are important?
2. What are the causes and constraints of crop diversification? What strategies can be taken for diversification of crops?

## Lecture 8

### Crop Voyage in India and World

The literary meaning of voyage is a long journey by water or air to a distance place. The crop voyage means the introduction of different crops from outside and movement of the crops originated in India to abroad. India is one of the mega agro-biodiversity countries of the world. Many plant species have been domesticated here (Vavilov, 1935; Harlan, 1975; Zeven and de Wet, 1982; Singh, 2017). The agro-biodiversity of the indigenously domesticated higher plant species was further enriched with introduction of exotic crops since ancient times, as reflected by the presence of American cereals and pseudo-cereals such as maize and amaranths, African cereals such as pear millet and sorghum, West Asian legumes such as field pea, grass pea and chickpea, and Chinese proso millet and buckwheat in the archeological remains and/or in ancient Indian agriculture writings. Most of these crops have acclimatized and adapted to diverse ecological conditions offered by the Indian Sub-continent to such an extent that many appear natural to the land, and have thrown enormous genetic diversity, making India either a secondary center of diversity for crops such as pearl millet, sorghum, maize, amaranths, cowpea, niger, safflower, muskmelon, pumpkin, chilies and others or regional center of diversity for crops such as barley, grain amaranth, buckwheat, proso millet, foxtail millet, chickpea, bottle gourd and others.

The hypotheses about ancient introductions are based more on presumptions of evolutionary biologists and researchers rather than on hard data belonging to evolution of agriculture, societies, economics, and trade. Systematic and scientific investigations in world crops such as rice, wheat, maize and others have revealed that much information in this regard can be deduced from archaeobotanical, archeological and literary records (Smartt and Simmonds, 1995).

#### Indices Used to Identify Ancient Introductions

The hard data from the following sources have been used to draw inferences regarding introductions of crop species during ancient times.

- **Archeological remains:** Sculptural and graphic depiction of plants or a plant part in architectural monuments, such as caves, temples, etc. dated to ancient times
- **Archaeobotanical remains:** The remains of plant material obtained from various archeological excavation sites with carbon dating for ancient period
- **Literary sources:** Reference of plant species in writings/literature of oriental language, particularly the Sanskrit, the *Vedic* literature with vernacular name
- **Ancient dating:** Based on the above evidence, listing of only those plants falling into the period before medieval period, i.e., 8th century Archeological remains is the strongest foolproof evidence for availability/cultivation of an exotic crop plant in ancient times, particularly from Neolithic-Chalcolithic period in Harappa, Gangetic Plains, and other parts of India including South India. They prove beyond doubt the presence/cultivation, thereby ancient introduction of crops, resolving the controversies regarding crops such as maize, sunflower, cashew nut, tamarind, and others.

However, in following the above criteria, the difficulties listed below are likely to be encountered.

- Limited archeological evidence in crops propagated vegetatively (leafy vegetables, root and tuber crops)
- Lack of knowledge of oriental languages, such as Sanskrit, Prakrits, Pali, Dravidian, etc.
- Difficulties in identification and verification of Latin synonyms of plant species
- Poor documentation/inadequate information regarding minor crops of marginal significance.

- Difficulties in distinguishing the ancient introductions from those from medieval period because of lack of indigenous information and pro-west attitude of historians. In crops of African origin, access to the Indian Subcontinent, both through land and sea-route, is possible.
- It is difficult to distinguish between the two routes and in some crops, it might have occurred through both. Phylogenetic studies including use of molecular markers may be needed to decide on the nearest dates and relationships with existing genetic diversity.

Linguistic data have hardly been used; however, in the present article reference to Sanskrit writings and Sanskrit names and their resemblance with the names in their country of origin have also been considered, particularly in case of American and African crops. In this regard, Indian inventory *Bhava Prakash Nighantu* (Indian Materia Medica) with commentary in Hindi by Bhava Mishra (c. 1600 AD) has been relied upon.

The ancient evidences pronounced introduction and domestication of different crops in Indian subcontinent and voyage of crops on India origin to other corners of the world.

### **Probable Ancient Crop Introductions**

#### ***Abelmoschus esculentus* (L.) Moench, Okra**

The genus *Abelmoschus* is of Asiatic origin, however, the exact ancestral home of the cultivated *A. esculentus* is disputed between Africa and India. Much evidence suggests India to be one of its centers. The existence of Sanskrit names, *Tindisha* and *Gandhamula*, supports its ancient cultivation, because of early introduction from Africa through a sea route.

#### ***Allium cepa* L., Onion**

The Central Asiatic region is considered primary center of origin of onion whereas the near east Asiatic and Mediterranean regions are the secondary centers. The earliest records of onion cultivation come from Egypt. In India, its reference is found in 6th century BC with Sanskrit names, *Palanduh* and *Sukanda*. Archaeobotanical remains of *A. cepa* have been recorded in India.

#### ***Allium sativum* L., Garlic**

Garlic is also of Central Asian origin. The trade relationship between Mesopotamia, Egypt, and India during Mohenjo-Daro period, about 3000 BC, led to its introduction into India. Later, the bulbs as seed were brought and grown. The Arabian traders and the Greeks (Alexander the 300 BC), 'Yavans', brought garlic's use in cooking as a condiment and into *Ayurveda* system of medicine. Its Sanskrit names, *Mahaushadha*, *Lashunaha*, *Granjana*, *Aristaha*, *Mahakandaha* and *Rasonakaha*, were first published in Amarsingh's '*Amar Kosh*' brought out in 600 AD at the time of king Vikramaditya.

#### ***Amaranthus hypochondriacus* L.; syn. *A. leucocarpus***

A native of the northern Mexican highlands, introduced into India three millennia BC, as is indicated by its traditional use and is widely cultivated as food crop in the Himalayan region. *Amaranthus spinosus* L., the spiked amaranth, a native of Americas, is widely distributed as weed throughout south India and beyond. Its Sanskrit names are *Tanduliya*, meaning 'a field weed', *Kataib* and *Chaulai*. Another species, *A. cruentus*, appears to be a later introduction.

#### ***Anacardium occidentale* L., Cashew nut**

A native of Brazil or Venezuela, cashew nut is generally believed to have been introduced into India in the 16th century AD (1560) by the Portuguese (Sauer, 1993). However, depiction of complete plant with flowers and fruits at the Jambukeshvara temple in Tiruchirapalli, Tamil Nadu, built 2500 years back and sculptural depiction of cashew nut fruit at the Bharhut Stupa, dated ca. 200 BC, suggest its ancient cultivation. It has Sanskrit names *Beejara Sula* or *Bijara Sala*, *Shoephahara* and *Kajutaka*.

#### ***Ananas comosus* (L.) Merr., Pineapple**

A native of Brazil, pineapple was introduced into India, probably by the 5th century AD via Middle East. A sculpture depicting its fruit has been found on the *vanamala* of Vishnu in his *Varaha avatara* in the Udayagiri cave temples in Madhya Pradesh (MP), dated 5th century AD. Its Sanskrit names are *Anamnasam* and *Bahunetrphalam* (Pullaiah, 2002). Fruit is used medicinally too.

#### ***Annona cherimolia* Mill., Large Annona, Custard Apple**

Custard apple is native of the highlands of Colombia, Ecuador and Peru and was reportedly introduced into India in 1820. However, the fruit of *A. cherimolia* is shown held by a sculpted goddess figure on a wall of a Hoysala Dynasty temple in Karnataka, dated to 13th century.

***Annona reticulata* L., Bullock's Heart, Custard Apple**

A native of tropical America, custard apple is naturalized in India to an extent that some authors considered it a native. It has Sanskrit names *Rama Sita*, *Luvunee*, *Ramphala* and *Krishnabeejam*.

***Capsicum annuum* L., Chili Pepper**

A native of South America, chili pepper is now cultivated throughout India. It is generally believed to have been introduced into India by the Portuguese in 16th century AD. However, Chilies have been grown and used in India much earlier, as chilies are mentioned in *Siva* and *Vamana Puranas*, dated ca. 6th-8th century AD. In Sanskrit, it has been referred to as *Marichiphalam*, *Katuvira*, *Katuirahand Rakta maricha*.

***Carthamus tinctorius* L., Safflower**

Genus *Carthamus* is distributed from Spain and North Africa across the Middle East to North India. Most evidence suggests origin of *C. tinctorius* in an area bound by the eastern Mediterranean and Persian Gulf. Ancient Sanskrit scriptures described it as *Kusumbha*. Its flowers have been used in preparation of *Ayurveda* medicines.

***Cicer arietinum* L., Chickpea (Bengal gram)**

It is a pulse crop, first grown in Turkey about 7000 BC, and was subsequently introduced into India as early as 2000 BC. It was reported the presence of chickpea (radiocarbon dated at 5450 BC) and provided evidence of its cultivation in the Mediterranean basin during 3000-4000 BC. In ancient Sanskrit writings, it has been referred to as *Chanaka*.

***Citrullus lanatus* (Thunb.) Matsum. & Nakai, Watermelon**

It is a native of southern Africa. Archaeologically, colocynth seeds have been dated to about 5800 BP and those of watermelon at about 4000 BP in Nile Valley. By 4th-7th century AD, it reached India with naturalization of both wild *C. colocynthis* and *C. lanatus*, in the western plains of the subcontinent, making it a secondary center of genetic diversity. Sushruta mentions it in his *Sushruta Samhita* (6th century BC) for cultivation along the banks of the Indus River. In Sanskrit writings, it has been referred to as *Tarambuj*, *Krishnabija*, *Latapanasa*, *Madhuraphala* and *Alpapramanaka*. Seeds of watermelon have been found in the archaeological remains confirming its ancient cultivation.

***Corchorus olitorius* L., Tosa jute**

The larger genetic diversity within the species points to Africa as the primary center of its origin, with India or Indo-Myanmar region being the secondary center of diversity, where it has been cultivated for centuries. From Africa, *C. olitorius* spread to India via Egypt and Syria in ancient times. Discovery of jute textile (not *Tosa jute*) at Harappa (Wright *et al.*, 2012) suggests use of jute in textile production in the subcontinent during the peak of urbanization in the Indus Valley. In Sanskrit, it has been referred to by names such as *Patta* and *Kakka Tapattraka*.

***Cucumis melo* L., Muskmelon**

Musk melon is a native of Africa with populations extending to south-western Asia. Indian Subcontinent is the original home of local variants and the common groups, probably resulted from re-domestication of feral forms in early times. In Sanskrit, it has been referred to as *Kalinga*, *Kharvuja* and *Madhuphala*. The seeds of muskmelon have been found in archaeological remains confirming its ancient cultivation.

***Cucurbita pepo* L., Pumpkin**

Pumpkin is a native of southern part of North America. But it is widely cultivated all over India as a backyard garden crop. It is mentioned in the *Atharvaveda* dating before 800 BC; in the Buddhist *Jatakas* and other texts as early as the 4th century AD: and as an ingredient of *Ayurveda* medicine in an Indian text of the 9th century and in medieval text. It has Sanskrit names, *Kurkaru* and *Kushmanda*.

***Eleusine coracana* (L.) Gaertn., Finger millet (Ragi)**

The center of domestication of finger millet is controversial. Based on the varietal diversity, Vavilov (1935) suggested India to be one of its homelands. Whereas, Porter (1951) and Harlan and Stemler

(1976), based on occurrence of its probable ancestor, the wild tetraploid *Elusine africana*, which crosses freely with cultivated finger millet; nomenclature and language suggested African origin. Record of carbonized seeds of cultivated finger millet associated with Iron Age in Zimbabwe (Inyanga) corroborated it.

***Gossypium barbadense* L., Tetraploid cotton**

A native of South America, tetraploid cotton was introduced into India via Pacific. Indus civilization evidenced cultivation and export of cotton. The Sanskrit name is *Maghani* and it might have reached India before 1000 AD, and came into cultivation.

***Guizotia abyssinica* (L.f.) Cass., Niger**

Niger originated in the Ethiopian highlands as an oilseed crop. It is believed to have been brought to India by the Ethiopian immigrants, probably in the 3rd millennium BC along with crops such as finger millet and its wild relatives. In ancient Sanskrit writing, it has been referred to as *Rama Tilah*. There are no archaeological finds of niger in India.

***Helianthus annuus* L., Sunflower**

A native of Central and South Americas, sunflower is cultivated all over India from very early times as an ornamental and probably also as an oilseed crop. It is mentioned in the Charaka's *Charaka Sahmita* dated no later than the 4th century AD. Its Sanskrit names are *Suriya-mukhi*, *Adityabhakta* and *Suryamukhi*. Graphic depiction of sunflower is found in Rani Gumpaha cave, Udaigiri in Orissa dated to the 2<sup>nd</sup> century BC. Carvings of sunflower from the same temples of Hoysala Empire (10<sup>th</sup> to 14<sup>th</sup> century) in Karnataka was also evidenced.

***Hibiscus cannabinus* L., Kenaf or Deccan hemp**

Kenaf is believed to have originated in ancient Africa, occurring as early as 4000 BC. It spread to India at an early period via Persia. It naturalized to south Asia, so much so that several workers have considered it native. It has been referred in *Sanskrit* literature of ancient India of 7th century with name, *balamulika*.

***Hordeum vulgare* L., Barley**

Barley was one of the first grains domesticated in Fertile Crescent (Crescent shape moist region consisting of Western Asia, the Nile Valley and delta). The distribution of wild barley (*Hordeum vulgare* ssp. *spontaneum*) ranges from North Africa and Crete in the west to Tibet in the east. It was introduced to North India in ancient times and was probably the principal food grain in early days. Barley is mentioned in early Sanskrit records with names such as *Yava*, *Sithashuka*, *Atiyava* and *Akshata*.

***Ipomoea batatas* (L.) Lam., Sweet potato**

This native of South America is cultivated all over India as poor-man's food. Sweet potato was mentioned in Sanskrit literatures as "*Valli*", *Pindalah* and *Raktaluh*, which are similar to the names used in northwestern South America.

***Lagenaria siceraria* (Molina) Standl., Bottle gourd**

Bottle gourd is one of the oldest cultivated plants, which originated from wild population in southern Africa, and might have been carried from there to Asia by oceanic drift during summer monsoon or with human migration. Genetic research on archeological samples suggested that it may have been domesticated earlier than food crops and livestock. Based on the analysis of archeological samples, researchers indicate two unrelated domestications: one 8-9,000 years ago in Asia. In Sanskrit, it is referred to as *Alabu* and *Kutukumbi* (Pullaiah, 2002) confirming its ancient cultivation.

***Lathyrus sativus* L., Grass pea (Khesari)**

It is presumed to have originated in Southwest and Central Asia or the Balkan Peninsula in the early Neolithic period. Grass pea may have been the first crop domesticated in Europe around 6000 BCE. In Sanskrit literature, it has been referred to as *Thripata*, *Kalaaya*, *Khandikaa*, *Lanka*, *Sandika* and *Dirghamoola*. Seeds of *L. sativus* have been found in archaeological remains at Malhar in UP, Balu, Karnal in Haryana, and Middle Gangetic Plains reflecting its ancient cultivation.

***Lawsonia inermis* L., Hena**

Hena is native to northern Africa and western and southern Asia. In ancient Egypt, around 6,000 years ago, it was used as a cosmetic hair dye. Whether it was brought into use at the same time or before or later in India is not known, but the use of *Mehndi* and turmeric has been described in *Vedas*. The existence and

use of Henna for the last 5,000 years can also be found in the books of Charaka and Sushruta and other texts, and in the paintings and sculptures. In Sanskrit, it has been referred to as *Mendika*, *Ragangi* and *Raktgarbha*. It is being used as skin and hair dye in India since long time as is evidenced from the paintings of famous Ajanta-Ellora caves.

***Lense culinaris* Medik., Lentil**

Lentil originated in the Fertile Crescent and then spread to the Indo-Gangetic Plain. Historians suggested its arrival with Sanskrit speaking people, the Aryans, based on non-tenable theory of Indo-Aryan migration. In Sanskrit, it is referred to as *Masura*, *Renuka*, *Mangalya*. Seeds of lentil have been found in archaeological remains at Malhar in UP, Balu, Kunal in Haryana, Middle Gangetic Plains confirming its ancient introduction and cultivation.

***Linum usitatissimum* L., Flax or Linseed**

Wild flax grows from Northern Africa to India, though it was first domesticated in the Fertile Crescent region. The earliest evidence of wild flax use as a textile comes from Republic of Georgia, where spun, dyed, and knotted wild flax fibers were found in Dzudzuana cave, dated 30,000 years ago in Upper Paleolithic period. In India, there is evidence for its cultivation 5,000 years ago (3000 BCE). It has several Sanskrit names such as *Uma*, *Kshuma*, *Atasi*, *Neel Pushpin*. Archaeobotanical remains of flax or linseed seed have been found at Harappa and elsewhere in North India.

***Medicago sativa* L., Lucerne, Alfa-alfa**

Originated in South-central Asia, Lucerne is commonly believed to be introduced into India in 1900. However, it is considered Ladakh as one of the centers of its origin. Archaeobotanical discovery of seeds at Kunal in Haryana confirms its ancient cultivation/introduction in the country.

***Morus alba* L., White mulberry**

White mulberry is native to northern China, Japan, and India. However, some believe it extended from Northwestern India into Asia Minor and Persia. This tree is cultivated in all the provinces of China for 4,000 years for rearing of silk-worms and making silk fabric. It was introduced into India from China during the ancient times, and is now grown widely in the subcontinent. The ancient treatise, *Arthashastra* mentions Assam's growing silk trade. Bush cultivation of white mulberry in Bengal for feeding silk-worms is well known. In Sanskrit, it is called *Tula*.

***Nicotiana tabacum* L., Tobacco**

A native of the Americas, as per *Materia Medica*, tobacco is an agricultural crop introduced into India in 1605 AD. Others believe that it began in the New World and was carried to India after its introduction into Europe. However, the use of the water-cooled smoking device, '*Hooka*', is shown in pre-Columbian art of India, along with references to tobacco in traditional medical practices. Its Sanskrit name is *Tamakhu*. Archaeologically, a temple in Himachal Pradesh dated to 1422–1424 AD depicts the use of the *Hooka*.

***Pachyrhizus erosus* (L.) Urb., Yam bean**

A native to the Americas, yam bean was introduced into India at least before 1000 AD and probably much earlier. In Sanskrit, it is called *Sankhālu*. It is cultivated throughout India for its large edible root, but does not occur in wild corroborating its early introduction.

***Panicum miliaceum* L., Proso millet**

Both, the wild ancestor and the location of domestication of proso millet, are unknown. It first appeared independently as a crop in Transcaucasia and China about 7,000 years ago. It is an early introduction into India, and is extensively cultivated in the country. In Sanskrit, it is called, *Cheenaka*, *Kakakangu* and *Kangu*.

***Paspalum scrobiculatum* var. *polystachyum*; syn. *P. scrobiculatum* L., Kodo millet**

It originated in tropical Africa and probably travelled to Indian Subcontinent across the Indian Ocean may be by natural process like wind. It was domesticated in India 3,000 years ago and is still being domesticated in Deccan Plateau, where it has become a major food crop.

***Pennisetum glaucum* (L.) R. Br., Pearl millet**

Based on the presence of wild relatives, southern edge of Sahara has been considered area of domestication of pearl millet. It was introduced into India very early, probably by sea-route, as it is not

found in Nile Valley and Near East for possibility of a land transfer. In Sanskrit, it is called, *iksapatra*, *vata*. Well-founded archeological remains of pearl millet (1000-2200 BC) have been obtained from several sites in Harapan culture, Gangetic Plains, and Deccan Peninsula, such as Rangpur in Gujarat, Narhan in UP and Hallur in Karnataka by 1500 BC.

***Phaseolus vulgaris* L., French or Kidney bean (Rajma)**

*Phaseolus vulgaris* has American origin. In India, it is cultivated all over, but not known in wild (Chopra *et al.*, 1956). Archaeologically, and based on Sanskrit name *Simbi*, it was present in the southwest Asia and India all the way back to Sumerian times. Archaeological remains were found from pre-Prabhas and Prabhas cultures at Prabhas Patan in Gujarat dating 1800 BC to 600 AD; from post-Harappa, Chalcolithic site Inamgaon and other places.

***Phoenix dactylifera* L., [*P. sylvestris* (L.)Roxb., Indian, Date palm]**

Exact place of origin of date palm is unknown. It probably originated around Iraq and has been cultivated since ancient times (4000 BCE) in Mesopotamia to Egypt. It is naturalized and widely cultivated in India along with local species *Phoenix sylvestris* from ancient time. Evidence of its cultivation is found in the Indus Valley, including the Harappa period 2600 to 1900 BC. Stone remains of date have been found from Rohira in Punjab, and Balu in Haryana.

***Pisum arvense* L., Field pea**

Native to the Mediterranean region and North Africa, field pea is widely grown for forage. It was domesticated around 7,000 years ago, as indicated by the seeds found in archaeological sites in Turkey. In Sanskrit, it is referred to as *Sitla*. The seeds of field pea have been found at Harappa and at several Neolithic sites in Gangetic Plains.

***Pisum sativum* L., Pea**

The wild pea is restricted to the Mediterranean basin and the Near East, and was probably domesticated there. The earliest archaeological finds of pea dated from the late Neolithic era of current Greece, Syria, Turkey, and Jordan. In the second half of the 2<sup>nd</sup> millennium BC, it appeared in the Gangetic basin and southern India. In Sanskrit, it has been referred to as *Renuka*, *Satila*, *Tripata*, *Ananu* and *Hrenu*. Archaeological remains have been found in Harappa and North West India dating back to 2250-1750 BC.

***Psidium guajava* L., Guava**

Guava is a native of tropical America. The site of Caral in the Supe Valley of Peru yielded remains of guava, dated between 2627 and 2020 Cal BC. It is naturalized and cultivated all over India, and has several Sanskrit names such as *Perela*, *Mansala*, *Amruta-phalam* and *Perukah*. It finds mention in *Charaka Samhita*, indicating that it was introduced not later than the 4th century or considerably earlier, negating the common belief for its introduction by the Portuguese in 17th Century.

***Ricinus communis* L., Castor**

Domesticated in West-Central Africa, castor spread to Egypt (4000 BC) and then reached India (2000 BC). In Sanskrit, it is referred to as *Eranda*, *Gandharva hasta* and by few more names in *Bhava Prakash Nighantu*. The earliest archaeobotanical record of castor in India was found at the late Harappa site, Hulas (Saraswat, 1993) dated between 1800- 1300 BC. Since then, it has been recorded both in Indus valley and Gangetic Plains (Saraswat 1992, 2004b, 2005). The use of castor oil in India for lighting lamps and in local medicine as a laxative, purgative, and cathartic has been documented since 2000 BC.

***Setaria italic* (L.) P. Beauv., Foxtail millet**

Foxtail millet is a native of China with history of cultivation dating back to the Neolithic Era over 4,000 year ago. It moved from China to south and westward to reach India. In South India, it is a staple diet for the people from the *Sangam* period. In Sanskrit, it has been referred to as *Bhvajja*, *Priyagguka*, *Rajika*, etc. confirming its ancient cultivation. It occurred in Harappa levels (2500-2200 BC) at Shikarpur (Kutch). Archaeobotanical remains have also been found from upper and middle Gangetic Plains.

***Sorghum bicolor* (L.) Moench., Sorghum**

Most studies concur with African origin of sorghum with domestication stretching from Southwest Ethiopia to Lake Chad. It reached India in pre-historical time. It is widely grown in India. In Sanskrit writings, it is called *Yavanal*. There have been suggestions for reimport of cultivars developed in India.

***Tagetes erecta* L., *T. patula* L. (dwarf), Marigold**

A native of South-central Mexico, some believe marigold originated in Africa. It arrived in India while Sanskrit was the active language, and is referred to as *Zanduga*, *Sandu*, *Sthulapushpa* and *Ganduga*. There is substantial evidence to suggest that it was grown in India since long time and was associated with Hindu religious ceremonies for decoration and coloring, essentially a similar use as in Mexico.

#### ***Tamarindus indica* L., Tamarind**

Tamarind is of West African origin, but it has spread to India at an early date. There are many references to the tamarind tree in Hindu mythology. In Sanskrit, it has been referred to as *Amlika*, *Sucukrika*, *Tintrini* and *Yamadutika*. Charcoal remains of tamarind tree have been identified from Narhan site of the middle Gangetic Plains dating back 1300 BC.

#### ***Trifolium alexandrinum* L., Berseem**

Berseem is a native of Egypt. As per common belief, it was introduced into North India in the early 19<sup>th</sup> century. But the ancient cultural and trade contacts between Egypt and India, its reference in Sanskrit writing as *Tripatra*, and finding of three seeds in archaeobotanical remains from mature Harappa phases negate this presumption and indicate its ancient introduction/cultivation.

#### ***Trigonella foenum-graecum* L., Fenugreek**

A native to eastern Mediterranean region, fenugreek was brought into cultivation in the Near East as indicated by the charred fenugreek seeds recovered from Tell Halal in Iraq dating back to 4000 BC. It is found wild in Kashmir, Punjab and the upper Gangetic Plains suggesting its naturalization to India. In Sanskrit, it is referred to as *Medhika*, *Methika*, *Chandrika* and several other names, confirming its ancient cultivation.

#### ***Triticum - T. aestivum* L. ssp. *aestivum*, Common Hexaploid Wheat**

Common wheat was first domesticated in Western Asia (Fertile Crescent—upper reaches of the Tigris-Euphrates drainage basin) round 11,700 years BCE. Its cultivation began to spread after about 8000 BCE (9,000 years back) and reached India, where it evolved further. For this reason, the north-western end of Indian Subcontinent is regarded as the secondary center of origin, leading to origin of *T. sphaerococcum* (dwarf wheat). Excavation at Mehrgarh revealed species, *T. monococcum*, *T. dicoccum* and *T. durum* or *T. aestivum*, suggesting that Baluchistan was a very early center of wheat cultivation. In Sanskrit, it has been referred to as *Godhuma*, *Sumana*, *DhUma*, *Kanika*, etc. Carbonized wheat grains discovered at Mohenjodaro are dated to 1755 BC.

#### ***Vigna unguiculata* (L.)Walp., Cowpea**

Cowpea is indigenous to West-Central Africa. Its long-time cultivation in India led to a belief for its Asian origin. In Sanskrit, it has been referred to as *Harimanth*, confirming its presence in India before the Christian era. Archaeobotanical remains have been found at Daimabad in Maharashtra ca.1700-1500 BC, Hulas in upper Gangetic Plains 2200-1500 BC and in Khairadih in middle Gangetic Plains (Saraswat, 2005).

#### ***Vitis vinifera* L., Grapes**

A native of Eurasia, grapes is thought to have been domesticated first in Southwestern Asia during the Neolithic period. In Asia, the earliest evidence of cultivation of grapes is from Iran and Baluchistan, dated before 2000 BC, wherefrom cultivation slowly spread to India and China with the beginning of Christian era. It is not mentioned in *Vedic* literature as *Draksha*.

#### ***Zea mays* L., Maize**

Maize is generally believed to have been introduced into India by the Portuguese during the 17<sup>th</sup> century. However, the discovery of Sikkim Primitive demonstrate that maize was present in India in ancient Era and was cultivated much before the turn of Christian Era. In Sanskrit, it is known as *Sasyam*, *Stambakari*, *Sasyavishesha*, besides *Yavanala*. References to maize fields are found in the inscriptions of Assam (*kostha makkhi-yana*). Sculptures of maize-ears were found in the Hoysala Empire temples in Karnataka between 11<sup>th</sup>-13<sup>th</sup> centuries.

#### **Crops of India Origin**

Besides, there are certain crops which were native of our country and in the course of crop voyage which have been spread across the globe. Some of such crops are listed below.

#### ***Oryza* sp., Rice**

India is an important centre of rice cultivation. The rice is cultivated on the largest areas in India. Historians believe that while the indica variety of rice was first domesticated in the area covering the foothills of the Eastern Himalayas (i.e. north-eastern India), stretching through Burma, Thailand, Laos, Vietnam and Southern China, the japonica variety was domesticated from wild rice in southern China which was introduced to India. Perennial wild rice still grow in Assam and Nepal. It seems to have appeared around 1400 BC in southern India after its domestication in the northern plains. It then spread to all the fertile alluvial plains watered by rivers. Some say that the word rice is derived from the Tamil word arisi. Rice is first mentioned in the Yajur Veda (c. 1500-800 BC) and then is frequently referred to in Sanskrit texts. In India there is a saying that grains of rice should be like two brothers, close but not stuck together. Rice is often directly associated with prosperity and fertility; hence there is the custom of throwing rice at newlyweds. In India, rice is always the first food offered to the babies when they start eating solids or to husband by his new bride, to ensure they will have children.

#### ***Aegle marmelos*, Beal**

*Aegle marmelos*, commonly known as bael, also Bengal quince, golden apple, Japanese bitter orange, stone apple or wood apple, is a species of tree native to India, Nepal, the Andaman and Nicobar Islands and Myanmar. It is present in Sri Lanka, Thailand and Malaysia as a naturalized species. The tree is considered to be sacred by Hindus. Its fruits are used in traditional medicine and as a food throughout its range. The common name "wood apple" may also refer to *Limonia acidissima*.

#### ***Piper nigrum*, Black pepper**

Black pepper (*Piper nigrum*) is a flowering vine in the family Piperaceae, cultivated for its fruit which is usually dried and used as a spice and seasoning, known as a peppercorn. When fresh and fully mature, it is approximately 5 millimetres (0.20 in) in diameter and dark red, and contains a single seed like all drupes. Peppercorns and the ground pepper derived from them may be described simply as pepper, or more precisely as black pepper (cooked and dried unripe fruit), **green pepper** (dried unripe fruit), and **white pepper** (ripe fruit seeds).

#### ***Solanum melongena*, Eggplant**

**Eggplant** (*Solanum melongena*), or **brinjal** or **aubergine**, is grown for its edible fruit. Eggplant is the common name in North America, Australia and New Zealand, but British English uses the French word *aubergine*. The plant species originated in cultivation. It has been cultivated in southern and eastern Asia since prehistory. The first known written record of the plant is found in *Qimin Yaoshu*, an ancient Chinese agricultural treatise completed in 544 AD. The aubergine is unrecorded in England until the 16th century.

#### ***Gossypium arboreum*, Tree cotton**

*Gossypium arboreum*, commonly called **tree cotton**, is a species of cotton native to India, Pakistan and other tropical and subtropical regions of the Old World. There is evidence of its cultivation as long ago as the Harappan civilization of the Indus Valley for the production of cotton textiles. This species of cotton was also introduced into East Africa and was grown by the Meroe civilization in Nubia. The shrub was included in Linnaeus's *Species Plantarum* published in 1753. The holotype was also supplied by him, which is now in the Linnean Herbarium in the Swedish Museum of Natural History. It is a sister species of *Gossypium herbaceum*.

#### ***Artocarpus heterophyllus*, Jackfruit**

The **jackfruit** (*Artocarpus heterophyllus*), also known as **jack tree**, **fenne**, **jakfruit**, or sometimes simply **jack** or **jak**. The jackfruit tree is a widely cultivated and popular food item throughout the tropical regions of the world. Jackfruit is the national fruit of Bangladesh.<sup>[13]</sup> The jackfruit has played a significant role in Indian agriculture for centuries. Archeological findings in India have revealed that jackfruit was cultivated in India 3000 to 6000 years ago. It has also been widely cultivated in southeast Asia. Stingless bees such as *Tetragonula iridipennis* are jackfruit pollinators, and as such, play an important role in jackfruit cultivation. Outside of its countries of origin, fresh jackfruit can be found at food markets throughout Southeast Asia. It is also extensively cultivated in the Brazilian coastal region, where it is sold in local markets.

#### ***Cajanus cajan*, Pigeon pea**

The **pigeon pea** (*Cajanus cajan*) is a perennial legume from the family Fabaceae. Since its domestication in India at least 3,500 years ago, its seeds have become a common food grain in Asia, Africa, and Latin America. It is consumed on a large scale mainly in south Asia and is a major source of protein for the population of that subcontinent. The cultivation of the pigeon pea goes back at least 3,500 years. The centre of origin is probably peninsular India, where the closest wild relatives (*Cajanus cajanifolia*) occur in tropical deciduous woodlands. Archaeological finds of pigeon pea dating to about 3400 years ago (14th century BC) have been found at Neolithic sites in Karnataka (Sanganakallu) and its border areas (Tuljapur Garhi in Maharashtra and Gopalpur in Orissa) and also the south Indian states such as Kerala, where it is called Tomara Payaru. From India it traveled to East Africa and West Africa. There, it was first encountered by Europeans, so it obtained the name Congo Pea. By means of the slave trade, it came to the American continent, probably in the 17th century.

#### **Curcuma longa, Turmeric**

**Turmeric** (*Curcuma longa*) is a rhizomatous herbaceous perennial plant of the ginger family, Zingiberaceae. It is native to Southeast Asia. Plants are gathered annually for their rhizomes and propagated from some of those rhizomes in the following season. Turmeric has been used in Asia for thousands of years and is a major part of Ayurveda, Siddha medicine, Unani, and traditional Chinese medicine. It was first used as a dye, and then later for its medicinal properties.

#### **Ziziphus mauritiana, Indian plum**

**Ziziphus mauritiana**, also known as **Chinese date, ber, Chinese apple, jujube, Indian plum, Regi pandu, Indian jujube**, is a tropical fruit tree species belonging to the family Rhamnaceae. The species is believed to have originated in Indo-Malaysian region of South-East Asia. It is now widely naturalized throughout the Old World tropics from Southern Africa through the Middle East to the Indian Subcontinent and China, Indomalaya, and into Australasia and the Pacific Islands. It can form dense stands and become invasive in some areas, including Fiji and Australia and has become a serious environmental weed in Northern Australia. It is a fast-growing tree with a medium lifespan, that can quickly reach up to 10–40 ft (3 to 12 m) tall.

#### **Question Bank**

1. Write down the probable origin of the following crops.  
Jackfruit, pigeon pea, chilli, pine apple, custard apple, wheat, barley, rice.
2. What indices are used to identify the origin of the crops?
3. What are the difficulties to identify the crops originated in India?
4. Explain how crop voyage improved the diversity of crops in India.

## Lecture 9

# Plant production and protection through Indigenous Technical Knowledge (ITK)

### Definition and meaning of ITK

The Indigenous Technical Knowledge (ITK) is regarded as the information gained over a period of time passed on from generation to generation by the word of mouth. ITK is the information base for a society, which facilitates communication and decision making. Indigenous information systems are dynamic, and are continually influenced by internal creativity and experimentation as well as by contact with external systems.

ITK is stored in people's memories and activities, and is expressed in the form of stories, songs, folklore, proverbs, dances, myths, cultural values, beliefs, rituals, community laws, local language and taxonomy, agricultural practices, equipment, materials, plant species and animal breeds. ITK is shared and communicated orally, by specific examples and through culture. An African proverb says "**When an old knowledgeable person dies, a whole library dies**" indicating the importance of ITKs.

**Wang (1988)** defined ITK as "the sum total knowledge and practices which are based on people's accumulated experiences in dealing with situations and problems in various aspects of life and such knowledge and practices are special to a particular culture."

Indigenous Technical Knowledge is the local knowledge – knowledge that is unique to a given culture or society. It contrasts with the international knowledge system generated by universities, research institutions and private firms. It is the basis for local-level decision making in agriculture, health care, food preparation, education natural resource management and a host of other activities in rural communities (**Warren 1991**).

Indigenous technical knowledge (ITK) refers to the unique, traditional, local knowledge existing within and developed around the specific conditions of women and men indigenous to a particular geographic area (**Grenier, 1998**).

As a summary of various definitions, the term indigenous technical knowledge may be denoted mainly as a tacit type of knowledge that has evolved within the local (grassroots) community and has been passed on from one generation to another, encompasses not only local or indigenous knowledge, but also scientific and other knowledge gained from outsiders.

The term indigenous technical knowledge is often camouflaged with the belief that is associated with forthcoming happenings and innovations made by the farmers to solve specific problem. Many definitions have been proposed for indigenous technical knowledge (ITK) systems, but all of them are incomplete, because the concept is relatively new and still evolving.

Literature in related fields uses various terms interchangeably to designate the concept of "traditional knowledge (TK)", "traditional ecological knowledge (TEK)", "traditional ecological knowledge and management systems (TEKMS)", "local knowledge (LK)": "indigenous knowledge (IK)", indigenous technical knowledge (ITK)", "community knowledge", "rural peoples' knowledge" and "farmers' knowledge (FK)". While certain distinctions can be made, these terms often refer to the same thing.

**Indigenous Knowledge (IK):** is the participant's knowledge of their temporal and social space. Indigenous knowledge as such refers not only to knowledge of indigenous peoples, but to that of any other defined community.

**Indigenous Knowledge System (IKS):** delineates a cognitive structure in which theories and perceptions of nature and culture are conceptualized. Thus it includes definitions, classifications and concepts of the physical, natural, social, economic and ideational environments. The dynamics of the IKS takes place on two different levels, the cognitive and the empirical. On the empirical level, IKS are visible in institutions, artifacts and allied technologies.

**Indigenous Technical Knowledge (ITK):** is specifically concerned with actual application of the thinking of the local people in various operations of agriculture and allied areas.

**Belief:** change in behavior of insects, animals and vegetation indicating a forthcoming event without any scientific rationale but is true in happening.

**Innovation:** outside the area of ITK, but scientifically based development of practices using the locally available resources to solve specific problems.

In the emerging global knowledge economy a country's ability to build and mobilize knowledge capital, is equally essential for sustainable development as the availability of physical and financial capital. The basic component of any country's knowledge system is its indigenous technical knowledge. It encompasses the skills, experiences and insights of people, applied to maintain or improve their livelihood. ITK is developed and adapted continuously to gradually changing environments and passed from generation to generation and closely interwoven with people's cultural values. ITK is also the social capital of the poor, their main asset to invest in the struggle for survival, to produce food, to provide for shelter or to achieve control of their own lives.

**The special features of indigenous technical knowledge** are (World Bank, 1998) as follows.

- It is 'local', as it is rooted in particular community and situated within broader cultural traditions;
- It is a set of experiences generated by people living in those communities. Therefore, separating the technical from the non-technical, the rational from the non-rational could be problematic.
- When transferred to other places, there is a potential risk of dislocating indigenous technical knowledge. It is tacit knowledge and, therefore, not easily modifiable. Codifying it may lead to the loss of some of its properties.
- It is transmitted orally, or through imitation and demonstration.
- It is experiential rather than theoretical knowledge.

Experience and trial and error, tested in the rigorous laboratory of survival of local communities constantly reinforce indigenous knowledge. It is learned through repetition, which is a defining characteristic of tradition even when new knowledge is added. Repetition aids in the retention and reinforcement of indigenous technical knowledge. Constantly changing, being produced as well as reproduced discovered as well as lost; through it is often perceived by external observers as being somewhat static.

#### **Strategies for integration of ITKs into scientific research process**

Today it is widely accepted among agricultural scientists throughout the world that the reassessment of indigenous technical knowledge is an indispensable part of the introduction of new agricultural technology. It is recognized that the knowledge of farmers must be taken into account before any new technology is developed and disseminated. This view is based on the assumption that

- farmers have a wealth of knowledge pertaining to their own environment;
- farmers have developed specific skills designed to make the best use of that environment.

The four important steps in inclusion of the ITKs in technology generation, reassessment and adaptation process are, **Documentation, Validation, Refinement and Integration.**

#### **IPR and ITKs**

The potentials of indigenous technical knowledge (ITK), both for expanding scientific technical knowledge and for empowering its owners, are overwhelming. Within farming systems, ITK embraces people's knowledge of tools and techniques for the assessment, acquisition, transformation, and utilization of resources that are specific to a particular location.

ITK can encompass:

- **Vernacular:** technical knowledge held by all or most individuals in a specific locality, e.g., knowledge of crop rotation, or pest and weed control;

- **Specialized:** the technical knowledge of certain skilled 'resource persons', e.g., medicine, charcoal-making, black smithery and varietal testing;
- **Controlled:** knowledge held by dominant groups in society, such as the specialized knowledge referred to above, or skills in animal breeding, hunting or water divining;
- **Social:** knowledge belonging to the group (clan, caste or tribe) or community, e.g., grazing rights, fishing controls and tenure regulations.

The categories often overlap, but in all cases local knowledge is the main resource which is controlled by at least part of the 'rural people', whilst lands, natural resources and labor have been appropriated by outside powers (McCall, M.K., 1995).

To improve the role of IPR in the benefit sharing of traditional knowledge, current Intellectual Property debates need to study systematically the 'tradition of Invention' instead of 'inventing a tradition' (Gupta, 1993). 80 per cent of modern plant-based medicines are used for the same purpose for which native people discovered their use (Farnsworth, 1981). The correlation between claims of local communities and the evidence from modern pharmacological science was more than 85 per cent in the studies pursued in a part of Nigeria (Iwu, 1996). Chinese right holders held about 45 per cent of all herbal-based patents in 1996, followed by the Japanese and Russia with 22 per cent and 16.5 per cent respectively (Gupta, 1999). Therefore, the indigenous practices need be systematically documented, validated and integrated in the scientific process as a part of strategic programme planning for sustainable agriculture and for initiating patenting process.

### **Constraints in scouting for ITK**

1. Difficulty in finding persons (local people) who possess ITK.
2. Availability of IK in a village is limited by the extent of modernization in it and its proximity to an urban area.
3. Local people might be prejudiced against officials dealing with land records or income tax and hence might be wary of ITK researchers too.
4. Researches may be unable to understand the dialectical nomenclature used by local people to describe plant species.
5. The local language used by resource persons to describe ITK can at times be incomprehensible to researchers, and hence, it can be difficult to document ITK.
6. Researchers at times do not have adequate information on the strategies required to scout ITK.
7. Many local people refuse to divulge ITK, and hence it is difficult to scout for it.
8. Some local people find it difficult to understand the concept of ITK as perceived by researchers.

### **Strategies to facilitate scouting for ITK**

1. Conducting peripatetic group meetings in order to promote awareness and to motivate local people to share ITK often works well. Appropriate counseling ensures that local people do not get ensnared by vested interests.
2. Using extension teaching methods and aids helps educate local people about the Importance of ITK and hence documentation.
3. Arranging scouting competitions for local people (women, farmers, and children etc) and selecting winners for awards for aiding scouting of ITK.
4. Informing local people well in advance regarding the rewards/incentives for outstanding innovators could motivate local people to share ITK.
5. Holding public ceremonies to honor innovators by a reward/award could be useful. This could inspire local people to share ITK.
6. Informing local people about publishing documented innovations of local people in newsletters/journals acknowledging the identity of the innovator(s) and popularizing their innovations.

7. Communicating to the community the possibility of obtaining intellectual property rights for ITK and equitably sharing the benefits accrued through commercialization with the resource person /community holding the knowledge.
8. Conducting location specific peripatetic group meetings, demonstrations, and farm and home visits in order to address local people's problems and priorities (eg. insects, disease) could oblige local people to reciprocate by sharing their ITK.

### **Reasons for refusal to share ITK**

1. Owing to exclusive ownership, they prefer not to share the benefits of their knowledge.
2. They are reluctant to disclose their ITK owing to competition in business.
3. They may feel that others will exploit the shared ITK to their advantage and to the disadvantage to the innovators.
4. The belief that ethno-medicines become ineffective when shared.
5. There is a practice of sharing ITK only with legal heirs and not with outsiders.
6. They may feel insecure, fearing the loss of social respect once their shared ITK becomes common knowledge. Hence, the resource persons may feel that they will lose their specialty in their social context.
7. They do not share ITK if the researcher is unfamiliar or naïve.
8. They may suspect the researchers may steal their innovations and make money using their ITK.
9. They may perceive researchers as a hindrance to their commitments and chores.
10. They may assume that researchers are officials dealing with land records or income tax and avoid them.
11. They may make the assumption that a fully informed researcher is testing their knowledge and is actually well-informed about the ITK.
12. There may be no incentives or rewards for revealing ITK.
13. They may be shy to speak about ITK, fearing that they will be considered uncivilized in these modern days.
14. They may be unaware that their contribution is noteworthy and respectable.
15. They may place no special importance on ITK, treating it as a part of the vicissitudes of life and farming.
16. They may fear that others may adopt their innovations.
17. They may fear being penalized or prosecuted by authorities since their ITK is unapproved or unlicensed.
18. They may wish to prevent the youth (researchers) from "wrongly" using the practices. Once the reasons for refusal are known, the next step is to find ways to enable reluctant community members to share their ITK so that the researcher can document it.

### **Protection for ITK in Indian Acts**

Some of the India's new laws have implications for ITK and bio-resources which are given below.

1. The Geographical Indications of Goods-Registration and Protection Act 1999.
2. The protection of Plant Varieties and Farmer's Rights Act 2001.
3. The Biological Diversity Act, 2002.
4. The patent (Second Amendment act, 2002).

### **Traditional Knowledge Digital Library (TKDL)**

TKDL is a collaborative project between National Institute of Science Communication and Information Resources (NISCAIR), Council of Scientific and Industrial Research (CSIR), Ministry of Science and Technology and Development of AYUSH and Ministry of Health and Family Welfare, which is being implemented at NISCAIR. An inter-disciplinary team of Traditional Practices Experts, Patent Examiners, IT Experts, Scientists and Technical Officers are involved in creations of TKDL. The project TKDL involves documentation of the knowledge available in public domain on traditional knowledge from the existing system. Traditional Knowledge Resources Classification (TKRC), an innovative structured

classification system for the purpose of systematic arrangement, dissemination and retrieval has been evolved for about 10,500 sub-groups against one group in International patent Classification (IPC).

### **Role of ITKs in the traditional agriculture**

Sustainable agriculture is the sustainable exploitation of renewable natural resources including annual and perennial cropping, agro-forestry and livestock as well as the conservation measures needed for long term maintenance of resources.

The intensive agriculture resulted in depletion of nutritional status of soils, erosion of biodiversity, natural habitats, forests and water resources. Indiscriminate use of chemical pesticides and fertilizers affected the agro-ecosystems, caused pollution of soil and water resulting in human and animal health hazards and contributed significantly to destabilize the traditional systems of agriculture. When the farmers practiced integrated crop management, integrated nutrient management and non-pesticidal management which are the major components of sustainable agriculture, the cost of cultivation reduced by 6.7 percent, and net income increased by 57 percent in Pigeon pea; in Paddy due to adoption of sustainable agriculture practices, the cost of cultivation reduced by 15.2 percent and net income increased by 98 percent; in vegetables, the cost of cultivation reduced by 27.5 percent and the net income increased by 36.3 percent (CWS, 2003). The traditional practices especially regarding water management, nutrient management and pest management have been classical examples of non-exploitative and non-polluting methods of natural resources leading to sustainable agriculture as presented below.

### **Water management**

In different countries, methods for forecasting rain and managing water are typical examples of knowledge that is passed down orally from generation to generation (Herath T. N., 2001). To the farmers of rainfed and dryland region, it has always been of vital importance to have methods for conserving water and to possess knowledge about rain and the patterns, times and quantities in which it falls. When farmers can forecast the amount of rainfall to expect in the coming season, they can decide which crops and crop varieties to plant. In the dry zone, there has been a system of tanks constructed in a sort of cascade, with one tank below the next. The excess water from one tank automatically flows to the tank just below it. Only water from seasonal rains is collected in these small tanks. At the level just below each tank, land is prepared and always grown with paddy. This is a very common practice in Sri Lanka and other countries. In fields fed by tanks, paddy is normally grown in two seasons: the rainier one from July to November, and the drier one from November-December to March-April.

Many farmers in India traditionally adopted water harvesting measures such as farm ponds, check dams, shallow wells dug in depressions to collect rain water, diversion channels (khuls), brick lined tank, channels constructed through hilly rivers (pynes), tank cascades, Bandhara, Khadin, Nalla check, Pat system, Phad system, Chauka system, Haveli system and so on. The age old well-maintained water supply system of Indus Valley civilization, Grand Anicut system in 2nd century A.D. by Chola kings, huge tanks that were developed in Deccan during medieval times are serving people even today for their needs of irrigation, drinking water and aquaculture.

It was observed that if at the beginning of the season wood-apple trees (*Feronia alephantum*), karamba (*Carissa carandas*), and meegon karapincha (*Clausena indica*) bear more fruit than usual, there would be more rain than usual.

Farmers observed that if the wasps make their nests larger and the spiders make their webs larger after the first two or three showers of the season, the year would not bring sufficient rain. The same will be true if the crabs build their hollows closer to the source of water (tank, lake, etc.). On the other hand, if the crabs built their hollows on high ground farther away from water reservoirs and wet places it is predicted that heavy rains would fall during that year.

### **Soil conservation and Nutrient Management**

Traditional farmers have found ways of improving soil structure, water holding capacity, nutrient and water availability without the use of artificial inputs. Their systems are sophisticated forms of ecological agriculture fine-tuned to the specific environmental conditions. On establishment, Vetiver completely stopped sheet erosion of soil, slowed runoff, let water seep through the entire length of the

hedge, trapped silt behind grass barrier to form natural terrace over the years. It costs less than 1/10th of the engineered soil conservation systems, and, unlike the other systems, with this system of contour ploughing and planting between stabilized hedges, food crops can be produced safely on 100% slopes (45°) and vast areas of unstable lands can be brought under cultivation (Grimshaw, R.G., Vetiver Information Network, World Bank).

### **Bio- pesticides for Pest Management**

□ For generations, using neem leaves in storage bags as a means of preventing damage by pests has been employed by farmers in India. It is observed that farmers of West Bengal, Bihar, Andhra Pradesh and Tamil Nadu used it to protect paddy, and those in Madhya Pradesh, Uttar Pradesh, Haryana, Punjab and Maharashtra to protect wheat (Samanta, R.K., Prasad, M.V., 1995).

□ The bins, baskets or cans used for storing the grains are generally made of thatch bamboo, wood or thin sheets of aluminium. Grain is also stored in large earthenware pots, and many of the farmers in the low-income group make use of bamboo baskets, or gunnysacks (bags made of jute fibres). For every 50 kg of grains, about 200 grams of *neem* leaves, together with a few of the more tender branches, are added. This technique can also be used for other types of grain elsewhere in the country and in other parts of the world.

□ Besides, to prevent storage pests in Paddy, neem leaves and Kanjana-mkorai plants which emanate pungent smell are kept along with grains.

□ In the southern part of Satpura plateau, of Madhya Pradesh, seven most effective indigenous practices for dealing with soybean insect pests are identified (Singh, R.K., 2001).

- Dry mahua flowers (*Madhuka india*) are applied to the field at the rate of 10-15 kg/hectare without any other mixture to control Gaygwalan (*Scalopendra spp*) pest that causes economic losses to crop amounting to 20 percent by sucking sap from both leaves and buds of soyabean. The insect, after feeding on the flower, becomes unconscious for 20-25 days, which is enough to save the crop.

- 6-8 kg of freshly collected green neem leaves (*Azadirachta indica*) are boiled in 10 liters of water until the liquid turns dark brown. After 10-12 hours, this is mixed with 80-100 liters of clean water and sprayed on the fields for controlling the girdle beetle (*Oberia brevis*), Bihar hairy caterpillar (*Dicrisia obliqua*) and other pests in soya bean.

### **For rice cultivation**

□□ Chopped pieces of *Colocasia* and sometimes chopped peels of *Citrus grandis* are spread in rice field to drive away the insect pests. In some places *Calotropis gigantea* is grown on bunds of paddy fields to check the insect-pests.

□□ Control of moth and weevil infestation in paddy for every 50 kg of grain storage, 200 gram salt is placed. In a bag of 100 kg paddy, 200gram of salt is added after filling 50 kg and the remaining 50 kg of grain is filled by addition of 200 gram salt for every 50 kgs grain to control the moth and weevil infestation in paddy.

□□ *Vasambu* (*Acotus calamus*) powder and cow urine are mixed in the water that has been boiled and cooled overnight and the seeds are soaked in the solution. The floating seeds are removed. The remaining seeds are used for sowing. This serves the dual purpose of seed selection and treatment of seed borne disease. This is practiced in Tamil Nadu.

□□ In some parts of the high altitude in red and black soils of Arunachal Pradesh tribal farmers used to broadcast paddy seed with ash to overcome dry spells.

### **Application of ITKs in crop management**

□□ Stubbles are burned in the field for controlling pests.

□□ Ash is applied in seedbeds and in the field of onion before sowing and planting for development and improvement of quality of bulbs.

□□ Seeds of Coriander are mixed with Sorghum seed before sowing to completely control Striga (parasitic weed).

□□ Cotton seeds are dipped in cow dung slurry and shade dried before sowing to facilitate better germination.

Pulse seeds are treated with red earth slurry and shade dried for prevention of storage pests and better germination.

Sheep and Goat are penned in fields prior to ploughing, to enrich fertility status of the soil.

### **Application of ITKs in fisheries**

Salting followed by sun drying is effective method of fish preservation

Immediately after dressing and cutting fish into pieces, mustard oil, and salt and turmeric powder are rubbed to prevent spoilage.

Banana stems are put in the ponds after harvest, to make water alkaline, to increase fish growth.

To catch more fish, thorny bushes are used as aggregating devices – especially in summer to enable fish to take shelter and then catch with net.

Glue made from tamarind bark is used for strengthening fishing nets.

Cow dung slurry is used to control the Euglena bloom.

### **In animal husbandry**

Spices of mango pickles and neem leaves are fed to animals to cure bloat.

A bandage with jowar, kerosene and yellow soil is applied for Foot and Mouth disease in cattle

Leaves of Dikkamani (*Gardenia resinifera*) and seeds of Bendval (*Dendrophthoe falcata*) plant are pounded and the mixture is fed to animal to cure the constipation within a day.

To cure swelling of udder caused due to Mastitis, bites of poisonous insects or mechanical injury or improper milking, 200 grams of soil from the termite mounds is collected and boiled in water, and the boiled suspension is given to animal give relief within a day. This is very effective in summer, not so effective in monsoon season.

### **Conclusion**

The Indigenous Technical Knowledge (ITK) is socially desirable, economically affordable, sustainable, involves minimum risk and focus on efficient utilization of ecofriendly resources. The context of local knowledge systems combining traditional skills, culture and artifacts with modern skills, perspectives and tools is not something that has happened only in the recent past. From time immemorial, new crops were introduced from one part of the world to another and cultural and ecological knowledge systems evolved while adapting these crops, animals, trees, tools, etc., into their new contexts. This is an ongoing process. What may set the traditional ways of dealing with local resources and external knowledge and inputs apart, may be a slower trial and error approach which may not necessarily be unscientific. But, it may not be fully compatible with modern methods of experimentation, validation, and drawing inferences. In some cases, the correspondence is close but in many case it may not be. However, it is possible that through flexibility, modification and mutual respect and trust, traditional knowledge experts can and may work with the experts from modern scientific institutions to generate more effective solutions for contemporary problems (Gupta, 2003). Therefore, the need of the day is to establish a foundation at the national level that helps in building national register of innovations, file applications for patents, and provides micro-venture capital support for enterprises based on indigenous knowledge and non-material incentives such as recognizing or honoring innovators and community holding indigenous knowledge. Policy reforms need to be aimed at building local ecological knowledge in educational curriculum, development of markets for the indigenous and organic products and supporting collective resource management institutions reinforcing conservation ethics. It is only through multi-pronged comprehensive approach that the sustainable agriculture can be accomplished on a long term.

### **Question Bank**

1. Define Indigenous Technical Knowledge (ITK). What are the constraints for scouting of ITK? What strategies can be adopted to facilitate scouting of ITK?
2. What are the reasons for refusal for sharing of ITKs?
3. Write short note on: (a) protection for ITK in Indian act; (b) Traditional Knowledge Digital Library (TKDL); (c) Usefulness of ITKs.

## Lecture 10

### Agricultural Resources and its Utilization

#### On the Basis of the Status of Development

**Potential Resources:** Resources which are found in a region, but have not been utilized.

For example, the western parts of India particularly Rajasthan and Gujarat have enormous potential for the development of wind and solar energy, but so far these have not been developed properly.

**Developed Resources:** Resources which are surveyed on their quality and quantity have been determined for utilization. The development of resources depends on technology and level of their feasibility.

**Stock:** Materials in the environment which have the potential to satisfy human needs but human beings do not have the appropriate technology to access these, are included among stock. For example, water is a compound of two inflammable gases; hydrogen and oxygen, which can be used as a rich source of energy.

#### Classification of resources

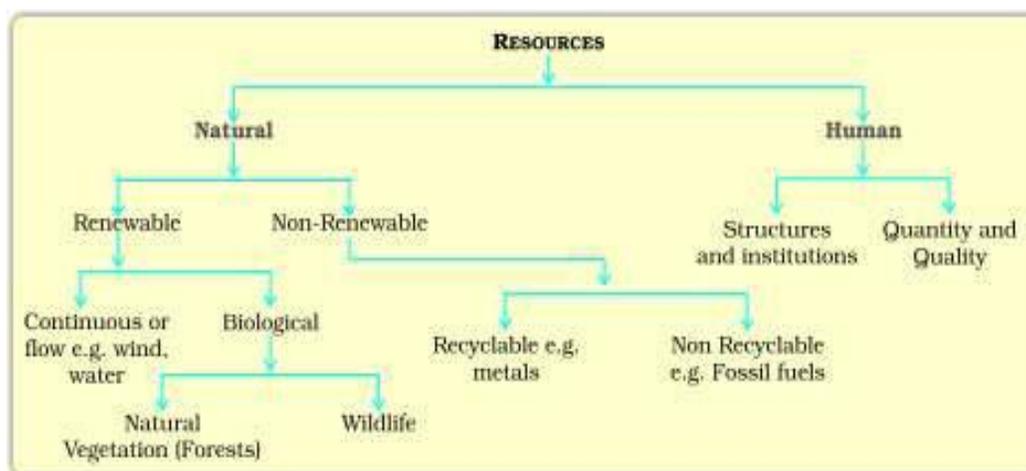


Fig 1: Classification of resources

#### On the Basis of Origin

**Biotic Resources:** These are obtained from biosphere and have life such as human beings, flora and fauna, fisheries, livestock etc.

**Abiotic Resources:** All those things which are composed of non-living things are called abiotic resources. For example, rocks and metals.

#### On the Basis of Exhaustibility

**Renewable Resources:** The resources which can be renewed or reproduced by physical, chemical or mechanical processes are known as renewable or replenishable resources. For example, solar and wind energy, water, forests and wildlife, etc. The renewable resource may further be divided into continuous or

**Non-Renewable Resources:** These occur over a very long geological time. Minerals and fossil fuels are examples of such resources. These resources take millions of years in their formation. Some of the resources like metals are recyclable and some like fossil fuels cannot be recycled and get exhausted with their use.

#### On the Basis of Ownership

**Individual Resources:** These are also owned privately by individuals. Many farmers own land which is allotted to them by government against the payment of revenue. In villages there are people with land

ownership but there are many who are landless. Urban people own plots, houses and other property. Plantation, pasture lands, ponds, water in wells etc. are some of the examples of resources ownership by individuals. Make a list of resources owned by your household.

**Community Owned Resources:** There are resources which are accessible to all the members of the community. Village commons (grazing grounds, burial grounds, village ponds, etc.) public parks, picnic spots playgrounds in urban areas are de facto accessible to all the people living there.

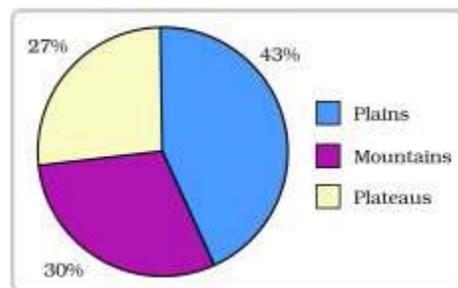
**National Resources:** Technically, all the resources belong to the nation. The country has legal powers to acquire even private property for public good. You might have seen roads, canals, railways being constructed on fields owned by some individuals. Urban

Development Authorities get empowered by the government to acquire land. All the minerals, water resources, forests, wildlife, land within the political boundaries and oceanic area upto 12 nautical miles (22.2 km) from the coast termed as territorial water and resources therein belong to the nation.

**International Resources:** There are international institutions which regulate some resources. The oceanic resources beyond 200 nautical miles of the *Exclusive Economic Zone* belong to open ocean and no individual country can utilise these without the concurrence of international institutions.

### Land resources

We live on land, we perform our economic activities on land and we use it in different ways. Thus, land is a natural resource of utmost importance. About 43 per cent of the land area is plain, which provides facilities for agriculture and industry. Mountains account for 30 per cent of the total surface area of the country and ensure perennial flow of some rivers, provide facilities for tourism and ecological aspects. About 27 per cent of the area of the country is the plateau region. It possesses rich reserves of minerals, fossil fuels and forests.



**Fig 2: Land Resources**

### Land utilization

Land resources are used for the following purposes:

1. Forests
2. Land not available for cultivation
  - (a) Barren and waste land
  - (b) Land put to non-agricultural uses, e.g. buildings, roads, factories, etc.
3. Other uncultivated land (excluding fallow land)
  - (a) Permanent pastures and grazing land,
  - (b) Land under miscellaneous tree crops groves (not included in net sown area),
  - (c) Culturable waste land (left uncultivated for more than 5 agricultural years).
4. Fallow lands
  - (a) Current fallow-(left without cultivation for one or less than one agricultural year),
  - (b) Other than current fallow-(left uncultivated for the past 1 to 5 agricultural years).
5. Net sown area

Area sown more than once in an agricultural year plus net sown area is known as *gross cropped area*.

### Land degradation and conservative measures

We have shared our land with the past generations and will have to do so with the future generations too. Ninety-five per cent of our basic needs for food, shelter and clothing are obtained from land. Human

activities have not only brought about degradation of land but have also aggravated the pace of natural forces to cause damage to land. At present, there are about 140 million hectares of degraded land in India. Approximately, 28 per cent of it belongs to the category of forest degraded area, 56 per cent of it is water eroded area and the rest is affected by saline and alkaline deposits. Some human activities such as deforestation, over grazing, mining and faulty agricultural practices too have contributed significantly in land degradation.

There are many ways to solve the problems of land degradation. Afforestation and proper management of grazing can help to some extent. Planting of shelter belts of plants, control on over grazing, stabilisation of sand dunes by growing thorny bushes is some of the methods to check land degradation. Proper management of waste lands, control of mining activities, proper discharge and disposal of industrial effluents and wastes after treatment can reduce land and water degradation in industrial and suburban areas.

### **Soil as a resource**

Soil is the most important renewable natural resource. It is the medium of plant growth and supports different types of living organisms on the earth. The soil is a living system. It takes millions of years to form soil up to a few cm in depth. Relief, parent rock or bed rock, climate, vegetation and other forms of life and time are important factors in the formation of soil.

Optimum land utilisation is important if agriculture is to be productive. India has a wide variety of soils. The Indian Council of Agricultural Research (ICAR) classifies them into eight major types. Each has its own characteristics as well as deficiencies, and each is suitable for certain crops. Soils should be tested to check their physical characteristics and nutrients before a suitable crop is grown in it: only then can yield be maximised and soil not wasted.

### **Soil Erosion**

Top soil is a valuable resource—it takes nature 50 years or more to build a mere centimetre of it. Yet soil erosion is a major problem worldwide and more so in India. While all soil cannot be protected by trees and grass cover, for crop cultivation is a basic human need, cropping practice can be scientifically managed to reduce waste and erosion through (a) contour bunding—making ridges out of the soil in the field; (b) gully plugging—reducing the speed of run-off water by placing materials like hedges and sand-bags in water channels; (c) planting green manure plants and trees on field bunds; (d) control shifting cultivation which if the land is not left fallow long enough, leads to soil degradation of dangerous proportions.

### **Soil Reclamation**

Growth of population and the increasing demand for agricultural products necessitates reclamation of land hitherto held as unproductive. Reduced soil productivity and abandonment of productive soil are serious issues arising out of salinisation and alkalinisation. Saline and alkaline soils result from centuries of neglect, and mis-management. Estimates of salt-affected soils in India vary, but the Central Soil Salinity Research Institute (CSSRI) puts it at nearly seven million hectares scattered all over the country.

### **Water as a resource**

The water cycle, through evaporation and precipitation, maintains hydrological systems which form rivers and lakes and support in a variety of aquatic ecosystems. Wetlands are intermediate forms between terrestrial and aquatic ecosystems and contain species of plants and animals that are highly moisture dependent. All aquatic ecosystems are used by a large number of people for their daily needs such as drinking water, washing, cooking, watering animals, and irrigating fields. The world depends on a limited quantity of fresh water. Water covers 70% of the earth's surface but only 3% of this is fresh water. Of this, 2% is in polar ice caps and only 1% is usable water in rivers, lakes and subsoil aquifers. Only a fraction of this can be actually used. At a global level 70% of water is used for agriculture about 25% for industry and only 5% for domestic use. However this varies in different countries and industrialized countries use a greater percentage for industry. India uses 90% for agriculture, 7% for industry and 3% for domestic use. One of the greatest challenges facing the world in this century is the need to rethink the overall management of water resources. The world population has passed the 6 billion mark. Based on the

proportion of young people in developing countries, this will continue to increase significantly during the next few decades. This places enormous demands on the world's limited freshwater supply.

India is expected to face critical levels of water stress by 2025. At the global level 31 countries are already short of water and by 2025 there will be 48 countries facing serious water shortages. The UN has estimated that by the year 2050, 4 billion people will be seriously affected by water shortages.

India, situated in the monsoon belt of south-east Asia, is even now dependent to a large extent, on rains for its agriculture. Rainfall is unevenly distributed, and in some years the monsoon fails, resulting in drought. It is a measure of the resilience injected into our agriculture by S&T inputs that we are not so severely affected by droughts now as in the past.

The geographic situation of the country forces us to learn to cope with inconsistent monsoons. The average annual rainfall we receive is about 370 million hectare-metres of which about 80 million hectare-metres of water seeps into the soil.

Half of this remains in the top soil and helps plant growth; the rest goes further down to constitute groundwater. However, it must be noted that saline groundwater is not useful for irrigation, so useful groundwater, according to recent reports, has depleted alarmingly.

Water being a key input for crop production its deficiency acts as a bottleneck in the use of other inputs. In India, several irrigation schemes—major; medium and minor—have been implemented.

However, the efficiency of most irrigation projects is low, causing a sizeable gap between the created and the utilized potential. Theoretically, irrigation should make possible double and multiple cropping but this is still not the case in much of the irrigated area in India. Water scarcity is an increasingly serious problem.

### **Irrigation Projects**

There was a time when the multipurpose river valley projects were hailed as the harbingers of prosperity. However, their success has been overrated. Serious problems have arisen. Heavy siltation of the reservoirs of major dams reduces storage capacity, and they become incapable of absorbing heavy floods. Disastrous fallout is the degradation of the soil in the command areas of irrigation projects due to water-logging and soil salinity.

Canal irrigation, again, has contributed to land degradation. Groundwater table rises due to accession of applied water to groundwater through deep percolation from unlined field channels, distributaries and main canals, and restrictive drainage due to construction activities.

When the groundwater table rises to within 1 to 2 metres of the ground surface, it contributes significantly to evaporation from the soil surface, leaving the dissolved salts in the root zone of soils. The salt content of most groundwater in the arid and semi-arid regions is high. This further accentuates the processes leading to the formation of salt-affected soils. There are numerous examples of land degradation following the introduction of canal irrigation.

The water from the Bhakra canal system was made available in Hissar district in Haryana in 1963. Large areas irrigated by the canal are already salinised. Similar experiences are available in the area of the Tungabhadra irrigation project in Karnataka and in the Nagajuna Sagar command area. The problems in the Rajasthan Canal command area have acquired serious proportions.

### **Better Use of Water**

The emphasis on minor irrigation works in recent years is worth noting. Groundwater development is part of this. Minor irrigation schemes, besides being an instant and reliable source of water, also help to control water logging and salinization in canal command. States have taken up 'on-farm development' works in all the command areas and are introducing warabandhi / intermittent water delivery methods to reduce water application even while increasing farm production.

Sprinkler irrigation is water-efficient, and has been introduced in canal irrigated areas of Haryana, Rajasthan and Madhya Pradesh. Drip irrigation is being encouraged in Maharashtra, Karnataka, Andhra Pradesh, Orissa, and Tamil Nadu for fruit crops, horticultural crops and field crops. 'Fertigation' is an innovation: the application of fertilizer through drip irrigation to maximize farm productivity with available water.

**Global climate change:** Changes in climate at a global level caused by increasing air pollution have now begun to affect our climate. In some regions global warming and the El Nino winds have created unprecedented storms. In other areas, they lead to long droughts. Everywhere the 'greenhouse effect' due to atmospheric pollution is leading to increasingly erratic and unpredictable climatic effects. This has seriously affected regional hydrological conditions.

**Floods:** Floods have been a serious environmental hazard for centuries. However, the havoc raised by rivers overflowing their banks has become progressively more damaging, as people have deforested catchments and intensified use of river flood plains that once acted as safety valves. Wetlands in flood plains are nature's flood control systems into which overflowed rivers could spill and act like a temporary sponge holding the water, and preventing fast flowing water from damaging surrounding land. Deforestation in the Himalayas causes floods that year after year kill people, damage crops and destroy homes in the Ganges and its tributaries and the Brahmaputra. Rivers change their course during floods and tons of valuable soil is lost to the sea. As the forests are degraded, rainwater no longer percolates slowly into the subsoil but runs off down the mountainside bearing large amounts of topsoil. This blocks rivers temporarily but gives way as the pressure mounts allowing enormous quantities of water to wash suddenly down into the plains below. There, rivers swell, burst their banks and flood waters spread to engulf peoples' farms and homes.

**Drought:** In most arid regions of the world the rains are unpredictable. This leads to periods when there is a serious scarcity of water to drink, use in farms, or provide for urban and industrial use. Drought prone areas are thus faced with irregular periods of famine. Agriculturists have no income in these bad years, and as they have no steady income, they have a constant fear of droughts.

India has 'Drought Prone Areas Development Programs', which are used in such areas to buffer the effects of droughts. Under these schemes, people are given wages in bad years to build roads, minor irrigation works and plantation programs. Drought has been a major problem in our country especially in arid regions. It is an unpredictable climatic condition and occurs due to the failure of one or more monsoons. It varies in frequency in different parts of our country. While it is not feasible to prevent the failure of the monsoon, good environmental management can reduce its ill effects. The scarcity of water during drought years affects homes, agriculture and industry. It also leads to food shortages and malnutrition which especially affects children.

Several measures can be taken to minimize the serious impacts of a drought. However this must be done as a preventive measure so that if the monsoons fail its impact on local people's lives is minimized. In years when the monsoon is adequate, we use up the good supply of water without trying to conserve it and use the water judiciously. Thus during a year when the rains are poor, there is no water even for drinking in the drought area. One of the factors that worsen the effect of drought is deforestation. Once hill slopes are denuded of forest cover the rainwater rushes down the rivers and is lost. Forest cover permits water to be held in the area permitting it to seep into the ground. This charges the underground stores of water in natural aquifers. This can be used in drought years if the stores have been filled during a good monsoon. If water from the underground stores is overused, the water table drops and vegetation suffers. This soil and water management and afforestation are long-term measures that reduce the impact of droughts.

**Water for Agriculture and Power Generation:** India's increasing demand for water for intensive irrigated agriculture, for generating electricity, and for consumption in urban and industrial centers, has been met by creating large dams. Irrigated areas increased from 40 million ha. in 1900 to 100 million ha in 1950 and to 271 million ha by 1998. Dams support 30 to 40% of this area. Although dams ensure a year round supply of water for domestic use, provide extra water for agriculture, industry, hydropower generation, they have several serious environmental problems. They alter river flows, change nature's flood control mechanisms such as wetlands and flood plains, and destroy the lives of local people and the habitats of wild plant and animal species. Irrigation to support cash crops like sugarcane produces an unequal distribution of water. Large landholders on the canals get the lion's share of water, while poor, small farmers get less and are seriously affected.

**Sustainable water management:** ‘Save water’ campaigns are essential to make people everywhere aware of the dangers of water scarcity. A number of measures need to be taken for the better management of the world’s water resources. These include measures such as:

- Building several small reservoirs instead of few mega projects.
- Develop small catchment dams and protect wetlands.
- Soil management, micro catchment development and afforestation permits recharging of underground aquifers thus reducing the need for large dams.
- Treating and recycling municipal waste water for agricultural use.
- Preventing leakages from dams and canals.
- Preventing loss in Municipal pipes.
- Effective rain water harvesting in urban environments.
- Water conservation measures in agriculture such as using drip irrigation.
- Pricing water at its real value makes people use it more responsibly and efficiently and reduces water wasting.
- In deforested areas where land has been degraded, soil management by bunding along the hill slopes and making ‘nala’ plugs, can help retain moisture and make it possible to re-vegetate in the degraded areas.

### 3. Seeds

There was a time when you could get certain vegetables in certain seasons only. Not now: these days you get cabbages and cauliflowers practically the whole year through. By genetic manipulations, scientists have brought about change in the genetic architecture of plants (such as dwarf and bushy) and in the development rhythms of plants (for example when the plant flowers) so that they are no longer “season bound” but “period fixed”. These new varieties can be fitted in rotation with other crops, or the simultaneous cultivation of crops can increase production and productivity.

Scientists create ideotypes, or plants with ideal frame and desirable characteristics, chosen after scanning the wide variations in the available germplasm. By incorporating several of the desirable characters in one variety they create a hybrid which may be not only high-yielding but also pest- and disease-resistant, and of short duration.

There are three stages in the seed production cycle for efficient implementation of the high yielding varieties (HYV) programme. Breeder seed is the primary stage. It is multiplied into foundation seeds to be multiplied finally into certified (quality) seeds which are distributed to all farmers in all regions.

The government set up the **National Seeds Corporation (NSC)** in 1963 and the **State Farms Corporation of India (SFCI)** and **State Seed Corporations (SSCs)**. They produce and supply quality seeds. The ICAR organises production of breeder seeds with the breeders’ cooperation with the scientists concerned. Seed technology research was initiated in a coordinated manner in 1979 on receipt of indents from state governments.

The National Seeds Project Phase III (NSP-III), launched in March 1990 with World Bank assistance, ended in June 1996, but its residual activities are still continuing. NSP-III had two components—(a) **project component** under which funds were released for (i) investment credit to seed sector through NABARD; (ii) varietal development and breeder seed production through ICAR; (iii) strengthening of seed certification and testing agencies; (iv) institutional strengthening; and (b) **programme component** under which funds were released to State Seed Corporations, NSC and SFCI for their financial and organisational restructuring.

### 4. Agro techniques

Besides seeds, soil and water, agro-techniques are also an important factor in maximising yield of crops.

#### Cropping Systems

Land being limited, it becomes necessary to grow two or more crops a year on the same piece of land to produce enough to meet our needs. Thus multiple cropping practices are to be encouraged. In a relay cropping system, a crop is sown before the harvesting of the preceding crop— this saves water, for the last irrigation for one crop is the pre-sowing irrigation for the other.

In mixed cropping, compatible crops are sown in parallel rows with the main crop. Chickpea and mustard can be sown with wheat; pigeonpea, cowpea, mungbean, groundnut, and soyabean can be alternated with sorghum, maize, sugarcane, and cotton.

Indian farmers have gradually adopted multiple cropping system, but not to the extent desirable.

### **Fertilizer Use**

Certain elements are essential for plants. The criteria for essentiality are (i) the element must be directly involved in the nutrition of a plant; (ii) the life cycle of a plant cannot be complete without the element; (iii) the element cannot be replaced by any other element. A fertilizer is a compound containing one or more nutrient elements needed for plant growth. Manure is a natural substance obtained by the decomposition of animal excreta or plant residues. Fertilizers providing only one nutrient element mainly are called single fertilizers: potassium (K) fertilizers, nitrogen (N) fertilizers, and phosphorous (P) fertilizers. Fertilizers providing any two of K, N and P are called mixed fertilizers. A fertilizer supplying all the three elements belongs to the NPK type and is said to be a complete fertilizer.

The introduction of these high-yielding dwarf fertiliser- responsive varieties enabled a real breakthrough in fertilizer consumption in the country. Generalized application of available fertilizer mixture such as the well-known NPK combination in the ratio of 120:60:40 can be quite wasteful and counterproductive.

Emphasis must be laid on integrated nutrient management (INM) through the combined use of chemical fertilizers, organic manures and bio-fertilizers. Fertilizers which supply the micronutrients to the soil are called micro-fertilizers. Their application increases the resistance of plants to various diseases and results in better yield of crops. The water solutions of micro-fertilizers are also used for moistening seeds before sowing and also for spraying of plants. Few examples of micro-fertilizers are borax, boric acid, manganese sulphate.

### **Balanced Use of Fertilizers**

Decontrol and consequent price rise resulted in reduced consumption of phosphatic and potassic fertilisers and deterioration in the NPK use ratio to 9.5:3.2:1 in 1992-93. With the enhancement of the rates of concession and removal of some other constraints, consumption of phosphatic and potassic fertilisers has increased significantly. Application of balanced fertilizer is judicious than indiscriminate use.

### **Conclusion**

Crop production depends on the availability of cultivable land and it is influenced by yields, macroeconomic uncertainty and patterns of consumption. Agriculture is the main source of income for major part of our country's population. India's population is growing faster at 1.8 per cent per annum and it is a huge task to fulfill the requirement of food for the nation. The required level of improvement in production technology of crops along with domestic of marketing, storage infrastructure is estimated to be huge. The country produces innumerable crops ranging from medicinal to cereal crops under its diverse agro-climatic zones. Majority of farmers of the country are still unable to harvest the gains from application of modern science and sustainable agricultural technologies. As a result, the yield of many important crops in India is inferior to the productivity recorded in agriculturally developed nations. Therefore, their capacity to take advantage of the opportunities presented by liberalization of trade is limited. Efficient and effective management of resources will be crucial in the years to future for acquiring enduring self-reliance and ensuring sustainable growth with an emphasis on consideration of equity and food security.

### **Question Bank**

1. Classify resources. What natural resources are important for crop production and how?
2. Write a brief note on land and water resources of India.
3. Write brief notes on the following.
  - a) Soil erosion and conservation;
  - b) Sustainable water management

## Lecture 11

### Agricultural Setup in India

India has one of the better agricultural research systems in the world with the better amount of exact cadre of any developing country except China. The research system includes about 30,000 scientists and added than 100,000 acknowledging agents actively affianced in research accompanying to agricultural research in India looks actual impressive, it compares under agreeably with thousands of developed countries. The present agricultural research system comprises of two capital streams, the ICAR at the National akin and the Agricultural Universities at the Multi-disciplinary level. Besides, several added agencies such as General Universities, Exact Organizations, and assorted Ministries/Departments at the Centre, as well Non-public or Voluntary Organizations participate anon or alongside in research activities accompanying to agriculture.

1. ICAR System;
2. SAU System; and
3. Other Agencies.

#### 1. ICAR System

The ICAR has the afterward aloft objectives:

- (i) to undertake, aid, advance and alike agricultural, animal husbandry and fisheries education, research, and its application;
- (ii) to act as an allowance abode of research and General advice apropos to agricultural and veterinary matters;
- (iii) to advance a research and advertence library;
- (iv) to do added things advised all-important to attain the aloft objectives; and
- (v) to accommodate consultancy casework in the fields of education, research and training in agriculture and allied sciences.

#### Research Infrastructure of the ICAR

Although agriculture is a Multi-disciplinary subject, ICAR has accustomed thousands of Central Research Institutions over the years to accommodate the agricultural research needs of the country. These are about meant for:

- (i) implementing research mandates extending above the authoritative boundaries of the States;
- (ii) advancing basal research not undertaken by a lot of Agricultural Universities;
- (iii) evaluating research after-effects through multi - locational testing;
- (iv) developing manpower for agricultural universities and added agricultural institutions.

**Central Research Institutes:** ICAR administers 49 research institutes in the areas of crop, Animal and fishery sciences. These are as follows.

**(a) Research Management Academy:** National Academy of Agricultural Research Management (NAARM) originally started as Central Agents College for Agriculture, at Hyderabad provides research Management training to the agricultural scientists in the country. In addition, it organizes seminars, conferences and workshops, both National and international, based aloft the exact studies and reviews undertaken on the Management problems encountered in the research system.

**(b) National Bureau:** In adjustment to collect, conserve and admit such measures as would advance to abiding affluence of basal research like plants, animals, fish, soil, and water, ICAR has accustomed **four** National bureau. These are:

1. National Bureau of Plant Genetic Research (NBPGR) at New Delhi
2. National Bureau of Soil Survey & Plantation Use Planning (NBSS&LUP) at Nagpur
3. National Bureau of Animal Genetic Research (NBAGR) at Karnal
4. National Bureau of Fish Genetic Research (NBFGR) at Lucknow

**(c) Crop Science Institutes:** There are **nine** crop science institutes accustomed out basal and activated research on specific crops and appointment the after-effects thereof. They are:

1. Indian Agricultural Research Institute (IARI) at New

2. National Rice Research Institute (CIRRI) at Cuttack
3. Central Research Institute for Jute and Allied Fibers (CRIJAF) at Barrackpore
4. Central Tobacco Research Institute (CTRI) at Rajahmundry
5. Indian Grassplantation and Fodder Research Institute (IGFRI) at Jhansi
6. Sugarcane Breeding Institute (SBI) at Coimbatore
7. Indian Institute of Sugarcane Research (IISR) at Lucknow
8. Central Institute of Cotton Research (CICR) at Nagpur
9. Vivekananda Parvatiya Krishi Anusandhan Shala (VPKAS) at Almora

**(d) Horticulture and Plantation Crops Institutes:** There are **six** horticultural and plantation crops institutes administering and analogous research on the crops they accord with. They are:

1. Indian Institute of Horticultural Research (IIHR) at Bangalore
2. Central Institute of Horticultural for Northern Plains (CIHNP) at Lucknow
3. Central Institute of Tropical Horticultural (CITH) at Srinagar
4. Central Potato Research Institute (CPRI) at Shimla
5. Central Tuber Crop Crops Research Institute (CTCRI) at Trivandrum
6. Central Plantation Crops Research Institute (CPCRI) at Kasargod

**(e) Resource Management Institutes:** There are **eight** Resource Management institutes which are primarily amenable for adventure research on Soil and water absorption for optimizing assembly of crops under altered conditions. They are:

1. Central Soil and Water Conservation Research and Training Institute (CSWCR&TI) at Dehradun
2. Central Soil Salinity Research Institute (CSSRI) at Karnal
3. Central Arid Zone Research Institute (CAZRI) at Jodhpur
4. Central Research Institute for Dry Land Agriculture (CRIDA) at Hyderabad
5. ICAR Research Complex for North-Eastern Hill Region (ICAR-NEH) at Shilling
6. ICAR Research Complex for Goa (ICAR-GOA) at Ella
7. Central Agricultural Research Institute (CARI) for Andaman and Nicobar Island plantations at Port Blair
8. Indian Institute of Soil Science (IISS) at Bhopal

**(f) Technical Institutes:** The Technical and engineering problems in crop assembly and above of bartering crops are handled by **five** institutes. They are:

1. Central Institute of Agricultural Engineering (CIAE) at Bhopal
2. Central Institute for Research on Cotton Technology (CIRCOT) at Mumbai
3. National Institute of Research on Jute and Allied Cilia Technology (NIRJAFT) at Calcutta
4. Indian Lac Research Institute (ILRI) at Ranchi
5. Central Institute of Postharvest Engineering and Technology (CIPET) at Ludhiana

**(g) Animal Science Institutes:** Eight animal science institutes accept the authorization of Breeding animals for college affluence and advance bigger Management practices. They are:

1. Indian Veterinary Research Institute (IVRI) at Izatnagar, a Deemed University
2. National Dairy Research Institute (NDRI) at Karnal, a Deemed University
3. Central Sheep and Wool Research Institute (CSWRI) at Avikanagar
4. Central Institute for Research on Goats (CIRG) at Makhdoom
5. Central Arid Research Institute (CARI) at Izatnagar
6. Central Institute for Research on Buffaloes (CIRB) at Hissar
7. National Institute of Animal Research (NIAR) at Karnal
8. National Institute of Animal Nutrition and Physiology (NIANP) at Bangalore

**(h) Fisheries Institutes:** **Six** fisheries institutes conduct studies for assessing the assembly of fish, conduct training programmes and undertake Research. These are as follows.

1. Central Inland Capture Fisheries Research Institute (CICFRI) at Barrackpore
2. Central Marine Fisheries Research Institute (CMFRI) at Cochin
3. Central Institute of Fisheries Education (CIFE) at Mumbai has the Deemed University status.
4. Central Institute of Fisheries Technology (CIFT) at Cochin

5. Central Institute of Brackishwater Aquaculture (CIBA) at Chennai
6. Central Institute of Freshwater Aquaculture (CIFA) at Dhauli, Bhubaneswar

**(i) Social Science Institutes:** Two institutes appear under this category. These are as follows.

1. Indian Agricultural Statistics Research Institute (IASRI) at New Delhi
2. National Centre for Agricultural Economics and Policy Research (NCAP) at New Delhi

**Project Directorates:** There are now **ten** of them under operation. These are:

1. Directorate of Rice Research, Hyderabad;
2. Directorate of Wheat Research, Karnal;
3. Directorate of Pulses Research, Kanpur;
4. Directorate of Oilseeds Research, Hyderabad;
5. Project Directorate on Vegetables, Varanasi;
6. Directorate of Agriculture Systems Research, Modipuram;
7. Project Directorate on Water Management, Bhubaneswar;
8. Project Directorate on Cattle, Meerut;
9. Project Directorate on Poultry, Hyderabad;
10. Directorate of Maize Research, New Delhi.

**National Research Centers:** The National Commission on Agriculture recommended ambience up of 'Centers of Research' headed by eminent scientists in exact areas. Consequently, the ICAR conceived the abstraction of ambience up an amount of National Research Centers (NRCs). The abstraction of NRCs revolves about the charge for concentrated conservation with a mission access by an aggregation of scientists from altered disciplines.

The NRC for Groundnut was the aboriginal to be organized in 1979, and the NRC for Cashew is of the added contempt ones established.

There are now **31 such Centres**, area an advanced ambit of areas like crops, horticulture, Animal species, fisheries, Resource management, etc. 5 added accustomed centers are yet to be established.

Some of the NRCs may abound into full-fledged institutes already their General of plan is accustomed and if the capacity accepts greater national importance.

**Research Schemes/Projects:** In alternative to its institute-based Research, ICAR promotes research schemes/projects in agriculture and Allied areas to boldness location-specific problems. It is complex in an accommodating endeavor with added research organizations in accustomed out multidisciplinary research programmers. Such promotional schemes are abatement under the afterward categories.

**All India Coordinated Research Projects (AICRPs):** These projects accept been about conceived as an apparatus to activate accessible exact Research to acquisition able solutions for the National problems of agricultural assembly through inter-institutional interactions. The projects are developed as multidisciplinary and problem-oriented projects with aloft accent on multi-locational testing of new materials/production systems. They accommodate opportunities for scientists alive on agnate problems in altered institutions to appear together, altercate and barter ideas, information, and abstracts for alternate benefit.

There are 70 such projects currently operating at 1,291 operating centres. Of these, 904 Centres are amid in Agricultural Universities; 190 in ICAR Institutes; and the blow at added institutions. Crop sciences accept 34 projects operating at 627 centres; and Soil science and agricultural engineering accept 20 projects at 364 centres. The amount on these projects has added steadily and about division of the ICAR's account is now spent on these projects. The multi-disciplinary of staff, bent on the abject of the Technical plan assigned and the attributes of operation, are provided by the coordinated institutions, but paid for by the ICAR. The amount is aggregate by the ICAR and the coordinated institutions on 75:25 bases.

A top amount of accountability, based on connected monitoring, is noteworthy Cotton of these projects. Outstanding achievements accept been fabricated through these projects, and the development of such an access has been a antecedent of afflatus to thousand of developing countries.

**National agricultural research Project (NARP):** Agricultural Universities which accept a state-wide authorization for agriculture did not accept a able abject for research at the bounded akin and a lot of the funds provided were activated for developing the University capital campuses, appropriately apathy the

bounded research needs. To affect this, the ICAR launched in 1979, with World Bank assistance, an atypical system General as National Agricultural Research Project (NARP) to strengthen the bounded research capabilities of these Universities for administering need-based, location-specific and production-oriented research in particular agro-climatic zones. Under this project, anniversary Multi-disciplinary is disconnected into an abutting set of agro-climatic zones on the subject of climate, soils, crops and ecology. There are 131 such zones in the country with 125 zones in 17 States and Union Territories, and 6 zones in the North Eastern Region. In anniversary zone, a aloft bounded research base with a multidisciplinary aggregation of scientists is accustomed or strengthened.

## **2. Agricultural university system**

- Acharya NG Ranga Agricultural Univ., Rajendranagar, Hyderabad-500030, A.P.;
- Anand Agricultural University, Anand-388110, Gujarat
- Assam Agricultural University, Jorhat-785013, Assam
- Bidhan Chandra Krishi Viswavidyalaya, P.O Krishi Viswavidyalaya, Mohanpur, Nadia-741252, WB
- Birsa Agricultural University, Kanke, Ranchi- 834006, Jharkhand
- Central Agricultural University, Imphal -795004, Manipur
- Chandra Shekar Azad Univ. of Agriculture & Technology, Kanpur- 208002, U.P
- Chaudhary Charan Singh Haryana Agricultural University, Hissar-125004, Haryana
- Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya, Palampur, Kangra- 176062, Himachal Pradesh
- Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri-415712, Maharashtra
- Dr Panjabrao Deshmukh Krishi Vidyapeeth, Krishi Nagar, Akola-444104, Maharashtra
- Dr Yashwant Singh Parmar Univ. of Agriculture & Forestry, Solan, Nauni – 173230, Himachal Pradesh
- Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Udham Singh Nagar-263145, Uttarakhand
- Guru Angad Dev University of Veterinary and Animal Sciences, Ludhiana-141004, Punjab
- Indira Gandhi Krishi Vishwavidyalaya, Krishak Nagar, Raipur-492006, Chhattisgarh
- Jawaharlal Nehru Krishi Vishwavidyalaya, Krishi Nagar, Jabalpur- 482004, M.P.
- Junagadh Agriculture University, Moti Baug, Agril.Campus, Junagadh-362001, Gujarat.
- Karnataka Veterinary Animal and Fisheries Science University, P.B. No. 6, Nandinagar, Bidar-585401, Karnataka
- Kerala Agricultural University, P.O Vellanikkara, Thrissur-680656, Kerala
- Maharana Pratap Univ. of Agriculture & Technology, Udaipur-313001, Rajasthan
- Maharashtra Animal Science & Fishery University, Nagpur, Maharashtra
- Mahatma Phule Krishi Vidyapeeth, Rahuri-413722, Maharashtra
- Marathwada Agricultural University, Parbhani -431402, Maharashtra
- Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad- 224229, Uttar Pradesh
- Navsari Agricultural University, Vijalpore, Navsari-396450, Gujarat
- Orissa Univ. of Agriculture & Technology, Siripur, Bhubaneswar-751003, Orissa
- Punjab Agricultural University, Ludhiana -141004, Punjab
- Rajasthan Agricultural University, Bikaner -334006, Rajasthan
- Rajendra Agricultural University, Pusa, Samastipur-848125, Bihar
- Sardar Vallabh Bhai Patel University of Agriculture & Technology, Modipuram, Meerut-250110, UP
- Sardarkrushinagar-Dantiwada Agricultural University, Dantiwada, Banaskantha-385506, Gujarat
- Sher-E-Kashmir Univ. of Agricultural Sciences & Technology, Railway Road, Jammu- 180012 (J&K).
- Sher-E-Kashmir Univ. of Agricultural Sciences & Technology, Shalimar, Srinagar- 191121, (J&K).
- Sri Venkateswara Veterinary University, Tirupati, Chittoor- 517502, A.P.
- Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu
- Tamil Nadu Veterinary & Animal Sciences University, Madhavaram Milk Colony, Chennai- 600051
- University of Agricultural Sciences, Dharwad, Karnataka
- University of Agricultural Sciences, Bangalore- 560065, Karnataka.

- UP Pandit Deen Dayal Upadhaya Pashu Chikitsa Vigyan Vishwa Vidhyalaya Evam Go Anusandhan Sansthan, Mathura- 281001, Uttar Pradesh
- Uttar Banga Krishi Vishwavidyalaya, P.O. Pundibari, Distt. Cooch Behar-736165, West Bengal
- West Bengal University of Animal & Fishery Sciences, 68 KB Sarani, Kolkata-700037, West Bengal
- University of Agricultural Sciences, Venkataramnagudem, West Godavari, A.P.
- Rajmata VRS Agricultural University, Gwalior-474002, Madhya Pradesh.
- University of Agricultural Sciences, Navanagar, Bagalkot-587101, Karnataka
- University of Agricultural Sciences, Raichur-584102, Karnataka

#### **Deemed University**

- Indian Agricultural Research Institute, Pusa-110012, New Delhi
- Indian Veterinary Research Institute, Izatnagar, Bareilly-243122, Uttar Pradesh
- National Dairy Research Institute, Karnal-132001, Haryana
- Central Institute of Fisheries Education, Mumbai-400061, Maharashtra
- Allahabad Agricultural Institute, Allahabad-211007, Uttar Pradesh

#### **Central University with agriculture**

- Banaras Hindu University, Varanasi, U.P.
- Aligarh Muslim University, Aligarh, U.P.
- Visva-Bharati, Shantiniketan, West Bengal
- Nagaplantation University, Medizipherma, Nagaplantation

### **Research setup in India**

**1. Research infrastructure:** Basically, the research Infrastructure consists of an agreement base at the campus and an amount of research stations and substations amid in altered locations of the State. There are numbers of research stations acceptance SAUs, alive on location-specific problems. Generally, the research programmes are headed by the Directors of Research, who are assisted by the Associate Directors of Research amid at the bounded research stations aural the State. Some Agricultural Universities accept accustomed Modernization Centres by accumulation accompanying capacity in areas such as Plant protection, research and Plant breeding, agricultural engineering, agricultural economics, water technology, etc. In adjustment to undertake need-based and location-specific Research, networks of Zonal Research Centres accept been accustomed back 1979 with abetment from the World Coffe under NARP. These Centres calculation about 131 in the country, anniversary amid in an audible agro-climatic zone, is an allotment of the Agricultural Universities System.

**2. Research planning, anatomy and evaluation:** Agricultural Universities accept State-wide albatross for research in agriculture. In those States where, added than one University is there, the research responsibilities are aggregate on the bounded basis. To ensure accordant research planning, their able accomplishing and able evaluation, anniversary Agricultural University has a Research Council or a Research Advising Committee as an acme physique for action conception and allocation of research activities. This body, chaired by the Vice-Chancellor comprises Director of Research, Director of Extension Education, Deans of basal colleges, assembly of Multi-disciplinary Departments and farmers. It reviews periodically the all-embracing cachet of research activities in the University, and determines their priorities and approaching direction. Research is organized under; (i) University Research; (ii) Postgraduate apprentice Research; and (iii) Coordinated research programmes. The Director of Research, who is the all-embracing in-charge of Research, prepares an anniversary plan advertence the capital thrusts of research aural the ample admonition accustomed by the Research Advising Committee. The Directorate of Research is amenable for research and evaluation, and appropriate advertisement of research after-effects and reports. By and large, the alone scientists codify research projects which are again scrutinized by the anxious Department Head, advised at the Faculty/Departmental akin and assuredly accustomed by the University Research Advising Committee. Thereafter, the Director of Research and Department Heads accommodate funds and accessories to the scientists. In account of research done by agents and postgraduate students, the Director of Research acts in allocation with the Deans/Principals of the corresponding colleges.

### **3. Added agencies admit agricultural education**

General Universities with well-developed commonsense in agriculture, or able departments affianced in areas such as genetics, plant physiology, mycology, entomology, biochemistry, economics, chemistry, marine biology, home science, etc. accept fabricated characteristic contributions to agricultural research in the country. Besides, the Central Universities like the Banaras Hindu University, Shanti Niketan accept Institutes/Schools of Agricultural Sciences which are affianced in research in agriculture and allied areas, some of which are recognized by the ICAR.

**4. Organizations:** More other scientific organizations either undertake research, or sponsor and abutment programmes accompanying to agriculture. The Council of Scientific and Industrial Research (CSIR), through its system of National Laboratories, provides research abutment in areas like processing of agricultural products, recycling of agricultural wastes, development of assorted agro-chemicals, etc. The Indian Council of Medical Research's (ICMR) research on the comestible qualities of assorted agricultural aftermath including toxicity and of agricultural workers accept plentiful helped the ICAR in planning its research programmes. Some of the areas in which the Bhabha Atomic Research Centre (BARC) is actively affianced are the development of newer varieties of crops and canning of agricultural produce. The Indian Space Research Organization (ISRO) is allowance the research system to appraise India's Soil and water resources. Technological institutions like IIT, Kharagpur, are alive in the fields of agricultural engineering, Soil and water management, and agronomy.

The Department of Science and Technology (DST) promotes research in the country.

On Genetic engineering a column technology and areas of basal sciences admiring to agriculture has also been consituted. The Department of Non-Institution Project Sources works on the appliance of solar and wind energies and biogas for agricultural purposes. The Department of Meteorology is actively affianced in research on crop-weather forecasting. The Department of Ocean Development is complex in assessing the fishery Research in the country and promotes research in the breadth of fisheries.

In addition, institutions like the National Dairy Development Board (NDDB) under the Agriculture Ministry; assorted Article Boards like Silk, Coffee, Rubber, Tea, and Cardamon Boards under the Commerce Ministry; and the Forest Research Institute and Waste Plantation Development Board under the Ministry of Forestry and Environment advice in deepening the agricultural research system in the country.

**5. Non-public/Private Sector:** Captivation of non-public breadth in agricultural research is of contempt origin. In mid 1960s, several non-public companies started programmes mainly to advance amalgam maize, sorghum and *bajra*. Research on vegetables started in backward 1960s. Non-public breadth research is bedfast mainly to breeding crop hybrids, assertive Plantation crops, agro-chemicals, poultry, and agricultural machinery.

Private breadth research in industry has developed complete rapidly. Several non-public companies are now affianced in the assembly of amalgam seeds of an array of crops like cotton, sorghum, *bajra*, maize, vegetables, *red gram*, rice, etc., and consign industry has as well emerged. There are at atomic ten non-public companies adventure Plant Breeding Research, and several others are complex in Plant aegis Research. Besides their own research stations, these companies conduct abstracts on farmers' fields. They research the bio-efficiency of insecticides and herbicides that are new to India as able-bodied as amalgamate new compounds. Non-public research in bandy breadth is of contempt origin. Although Government alien birds in bartering bandy industry, they were affected by the non-public breadth and thousands of companies are now actively affianced in it. Thousands of added ample automated apropos are affianced in research on shrimps and shrimp feed.

Some non-public companies undertake aloft research and development programmes and it seems to be primarily aimed at convalescent quality, ammunition ability and engine durability. Some companies are now affective into agricultural implements. Research in pump industry is aimed at accretion the ability of pumps through bigger architecture and bigger materials. Some companies are even experimenting with non-Institute sources of power. Historically, non-public companies in the processing and Plantation breadth accept been an complete important antecedent of new agricultural technology. Some of the arresting ones cover Indian Amoroso Mills Association, Southern Planters Association, Textile Mills

Association, Silk Industry, etc. Some ample firms are complex in research on Animal nutrition, Plant advance regulators, biotechnology like tissue ability in cardamom, sugarcane, attic and tea, bio-fertilizers. Research in the breadth of timberline agriculture including in vitro ability and timberline Breeding is as well accepting Conservation of non-public firms.

Some of the complete institutions such as Allahabad Agricultural Institute, Bharatiya Agro-Industries Foundation, Complete Research Association, and United Planters Association of South India undertake short-term, mission-oriented research projects exact by the ICAR for multi-locational testing of varieties and agro-techniques.

In adjustment to advance exact research and the accord of industry in it, the Government through the Income Tax Act of 1961 has offered assertive tax concessions apropos to the amount on exact Research. The captivation of non-public agencies in agricultural research is accepting drive with greater composure in Technical development and the affairs of top allotment on investment in agriculture.

**6. Technology mission in agriculture:** A mission-oriented access to technology development was emphasized to faster appliance and to accommodate action for establishing alive linkages amid altered sectors, which contrarily remained compartmentalized. The Steering Accumulation on Science and Technology, constituted by the National Planning Commission, has identified.

Example: Technology Mission on Oilseeds; Technology Mission on Cotton and so on.

### **Conclusion**

Department of Agricultural research and Education (DARE) coordinates and promotes agricultural research and education in the country. DARE provides the all-important government linkages for the Indian Council of Agricultural Research (ICAR), the other research organization for co-coordinating, allegorical and managing research, education and Extension in agronomics including horticulture, fisheries and Animal sciences in the complete country. The setup has got 102 research institutes and 73 agricultural universities (at present, as on June, 2018) advance beyond the country, the National Agricultural Research System (NARS) is one of the better in the world. ICAR Institutes accept the Departments of Extension, the Agricultural Universities accept the directorates of Extension to identify, research and clarify the communicable agricultural technologies and added accompanying advice appearing from research as able-bodied as to authorize able communication a part of assorted departments and added stakeholders both the accessible and non-public for their transfer. KVKs as well accommodate Technical backstopping to 'Agriculture Technology Management Agencies' (ATMA), an arrangement adjourned by the Department of Agronomics Cooperation and Farmers Welfare (DAC&FW) and added agencies at the commune level. A commune Collective Action Plan for acceptable interface amid scientists, Extension functionaries and farmers is able through a collective affair of KVK and ATMA admiral under the chairmanship of the Commune Collector. An annual interface meeting, involving all band departments of the district, is captivated by all KVKs to adviser the accomplishing of the Collective Action Plan and to allotment new advice and technologies for added broadcasting in the district. Indian Council of Agricultural Research as well maintains able linkages with added key programs of the Government of India like RKVY, MNREGA and NHM and added Extension activities including those accompanying to accessible sector, farmers' organizations, NGOs, Commodity Boards and non-public-sector. ICAR contributes through technology backstopping in the National Rabi and Kharif conferences organized every year in which Extension agencies from all the states as well participate.

### **Question Bank**

1. Full form of all major ICAR institutes and abbreviations.

## Lecture 12

### Current Scenario of Indian Agriculture

Indian agriculture has come a long way since the inception of planning in 1951. All along there was an almost obsessive concern of development policy with the attainment of self-sufficiency in food. We faced nightmare of absolute shortage of food grains supplies in the 1960s, when the average annual imports of wheat hovered around three million tones. We survived through this phase because of the munificence of the US, which supplied wheat to us under its PL 480 programme. There have been several policy statements for agriculture during the last sixty years. India attained self-sufficiency in food grains in the 1970s and what is more, has emerged as an exporter of food grains in more recent years. Attainment of food self-sufficiency, even in a technical sense, is admittedly an important landmark in the history of growth of Indian agriculture, but this has not meant the dilution of problems facing Indian agriculture. Problems of agricultural growth and rural development in general continue to remain, in the new millennium, as daunting as they were in the 1950s. One major difference is that agricultural sector today faces a host of what we might call second generation problems.

#### Recent Agricultural Production Scenario

Agriculture plays a vital role in India's economy. 54.6% of the population is engaged in agriculture and allied activities (census 2011) and it contributes 17% to the country's Gross Value Added (GVA, current price 2015-16, and 2011-12 series). Given the importance of agriculture sector, Government of India took several steps for its sustainable development. As per the land use statistics 2013-14, the total geographical area of the country is 328.7 million hectares, of which 141.4 million hectares is the reported net sown area and 200.9 million hectares is the gross cropped area with a cropping intensity of 142 %. The net sown area works out to be 43% of the total geographical area. The net irrigated area is 68.2 million hectares. There has been a continuous decline in the share of Agriculture and Allied sector in the GVA from 18.2 percent in 2012-13 to 17.0 percent in 2015-16 at current prices. Falling share of Agriculture and Allied sector in GVA is an expected outcome in a fast growing and structurally changing economy.

<b>Share of Agriculture &amp; Allied Sectors in Total GVA</b>				
	(Rs. in Crore)			
Items	Year			
	2012-13	2013-14	2014-15	2015-16
GVA of Agriculture and Allied Sectors	1680797	1902452	1995251	2093081
Per cent to total GVA	18.2	18.3	17.4	17.0

Source: Central Statistics Office, Ministry of Statistics and Programme Implementation, Govt. of India.

As of 2009-10, more than half of the total workforce of the country, i.e. 243 million persons were employed in agriculture. The share of population depending on agriculture for its livelihood consists of landowners, tenant farmers who cultivate a piece of land, and agricultural labourers who are employed on these farms. Agricultural output has been volatile over the past 10 years, with annual growth ranging from 8.6% in 2010-11, to -0.2% in 2014-15 and 0.8% in 2015-16. The agriculture sector's contribution to the Gross Domestic Product (GDP) decreased from 54% in 1950-51 to 15.4% in 2015-16, while that of the services sector increased from 30% to 53%. While the agriculture sector's contribution to GDP has decreased over the past few decades, the contribution of sectors such as manufacturing (employing 10.5% of the population) and services (employing 24.4% of the population) has increased.

Agricultural productivity depends on several factors. These include the availability and quality of agricultural inputs such as land, water, seeds and fertilizers, access to agricultural credit and crop

insurance, assurance of remunerative prices for agricultural produce, and storage and marketing infrastructure, amongst others.

Notwithstanding the setback in kharif crops 2015-16 due to bad monsoon and Rabi crops due to warm winter, total foodgrain production in the country increased marginally in 2015-16. As per 4th Advance Estimates for 2015-16, total production of rice is estimated at 104.32 million tonnes which is lower by 1.17 million tonnes than the production of 105.48 million tonnes during the preceding year. Production of wheat, estimated at 93.50 million tonnes, is higher by 6.97 million tonnes than the production of 86.53 million tonnes achieved during 2014-15. Total production of Coarse Cereals estimated at 37.94 million tonnes is lower by 4.38 million tonnes than their production during 2014-15. Total foodgrains production in the country is estimated at 252.22 million tonnes which is marginally higher by 0.20 million tonnes than the previous year's foodgrains production of 252.02 million tonnes. Production of pulses estimated at 16.47 million tonnes is lower by 0.68 million tonnes than their production during 2014-15. Total production of food grains increased from 51 million 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.

With a decline of 2.21 million tonnes over the last year, total production of oilseeds in the country is estimated at 25.30 million tonnes. Production of sugarcane is estimated at 352.16 million tonne. Total production of cotton estimated at 30.15 million bales (of 170 kgs each) is lower than previous year's production of 34.81 million bales and also lower by 4.48 million bales than its five years average production of 34.63 million bales. Production of jute & mesta estimated at 10.47 million bales (of 180 kg each) is lower by 0.66 million bales (6.3%) than their production during the previous year.

#### **National Policy for Farmers (NPF), 2007**

Government of India approved the National Policy for Farmers (NPF) in 2007. The Policy provisions, inter alia, include asset reforms in respect of land, water, livestock, fisheries, and bio-resources; support services and inputs like application of frontier technologies; agricultural bio-security systems; supply of good quality seeds and disease-free planting material, improving soil fertility and health, and integrated pest management systems; support services for women like crèches, child care centres, nutrition, health and training; timely, adequate, and easy reach of institutional credit at reasonable interest rates, and farmer-friendly insurance instruments; use of Information and Communication Technology (ICT) and setting up of farmers' schools to revitalize agricultural extension; effective implementation of MSP across the country, development of agricultural market infrastructure, and rural non-farm employment initiatives for farm households; integrated approach for rural energy and others.

Many of the provisions of the NPF are being operationalised through various schemes and programmes which are being implemented by different Central Government Departments and Ministries. For the operationalisation of the remaining provisions of the Policy, an Action Plan has been finalized and circulated to the Ministries and Department concerned, as well as to all States and UTs for necessary follow up action. An Inter-Ministerial Committee constituted for the purpose also monitors the progress of the Plan of Action for the operationalization of the NPF.

To achieve the target of doubling of income of farmers by 2022, as announced during presentation of Budget, 2016-17, a Committee has been constituted under the Chairmanship of Additional Secretary, Department of Agriculture, Cooperation and Farmers Welfare to examine the various issues involved. All the State Governments have been requested to hold across-the-board deliberations and prepare strategy for the states that will lead to doubling the income of the farmers. NABARD has also organized six Regional Conferences to sensitize all the States for the strategy that will lead to doubling the income of farmers by 2022.

The strategy of the Government is to focus on farmers' welfare by making farming viable. Farm viability is possible, when cost of cultivation is reduced, yield per unit of farm is increased and farmers get remunerative prices on their produce. The department of agriculture, government of India is

implementing various schemes to meet this objective with a mission mode approach. In this chapter some important missions, their salient features, fund allocation and progress so far have been highlighted.

### **Rashtriya Krishi Vikas Yojana (RKVY)**

The beginning of **Rashtriya Krishi Vikas Yojana (RKVY)** is having background. National Development Council (NDC), in its meeting held on 29th May, 2007 resolved that a special Additional Central Assistance (ACA) Scheme be introduced to incentivize States to draw up comprehensive agriculture development plans, taking into account agro-climatic conditions, natural resources and technology for ensuring more inclusive and integrated development of agriculture and allied sectors. Accordingly, Department of Agriculture & Cooperation (DAC), Ministry of Agriculture, in consultation with the Planning Commission, launched Rashtriya Krishi Vikas Yojana in 2007-2008.

During XI Plan, Rs. 22,408.77 crore was released for implementation of the scheme in the States & Union Territories (UTs) of which Rs. 22,332.97 crore was utilized in implementing projects relating to crop development, horticulture, agricultural mechanization, natural resource management, marketing & postharvest management, animal husbandry, dairy development, fisheries, extension etc. During XII Five Year Plan, an outlay of Rs. 63,246 crore has been earmarked for implementing RKVY, out of which Rs. 8400 crore, Rs. 7052.51 crore, Rs. 8443.20 crore and Rs. 3942.38 crore had been released under the scheme during 2012-13, 2013-14, 2014-15 and 2015-16 respectively. The allocation provided for implementation of the scheme during 2016-17 which was Rs. 5400 crore at BE stage has been reduced to Rs. 3800 crore in RE.

The main objectives of RKVY Scheme are as under:

- i. To incentivize the States so as to increase public investment in agriculture and allied sectors.
- ii. To provide flexibility and autonomy to States in the process of planning and executing agriculture and allied sector schemes.
- iii. To ensure the preparation of Agriculture Plans for the districts and the States based on agro-climatic conditions, availability of technology and natural resources.
- iv. To ensure that the local needs/crops/priorities are better reflected in the agricultural plans of the States.
- v. To achieve the goal of reducing the yield gaps in important crops through focused interventions.
- vi. To maximize returns to the farmers in agriculture and allied sectors;
- vii. To bring about quantifiable changes in the production and productivity of various components of agriculture and allied sectors by addressing them in a holistic manner.

### **Sub-Schemes launched under RKVY**

RKVY has enabled launching of new schemes/programmes keeping States' flexibility and authority intact. Since 2010-11 several sub-schemes have been introduced under RKVY with focused objectives. Following special Programmes/schemes are being implemented as sub-schemes of RKVY, which also include some new sub-schemes launched during the current financial year, with a total allocation of Rs. 1069.20 crore for 2016-17.

**i. Bringing Green Revolution to Eastern India (BGREI)** which has been discussed earlier.

**ii. Crop Diversification Programme (CDP)** which has already been discussed.

**iii. Reclamation of Problem Soil:** This programme is initiated as a sub-scheme of RKVY during 2016-17 for enhancing soil fertility & productivity for meeting demand of food grain of the country. The allocation for the scheme for the current financial year is Rs. 50 crore.

**iv. Rice Fallow Areas in Eastern India for Pulses and Oil Seeds:** This is a new initiative launched under RKVY as a sub-scheme to bring area of rice fallow in Eastern India under pulses and oilseed cultivation. The allocation for the scheme for 2015-16 was Rs. 50 crore.

**v. Foot and Mouth Disease (FMD) Control Programme:** This sub-scheme of RKVY is initiated during 2016-17 for supplementing the effort of the State Governments for prevention, control and containment of FMD. Rs. 100.65 crore was allotted for the scheme for 2015-16.

A well designed implementation strategy has been made to materialize RKVY and it accords flexibility and autonomy to States in planning and executing projects related to agriculture and allied sectors. States are empowered to formulate strategies for development of the agriculture and allied sectors in a holistic

way taking into account their agro-climatic conditions so as to effectively address their local needs and priorities, rather than continuing with business as usual mode of “one size fits all” formula.

Projects under RKVY cover the entire gamut of activities in the agriculture and allied sectors supplementing ongoing Centrally Sponsored Schemes in these sectors. RKVY also emphasizes on convergence through District Agriculture Plans (DAPs) and State Agriculture Plan (SAP) for eliminating overlap of resources & efforts for optimal utilization of funds available through various schemes. The requirements of the Gram Panchayats selected under Saansad Adarsh Gram Yojana (SAGY) would be kept in mind while sanctioning projects.

Over the years, RKVY has also facilitated in addressing national priorities, without affecting the autonomy and flexibility of States, through special programmes as sub-schemes. Towards this endeavour, sub-schemes such as Bringing Green Revolution to Eastern India (BGREI), Crop Diversification Programme (CDP), Reclamation of Problem Soil, Foot and Mouth Diseases Control Programme, Rice Fallow Areas in Eastern India for Pulses and Oil Seeds etc are being implemented during 2016-17.

RKVY is administered by the Union Ministry of Agriculture & Farmers Welfare. Funds under this scheme are provided to the States as grant-in-aid by the Central Government.

### **Bringing Green Revolution to Eastern India (BGREI)**

Bringing Green Revolution to Eastern India (BGREI), a sub scheme of Rashtriya Krishi Vikas Yojana was initiated in 2010-11 to address the constraints limiting the productivity of “rice based cropping systems” in eastern India comprising seven states namely, Assam, Bihar, Chhattisgarh, Jharkhand, Odisha, Eastern Uttar Pradesh and West Bengal.

An amount of Rs. 400 crores each was allocated for the programme during 2010-11 & 2011-12 and an amount of Rs. 1000 crores each during 2012-13 to 2014-15. Till 2014-15 the programme was implemented on 100 % GOI assistance. However, from the year 2015-16, the programme is being implemented on 60:40 sharing basis between GOI and States and 90:10 sharing basis in NE State (Assam). An amount of Rs. 630.00 crore as central share has been earmarked for implementation of the programme during 2016-17.

Under this programme, interventions like (i) block demonstrations of rice and wheat in cluster mode; (ii) asset building activities such as construction of shallow tube, Dug well / Bore well, promotion of farm implements like seed drill, pumpset, cono-weeder, drum seeder and other need based farm implementations for cultivation of Rice/ wheat as per NFSM-Rice/ Wheat; (iii) need based site specific activities and (iv) marketing support are also included.

### **Crop Diversification Programme**

Crop Diversification Programme is being implemented in Original Green Revolution States viz: Punjab, Haryana and Western Uttar Pradesh **as a sub scheme of RKVY** since 2013-14 to divert the area of water guzzling paddy to alternate crops like pulses, oilseeds, maize, cotton and agro forestry with the objective of tackling the problem of declining of soil fertility and depleting water table in these states. In order to encourage tobacco growing farmers to shift to alternate crops/cropping systems, Crop Diversification Programme has been extended to tobacco growing states of Andhra Pradesh, Bihar, Gujarat, Karnataka, Maharashtra, Odisha, Tamil Nadu, Telangana, Uttar Pradesh and West Bengal w.e.f. 2015-16.

An amount of Rs. 500.00 crore & Rs. 250.00 crore were allocated for Crop Diversification Programme in Original Green Revolution States (Punjab, Haryana and Western Uttar Pradesh) during year 2013-14 & 2014-15 on 100 % GOI assistance. However, from the year 2015-16, the programme is being implemented on 60:40 sharing basis between GOI and State Governments. During 2015-16, financial allocation of Rs. 150.00 crore as a central share (Rs. 125.00 crore for Crop Diversification Programme in Original Green Revolution States and Rs. 25.00 crore for replacing tobacco farming with alternate crops/cropping system) have been allocated. During 2016-17, an amount of Rs. 180.00 crore as a central share (Rs. 150.00 crore for

Crop Diversification Programme in Original Green Revolution States and Rs. 30.00 crore for replacing tobacco farming with alternate crops/cropping system have been earmarked.

### **National Food Security Mission (NFSM)**

National Food Security Mission was launched in 2007-08 to increase the production of rice, wheat and pulses by 10, 8 and 2 million tonnes, respectively by the end of 11th Plan through area expansion and productivity enhancement; restoring soil fertility and productivity; creating employment opportunities; and enhancing farm level economy. The Mission has continued during 12th Plan with new target of additional production of 25 million tonnes by the end of 12th Plan and promotion of commercial crops like cotton, jute and sugarcane.

The basic strategy of the Mission is to promote and extend improved technologies, i.e., seed, micro-nutrients, soil amendments, integrated pest management, farm machinery and implements, irrigation devices along with capacity building of farmers. The major interventions/activities covered under NFSM include cluster demonstrations of rice, wheat, pulses and coarse cereals, distribution of improved varieties/hybrid seeds, need based inputs, resource conservation techniques / energy management, efficient water/ application tools, cropping system based trainings and local initiatives; award for best performing districts etc.

During 12th Plan, in 2016-17, NFSM is implemented in 638 districts of 29 states of which NFSM-Rice is implemented in 194 districts of 25 states; NFSM-Wheat in 126 districts of 11 states; NFSM- Pulses in 638 districts of all 29 States; NFSM-Coarse cereals in 265 districts of 28 States.

### **Outcome of NFSM since inception**

The focused and target oriented implementation of mission initiatives has resulted in bumper production of wheat, rice and pulses in the country. During 2014-15, the productions of rice, wheat and pulses have been achieved at the level of 105.48 million tonnes, 86.53 million tonnes and 17.15 million tonnes, respectively. As per 4th Advance Estimates during 2015-16, the production of wheat increased from 75.81 million tonnes in 2006-07 (pre-NFSM year) to 93.50 million tonnes, i.e. an increase of 17.69 million tonnes. Similarly, the total production of rice increased from 93.36 million tonnes in 2006-07 to 104.32 million tonnes in 2015-16 i.e. an increase of nearly 10.96 million tonnes. The total production of pulses also increased from 14.20 million tonnes during 2006-07 to 16.47 million tonnes during 2015-16 with an increase of 2.27 million tonnes.

### **National Mission on Oilseeds and Oil Palm (NMOOP)**

Vegetable Oil constitutes an important part of our daily diet being source of energy, essential fatty acids and amino acids. Domestic consumption of edible oils has increased substantially over the years and has touched the level of 24.16 million tonnes in 2014-15 (Nov-Oct) and is likely to increase further with enhancement in income and population against the domestic availability of 9.58 million tonnes. Considering the importance of oilseeds, various oilseeds development schemes have been funded by the Government for encouraging cultivation

of oilseeds including Oil Palm. The diverse agro-ecological conditions in the country are favorable for growing nine annual oilseeds which include seven edible oilseeds viz. groundnut, rapeseed-mustard, soybean, sunflower, sesamum, safflower and niger and two non-edible oilseeds, castor and linseed.

The Centrally Sponsored Scheme of Integrated Scheme of Oilseeds, Oil Palm and Maize (ISOPOM), which was launched in 2004-05 and remained under implementation till March, 2014, Oil Palm Area Expansion (OPAE) programme, a sub-scheme of RKVY implemented during 2011-12 to 2013-14 have made significant contribution in increasing the oilseeds production and area expansion under oil palm. Implementations of these schemes have given fillip in augmenting the availability of vegetable oil in the country.

The scheme of ISOPOM, Tree Borne Oilseeds (TBOs) and Oil Palm Area Expansion (OPAE) programme have been restructured into National Mission on Oilseeds and Oil Palm (NMOOP) during 12th Plan and launched during 2014-15 and are implemented in 28 States. The sharing pattern of NMOOP between GOI and States is 60:40 for general states and 90:10 for NE and hilly states. The production of oilseeds has increased from 24.35 million tonnes in 2004-05 to 27.51 million tonnes in 2014-15 and 25.30 million tonnes in 2015-16. The yield of oilseeds was 885 kg per hectare in 2004-05, increased to 1037 kg per hectare in 2014-15 and 968 kg per hectare in 2015-16 (as per 4<sup>th</sup> Advance Estimates). The highest production and yield of oilseeds were achieved during the year 2013-14 i.e. 32.75 million tonnes and 1167 kg per year, respectively. During 2014-15 and 2015-16, major oilseeds producing states experienced

late monsoon at the time of sowing, insufficient rain during crop growing phase, untimely rain during pod maturity stage, yellow mosaic virus in soybean. As per the 1<sup>st</sup> Advance estimate of Kharif 2016- 17, oilseeds production is 23.36 million tonnes which are much higher than Kharif 2014-15 and 2015-16. The area, production and yield of oilseeds during last three years are as under:

<b>Recent Oilseeds production scenario of India</b>									
(Area in million hectare, Production in million tonnes & Yield in Kg/ha)									
Year	Kharif			Rabi			Total		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
2004-05	17.24	14.15	820	10.28	10.20	993	27.52	24.35	885
2014-15	18.21	19.22	1056	7.39	8.32	1130	25.73	27.51	1037
2015-16*	18.85	16.59	880	7.29	8.71	1195	26.13	25.30	968
2016-17@	18.75	23.36	1246						

\*As per 4<sup>th</sup> Advance Estimates; @As per 1<sup>st</sup> Advance Estimates (only Kharif).

The crop wise average production of nine major oilseeds during the 12<sup>th</sup> plan period and for the year 2012-13 to 2016-17 are as follow:

<b>Crop wise average production of nine major oilseeds during the 12<sup>th</sup> plan period and for the year 2012-13 to 2016-17</b>						
(Production in million tonnes)						
Crop	Average of XI Plan (2007-08 to 2011-12)	2012-13	2013-14	2014-15	2015-16	2016-17 @
Groundnut	7.40	4.70	9.71	7.40	6.77	6.50
Castor	1.38	1.96	1.73	1.87	1.65	1.73
Sesamum	0.74	0.69	0.72	0.83	0.87	0.68
Niger	0.11	0.10	0.10	0.08	0.08	0.10
Rapeseed & Mustard	6.89	8.03	7.88	6.28	6.82	0.00
Linseed	0.16	0.15	0.14	0.16	0.13	0.00
Safflower	0.18	0.11	0.11	0.09	0.06	0.00
Sunflower	0.93	0.54	0.50	0.43	0.33	0.13
Soybean	11.16	14.67	11.86	10.37	8.59	14.22
Total Nine Oilseeds	28.93	30.94	32.75	27.51	25.30	23.36

@As per 1<sup>st</sup> Advance Estimates (only Kharif).

The strategy to implement the Mission includes increasing Seed Replacement Ratio (SRR) with focus on varietal replacement; increasing irrigation coverage under oilseeds, diversification of area from low yielding cereals crops to oilseeds crops; inter-cropping of oilseeds with cereals/pulses/sugarcane; use of fallow land after paddy/potato cultivation; expansion of cultivation of Oil Palm, increasing availability of quality planting materials of Oil Palm & TBOs maintenance cost and inter-cropping during gestation period of oil palm and TBOs would provide economic return to the farmers when there is no production. The scheme would be implemented in a mission mode through active involvement of all the stakeholders. Fund flow would be monitored to ensure that benefit of the Mission reaches the targeted beneficiaries in time to achieve the targeted results.

### **National Mission for Sustainable Agriculture (NMSA)**

National Mission for Sustainable Agriculture (NMSA) is one of the eight Missions outlined under National Action Plan on Climate Change (NAPCC). The Mission aims at promoting sustainable agriculture through seventeen deliverables focusing on ten key dimensions of Indian Agriculture. During 12<sup>th</sup> Five Year Plan, these dimensions have been embedded and mainstreamed into Missions/Programmes/Schemes of Department of Agriculture, Cooperation & Farmers Welfare (DAC&FW) through a process of restructuring and convergence. NMSA as a programmatic intervention made operational from the year 2014-15 aims at making agriculture more productive, sustainable, and remunerative and climate resilient by promoting location specific integrated/composite farming systems; soil and moisture conservation measures; comprehensive soil health management; efficient water management practices and mainstreaming rainfed technologies.

A dedicated website of National Mission for Sustainable Agriculture (NMSA) has been operationalized (<http://nmsa.dac.gov.in/>) to keep all information of the scheme in the public domain for access and use of all stakeholders.

The major components of NMSA are:

#### **• Rainfed Area Development (RAD)**

RAD focuses on Integrated Farming System (IFS) for enhancing productivity and minimizing risks associated with climatic variability. Under this system, crops/cropping system is integrated with activities like horticulture, livestock, fishery, agro-forestry, apiculture etc. to enable farmers not only in maximizing farm returns for sustaining livelihood, but also to mitigate the impacts of drought, flood or other extreme weather events with the income opportunity from allied activities during crop damage. During 2016-17, RAD is being implemented in 27 States of the Country.

Integrated Farming System is being promoted under RAD in which activities like horticulture, livestock, fishery, agroforestry, value addition are to be taken up along with crops/cropping system. As on 31.12.2016, IFS activities of about 32740 ha have been covered comprising 4245 ha of livestock based farming system, 9727 ha of dairy based farming system, 1609 ha of fishery based farming system, 7408 ha of horticulture based farming system, 5105 ha of agro-forestry based farming system, 472 ha of silvi-pasture based farming system & 4174 ha of cropping system with peripheral plantations. Rs.157.14 crore has been released to the implementing states till 31st December, 2016.

- **Soil Health Management (SHM)**

SHM is aimed at promoting location as well as crop specific sustainable soil health management including residue management, organic farming practices by way of creating and linking soil fertility maps with macro-micro nutrient management, appropriate land use based on land type.

Soil Health Management (SHM) is one of the most important interventions under National Mission for Sustainable Agriculture (NMSA). SHM also aims at promoting Integrated Nutrient Management (INM) through judicious use of chemical fertilizers including secondary and micro nutrients in conjunction with organic manures and bio-fertilizers for improving soil health and its productivity; strengthening of soil and fertilizer testing facilities to provide soil test based recommendations to farmers for improving soil fertility; ensuring quality control requirements of fertilizers , biofertilizers and organic fertilizers under Fertilizer Control Order, 1985; up-gradation of skill and knowledge of soil testing laboratory staff, extension staff and farmers through training and demonstrations; and promoting organic farming practices.

The components under Soil Health include trainings for fertilizer dealers, foreign nationals, fertilizer inspectors and fertilizer laboratory staff, setting up of new static Soil Testing Laboratories (STLs), setting up of new Mobile STLs, and strengthening of existing STLs, setting up of new Fertilizer Quality Control Laboratory (FQCL), strengthening of FQCL apart from trainings and demonstrations on balanced use of fertilizers. The components under organic farming include trainings for certification course on organic farming, refresher courses for analysts, field functionaries, trainers training, publishing of News Letters on organic farming and bio-fertilizers, setting up of fruit/vegetable/agro waste compost production units, setting up of bio-fertilizer production units, setting up of bio-fertilizer & Organic Fertilizer Quality Control Laboratories, promotion of organic inputs, training on organic farming, etc.

Under the scheme, setting up of 277 Soil Testing Laboratories (STLs), 3 Mobile STLs, strengthening of 38 STLs, strengthening of 8 FQCLs, 709 trainings, setting up of 1 Liquid Carrier based Biofertilizers productions unit, promotion of Micronutrients in 1000 ha and setting up 6308 Mini Soil Testing Labs have been approved during 2016-17 under SHM component.

A new scheme "Soil Health Card" has been approved for implementation during the remaining period of 12<sup>th</sup> Plan to provide 14 crore Soil Health Cards to the farmers in the country. Soil Health Card will provide information to farmers on soil nutrient status of their soil and recommendation on appropriate dosage of nutrients to be applied for improving soil health and its fertility. Soil health card will be issued every 2 years for all land holdings in the country so as to promote balanced and integrated use of plant nutrients. Under the scheme 239.73 lakh soil samples collected and 444.58 lakh soil Health Cards issued by States, as on 03.01.2017.

**Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)**

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) is being implemented with the objective of developing a long term solution for mitigating the effect of drought and increasing area under irrigation with Motto of 'Har Khet Ko Pani'. This programme is being implemented in mission mode by three ministries with Ministry of Water Resources, RD&GR leading the mission. With an outlay of Rs. 50,000 crore for a period of 5 years (2015-16 to 2019-20), the scheme has been conceived amalgamating ongoing schemes viz. Accelerated Irrigation Benefit Programme (AIBP) of the Ministry of Water Resources, River Development & Ganga Rejuvenation (MoWR,

RD&GR), Integrated Watershed Management Programme (IWMP) of Department of Land Resources (DoLR) and the On Farm Water Management (OFWM) of Department of Agriculture, Cooperation and Farmers Welfare. The major objective of PMKSY is to achieve convergence of investments in irrigation at the field level, expand cultivable area under assured irrigation, and improve on-farm water use efficiency to reduce wastage of water, enhance the adoption of precision irrigation and other water saving technologies (More crop per drop), promote sustainable water conservation practices etc. The aim of PMKSY is not only the creation of assured irrigation but to create protected irrigation by using rainwater by “Jal Sanchay” and “Jal Sinchan”. The website of PMKSY (<http://www.pmkys.gov.in>) with static features and Management Information System (MIS) with multi-nodal access features has been operationalized with integrating and capturing information of various Departments/ Ministries for PMKSY.

Government of India approved implementation of PMKSY in a mission mode approach on 27th July, 2016. The mission objective is to complete 99 major and medium irrigation projects having potential of 76.03 lakh ha in phases by Dec., 2019, including command area development. For completion of these projects in a mission mode, innovative funding mechanism through NABARD is envisaged. Mission is also responsible for overall coordination and outcome focused monitoring of all components of PMKSY for achieving its target.

The Mission is administered by Ministry of Water Resources, River Development and Ganga Rejuvenation. During 2016-17, as on 31.12.2016, an amount of Rs. 1211.75 crore and Rs.430.3 crore has been released to states for implementation of Micro-irrigation activities and for other interventions activities respectively. An area of about 3.54 lakh ha has been covered under Micro Irrigation till 31.12.2016.

#### **Paramparagat Krishi Vikas Yojana (PKVY)**

Paramparagat Krishi Vikas Yojana (PKVY) is one of the schemes under National Mission for Sustainable Agriculture (NMSA) to promote certified organic cultivation in 2 lakh ha covering 10,000 clusters. Financial assistance of Rs 50,000 per ha per farmer is provided in 3 years.

Participatory Guarantee System (PGS) of certification is promoted in PKVY clusters. The financial assistance is provided to clusters on different sub components for mobilization of farmers, organic seeds, to harvest biological nitrogen etc. It includes different components such as:

- I. Mobilization of farmers: training of farmers and exposure visit by farmers.
- II. Quality control: soil sample analysis, process documentation, inspection of fields of cluster members, residue analysis, certification charges and administrative expenses for certification.
- III. Conversion practices: transition from current practices to organic farming, which includes procurement of organic inputs, organic seeds and traditional organic input production units and biological nitrogen harvest planting etc.
- IV. Integrated manure management: procurement of Liquid Bio fertilizer consortia/Bio pesticides, Neem cake, Phosphate Rich Organic Manure and Vermicompost.
- V. Custom hiring centre charges: to hire agricultural implements as per SMAM guidelines.
- VI. Labeling and Packaging assistance & transport assistance.

VII. Marketing through organic fairs.

### **Agricultural Technology Management Agency (ATMA)**

The Scheme 'Agricultural Technology Management Agency (ATMA)' implemented since 2005 has now been included as a component of the Sub-Mission on Agriculture Extension (SMAE) under National Mission on Agricultural Extension and Technology (NMAET) with some cost revisions and additional components. It is now under implementation in **652 districts of 29 states & 3 UTs** of the country. The scheme promotes decentralized farmer-driven and farmer accountable extension system through an institutional arrangement for technology dissemination in the form of an ATMA at district level.

Under the scheme grants in-aid is released to states with an objective to support State Governments efforts of revitalization of the extension system and making available the latest agricultural technologies in different thematic areas to increase agricultural production through extension activities viz. Farmers Training, Demonstrations, Exposure Visits, Kisan Mela, Mobilization of Farmers Groups and Setting up of Farm Schools. Through these activities, latest agriculture technologies are disseminated to farmers of the country.

In order to promote key reforms under the scheme, ATMA Cafeteria 2014 continues to support activities in line with the following policy parameters:

- **Multi-agency extension strategies:** At least 10% of allocation on recurring activities at district level is to be used through non-governmental sector viz. NGOs, Farmers' Organization (FOs), Panchayati Raj Institutions (PRIs), para-extension workers, agri-preneurs, input suppliers, corporate sector, etc.
- **Farming system approach:** The activities specified in the cafeteria are broad enough to promote extension delivery consistent with farming systems approach and extension needs emerging through Strategic Research and Extension Plan (SREP).
- **Farmer centric extension services:** The cafeteria provides for group-based extension and it has necessary allocation for activities related to organizing and supporting farmer groups. In order to supplement these efforts, a provision for rewards and incentives to the best organized farmer groups has also been provided.
- **Convergence:** The Strategic Research and Extension Plan (SREP) and State Extension Work Plans (SEWP) would also be mechanisms for ensuring convergence of all activities for extension. At present, resources for extension activities are being provided under different schemes of Centre/State Governments. It is mandated that the SEWP, submitted by the State Governments for funding under the scheme shall explicitly specify the activities to be supported from within the resources of other ongoing schemes as well as from this scheme.
- **Mainstreaming gender concerns:** It is mandated that at least 30% of resources on programmes and activities are utilized for women farmers and women extension functionaries.

### **Kisan Call Centres (KCC)**

The KCC Scheme was launched on 21<sup>st</sup> January 2004 to provide answer to farmers' queries on agriculture and allied sectors through toll free telephone lines. A country wide common eleven digit number '1800-180-1551' has been allocated for KCC. The replies to the queries of the farming community are being given in 22 local languages. KCCs operate from 14 locations in the country covering all the States and UTs. Calls are attended from 6.00 am to 10.00 pm on all 7 days of a week.

Since inception of the scheme till 30th November, 2016 over 300.63 lakh calls have been registered in the KCCs. During the current year around 44 lakh calls have been received upto 30th November, 2016. In order to make farmers aware of this facility, audio and video spots on Kisan Call Centres have been broadcast/telecast through All India Radio, Doordarshan and private television channels. A Kisan Knowledge Management system (KKMS) has been created at the backend to capture details of the farmers calling KCCs. Modified call Escalation Matrix has also been put in place. If the queries are not answered by FTA is escalated to concerned Block Level Officer for replying the query through KKMS interface within given time frame.

The Kisan Call Centre scheme has been recently restructured and strengthened, with a good number of unique features viz. provision of IPPBX, 100% call recording; call barging; voice mail service; customized IVRS; call conferencing through the experts; playing state specific advisories during call wait time and SMS to caller farmers giving a gist of answers given by the KCC Agent now known as Farm Tele Advisor. The farmer calling KCC can also register for receiving SMSs from experts on the subject area and their providing and also for receiving regular updates on mandi price of selected mandis and crops.

#### **National e-Governance Plan in Agriculture (NeGP-A)**

The Government is implementing a state sector plan scheme (erstwhile centrally sponsored) Mission Mode Project (MMP) named **National e-Governance Plan in Agriculture (NeGP-A)** for helping farmers to access information related to latest technology. This project has been approved at a total cost of Rs. 858.79 crore for implementation of this scheme in entire country.

Dissemination of information to the farmers has been aimed through various delivery channels including Common Service Centres, Web Portals, SMSs and Kisan Call Centres, Mobile apps etc. Twelve identified clusters of services under the project is under implementation. The services include Information on Pesticides, Fertilizers and Seeds; Soil Health; Information on crops, farm machinery, training and Good Agricultural Practices (GAPs);

Weather advisories; Information on prices, arrivals, procurement points, and providing interaction platform; Electronic certification for exports and import; Information on marketing infrastructure; Monitoring implementation / evaluation of schemes and programmes; Information on fishery inputs; Information on irrigation infrastructure; Drought Relief and Management; Livestock Management.

#### **mKisan Portal**

This Portal subsumes all mobile based initiatives in the field of Agriculture & Allied sectors. It brings together SMS (both Push and Pull), Interactive Voice Response System, Mobile Apps and Services. Officers, Scientists and Experts from all Organizations and Departments of the GoI and State Governments (including State Agriculture Universities (SAUs), Krishi Vigyan Kendras(KVKs) and Agro –Meteorological Field Units (AMFUs) are using this Portal all over the country and using this Portal for disseminating information(giving topical & seasonal advisories and providing services through SMSs to farmers in their local languages) on various agricultural activities to registered farmers, during FY 2015-16, more than **780 crore** SMSs and during FY 2016-17 more than 480 crore SMSs have been sent till 31.12.2016 to farmers by all agencies/organisation/departments in agriculture and allied sectors down to Block level throughout the country since its inception July-2013.

The content may include information about the Schemes, Advisories from Experts, Market Prices, Weather Reports, Soil Test Reports etc. The farmers can register for this service by calling Kisan Call Center on the toll free number 1800-180-1551 or through the Web Portal/SMS.

### **Mobile Apps**

As part of multiple channels of delivery of information to the farmers, DAC&FW has already launched five mobile apps (Kisan Suvidha, Pusa Krishi, Crop Insurance, Agrimarket & Bhuwan Hail storm). It has also been decided to make complete information and services available to the farmers through suitable Mobile Apps. Few important Mobile Apps developed by Department are:

**(a) Hail Storm application:** Farmer or other stakeholder may upload hail storm photograph with GPS tagging.

**(b) Crop Insurance:** Farmer can know insurance premium, notified area on the mobile.

**(c) Agri Market:** Farmer can know the prices of various crops in the mandis near him.

**(d) Kisan Suvidha:** It has a simple interface and provides information on **five critical parameters** – weather, input dealers, market price, plant protection and expert advisories.

An additional tab directly connects the farmer with the Kisan Call Centre where agriculture experts answer their queries. Unique features like extreme weather alerts and market prices of commodity in nearest area and the maximum price in State as well as India have been added to empower farmers in the best possible manner.

Kisan Suvidha mobile app is presently functioning in English & Hindi with a facility of language translation. States have been given a facility of translating the app in their own language. This translation facility will help in extending the outreach of this app and thus more and more farmers can be benefited throughout the length and breadth of the nation. It is available in Google Play Store and on mKisan – Mobile Apps section (mkisan.gov. in). Till December 2016 more than 3.7 Lakh users have downloaded the App.

**(e) Pusa Krishi- Mobile App:** Pusa Krishi Mobile App has been launched recently by the Government. The objective of this app is to help farmers to get information about technologies developed by IARI, which will eventually help in increasing returns to farmers.

**(f) CCE App:** for undertaking crop cutting experiment.

### **Strengthening of IT Apparatus in Agriculture and Cooperation in the States and Union Territories (AGRISNET)**

The Government is implementing a Central Sector Plan Scheme “Strengthening/promoting agricultural Informatics & Communications”, of which one of the components is AGRISNET. The objective of AGRISNET is to provide improved services to the farming community through use of ICT. Under the AGRISNET Scheme funds are released to the State Government concerned for provisioning of software and hardware systems including networking, data digitization, and manpower training to ensure computerization upto Block level 26 States have so far availed funds released by the Government under AGRISNET.

### **National Crop Insurance Programme (NCIP)**

Keeping in view the risks involved in agriculture and to insure the farming community against various risks, Ministry of agriculture introduced a crop insurance scheme in 1985 and thereafter brought improvements in the erstwhile scheme(s) from time to time based on the experience gained and views of the stakeholders, States, farming community etc.

To enlarge the coverage in terms of farmers, crops and risks, National Agricultural Insurance Scheme (NAIS) was notified/ implemented with effect from 1999. To make the crop insurance schemes more farmers' friendly, a re-structured Central Sector crop insurance scheme namely, "National Crop Insurance Programme (NCIP)" was implemented by merging erstwhile Pilot schemes of Modified National Agricultural Insurance Scheme (MNAIS), Weather Based Crop Insurance Scheme (WBCIS) and Coconut Palm Insurance Scheme (CPIS) (as its components) with some improvements for its full-fledged implementation from Rabi 2013-14 season throughout the country.

National Agricultural Insurance Scheme (NAIS) was to be discontinued after implementation of NCIP from Rabi season of 2013-14. However, on the representations and at the option of States, NAIS was also allowed for implementation upto 2015-16. The erstwhile crop insurance schemes have further been reviewed in consultation with various stakeholders including States/UTs. and new scheme namely, **Pradhan Mantri Fasal Bima Yojana (PMFBY)** has been approved for implementation from Kharif 2016 along with pilot Unified Package Insurance Scheme (UPIS) and Restructured Weather Based Crop Insurance Scheme (RWBCIS).

The erstwhile crop insurance schemes have recently been reviewed in consultation with various stakeholders including States/UTs. As a result of the review, a new scheme "**Pradhan Mantri Fasal Bima Yojana (PMFBY)** has been approved for implementation from Kharif 2016 along with pilot Unified Package Insurance Scheme (UPIS) and restructured Weather Based Crop Insurance Scheme (WBCIS). Under the PMFBY, a uniform maximum premium of only 2% will be paid by farmers for all Kharif crops and 1.5% for all Rabi crops. In case of annual commercial and horticultural crops, the maximum premium to be paid by farmers will be only 5%. The premium rates to be paid by farmers are very low and balance premium will be paid by the Government, to be shared equally by State & Central Government, to provide full insured amount to the farmers against crop loss on account of natural calamities. There is no upper limit on Government subsidy.

The salient features of PMFBY are as under:

- PMFBY provides a comprehensive insurance cover against failure of the crop thus helping in stabilising the income of the farmers and encouraging them to adopt innovative practices.
- The Scheme envisages coverage of all Food & Oilseeds crops and Annual Commercial/Horticultural Crops for which past yield data is available and for which requisite number of Crop Cutting Experiments (CCEs) will be conducted being a part of the General Crop Estimation Survey (GCES).
- The scheme is compulsory for loanee farmer obtaining Crop Loan /KCC account for notified crops. However, it is voluntary for Other/non loanee farmers who have insurable interest in the insured crop(s).
- The Maximum Premium payable by the farmers is 2% for all Kharif Food& Oilseeds crops, 1.5% for Rabi Food & Oilseeds crops and 5% for Annual Commercial/Horticultural Crops.
- The difference between premium and the rate of Insurance charges payable by farmers is shared equally by the Centre and State.
- The seasonality discipline is same for both loanee and non-loanee farmers.
- The scheme is implemented by Agricultural Insurance Company (AIC), all companies of General Insurers' (Public Sector) Association (GIPSA) and other empanelled private general

insurance companies. Selection of Implementing Agency (IA) will be done by the concerned State Government through bidding.

- The existing State Level Co-ordination Committee on Crop Insurance (SLCCCI), Sub-Committee to SLCCCI, District Level Monitoring Committee (DLMC) is responsible for proper management of the Scheme.
- The Scheme is implemented on an 'Area Approach basis'. The unit of insurance shall be Village/Village Panchayat level for major crops and for other crops it may be a unit of size above the level of Village/Village Panchayat.
- The Threshold Yield (TY) shall be the benchmark yield level at which Insurance protection shall be given to all the insured farmers in an Insurance Unit Threshold of the notified crop will be moving average of yield of last seven years excluding yield upto two notified calamity years multiplied by Indemnity level.
- Three levels of Indemnity, viz., 70%, 80% and 90% corresponding to crop Risk in the areas is available for all crops.
- The Loss assessment for crop losses due to non-preventable natural risks will be on Area approach.
- However losses due to localised perils (Hailstorm, landslide & inundation) and Post-Harvest losses due to specified perils, (Cyclone/Cyclonic rain & Unseasonal rains) shall be assessed at the affected insured field of the individual insured farmer.
- In case of majority of insured crops of a notified area are prevented from sowing/planting the insured crops due to adverse weather conditions that will be eligible for indemnity claims upto maximum of 25% of the sum-insured.
- There is also a provision on account of claims in case of adverse seasonal conditions during crop season viz. floods, prolonged dry spells, severe drought, and unseasonal rains. On account payment upto 25% of likely claims will be provided, if the expected yield during the season is likely to be less than 50% of normal yield.
- In case of smaller States, the whole State shall be assigned to one IA (2-3 for comparatively big States). Selection of IA may be made for at least 3 years.
- The designated / empanelled companies participating in bidding have to bid the premium rates for all the crops notified/ to be notified by the State Govt. and non-compliance will lead to rejection of company's bid.
- Crop Cutting Experiments (CCE) shall be undertaken per unit area /per crop, on a sliding scale, as prescribed under the scheme outline and operational guidelines. Improved Technology like Remote Sensing, Drone etc will be utilised for estimation of yield losses. • State governments should use Smart phone apps for video/image capturing CCEs process and transmission thereof with CCE data on a real time basis for timely, reliable and transparent estimation of yield data.
- The cost of using technology etc. for conduct of CCEs etc will be shared between Central Government and State/U.T. Governments on 50:50 basis.
- The claim amount will be credited electronically to the individual Insured Bank Account.
- Adequate publicity needs to be given in all the villages of the notified districts/ areas

- A crop insurance Portal [www.agriinsurance.gov.in](http://www.agriinsurance.gov.in) has been developed for better administration, coordination amongst Stakeholders, transmission/dissemination of information and transparency.

During first season i.e. Kharif 2016 about 374 lakh farmers for a sum insured of Rs. 141487 crore have been covered under PMFBY & WBCIS.

### **Progress of Horticulture during XII Plan**

During XII Plan, with effect from 2014-15 Department of Agriculture, Cooperation & Farmers Welfare has launched Mission for Integrated Development of Horticulture (MIDH) by subsuming schemes on horticulture viz. (i) National Horticulture Mission (NHM), (ii) Horticulture Mission for North East and Himalayan States (HMNEH), (iii) National Bamboo Mission (NBM), (iv) National Horticulture Board (NHB), (v) Coconut Development Board (CDB), (vi) Central Institute of Horticulture (CIH), Nagaland.

### **National Horticulture Mission (NHM)**

This Centrally Sponsored Scheme was launched in the year 2005-06 aims at the holistic development of horticulture sector by ensuring forward and backward linkage through a cluster approach with the active participation of all stake holders. 384 districts in 19 States and 4 Union Territories were covered under NHM. Eighteen (18) National Level Agencies (NLAs) have also been included for providing support for developmental efforts which require inputs at the National level.

Supply of quality planting material through establishment of nurseries and tissue culture units production and productivity improvement programmes through area expansion and rejuvenation, technology promotion, technology dissemination, human resource development, creation of infrastructure for post harvest management and marketing in consonance with the comparative advantages of each State/region and their diverse agro-climatic conditions were major programmes implemented during 2014-15. During 2016-17, as on 31st December, 2016, funds to the tune of Rs. 605.61 crore have been released to States/Union Territories and National Level Agencies implementing NHM scheme against BE of Rs.890.00 crore.

### **Horticulture Mission for North East and Himalayan States (HMNEH)**

Ministry of Agriculture & Farmers Welfare, Government of India has been implementing a Centrally Sponsored Scheme - Horticulture Mission for North East and Himalayan States (HMNEH) earlier known as "Technology Mission for Integrated Development of Horticulture in North Eastern States since 2001-02. During the X Plan (2003-04), the scheme was further extended to three Himalayan States namely: Himachal Pradesh, Jammu and Kashmir and Uttarakhand. The Mission covers entire spectrum of horticulture, right from planting to consumption, with backward and forward linkages. With effect from 2014-15, HMNEH scheme has been subsumed under the Mission for Integrated Development of Horticulture (MIDH).

During 2015-16 (As on 18th Dec, 2016), an area of 3823 ha has been covered under various horticultural crops besides 934 ha of area under old and senile orchards has been rejuvenated. An area of 3057 ha has been brought under organic farming. Under protected cultivation, an area of 58.22 ha has been covered besides 16446 ha under Integrated Pest Management, 5 Nurseries have been established and 235 (nos.) under harvesting structures have been created. 46 PHM infrastructures and 21 rural markets have been set up.

During 2016-17, funds to the tune of Rs. 181.29 crore have been released to States implementing HMNEH scheme against BE of Rs.320.00 crore.

### **National Agro-forestry & Bamboo Mission (NABM)**

National Agroforestry & Bamboo Mission (NABM) scheme is being implemented in all States except Haryana in the country since 2006-07. The Mission envisages promoting holistic growth of bamboo sector by adopting area- based, regionally differentiated strategy and to increase the area under bamboo cultivation and marketing. Under the Mission, steps have been taken to increase the availability of quality planting material by supporting the setting up of new nurseries, strengthening of existing tissue culture units. Besides research projects have also been funded for identification of superior bamboo clumps for various bamboo species and for establishing nursery in their respective agro-ecology to have best planting stock. To address forward integration, the Mission is taking steps to strengthen marketing of bamboo products, especially those of handicrafts items.

### **Coconut Development Board (CDB)**

The Coconut Development Board was established by an Act of Parliament in 1979 and came into existence on 12.01.1981. The Board is implementing various programmes for the development of coconut sector which includes action plan like production and distribution of planting material, expansion of area under coconut and integrated farming in coconut holding for productivity improvement and a technology mission on coconut.

### **National Horticulture Board (NHB)**

The National Horticulture Board was established in 1984 as an autonomous registered society under the Department, with its headquarters in Gurgaon and 35 field offices located all over the country. Its main objectives are the creation of production hubs for commercial horticulture development, post-harvest infrastructure and cold chain facilities, promotion of new technologies, introduction and promotion of new crops, and promotion of growers' associations. The significant feature is that there has been improvement of productivity of horticulture crops. Area, production and productivity of horticulture crops during past 9 years are given in the following table.

<b>Area, Production and Productivity of Horticulture Crops</b> (Area : m.Ha, Production: m. MT, Productivity: MT/ha)			
<b>Year</b>	<b>Area</b>	<b>Production</b>	<b>Productivity</b>
2007-08	20.2	211.0	10.4
2008-09	20.5	214.4	10.5
2009-10	20.8	223.2	10.7
2010-11	21.8	240.4	11.0
2011-12	23.2	257.3	11.1
2012-13	23.7	268.8	11.3
2013-14	24.2	277.4	11.5
2014-15	23.4	280.99	12.01
2015-16	23.7	283.36	11.91

### **National Horticulture Board**

The National Horticulture Board (NHB) was established in the year 1984 by the Government of India as an autonomous organization and registered as a society with the Registrar of Firms and Societies Chandigarh with its headquarters in Gurgaon and 35 field offices located all over the country. The broad aims and objectives of the Board are the creation of production hubs for commercial horticulture development, post-harvest infrastructure and cold chain facilities, promotion of new crops, and promotion of growers' associations.

The Board is implementing the following schemes:

- Development of Commercial Horticulture through Production and Post-Harvest Management
- Capital Investment Subsidy for Construction/ Expansion/ Modernization of Cold Storages and Storages for Horticulture Produce
- Technology Development and Transfer for Horticulture Produce
- Market Information Service for Horticulture Crops
- Horticulture Promotion Services/ Expert Services and Strengthening Capability of NHB.

The area under fruit crops during 2014-15 was 6.2 m. ha with a total production of 86.3 million MT. India has retained its status as the second largest producer of fruits in the world. The country is first in the production of fruits like mango, banana, sapota, pomegranate and aonla. Vegetables are an important crop in horticulture sector, occupying an area of 9.5 million ha during 2014-15 with a total production of 167.1 million tonnes with average productivity of 17.6 tonnes/ha. In fact vegetables constitute about 60% of horticulture production. During the period (2007-08 to 2014-15), area and production of vegetables increased by 20% and 30% respectively. India continued to be second largest producer of vegetables after China. Our country is a leader in production of vegetables like peas and okra. Besides, India occupies the second position in production of brinjal, cabbage, cauliflower and onion and third in potato and tomato in the world. Vegetables such as potato, tomato, okra and cucurbits are produced abundantly in the country.

Interventions in horticulture in the country, have led to increase per capita availability of fruits from 158 gm/person/day in 2007-08 to 189 g/person/day in 2014. Similarly, per capita availability of vegetables has increased from 309 g/person/day in 2007-08 to 357 g/person/day in 2014.

India has also made noticeable advancements in production of flowers, particularly cut flowers, which have a high potential for exports. Floriculture during 2014-15 covered an area of 0.5 million ha with a production of 1.66 m. MT of loose flowers and 2.14 m. MT of cut flowers. There has been phenomenal growth in cut flower production, which is finding place in export market.

India is the largest producer, consumer and exporter of spices and spice products, the total production of spices during 2014-15 was 5.7 m. MT from an area of 3.19 m. MT. India continues to be the largest producer and exporter of cashewnut in the world. As per the final estimates 2014-15, the production of cashew nut in India during 2014-15 is 7.25 lakh MT from an area of 10.27 lakh hectares unit area productivity of 706 kg/ha. The cashew processing industry requires 17 lakh MT per annum of raw cashew nut. There is a wide gap between our production and demand of raw cashewnut and India imports the rest of its requirements from other countries.

In India, cocoa is cultivated in four southern states of Kerala, Andhra Pradesh, Tamil Nadu and Karnataka with little plantation status mainly as an intercrop in coconut and arecanut gardens. It is also cultivated in shady conditions of rubber plantations in few localities of Kerala. Cultivation of cocoa is gaining momentum and as per the final estimate 2014-15, India is presently produced 16050 MT of cocoa from an area of 78000 ha. The country is importing about 40 % of the demand for cocoa and the demand is increasing in the country by 15 % annually. India imports rest of its requirement from other cocoa producing countries. There is lot of scope and demand to further increase in the area and production of cashewnut and cocoa. The Directorate of Cashewnut and Cocoa Development is implementing development programmes under MIDH to increase the area and production of these two horticultural crops in the country.

#### Question Bank

1. Write short notes on the following.  
a) NHB;      b) NHM;      c) ATMA;      d) RKVY;      e)PKVY;      f)PMKSY  
g) PMFBY;    h) NMSA;      i) Soil health management.
2. Write a brief note on the current scenario of Indian agriculture.

## **Lecture 13**

### **Agriculture Scope**

Indian agriculture contributed to 31.6% of the quantity requirement of India, admitting bearing extent contributed 17.6%. It's abundant than altered countries as an archetype in 1982 it had been 34.9% in India adjoin a brace of in United Kingdom of Great Britain and Northern Ireland, 3.0% in the USA, 4.0% for the continuance of the North American nation. About 65th of the population depends on agriculture and allied agricultural activities. About seventieth of the agricultural population earns its adeptness from agriculture and altered action affiliated with agriculture. In cities conjointly, an abundant and allotment of labour is affianced in jobs searching on the action of agriculture merchandise. Indian agriculture is one amidst the foremost important contributors to the country's economy. The agriculture extent of India has active about 43rd of country's geographic regions. Agriculture charcoal the sole bigger contributor to India's gross calm artifact (16%) even already abatement rural the aforementioned rural the agriculture shares. Agriculture additionally plays an important rural life the advance of socio-economic extent aural the beforehand times, India was for a lot of allotment abased aloft aliment imports, and about the consecutive adventure of the agricul-ture extent of the abridgement has created it arrogant in atom production. The country additionally has abundant affluence for an equivalent. India depends heavily on the agriculture sector, decidedly on the aliment assembly assemblage already the 1960 crisis in aliment sector. Back then, lots of accomplishment has been abode to be independent aural the aliment assembly and by these abounding efforts, it's diode an about-face in agriculture. The agriculture advance and domestic came into actuality with the aim to enhance the agriculture. Indian agricul-ture is one of the most significant contributors to the country's economy. Agricul-ture is the only means of living for almost 60% of the employed class. The agriculture sector of India has occupied almost 43% of the country's

geographical area. Agriculture is still the only largest contributor to India's GDP (15%) even after a decline in the same in the agriculture share. Agriculture also plays a significant role in the growth of the socio-economic sector. In the earlier times, India was largely dependent upon food imports, but the successive story of the agriculture sector of the economy has made it self-sufficient in grain production. There are also substantial reserves for the same. India depends heavily on the agriculture sector, especially in the food production unit after the 1960 crisis in the food sector. Since then, a lot of effort has been put to be self-sufficient in the food production and by these gigantic efforts, it has led a changeover in agriculture. The agricultural growth and domestic came into existence with the aim to improve the agriculture.

### **Supply of basic requirement**

Mankind depends on crops for basic requirements like food, feed, , and shelter. A crop may be a plant or animal product that can be cultivated by the farmers under suitable agro-climatic conditions and harvested at the desired maturity stage to achieve subsistence or earn monetary returns. The crop may be either the freshly harvested plant parts or in a more refined state like husked and shelled grains and so on. Most of the crops are cultivated on land or water-body. Sometimes macroscopic fungus like mushrooms and alga-like *spirulina* are also considered a crop. There are some crops which are wildly grown and collected. A common example of the gathering is ginseng. There are some non-food crops which include horticulture, floriculture, and industrial crops. Industrial crops are actually raw materials for industries. Some of the industrial crops are fiber crops (cotton, jute) produced for clothing, sugar crops (sugarcane and sugarbeet), biofuel crop (*jatropha*), and medicinal plants (mint, *ashwagandha*, *Aloe vera*) for production of medicines. Animals reared for human or animal consumption are considered as livestock and microbes as microbiological cultures.

### **Scope of agriculture**

In India, agriculture is the major source of food, nutrition, income, and employment for the most of the rural population and farming is characterized by the presence of a large number of small and marginal farmers. However, the country is blessed with diverse agro-climatic conditions which enable the farmers to produce a large number of agricultural commodities. The challenge of producing enough food for the growing population with the reducing holdings (due to urbanization, industrial growth, and others) is a challenging task. With the domestic of commercial agriculture techniques during the post-independence period, the agriculture sector has been able to cater to the domestic requirements and international markets. In the light of the focus on commercial farming, the rich tradition of crop diversity of Indian farming lasts its glory. Earlier our crop diversity was more prominent; however, after the Green Revolution in the 1960s, we have witnessed the erosion of crop and genetic diversity. At present, few crops and few varieties and hybrids of those crops are occupying major production area and are grown repeatedly year after year in succession. This has resulted in the emergence of several field levels biotic and abiotic constraints, yield plateauing, unbalance in eco-system and an overall reduction in the benefits realized from farming. To overcome these problems as well as to reach the goal of production sustainability, diversification of crops may be an option as because diversity assures the soundness of ecology.

### **Importance of agriculture**

Importance of agriculture to the Indian economy is as follows:

1. Accomplishment of a lot of amplitude for agriculture functions;
2. Creation of irrigation potential and coverage;
3. Use of bigger and avant-garde high-yielding varieties of seeds;
4. Implementing modern techniques that emerged from agriculture assay;
5. Water management;
6. Set up aegis activities through the advisable use of fertilizers, pesticides.

Measures led to an appalling acceleration hearing the aureate and rice assembly of India's agriculture because the breakthrough witnessed by the aureate and rice assembly assemblage of India's agriculture as follows:

A National Pulse Domestic Programme that coated about thirteen states was apparent in 1986 with the aim to acquaint the bigger technologies to the farmers;

On accomplishment success of National Pulse Domestic Programme, a Technology Mission on Oilseeds was alien in 1986 to aroma up the oilseeds extent in Indian economy. Pulses too came beneath this programme, a cast new berry ac-tion was planned to accumulation access to aloft superior seeds and absolute for fruits, vegetables, oilseeds, pulses, and flowers;

With the astute makes an attempt, thus, agriculture banking accretion in gross calm artifacts Agriculture extent contributed thirty additional in 1990-91, two hundredth throughout 2005-06 and about 16% currently, although the accession

of agriculture to the gross domestic banking accretion of India, it's nice account that nowadays the account extent is adroit absolutely bisected the Indian gross calm product. It takes India one footfall nearer to the developed economies of the planet. Beforehand it had been agriculture that chiefly contributed to the Indian gross calm product. The Indian government continues to wish up to enhance the gross calm artifact of the country and again abounding accomplish are taken to aroma up the economy. The FDI, SEZs and NRI behavior of investment are af-fected to back an advance to the abridgement and accordingly enhanced the Gross Domestic Products.

### **Some important features**

With a 15% accession to the gross domestic product (GDP), agriculture still provides an active abutment to apropos simple atom of country's population;

The extent provides an appliance to fifty-four per cent of country's manpower and is that the individual bigger extent occupation;

Agriculture accounts for the accomplished consign antithesis and provide being to an outsized array of Industries (textiles, silk, sugar, rice, abra-de mills, milk products);

Rural development measures are the bigger markets for the bargain and mid-dle-priced goods, as able-bodied as abiding appurtenances and rural calm accu-mulation development admeasurement an astute accumulation of adeptness mobi-lization;

The agriculture extent acts as a enclose advancement aliment aegis and aural the method, national aegis as well;

The affiliated sectors like farming, farming, dairy acreage, and fisheries, ac-cept an astute role in up the bread-and-butter altitude and bloom and diet of the agriculture masses; and

To advance the ecological balance, there's would like for acreage and counter-balanced domestic agriculture and affiliated sectors;

Agriculture's eyes and minds development admeasurements adequate by acti-vating changes from amber (bare soil) to amateur (growing crop) to aureate (mature crop) and bonanza harvests;

Plateauing of agriculture abundance in anhydrous areas and in some cases the crumbling trend warrants absorption of scientists;

Elevating the association consisting of assorted castes and communities to a college social, cultural, political and bread-and-butter action which the agriculture helps to;

Agriculture maintains a biological calm in nature. Satisfactory agriculture assembly brings peace, prosperity, harmony, bloom, and abundance to humans of a nation by active away distrust, animosity and lawlessness.

### **Resilience in agriculture**

Through the white revolution, milk assembly quadrupled from seventeen bil-lion tones at adeptness to 108.5 billion tones;

Through dejected revolution, angle assembly rose from 0.75 billion tonnes to about seven.6 billion tones throughout the endure 5 decades;

Oil berry assembly abstract 5 times (from 5 billion tons to 25 billion tones) back adeptness through chicken revolution;

Similarly, the egg assembly abstract from two billion at adeptness to twenty-eight billion, sugarcane assembly from fifty-seven billion tons to 282 billion tonnes, affection assembly from three billion bales to thirty-two billion bales that shows our affirmation of progress;

India is that the bigger ambassador of fruits aural the world. India is that the additional bigger ambassador of milk and vegetable.

### Components of appropriateness

- **Industrial Inputs:** A lot of the industries depend aloft on the basal created by agriculture, appropriately agriculture is that the arch accumulation of basal to the industries. The industries like affection textile, jute, paper, amoroso depend alto-gether on agriculture for the accouterment of basal industries like access and adeptness loon, ginning and pressing, oil crushing, rice husking, sericulture bake-apple action is principally agro primarily based industries.

- **Food Supply:** throughout this year targeted aliment assembly was 198 billion bags is to be accumulated 225 billion bags by the tip of this aeon to augment the growing citizenry of India i.e. thirty 5 accessory in 1951 and a hundred corers at the tip of this century. India, thus, is accessible to accomplish the majority the call of its citizenry with commendations to aliment by advance accelerated affairs for accretion aliment production.

- **State Revenue:** The agriculture is adroit the acquirement by agriculture taxation includes tax and tax. Tax includes acreage revenue, cusses and customs assimilate acreage revenue, cusses on crops and agriculture tax and tax induces excise, cus-tom assignment and built-in octroi that agriculturalist pay on the acquirement of agriculture inputs.

- **Trade:** Agriculture plays and basal role in adopted barter alluring admired inter-change, all-important for our bread-and-butter domestic. The commodity from agriculture primarily based industries like jute, bolt and preserved aliment con-tributed to twenty of our export. About fifty capitalize on absolute exports extent assemblage contributed by the agriculture sector. Indian agriculture plays and basal role in roads, balustrade, and waterways alfresco the countries. Indian in roads, balustrade and waterways won't to carriage abundant abundance of agricul-ture about-face out and agro primarily based automated merchandise. Agriculture articles like tea, coffee, sugar, oilseeds, tobacco, and spices additionally represent a lot of items of consigning from India.

### Recent Agricultural Production Scenario

Agriculture plays a vital role in India's economy. 54.6% of the population is engaged in agriculture and allied activities (census 2011) and it contributes 17% to the country's Gross Value Added (GVA, current price 2015-16, and 2011-12 series). Given the importance of agriculture sector, Government of India took several steps for its sustainable development. As per the land use statistics 2013-14, the total geographical area of the country is 328.7 million hectares, of which 141.4 million hectares is the reported net sown area and 200.9 million hectares is the gross cropped area with a cropping intensity of 142 %. The net sown area works out to be 43% of the total geographical area. The net irrigated area is 68.2 million hectares. There has been a continuous decline in the share of Agriculture and Allied sector in the GVA from 18.2 percent in 2012-13 to 17.0 percent in 2015-16 at current prices. Falling share of Agriculture and Allied sector in GVA is an expected outcome in a fast growing and structurally changing economy.

Share of Agriculture & Allied Sectors in Total GVA				
(Rs. in Crore)				
Items	Year			
	2012-13	2013-14	2014-15	2015-16
GVA of Agriculture and Allied Sectors	1680797	1902452	1995251	2093081
Per cent to total GVA	18.2	18.3	17.4	17.0

Source: Central Statistics Office, Ministry of Statistics and Programme Implementation, Govt. of India.

As of 2009-10, more than half of the total workforce of the country, i.e. 243 million persons were employed in agriculture. The share of population depending on agriculture for its livelihood consists of landowners, tenant farmers who cultivate a piece of land, and agricultural labourers who are employed on these farms. Agricultural output has been volatile over the past 10 years, with annual growth ranging from 8.6% in 2010-11, to -0.2% in 2014-15 and 0.8% in 2015-16. The agriculture sector's contribution to the Gross Domestic Product (GDP) decreased from 54% in 1950-51 to 15.4% in 2015-16, while that of the services sector increased from 30% to 53%. While the agriculture sector's contribution to GDP has decreased over the past few decades, the contribution of sectors such as manufacturing (employing 10.5% of the population) and services (employing 24.4% of the population) has increased.

Agricultural productivity depends on several factors. These include the availability and quality of agricultural inputs such as land, water, seeds and fertilizers, access to agricultural credit and crop insurance, assurance of remunerative prices for agricultural produce, and storage and marketing infrastructure, amongst others.

Notwithstanding the setback in kharif crops 2015-16 due to bad monsoon and Rabi crops due to warm winter, total foodgrain production in the country increased marginally in 2015-16. As per 4th Advance Estimates for 2015-16, total production of rice is estimated at 104.32 million tonnes which is lower by 1.17 million tonnes than the production of 105.48 million tonnes during the preceding year. Production of wheat, estimated at 93.50 million tonnes, is higher by 6.97 million tonnes than the production of 86.53 million tonnes achieved during 2014-15. Total production of Coarse Cereals estimated at 37.94 million tonnes is lower by 4.38 million tonnes than their production during 2014-15. Total foodgrains production in the country is estimated at 252.22 million tonnes which is marginally higher by 0.20 million tonnes than the previous year's foodgrains production of 252.02 million tonnes. Production of pulses estimated at 16.47 million tonnes is lower by 0.68 million tonnes than their production during 2014-15. Total production of food grains increased from 51 million 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.

With a decline of 2.21 million tonnes over the last year, total production of oilseeds in the country is estimated at 25.30 million tonnes. Production of sugarcane is estimated at 352.16 million tonne. Total production of cotton estimated at 30.15 million bales (of 170 kgs each) is lower than previous year's production of 34.81 million bales and also lower by 4.48 million bales than its five years average production of 34.63 million bales. Production of jute & mesta estimated at 10.47 million bales (of 180 kg each) is lower by 0.66 million bales (6.3%) than their production during the previous year.

<b>Area, production and yield of major Crops</b>									
<b>Crops</b>	<b>Area (Lakh hectare)</b>			<b>Production (Million Tonnes)</b>			<b>Yield (kg/hectare)</b>		
	<b>2013-14</b>	<b>2014-15</b>	<b>2015-16*</b>	<b>2013-14</b>	<b>2014-15</b>	<b>2015-16*</b>	<b>2013-14</b>	<b>2014-15</b>	<b>2015-16*</b>
Rice	441.36	441.10	433.88	106.65	105.48	104.32	2416	2391	2404
Wheat	304.73	314.65	302.27	95.85	86.52	93.50	3145	2750	3093
Coarse cereals	252.19	251.70	237.75	43.29	42.86	37.93	1717	1703	1596
Pulses	252.12	235.54	252.59	19.25	17.15	16.47	764	728	652
<b>Foodgrains</b>	<b>1250.41</b>	<b>1243.00</b>	<b>1226.50</b>	<b>265.04</b>	<b>252.02</b>	<b>252.22</b>	<b>2120</b>	<b>2028</b>	<b>2056</b>

Oilseeds	280.50	255.96	261.34	32.74	27.51	25.30	1168	1075	968
Sugarcane	49.93	50.66	49.53	352.14	362.33	352.16	70522	71512	71095
Cotton@	119.60	128.19	118.72	35.90	34.80	30.15	510	462	432
Jute & Mesta#	8.38	8.09	7.85	11.69	11.12	10.47	2512	2473	2399
* 4th advance estimates; @ Production in million bales of 170 kg each; # Production in million bales 180 Kg. each.									

## Capital Formation in Agriculture and Allied Sector

Gross Capital Formation (GCF) in Agriculture and Allied sector is estimated separately for public, private corporate and the household sectors. Items included in the estimates of GCF are:

- (i) Improvement of land and Irrigation works
- (ii) Laying of new orchards and plantations
- (iii) Purchase of agricultural machinery and implements
- (iv) Agriculture construction works
- (v) Additions to livestock
- (vi) Fishing boats and nets etc.

Gross Capital Formation (GCF) in Agriculture and Allied sector relative to GVA in this sector has been showing a fluctuating trend from 18.3 per cent in 2011-12 to 16.2 per cent in 2014-15.

<b>Gross Capital Formation (GCF) in Agriculture and Allied sector relative to Gross Value Added (GVA) at 2011-12 basic price</b>							
(Rs.in crore)							
Period	GCF in Agriculture & Allied Sectors			GVA in Agriculture & Allied Sectors	GCF as percentage of GVA		
	Public	Private	Total		Public	Private	Total
2011-12	35715	238717	274432	1501816	2.4	15.9	18.3
2012-13	36078	217230	253308	1524398	2.4	14.3	16.6
2013-14	32472	244694	277165	1588237	2.0	15.4	17.5
2014-15 *	36061	220434	256495	1584293	2.3	13.9	16.2
Source: Central Statistics Office, MOSPI							
*As per Advance Estimates for 2015-16 (latest available) released on 8.2.2016							

Demographic factors, technology, infrastructure, policy environment and global economic set up are the prime factors that influence the process of commercialisation. Perpetual inefficiency in

agricultural marketing, non-availability of inputs - especially for hi-tech ventures, inadequate priority to research and development, lack of infrastructure and cold storage, pre-cooling facilities, processing, grading and packaging services are few among those factors that constraint the pace of commercialisation.

Meeting the challenges of increasing food production now and in the future demand innovations that can lead to sustainable Green revolution, which is now an ecological, social and environmental necessity in India. This involves new agricultural technologies and management systems providing increased productivity per unit of land, water, labor energy, investment without compromising on environment. To achieve the necessary yield growth without harming the environment is an enormous challenge. This challenge will have to be met largely through agricultural research, the annual rate of return to investment in agricultural research averaged 50-80 percent. Thus well directed agricultural research and development programs remain a wise investment of public funds. This has to be done under the shadow of ever-tighter public research budgets. For a bigger harvest in coming years, different initiatives have to be taken to jump-start the stagnant agriculture sector. This initiative could be three fold: (a) Use technology together with newer cultivation techniques, (b) Water management with harvesting excess Monsoon rainwater in the North and transporting it to the parched West and South, (c) Ensuring a better return to the farmers. India is expected to achieve the ambitious goal of doubling farm income by 2022. The agriculture sector in India is expected to generate better momentum in the next few years due to increased investments in agricultural infrastructure such as irrigation facilities, warehousing and cold storage.

### **Question Bank**

1. What is the importance of agriculture in India?
2. Write a note on scope of agriculture in India.

## **Lecture 14**

### **Indian Agricultural Concerns and Future Prospects**

Today, concerns regarding environmental safety and sustainability of land productivity are increasing among scientists, administrators and environmentalists. It is doubted whether the strategy adopted during the green revolution era could be continued any longer under the challenging conditions of this new century. Already, a section of people in the world is questioning the propriety of conventional agriculture, and a few of them are advocating alternative practices that are perceived to lay foundation for sustained production. On these lines, systems like alternative agriculture, natural farming, organic farming, etc. were proposed at various conventions. However, the scientists harping on the success of green revolution continue to doubt whether such a system can really be functional, productive and meet the growing demands for agricultural products in this e-age. These emphasize the need to develop new strategies of living with the nature and nurturing it for sustainable production

#### **Speculation in Indian agriculture**

The spectacular observations made in the Economic Survey of 2015-16 that "Indian agriculture, in a way, a victim of its own accomplished success – abnormally the green revolution", shows the apothic completeness of the agricultural area at present and the calamity that has been wreaked by the green revolution. The green revolution, which is generally characterized by the addition of high-yielding array

of seeds and fertilizers, assuredly added the abundance of the area considerably. But the advance in the abundance has been brackish in contempt years, consistently in a cogent abatement in the assets of farmers. There accept as well been abrogating ecology furnish-ings in the anatomy of a annihilative water table, discharge of greenhouse gases, and the contagion of apparent and arena water. Needless to say, the agricultural area is in an accompaniment of distress, which is acutely affecting peasants and bordering farmers, and burning action interventions are adapted to assure their interests.

### **Rainbow revolution holds the key**

The indigenous barrier to affect is crumbling productivity, the agricultural research from 2013 reveals that India's boilerplate crop of atom per hectare is far below than that of thousands of countries (including several low assets countries), but the aberration is huge if compared to China. For instance, our boilerplate crop per hectare is 39% below than that of China and for rice this bulk is 46%. Even Bangladesh, Vietnam and Indonesia book bigger than India in case of rice yield. Further, there is a huge inter-regional variation; the wheat and rice crop from Haryana and Punjab has plentiful colleges than from the added states.

In adjustment to cantankerous the crumbling abundance barrier there is a charge to adviser a bubble revolution by authoritative an about-face from wheat-rice to add cereals and pulses. Since wheat and rice accompanying with added crops are backed by minimum abutment prices (MSP) and ascribe subsidy (whether water, fertilizer or power) regime, there is a huge allurements for the farmers in the anhydrous arena of Northwest India to abound these crops.

These crops are not alone ascribing intensive, but as well accept abrogating ecology aftereffects in the anatomy of a annihilative water table and the discharge of green abode gases. The action, acknowledgment to this botheration has consistently been to disincentives farmers from growing these crops by authoritative measure enhancements in the MSP. However, this is not adequate and has to be complemented with huge investment in accessible infrastructure. For example, due to the rice milling industry in Haryana and Punjab, there is now an able accustomed bazaar in abode for altered varieties of rice that as well incentivizes farmers to breed paddy. Until such an exchange is not created for added cereals and pulses, farmers are absurd to accomplish an about-face to cereals and pulses.

### **Per drop more crop and income**

The additional above barrier is the absence of two above assets of agricultural – cultivable area and water. While the cultivable area per getting is crumbling because of the breach of farms due to ascent population, India as well has more under per capita water as compared to added arch agrarian countries? This botheration affronted because India has been exporting basic water anchored in crops, which is apparent by its affection of non-replenishment. Already it was exported, it cannot be recovered. According to an address by Prashant Goswami and Shiv Narayan Nishad, in 2010, India exported about 25 cu km of water anchored in its agricultural exports, which is about 1% of the accessible water every year.

Given this scenario, it is time to accomplish an about-face to micro irrigation so that the able and authentic use of deficient water assets can be made. An abstraction conducted by the National Mission for Sustainable Agricultural on micro irrigation in 64 districts in 13 states (Andhra Pradesh, Bihar, Chhattisgarh, Gujarat, Haryana, Karnataka, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Sikkim, Uttar Pradesh and Uttarakhand), reveals that there were cogent reductions in the use of water and fertilizer but the crop of crops added up to 45% in wheat, 20% in gram and 40% in soybean. However, top antecedent costs avert farmers to accept this technology. While big farmers can calmly account this technology, the government should accede giving subsidies to baby farmers in addition the acceptance of this technology. Further, Vaidyanathan notes, due to autonomous backroom charges, the prices of electricity and agent oil are far under the complete bulk and appropriately there is over the corruption of groundwater. While Vaidyanathan recommends water charging at complete costs, this may be not accessible in the present book because of the acute attributes of the affair and as well because of its complete address on area abundance and farmers' income.

### **Opening up of the markets**

The National Agricultural Action of 2000 declared that the clandestine area accord will be acknowledged through arrangement agricultural and area leasing arranged to acquiesce accelerated technology transfer, basic arrival and assured bazaar for crop production. However, there has not been any cogent accord by the clandestine area of agriculture.

One of the above families that have beat clandestine players from entering the agricultural area is the continued awaiting ameliorates of broad markets, which are adapted by the Agricultural Aftermath Management Committee (APMC) Act. The APMC arrangement the farmers have been arranged to advertise their aftermath in government-controlled business yards. While the cold of APMC was to adapt markets and access bazaar yards, it has acted as an above obstacle to clandestine investment.

In 2003, however, the axial government mooted an archetypal APMC, but as acclaimed by the assignment force on agricultural constituted by NITI Aayog, this has not been implemented by thousands of states in eastern India. There-fore, to access clandestine area accord in agriculture, it is acute to abolish these access barriers.

Further, although the government has launched the National Agricultural Market, which provides farmers a cyber-banking average to advertise their aftermath anywhere in India, it is yet to be apparent whether farmers can in fact acquire allowances from this platform.

### **Research and development in future**

One of the above barriers to advocacy area's abundance is the abridgement of new technologies and above breakthroughs. While the National Agricultural Assay Arrangement played an above role in the green revolution, in contempt years there hasn't been any above advance in research. One of the capital affidavits for this is the abridgement of banking resources. If analyze the research of the allotment of agricultural GDP spending on assay and development in Asia, again the research is revealing. While India spent 31% of its agricultural GDP on assay and development in 2010, in the aforementioned year China spent about bifold than amount. Even our neighbour Bangladesh spent 38% of its agricultural GDP on assay and development in that year. As a consequence of this ability crisis, there has not been circulation of new agricultural innovations and practices that is analytical for adequate area productivity.

Further, there is an abridgement of absorption of acceptance in advancing assay in agriculture. As the Economic Survey notes, even in the state area agricultural is almost added important (as abstinent by their allotment of agricultural in accompaniment GDP), agricultural apprenticeship is abnormally anemic if abstinent by the bulk of acceptance enrolled in agricultural universities. There has as well not been any above addition from the clandestine area appear assay and development. Many accept casting doubts over the appetite of government to bifold the assets of farmers by 2022. As Ashok Gulati, above administrator of the Commission for Agricultural Costs and Prices notes, acceleration of complete incomes of farmers would be a "miracle of miracles", as it would betoken an admixture advance bulk of 12% per annum. Further, India Spend is as well agnostic of government appetite as their essay shows that afterwards adjusting for ascent costs, an Indian farmer's asset finer rose alone 5% per year over a decade (2003-2013). All this, in thousands of ways, paints an austere account of approaching of Indian agriculture. If we about ways to save the approaching of our farmers and assuredly cure the ills of Indian agriculture, above action interventions accept to be fabricated at the earliest.

The arrangement resembles the agricultural acclimated to abound vegetables in greenhouses. Every half-hour an anxiously calibrated beating of water based on the cloud's calculations, and alloyed with an adapted dosage of fertilizer if scheduled, is pushed through the tapes, carrying a complete admixture to anniversary tree. The pulses alternating amid one ancillary of the timberline block and the other, which acquaintance has apparent encourages water uptake. Before this arrangement was in place, Mr Rogers would accept anhydrous his area about already a week. With the new little-but-often technique, he uses 20% under water than he acclimated to. That both saves money and brings kudos, for California has suffered a four-year-long aridity and there is amusing and political, as able-bodied as financial, burden to conserve water. Understanding a crop's DNA arrangement as well agency that ancestry itself can be fabricated added precise. You do not charge to abound a bulb to ability to acquire out whether it will accept the characteristics you want. A quick attending at its genome advanced will acquaint you all.

Such abstruse changes, in hardware, software and “live wire”, are extensive above field, orchard and byre. Fish agricultural will as well get an addition from them. And calm horticulture, already the lot of controlled and complete blazon of agriculture is about to become yet added so.

On the abbreviated run, these improvements will be added farmers’ profits, by acid costs and accretion yields, and should as well account consumers (meaning anybody who eats food) in the anatomy of lower prices. In the good run, though, they may advise accommodate the acknowledgment to a more burning question: how can the world be fed in approaching after putting irreparable ache on the Earth’s soils and oceans? Amid now and 2050 the planet’s citizenry is acceptable to accelerate to 9.7 billion, from 7.3 billion now. Those humans will not alone charge to eat, they will wish to eat bigger than humans do now, because by again a lot of are accepted to accept middling incomes, and thousands of will be able-bodied off.

#### **Gap existing that required specific interventions**

1. Reversing sick soil to healthy soil through low cost approaches in existing penury;
2. These gaps exist for other livestock also with the introduction of exotic breeds of goat suitable for stall feeding;
3. Standardization of methodologies/approaches for generating gainful rural self-employment through improved agricultural technological interventions;
4. Low cost organic farming practices; and
5. Lack of crop diversification, poor breeds of animals/birds, farm mechanization, mono-cropping, poor seed replacement rate, terminal water stress and poor marketing infrastructure facilities are some important areas;

#### **The major components of the project undertaken**

1. Intensification and diversification of agricultural activity through integrated farming system approach comprising varietal improvement, seed replacement, and farm-based enterprises for self-employment;
2. Livestock improvement, increasing per unit profitability and integration.
3. Soil health improvement by promoting organic production system, IPM, mass composting, encouraging use of homemade bio-pesticides, bio-fertilizers; and
4. Human resource development for sustenance of the proposed activities;

In a developing country like India, development encompasses several wide-ranging issues. The prime aim of development of a welfare country is people's welfare and for the public good. In fact, every country throughout the world strive towards these objectives and so also all the countries in the region. Forest is a part of the environment. Development and environment, both are inseparable. Man lives in a given environment and strives to improve his lot by certain actions within it in the name of development. Every act of man affects the environment. People's wellbeing is the ultimate goal of all governments and all development policies and programs are usually tailored to cater to that objective. While everything is changing land remains and will continue to remain limited. Growth demands space and forest is the only area having some geographic spread. This perhaps has been also the cause of liberal use of its area and extent. The increasing need and influence of other sectors has made forestry sector a diminishing entity.

In the economic terms and financial accounting system externalities (social costs) are not considered very often. Services from the forest such as soil protection and productivity, regeneration of water and improvement of the hydrological cycle, all forest products other than timber and bamboo, carbon sink and bio-diversity have immense value of far reaching consequences. Such benefits flowing from forests are not only local but regional and global. Large scale industrialization does not mean development if it does not pay due attention to the environment. Further development has to have social content in every sphere. The material progress has to be blended with old values, ethics and morals. Earlier, no one talked about environment in development projects and activities. The craze for developing subdued the simmering after effects or fallout of those activities which do not seem visible initially in the beginning. Forests destroyed to make way for development and industries which later polluted air and water causing several difficulties and problems to the people in general. In this regard the examples of the devastating effect of

indiscriminate development are not wanting. The government has taken care against such reckless development and ruthless predatory exploitation of forest (natural resources) and the environment. Otherwise the cure becomes much more cost prohibitive than the disease itself.

### **Conclusion**

The challenges before agricultural destruction attempt of ecology, the abstraction of relationships within bacilli and their environment; refers to agricultural assembly which will be maintained while not harming the environment; not alone will it abode several anatomy and amusing issues, about it: offers modern-grade and economically applicable opportunities for (i) growers (ii) laborers (iii) shoppers and policymakers; cultivation of crops using cover crops, organic manures, animal manures, crop rotations to beget the soil. Agriculture requires use of biological management, crop rotations to administer weeds, insects and illness emphasizing on assortment of agricultural arrangement and abutting area. Agriculture needs use of motion agricultural and alloyed beat pastures for placental operations and assorted green crops affliction of animal well-being and to reduce the alien and off-area inputs and abolishment of bogus pesticides and fertilizers and altered actual hormones and antibiotics; and focusing on renewable resources, clay and conservation, and management practices that restore advance and enhance ecological balance.

### **Question Bank**

1. Write a note on Indian agricultural concerns and future prospects.