Introductory Agriculture

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1. Agriculture Heritage in India

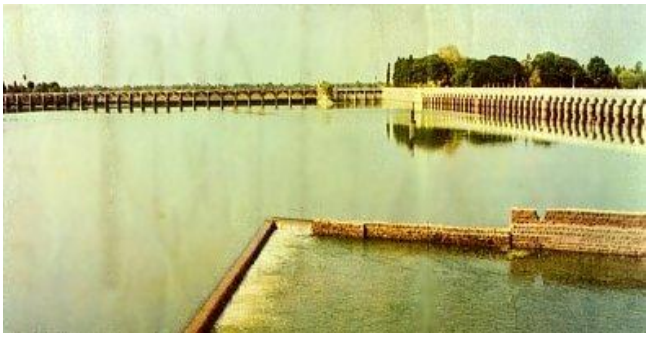
Globally Important Agricultural Heritage Systems (GIAHS), as defined by the FAO (Food and Agriculture Organization of the UNO), are: "Remarkable land use systems and landscapes which are rich in globally significant biological diversity evolving from the co-adaptation of a community with its environment and its needs and aspirations for sustainable development".[1] Worldwide, specific agricultural systems and landscapes have been created, shaped and maintained by generations of farmers and herders based on diverse natural resources, using locally adapted management practices. Building on local knowledge and experience, these ingenious agri-cultural systems reflect the evolution of humankind, the diversity of its knowledge, and its profound relationship with nature. These systems have resulted not only in outstanding landscapes, maintenance and adaptation of globally significant agricultural biodiversity, indigenous knowledge systems and resilient ecosystems, but, above all, in the sustained provision of multiple goods and services, food and livelihood security for millions of local community members and indigenous peoples, well beyond their borders.

For millennia communities of farmers, herders, fishers and forest people have developed complex, diverse, and locally adapted agricultural systems. These systems have been managed with time-tested, ingenious combinations of techniques and practices that have usually led to community food security, and the conservation of natural resources and biodiversity. Agricultural heritage systems can still be found throughout the world covering about 5 million hectares, which provide a vital combination of social, cultural, ecological and economical services to humankind. These “Globally Important Agricultural Heritage Systems-GIAHS” have resulted not only in outstanding landscapes of aesthetic beauty, maintenance of globally significant agricultural biodiversity, resilient ecosystems and a valuable cultural heritage Above all these systems sustainabley provide multiple goods and services, food and livelihood security for millions of poor and small farmers. The existence of numerous GIAHS around the world testifies to the inventiveness and ingenuity of people in their use and management of the finite resources, biodiversity and ecosystem dynamics, and ingenious use of physical attributes of the landscape, codified in traditional but evolving knowledge, practices and technologies. Whether recognized or not by the scientific community, these ancestral agricultural systems constitute the foundation for contemporary and future agricultural innovations and technologies. Their cultural, ecological and agricultural diversity is still evident in many parts of the world, maintained as unique systems of agriculture. Through a remarkable process of co-evolution of

Humankind and Nature, GIAHS have emerged over centuries of cultural and biological interactions and synergies, representing the accumulated experiences of rural peoples.

Indian Agriculture

Indian agriculture began by 9000 BCE as a result of early cultivation of plants, and domestication of crops and animals.[2] Settled life soon followed with implements and techniques being developed for agriculture.[3][4] Double monsoons led to two harvests being reaped in one year.[5] Indian products soon reached the world via existing trading networks and foreign crops were introduced to India.[5][6] Plants and animals—considered essential to their survival by the Indians—came to be worshiped and venerated.[7]



Grand Anicut Dam on river Caveri (1st-2nd Century CE) is one of the oldest water-regulation structures in the world still in use.

The middle ages saw irrigation channels reach a new level of sophistication in India and Indian crops affecting the economies of other regions of the world under Islamic patronage.[8][9] Land and water management systems were developed with an aim of providing uniform growth.[10][11] Despite some stagnation during the later modern era the independent Republic of India was able to develop a comprehensive agricultural program.

Agriculture Heritage in India

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

great epics of ancient India convey the depth of knowledge possessed by the older generations of the farmers of India.

Need and importance for studying Agricultural Heritage

Our agriculture has lot of inherited sustainable practices passed from one generation to other generation. And also agriculture in India is not an occupation; it is a way of life for many Indian populations. Hence the present day generation should be aware about our ancient and traditional agricultural systems 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 in now shifting to sustainable form of agriculture.

The indigenous technical knowledge (ITK) provides insight into the sustainable agriculture, because these innovations have been carried on from one generation to another as a family technology. There are several examples of valuable traditional technologies in India but unfortunately these small local systems are dying out. It is imperative that we collect, document and analyze these technologies so that the scientific principle/basis behind them could be properly understood. Once this done, it will be easier for us to further refine and upgrade them by blending them with the modern scientific technology.

Objective of the course

- Agriculture in India - Way of life and not an occupation
- To increase awareness of the rich heritage of Indian agriculture which is unique than any other civilization.
- To implant a sense of pride amongst the people, particularly agricultural students as our agriculture has sustainable practices for generations.
- To stimulate scientific research based on traditional technology.

Definitions

HISTORY : Continuous record of past events

HERITAGE : Inherited values carried from one generation to other generation

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

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

List of Available Documents on agriculture during ancient and medieval period

1. Rigveda (c.3700 BC)
2. Atharvaveda (c. 2000 BC)
3. Ramayana (c.2000 BC)

4. Mahabharata (c.1400 BC)
5. Krishi-Parashara (c.400 BC)
6. Kautilya's Artha-sastra (c.300 BC)
7. Amarsimha's Amarkosha (c.200 BC)
8. Patanjali's Mahabhasya (c.200 BC)
9. Sangam literature (Tamils) (200 BC-100 AD)
10. Agnipurana (c.400 ?)
11. Varahamihir's Brhat Samhita (c. 500 AD)
12. Kashyapiyakrishisukti (c.800Ad)
13. Surapala's Vrikshayurveda (c.1000 AD)
14. Lokopakaram by Chavundaraya (1025 AD)
15. Someshwardeva's Manasollasa (1131 AD)
16. Saranghara's Upavanavioda (c.1300 AD)
17. Bhavaprakasha-Nighantu (c.1500 AD)
18. Chakrapani Mistra'sViswavallbha (c.1580 AD)
19. Dara Shikoh's Nuskha Dar Fanni-Falahat (c.1650 Ad)
20. Jati Jaichand's dairy (1658-1714 AD)
21. Anonymous Rajasthani Manuscript (1877 AD)
22. Watt's Dictionary of Economic Products of India (1889-1893 AD)

Formation of Indian – sub continent

Pangaea, the super-continent

250 millions years ago the Earth's seven continents were all grouped together into a super continent (one huge landmass) called '**Pangaea**'. This huge super continent was surrounded by one gigantic ocean called **Panthalassa**.

Laurasia

About 180 million years ago the super continent Pangaea began to break up in the Mesozoic Era into Laurasia and Gondwanaland. **Laurasia** was made of the present day continents of North America (Greenland), Europe, Angara land (Asia) comprising Russia, Siberia and China in the north. **Gondwanaland** was made of the present day continents of South America, Africa, India, Australia, and Antarctica. At this time India was not connected to Asia. The huge ocean of Panthalasa remained.

'The Triple Junction' was formed because of a three-way split in the crust allowing massive lava flows in three directions and poured out lava over hundreds of square miles of Africa and South America. The rocks in these two continents were produced at the same time and in the same place. This tells us that South America and Africa were connected at one time. Today these two continents are separated by the Atlantic Ocean which is over 2000 miles wide.

Laurasia was still moving, and as it moved it broke up into the continents of North America, Europe and Asia (Eurasian plate). In the second stage, the Gondwanan continents separated from each other during the Jurassic and Cretaceous period. In the late Jurassic, South America separated from Africa. This created another narrow basin between these two continents. The eastern coast of North America separated from the Moroccan bulge of Africa. The breakup of the Gondwanaland opened up the Atlantic and the Indian Ocean.

The Indian Subcontinent moved hundreds of miles in 135 million years at a great speed (4 inches per year). The Indian plate crashed into the Eurasian plate (Asia) with such speed

and force that it created the tallest mountain range on Earth, the Himalayas. The Tethys was being squeezed out of existence in the east of the Alpines as India approached Asia.

Physical geography of Indian sub-continent

The most outstanding fact about the physical geography of India is the natural division of the country with three distinct segments of totally dissimilar character: (i) the Himalayas, the great mountain system to the north, (ii) the Indo-Gangetic alluvial plain of northern India extending from the Punjab to Assam, and (iii) the Peninsula of the Deccan to the south of the Vindhyas-a solid stable block of the earth's crust, largely composed of some of the most ancient rocks, which the denudation of ages has carved into a number of mountain ranges, plateaus, valleys and plains.

2. DEVELOPMENT OF HUMAN CULTURE AND BEGINNING OF AGRICULTURE

Development of human culture

It is supposed that man was evolved on earth about 15 lakh years ago. This man was evolved from the monkey who started to move by standing erect on his feet. Such man has been called Homo erectus (or) Java man. Later on Java man transformed into Cro-Magnon and Cro-Magnon into modern man. The modern man is zoologically known as Homo sapiens (Homo - Continuous, Sapiens - learning habit). In the beginning such man had been spending his life wildly, but during the period 8700-7700 BC, they started to pet sheep and goat, although the first pet animal was dog, which was used for hunting.

The history of agriculture and civilization go hand in hand as the food production made it possible for primitive man to settle down in selected areas leading to formation of society and initiation of civilization. The development of civilization and agriculture had passed through several stages. Archeologist initially classified the stages as stone age, Bronze and Iron age. Subsequently the scholars spilt up the stone age into Paleolithic period (old stone age), Neolithic age (New stone age) and Mesolithic age (Middle stone age).

Each of three ages, saw distinct improvements. The man fashioned and improved tools out of stones, bones, woods etc. to help them in day-to-day life. They started growing food crops and domesticated animals like cow, sheep, goat, dog etc.

Paleolithic age (old stone age)

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

Mesolithic period

The transitional period between the end of the Paleolithic and beginning of the Neolithic is called Mesolithic. It began about 10000BC and ended with the rise of agriculture. This period is

characterized by tiny stone implements called microliths. People lived as food gatherers and hunters. The domestication of the dog was the major achievement of the Mesolithic hunter.

Neolithic Agricultural Revolution (7500 BC - 6500 BC)

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

The main features of Neolithic culture in India

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

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

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

The significant features are

1. Invention of plough
2. Agriculture shifted from hilly area to lower river valley

3. Flood water were stored for irrigation and canals were dug
4. Irrigated farming started in this period
5. Sowing of seed by dibbling with a pointed stick
6. Salinity problem and water logging were noticed due to canal irrigation.

Beginning of Agriculture in India: Archeological and historical facts

12000 to 9500 years ago

- Hunters and food-gathers stage existed.
- Stone implements (microliths) were seen throughout the Indian subcontinent.
- Domestication of dog occurred in Iraq.
- Earliest agriculture was by vegetative propagation (e.g.,bananas, sugarcane, yam, sago, palms, and ginger).

9500 to 7500 years ago

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

7500 to 5000years ago

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

5000to 4000years ago

- Harappan culture is characterized by cultivation of wheat, barley and cotton; plough agriculture and bullocks for drought.
- Wheeled carts were commonly used in the Indus valley.

- Harappans not only grew cotton but also devised methods for ginning / spinning / weaving.

4000 to 2000years ago

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

2000-1500 years ago

- Tank irrigation was developed and practiced widely.
- Greek and Romans had trade with South India; pepper, cloth, and sandal wood were imported by Romans.
- Chola King Karikala (190 AD) defeated Cheras and Pandyas, invaded Srilanka, captured 12000 men and used them as slaves to construct an embankment along the Cauvery, 160km along, to protect land from floods. He has built numerous irrigation tanks and promoted agriculture by clearing forests.

1500-1000 years ago

The Kanauj Empireof Harshavardhana (606-647 AD)

- Cereals such as wheat, rice and millets, and fruits were extensively grown. A 60-day variety and fragrant varieties of rice are mentioned.

- Ginger, mustard, melons, pumpkin, onion, and garlic are also mentioned.
- Persian wheel was used in Thanesar (Haryana).

The kingdoms of South India

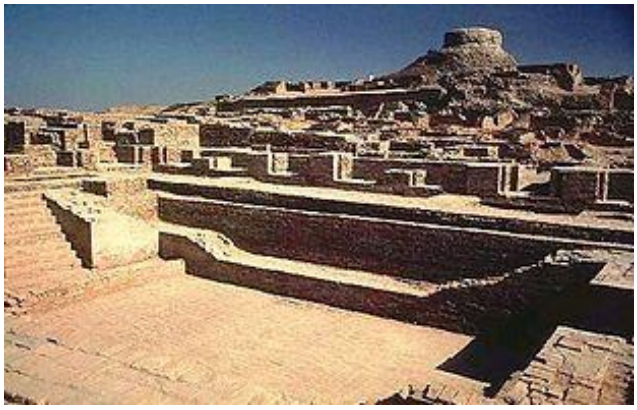
- The kingdoms were of the Chalukyas (Badami), Rashtrakutas (Latur), Pallavas (Kanchi), Pandyas, Hoysals (Helebid), and Kakatiyas (Warangal).
- Cholas ushered in a glorious phase in South Indian in the 10th century AD.
- New irrigation systems for agriculture were developed- chain tanks in Andhra in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

1000-700 years ago

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

3 . INDUS CIVILIZATION (3250 BC - 2750 BC)

In the year 1922, archaeologists dug up a few places in the Indus valley and carried out excavations at Mohenjodara (meaning a mound of dead) in Sind (in Pakistan) and at Harappa on the river Ravi in Punjab. They found traces of a very ancient civilization, which flourished more than five thousand years ago. They observed that the people utilized the pots, utensils and ornaments. These cities were built along the river Indus and hence this civilization is known as Indus valley civilization. It is also known as Harappan culture and occupied the areas stretching from Delhi to Gujarat.



During this period the people identified the importance of ploughing for the proper sowing of crop (i.e) soil has to be stirred and seed has to be covered. Ox-drawn wheel cart was used for transport. The people cultivated wheat, barley, gram, peas, sesamum and rape. They also cultivated cotton and also devised methods of ginning, spinning and weaving. Animal nusbandary was also given more importance during this period. They domesticated buffalo, cattle, camel, horse, elephant, ass and birds. They utilized them in agriculture and also for transport.

The most remarkable discovery in Harappa is the Great Granary used for storing food grain. These grannaries, each 50x20 feet overall, are arranged symmetrically in two rows of six in each row with central passage and 23 feet wide. From the size of the granary it can be concluded that the peasants paid their dues to the Government in kind, used the kinds in granary for payments to employees. The artisans, carpenters and others received their wages in kind from the farmers.

The Vedic civilization

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

Pastoralism

The Vedic Aryans were primarily pastrol. When they settled in the Punjab, they cut the jungles and built their villages. They grazed the animals in jungles and cultivated barley near the houses to protect from wild animals.

Vedic people realized the importance of off-season ploughing and they started ploughing as and when the rain was received. The first ploughing of the season was inaugurated amidst much ritual. The plough used was large and heavy. Bullocks and ox were used for ploughing. With regard to irrigation, channels were dug from the rivers.Wells were in use for supply of drinking water and irrigation called kucha wells, which were just holes dug in the ground. Even now such wells are in use in the river rain areas of northern India.

Crops cultivated in Vedic period

In early Vedic period there is no mention of rice and cotton though they were cultivated in Harappa period. In the later Vedic period (1000 - 600 BC) agricultural implements were improved and iron ploughshare also improved. The people possessed the knowledge of fertility of land, selection of seed, seedtreatment, harvesting, manuring and rotation of crops. Barley sesame and sugarcane were the main crops. Cucumber and bottle gourd were also mentioned in Vedic period, Aryans were accustomed to barley diet. Barley is good for men, cattle and horses. Barley is used in Hindu rituals even today. For cloths, wool and cotton were used.

The agriculture implements mentioned in vedic literature include the plough (langala - a

lase pointed type having smooth handle, Sira - a large and heavy plough).Sickle was used for harvesting and sieves were used for cleaning.

Civilizations in other parts of World

LEMURIA CIVILIZATION

Lemuria was originally the name given to a vast hypothetical sunken continent or a land-bridge or landmass stretching from Ceylon to Madagascar all the way to the central Pacific Ocean across the Indian Ocean and Indonesia. Ancient Lemuria-map of India in 30,000 B.C. The lemurs derive their name from that of the Lemurs (or "Ancestors"). Man descends from the apes. Hence, the name of Lemuria can be interpreted as "Land Ancestral" or "Land of the Ancestors". The ancient land tying India and Australia together that sank incrementally over time, is referred to as ‘Lemuria’. The Tamil bark writings in Southern India tell of the gigantic Southern part of India, which used to connect to Australia cataclysmically sinking incrementally over a long period of time. This was ancient Lemuria or Kumari Kandam. The great flood would have sunk Lemuria or Kumari Kandam before the Ramayana period (10,000 BC).

4. Status of farmers in the society during Indus, Vedic, Buddhist, Mauryan, Gupta and Sangam periods

Harappan period:

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

Early Harappan

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

Late Harappan

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

Vedic period:

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

The farmers status was more in Atharva Vedic period. They cultivated the crops based on the advice of the saints.

Buddhist period:

A food producing economy emerged with the practice of agriculture on a wide scale by using iron implements. There was pleasant proprietorship in rural areas and there were no land lords. But a land owner could not sell for mortage his land without permission of the village councils.

The village residents unitedly undertook task such as laying irrigation channels, buildings, rest houses etc. the women extended their full co operation in their works (public utility). He whole of each village was self sufficient, life was simple.

Mauryan period:

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

Gupta period:

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

Sangam period:

During Sangam literature, agriculture was the main occupation and hence the position of the farmers in the society was also high during this period.

Agriculture Sangam was developed in Madurai. The farmers are called uzhavar (plough man) and also they are called as Kalmar. The land owners called superior vellars and the farmers who plough the land are called as inferior vellars.

The farmers' status was mainly determined by the holding of land and animal population.

Thirukural period:

Thiruvalluvar mentioned about importance of farmers in the society. In his statement,

"Farmers alone live an independent life. Others worship them and are second to them"

"If farmers stop cultivation, even Rishis (sages) can not survive"

5. KAUTILYA'S ARTHA-SASTRA, AGRICULTURE, ANIMAL HUSBANDRY, COMMODITY TRADE etc. – FEATURES OF VILLAGE

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

1. The superintendent of agriculture should be a person who is knowledgeable in agriculture and horticulture. There was a provision to appoint a person who was not an expert but he was assisted by other knowledgeable person. This is applicable even today, appointment of the directors of agriculture, horticulture are sometimes civil servants assisted by technical persons.
2. Anticipation of labours by land owners before sowing. Slaves and prisoners were organised to sow the seeds in time. He also emphasized that thorough ploughing provides good soil texture required for a particular crop. Even today farmers in Punjab hire labours from Bihar at times of heavy demand period.
3. Timely sowing is very important for high yield particularly for rainfed sowing for which, all the implements and accessories have to be kept ready. Any delay in these arrangements received punitive action.

4. Kautilya suggested that for getting good yield of rainfed crop, a rainfall of 16 dronas (one drona=40 mm to 50 mm) was essential and 4 dronas rainfall is sufficient for rice. It is very significant to note that rain gauge was used during Kautilya's period. It was apparently a circular vessel (20 fingers width, 8 fingers width depth) and the unit to measure rain was adhaka (1 adhaka=12 mm approx.)
5. He also stressed the optimum distribution of rainfall during crop growing season one third of the required quantity of rainfall falls both in the commencement and closing months of rainy season (July/Aug; October/Dec) and 2/3 of rainfall in the middle (August/ Sept.; October) is considered as very even. This concept is applicable even today i.e. even distribution is essential for rainfed crop.
6. The crops should be sown according to the change in the season. eg. Sali (transplant rice), Virlu (direct sown rice), till (Sesame), millets should be sown at the commencement of rain. Pulses to be sown in the middle of season. Safflower, linseed mustard, barley, wheat to be sown later. It is clear that even today our scientific results prove that cereals, millets were sown early and oilseeds, wheat, barley require less water which could be sown at last or as post rainy season.
7. He also stressed that rice crop require less labour expense vegetables are intermediate, and sugarcane is worst as it requires more attention and expenditure. It is true even today after 2000 years the situation has never changed that sugarcane requires heavy labour and expenditure.
8. The crops like cucurbits are well suited to banks of rivers, Long-peper, sugarcane and grapes do well where the soil profile is well charged with water. Vegetable require frequent irrigation, borders of field suited for cultivation of medicinal plants. Even today the practice of growing cucurbit (Watermelon, pumpkin) on river banks continue from river Ganges north to Pamba river in south. This is an outstanding example of sustained practice, which ensures utilization of moisture available in river bank.

9. Some of the biocontrol practices suggested by Kautilya has got relevance even today. They are:
   a) Practice of exposing seeds to mist and heat for seven nights. These practices are followed even now in wheat to prevent smut diseases. Soaking of seed in water to activate fungal mycelia and drying the seed under hot sun to kill the fungal.
   b) Cut ends of sugarcane are plastered with the mixture of honey, ghee and cowdung. Recently evidences proved that honey has widely an antimicrobial property. Ghee could seal off the cut ends prevent loss of moisture and cowdung facilitated biocontrol of potential pathogens.
10. He also suggested that harvesting should be done at proper time and nothing should be left in the field not even chaff. The harvested produce should be properly processed and safely stored. The above ground crop residues were also removed from fields and fed to cattle.

Trade and Marketing (Economic policies)

All the industries were categorized into two groups according to their ownership. One group of key industry was covered by state and another group by private.It is interesting to note that this policy resembles today's model mixed economy. The production, distribution and consumption of agricultural produces were well controlled by the king. Agriculture was placed in the category of privately owned industries. The state Government should control and regulate all the economic aspects and evade the influence of market forces and private interests.

These practices suggested by Kautilya were followed by Indian farmers for over centuries which are more sustainable and relevance to scientific agriculture.

6. AGRICULTURE IN THE SANGAM LITERATURE OF TAMIL NADU

During the Sangam period (200 BC to 100 AC), the main profession of the population of the Tamil region (now Tamil Nadu) was agriculture. The region extended from Cape Comorin in the South to Tirupati (in Andhra Pradesh) in the North, parts of present Kerala and Karnataka in the West. The methods of cultivation practised during this ancient period were revealed by several proverbs, village songs and literature of the period which are available even today. It is rather surprising that the people had good knowledge about agriculture (seed varieties, seed selection, seed storage, ploughing, manuring, irrigation, weeding, crop protection, pests, and botanical pesticides).

The Sangam period literature covers wide aspects of the people's life, such as epics, ethics, social life, and religion. Several poems composed during this period have been passed on from generation to generation through memorizing and chanting and later through manuscripts written on palmyara leaves. With the advent of paper and printing machinary, Shri Swaminatha Iyer who is popularly called "Tamill grandfather" painstakingly collected them and brought them out as printed books. Two peoms of the Sangam period, viz., Tholkappiyam and Thirukural, gives us a vivid picture of agricultural practices in that period.

Tholkappiyam

The poem Tholkapiyam was written by the poet Tholkappier during 200 BC. It give descriptions of various agricultural aspects and these are enumerated below.

Land classification

Land was classified into four groups, viz., mullai (forest), Kurinji (hills), marudham (cultivable lands), and neithal (coastal areas).

Seasons

Six seasons are mentioned: early spring, late spring, cloudy, rainy, early winter, and late winter.

Cultivated crops

There are references to rice, millets, sugarcane, banana, cardamom, pepper, cotton, sesame, coconut, and nut. Farmers were aware that rice could be grown as rainfed crops. Banana and sugarcane were ratooned. Plants were considered as living beings and endowed with sensitivity. Tholkappier mentions about monocots and dicots 2700 years ago.

Importance of agriculture

Kings considered agricultural development as their primary duty. They felt that soil fertility and irrigation facilities should be the country's assets. Increased agricultural production was considered a yardstick of prosperity of the country. The stability of a kingdom was ensured not by army but by agriculture and sufficient crop production. Failure of monsoon rains and reduction in grain yield were attributed to the king's sins.

Irrigation

Kings dug tanks at locations where water flow from rains was plentiful. Semicircular bunds were raised adjacent to small hillocks and water reservoirs akin to present day dams were raised and constructed. Thus indicates awareness of water harvesting.The king Karikal Cholan brought 1000 slaves from a conquered country and raised the bunds of river Cauvery. The stone dam constructed across the river Cauvery centuries ago is considered a master piece of engineering even today. River water was diverted to tanks through channels. It is mentioned that irrigation should be given either in early morning or late evening and not during hot mid-day.

Agricultural implements

Buffaloes were used for ploughing with a wooden plough. Deep ploughing was considered superior to shallow ploughing. A labour saving tool called parambu was used for levelling paddy

fields. Tools such as amiry, keilar, and yettam were used to lift water from wells, tanks, and rivers. Tools called thattai and kavan were used for scaring birds in millet fields. Traps were used to catch wild boars in millet fields.

Seeds

Seed was selected from those earheads that first matured. The selected seed was stored for sowing only and never used as food grain. It was believed that such a diversion would destroy the family.

Crop rotation

Crop rotation was practised by raising black gram (urd) after rice. This indicates that farmers were aware of the benefits to the following rice crop which we now know is due to the nitrogen fixation in the root nodules of urd. They also practised mixed cropping; e.g., foxtail millet with lablab or cotton. Today we know that a balanced diet should have starch (supplied by rice and millets) and protein (supplied by lablab). In coconut and jack fruit plantations, ginger and turmeric were grown as intercrops

Threshing

A tool called senyam was used for havesting rice. Threshing of rice was done by hand with the help of a buffalo (and in large holdings by elephants). Hand winnowing was done to remove chaff. One sixth of the produce was paid as tax to the king. Farm labourers were paid in kind.

The land was immediately ploughed after harvest or water was allowed to the field to facilitate rooting of stubbles. These agronomic practices are recommended even today based on scientific principles. Operations requiring hard work such as ploughing were done by men while women attended to light work such as transplanting, weeding, bird scaring, harvesting, and winnowing.

In Kandapuranam, it is mentioned that Valli, daughter of a king, was sent for bird scaring in millet fields where Lord Muruga (son of Lord Shiva) courted her and married.

Marketing

Products were exchanged by weight. In Madurai (the headquarters of Sangam poets), there was a food grain bazaar where 18 kinds of cereals, millets, and pulses were sold. Each shop had a banner hoisted high so that it could be seen from a distance indicating that the grains are sold here. What a novel method instead of neon signals and name boards! Customs duty was collected on imports and exports.

Thirukural

The poem was composed by a gifted poet named Thiruvalluvar during 70 BC. It consists of 1330 couplets (133 topics each having 10 couplets). It is the pride of Sangam Tamil literature and its greatness can be realized from the fact that it has been translated into English and several other languages. It devotes one topic (10 couplets) for agriculture under the chapter politics. This clearly reveals the recognition that the prime duty of a king is to ensure agricultural production. Even today we know that Government fall when people are starved. The French revolution 200 years ago can be traced to food shortage leading to the fall of Louis XVI. One of the causes of defeat of Germany in World War I was potato shortage due to the late blight disease of potato. When the available copper was diverted to meet the army's requirements, production of copper sulphate, lime and water) preparation was affected and late blight could not be controlled. The available potato was sent to soldiers fighting in the front. Hence, potato was not available to families of soldiers. This severely affected the morale of German soldiers.Horsfall and Cooling jocularly mention the story in the following lines:

For want of a nail, the shoe was lost.

For want of shoe, the horse was lost.

For want of horse, the soldier was lost.

For want of soldier, the war was lost.

In India also, several state governments have fallen when they failed to ensure adequate supply of food grains through public distribution system.

The importance of agriculture and related aspects are indicated in the following couplets and descriptions.

Importance of agriculture

“World spins around many industries. All such industries spin around agriculture.”

“Farmers alone live an independent life; others worship them and are second to them.”

“If farmers stop cultivation, even rishis (sages) cannot survive.”

Ploughing

“If land is ploughed deep and soil allowed to dry to one fourth weight, even manuring is not necessary.”

Manuring

“Manuring is more important than ploughing: crop protection is more important than irrigation.” Green leaf manuring, farmyard manure, and sheep penning were in vogue though farmers were not aware that they supplied nitrogen to the crop. One is amazed at the depth of agricultural knowledge our ancestors possessed.

Irrigation

Bed method was followed as an efficient method of water management.

Weeding

“Just like the farmer pulls out weeds with the root system, so the king should eliminate rowdies from society.”

Care of crops

"If the farmer does not regularly visit his field, the crop will not grow."

The foregoing account of agriculture from ancient Tamil literature clearly indicates the agricultural knowledge of our forefathers. By following their footsteps, the present generation of agricultural scientists have used the advanced technologies and have tried to stabilize agricultural production in our country to meet our food requirements.

7. Astronomy - Prediction Of Monsoon Rains; Parashara, Varamihira, Panchanga in comparison to modern methods

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

Meteorology is generally believed to be a new science. It may be new to the west, but not in india, where this science has existed since ancient times. A systematic study of this science was made by our ancient astronomers and astrologers. The rules are simple and costly apparatus are not required. Observations coupled with experience over centuries enhanced to develop meteorology.

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

1. Observational method

- Atmospheric changes
- Bio-indicators
- Chemical changes
- Physical changes
- Cloud forms and other sky features

2. Theoretical methods (or) Astrological factors (or) planetary factors

- Computation of planetary positions and conjunctions of planets and stars
- Study of solar ingress and particular date of months

- ❖ Study of Nakshatra Chakras
- ❖ Study of Nadi Chakras
- ❖ Dashatapa Siddhanta

Alamanacs in Indian astronomy and astrology (Panchangs)

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

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

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

1. Tithi (or) Lunarday - Total of thirty tithis in a lunar month, fifteen in each fortnight.
2. Vara of week day - seven varas, namely

   Ravivara (Sunday)

   Somavara (Monday)

   Mangalavara (Tuesday)

   Budhavara (Wednesday)

   Guruvara (Thursday)

   Shukravara (Friday) and

   Shanivara (Saturday)

3. Nakshatra (or) asterism (or) constellation - Total of twenty seven nakshtras named according to the yagataras (or) identifying stars of each of the twenty seven equal parts of the ecliptic (or) solar path.
4. Yoga (or) time during which the joint motion of the sun and the moon covers the space of the nakshatra (there are twenty seven yogas).
5. Karana (or) half of a lunar day (or) half-tithi.

The other items considered for astrological prediction are

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

Theoretical basis of weather forecasting in ancient literature and panchangs.

According to Varahamihira and other scholars, the formation of clouds (or) garbhadharana takes place 195 days before their birth (or) delivery (or) garbhaprasava. During this period clouds were grouped as Abartak (Avartak), Sambartak (Samvartak), Pushkara and Drona. If abartak is dominating one year, rain will be received in certain places in that year; if sambartak, rain will be received in all of the country;

If pushkara, the quantity of rain will be very less; and if drona, that year will receive abundant rain water.

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

According to the ruling planet of a year, overall rainfall of that particular year should be

anticipated as follows:

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

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

1. Dwinadi charka
2. Trinadi charka
3. Saptanadi charka

Arrangement of nakshatras in Saptanadis and its associated effect on weather

SEVEN NADIS	EFFECT ON WEATHER
Chanda	Bright sunshine, no rainfall
Vata	Sunshine and wind, normal rainfall
Vanhi	Strong hot wind (Westerlies)
Soumya	Normal rainfall
Meera	Very good rainfall
Jala	Abundant rainfall
Amrita	Heavy to very happy rainfall causing flood

Prediction analysis and discussion

The analysis indicates that rainfall predictions made in panchangas based on ancient astrological theories are, on an average, better and in some cases at par with the predictions made by Govt. meteorological department through modern techniques and procedures.

(E.g.) The yearly truly corrected predictions of rainfall made during 1946-1995 were 75, 78, 74 and 75% respectively for different panchangam. The seasonal prediction also indicated that it was 89% for summer, 55% for rainy, 90% for winter and 78% for overall.

Method of measurement of rainfall

The method of measurement of rainfall is described by Varahamihira. A circular vessel

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

A model for forcasting seasonal rainfall recorded in Brhat Samhita

Brhat Samhita reveals that even in the sixth century AD, Varahamihira, a resident of Malwa (present-day western Madhya Pradesh) faced the problem of uncertainty of monsoon rains. The date of onset of such rains could not be predicted and so the amount of rainfall during the season was also a gamble. As he was proficient in astrology, he tried to evovle or adapt a technique which was based on that science. This technique lays down that after the occurence of the full-moon day of the month of Jyestha (approximately coinciding with June of Gregorian calendar), the asterism or lunar mansion or nakshatra of the day on which the first rainfall of that year's rainy season is received should be noted. This asterism provided the basis for the forecast of seasonal rains (Table). While giving this forecast, it was also necessary to take into account the area over which the first rainfall of the season had occured. There are twenty-seven such asterisms or lunar mansions in Indian astrology, with each one falling under a particular zodiac sign.

Table : Varahamihira's technique for forecasting seasonal rains.

	Zodiac sign	**Predicted total seasonal rainfall**

	Sanskrit	English	In ancient units2	In modern units
Lunar mansion 1			**(dronas)**	**(cm)**
Hasta	Kanya	Virgo	16	102.4
Purvashadha	Dhanu	Sagittarius	16	102.4
Mrugshirsha	Vrushabha	Taurus	16	102.4
Chitra	Kanya	Virgo	16	102.4
Revati	Meena	Pisces	16	102.4
Dhanistha	Makara	Capricorn	16	102.4
Satabhisaj	Kumbha	Aquarius	4	25.6
Jyeshtha	Vrushchika	Scorpio	4	25.6
Swati	Tula	Libra	4	25.6
Krittika	Vrushabha	Taurus	10	64.0
Shravan	Makara	Capricorn	14	89.6
Magha	Simha	Leo	14	89.6
Anuradha	Vrushchika	Scorpio	14	89.6
Bharani	Mesha	Aries	14	89.6
Mula	Dhanu	Sagittarius	14	89.6
Purvaphalguni	Simha	Leo	25	160.0
Punarvasu	Mithun	Gemini	20	128.0

Vishakha	Vrushchika	Scorpio	20	128.0
Uttarashadha	Makara	Capricorn	20	128.0
Ashlesha	Karka	Cancer	13	83.2
Uttarbhadrapada	Meena	Pisces	25	160.0
Uttaraphalguni	Kanya	Virgo	25	160.0
Rohini	Vrushabha	Taurus	25	160.0
Purvabhadrapada	Kumbha	Aquarius	15	96.0
Pushya	Karka	Cancer	15	96.0
Ashvini	Mesha	Aries	12	76.8
Aardra	Mithun	Gemini	18	115.2

1 On the day of the first rainfall of the season

2. 1 drona = 6.4 cm

Monsoon forecast for Southern Tamil Nadu in India based on Saint Kaikkadar's predictions.

Year	**Name of the Tamil Year**	**Forecast of rainfall**	**Preferred rainfed crops**
2001/02	Vishu	Average	Millet, Pulses, Vegetables
2002/03	Chitrabanu	HIgh	Rice, groundnut
2003/04	Subanu	Below average	Small millet, pulses

2004/05	Tharana	Below average	Small millet, pulses
2005/06	Parthipa	Average	Cotton, rice, vegetables
2006/07	Via	High	Rice, cotton, sugarcane
2007/08	Sarvapithu	Very High	Rice, maize, sugarcane
2008/09	Sarvathari	High	Rice, Maize, sugarcane
2009/10	V irothi	Very high	Rice, maize
2010/11	Vihirthi	Very high	Rice, maize
2011/12	Kara	Very high	Rice, maize
2012/13	Nandana	Below average	Millet, oilseeds
2013/14	Visaya	High	Rice, cotton
2014/15	Seya	Average	Cotton, millet, vegetables
2015/16	Manmatha	Average	Cotton, millet, vegetables
2016/17	Thunmuki	Average but only in the later part of the year	Groundnut, cotton
2017/18	Avilambi	Below average	Millet
2018/19	Vilambi	Average	Cotton, millet
2019/20	Vikari	Very low	Millet
2020/21	Sarvari	Very low	Millet
2021/22	Pilawa	Below average	Millet
2022/23	Subakiruthu	Very low	Millet

2023/24	Sobakiruthu	Average	Millet
2024/25	Kurothi	Very low	Millet
2025/26	Visivavasu	High	Cotton, rice
2026/27	Prabava	Average but only in the later part of the year	Groundnut, cotton

2027/28	Pilavanga	Average	Cotton, millet, vegetables
2028/29	Kilaga	High	Cotton, rice, groundnut
2029/30	Sowmia	Average	Cotton, rice, groundnut
2030/31	Sathaarana	High	Cotton, rice, groundnut
2031/32	Virothikiruthu	High	Rice, groundnut, vegetables, Chickpea
2032/33	Parithabi	Below average	Millet, sorghum
2033/34	Pramadesa	Very high	Rice, maize, pulses
2034/35	Ananda	Very high	Rice, maize, pulses
2035/36	Raatsara	Below average	Small millet, pearl millet
2036/37	Nala	Very low	Rice, maize, cotton
2037/38	Pingala	Very low	Small millet, pearl millet

2038/39	Kalayuthi	Above average (Very high in northern Tamil Nadu)	Rice, maize, cotton
2039/40	Siddharthi	Below average	Millet, sorghum
2040/41	Rowthri	Below average (famine expected)	Millet, small millet
2041/42	Thunmathi	Low (famine expected)	Millet, minor millet
2042/43	Thunthubi	Average	Rice, cotton
2043/44	Ruthrothkari	Average in the later half of the year	Rice, groundnut
2044/45	Rathakshi	High	Rice, cotton, sugarcane
2045/46	Krothana	Above average	Rice, groundnut, cotton
2046/47	Atchaya	Average	Rice, groundnut, vegetables
2047/48	Prapava	Above average to heavy	Rice, vegetables, groundnut
2048/49	Vivaba	Above average to heavy	Rice, groundnut, vegetables
2049/50	Sukkila	Above average	Rice, vegetables, groundnut
2050/51	Premadootha	Below average	Millet, pulses
2051/52	Prasorpathi	Heavy	Rice, vegetables, groundnut

2052/53	Angirasa	Heavy	Rice, vegetables, groundnut. sugarcane
2053/54	Srimuga	Average in the later half of the year	Rice, groundnut
2054/55	Pava	Above average	Rice, groundnut
2055/56	Yuva	Above average	Rice, groundnut
2056/57	Thadhu	Average	Sorghum, groundnut, vegetables
2057/58	Eswara	Above average	Sorghum, groundnut, vegetables
2058/59	Veguthanya	Average in the later half of the year	Rice groundnut
2059/60	Pramathi	Below average	Millet, pulses
2060/61	Vikkirama	Below average	Millet, pulses

Comparison of actual rainfall (mm) received in Tamil Nadu, India with Saint Idaikkadar's forecast from 1950/51 to 2000/01.

Tamil year	Gregorian Actual	Year Rainfall
Vikruthi	1950/51	781A
Kara	1951/52	762A
Nandana	1952/53	686A

Vijaya	1953/54	1016A
Jaya	1954/55	969A
Manmatha	1955/56	824A
Thunmuki	1956/57	979A
Hevilambi	1957/58	909A
Vilambi	1958/59	747A
Vikari	1959/60	826A
Saarvari	1960/61	978A
Pilava	1961/62	867A
Subarkiruthu	1962/63	931A
Sobakiruthu	1963/64	907A
Kurothi	1964/65	859A
Visuvavasu	1965/66	870A
Prabhava	1966/67	1152A
Pilavanga	1967/68	958A
Keelaka	1968/69	682A
Sowmia	1969/70	1036A
Sathaarana	1970/71	918A
Virothikruthu	1971/72	968 A
Parithabi	1972/73	990A

Pramadesa	1973/74	839A
Ananda	1974/75	643A
Radshasa	1975/76	857A
Nala	1976/77	941A
Pingala	1977/78	1123A
Kalayukhi	1978/79	949A
Siddharthi	1979/80	1091A
Rowthri	1980/81	669A
Durmathi	1981/82	952A
Dundubi	1982/83	662A
Ruthrothkari	1983/84	1222[a]
Rathakshi	1984/85	791A
Krothana	1985/86	950[a]
Akshaya	1986/87	700A
Prabava	1987/88	982A
Viba	1988/89	708A
Sukkila	1989/90	916[a]
Premadootha	1990/91	714A
Prajorpathi	1991/92	898A
Ankirasa	1992/93	862A

Srimuga	1993/94	1171[a]
Pava	1994/95	933A
Yuva	1995/96	668DA
Thadhu 1	1996/97	1121 DA
Easwara	1997/98	1133A
Vekuthanya	1998/99	825A
Pramathi	1999/2000	904A
Vikrama	2000/01	705A

This above table clearly indicates that annual rainfall forecast for the tamil year was test verified. Out of fifty years forty eight years the forecast was in agreement (A) with prediction and only two years were in disagreement. (DA)

Krishi-Panchang

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

The contents of the proposed Krishi-Panchang can broadly be categorized into two major

groups as follows:

1. Information which changes every year

- ❖ Annual date and Holiday calendar
- ❖ Month-wise daily guide for the whole year
- ❖ “Rashiphal”, i.e., month-wise forecasting of persons having different zodiac signs.
- ❖ Daily/monthly/annual weather forecasting for the particular year
- ❖ Crop prospects of that year based on planetary positions
- ❖ Season-wise crop strategy based on anticipated weather

2. Information which remains the same irrespective of any particular year

- ❖ Theories relating to agricultural and meteorological forecasting
- ❖ Auspicious moments for agricultural and allied activities
- ❖ Some general agricultural guidance.

Panchang-making

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

- ❖ The **Krishi-Panchang** is largely meant for the local farming communities, having very low educational status. Hence, it must be in the local colloquial language to facilitate

reading and comprehension.

- Care should be taken to make the Krishi-Panchang easily understandable and clear in its meaning.
- It should be very comprehensive in its content and coverage with proven predictive information only.
- It should not contain any astrological details or complexities which would go beyond the understanding capability of our less educated farmers and agriculturists.
- It should be attractive in colour, and presentation of information should be systematic according to seasons (kharif, rabi, and summer) and crops.
- It must be low-priced/nominal-priced, within the affordable range of small and marginal farmers.
- More important is, it must be made available to the farmers and needy persons sufficiently in advance, i.e., at least1-2 months before the start of the agriculture year (july-june)

8. ANCIENT SOIL CLASSIFICATION AND MAINTENANCE OF SOIL PRODUCTIVITY

SOIL CLASSIFICATION

In ancient times geographical distribution by Surapala was jangala (arid), anupa (marshy) and samanya (ordinary). It is further divided by colour into black, white, pale, dark, red and yellow by taste into sweet, sour, salty, pungent, bitter and astringent. Samanya land was suitable for all kinds of trees.

Rig-veda identified productive and non-productive soils. There were 12 classification based on soil fertility, irrigation and physical characteristics. These soil classifications are as follows :

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

Another classification based on crops suitable

a. Vrdiheyam (rice (rainfed) / corn)

b. Shaleyam (kamala (wet) rice)

c. Tilyam (sesamum)

d. Mashyam (blackgram)

e. Maudginam (mung bean)

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

Maintenance of soil productivity

Traditional soil management practices are the product of centuries of accumulated knowledge, experience and wisdom refined and perpetuated over generations. These practices were evolved within the framework of local technical possibilities. They enlivened the soil, strengthened the natural resources diversify and maintained the production levels in accordance with the carrying capacity of agro-ecosystem without damaging it.

Ancient farmers mostly relied on crop residues, manures, legumes and neem for enriching soil fertility.

In Kirishi - parashara, it is stated that crops grown without manure will not give yield and stressed the importance of manures. He also recommended compost preparation from cow dung. The dried, powdered cow dung is placed in pit for decomposition where weed seeds are destroyed. The time duration for composting is two weeks.

Kautilya mentioned the use of cowdung, animal bones, fishes, milk as manure. Surapala describes the ancient practice of preparing liquid manure (kunapa) prepared by boiling a mixture of animal excreta, bone marrow, flesh, dead fish in an iron pot and then add it to sesame oil cake, honey and ghee. This is clearly evident that present day Panchakavya is prepared in the same way and used in all crops.

Liquid manure (Kunapa) : Preparation of kunapa involves boiling flesh, fat, and marrow

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

Green manures :

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

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

In North India : A traditional weed Kochia indica used as green manure.

Ancient farmers adopted crop rotation and inter cropping to restore soil fertility. Mixed or inter cropping with legumes in cereal and oil seed cultivation were widely practices. All these practices adopted in ancient time are now being recommended today under organic farming concept.

09 . Water harvesting and irrigation developments during different periods – water storage – distribution and relevance to modern agriculture.

The need for continuous supply of water for irrigation whether from canal, well, pond or lake is realized as the most important for agriculture in ancient period. It should be preserved by all sorts of efforts for the benefit of agriculture. The different irrigation principles adopted in ancient period are :

- Construction of large mud embankment on a stone foundation for diverting flood water from the river.
- Building of small tanks.
- It is also indicated that severe penalty was imposed when water is let out other than sluice gate.
- Extensive tank irrigation systems were adopted in Sri Lanka and later in South India. In Srilanka ancient kings practiced that not even a drop of rainfall should go to sea without benefiting man.
- The topography of Telengana region of Andhra Pradesh and Karnataka is ideally suited for the construction of tanks. A special feature of tanks in Telengana tank construction in series, by bunding the same valley at several points and surplus water from lower elevation and so on. Even now the tanks constructed by chola king in the same way exist today in Tamil Nadu.
- Every farmer emphazises the efficient and skilful use of water.
- It is also suggested that preference of the use of water should be in the order of food crop, vegetables and flowers.
- For the mainteance of tanks, a committee of villages called `eri- variyam' was appointed. The committee ensured repairs and de-silting tanks and distribution of

irrigation from wells.

Bullocks to draw water from wells for irrigation was practiced and pulled a leather bag with ropes. Persian well was used for drawing water from wells which was developed in North India.

HISTORY OF IRRIGATION DEVELOPMENT IN INDIA

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

			1. Construction of western yamuna canal 2. Constructions of Anantaraja sagar.

Methods of conserving rain water

In ancient days itself, people, especially Indians, know the methods of conservation of rain water. There are evidences that, even during Harappan period, there was very good system of water management as could be seen in the latest excavation at Dholavira in Kachch. During Independence period, the people use to manage water resources considering it as part of the nature which is essential for their survival. This could be seen from the rain water harvesting structures in the low rainfall areas of Rajasthan, harvesting springs in hilly areas and mountainous region and percolation ponds and tanks in southern India.

In Tamil Nadu, the ancient people stored rainwater in public, placed separately one for drinking purposes and another for bathing and other domestic purposses and called them as Ooranies. They also formed percolation tanks or ponds, for the purpose of recharging irrigation or domestic wells. They periodically clean the water ways so as to get clean water throughout the year. These are instances in the history that people constructed crude rubble bunds across river courses either for diversion of water or for augmenting the ground water. The various methods of rainwater harvesting are classified below under two category, Traditional and Modern methods.

Traditional rainwater harvesting, which is still prevalent in rural areas, was done in surface storage bodies like lakes, ponds, irrigation tanks, temple tanks etc. In urban areas, due to shrinking of open spaces, rainwater will have to necessarily be harvested as ground water,

Hence harvesting in such places will depend very much on the nature of the soil viz., clayey, sandy etc. The below listed are the various kinds of traditional rainwater harvesting methods.

The Modern methods of rainwater harvesting are categorised under two, they are Artifical Recharging and Rain Water Harvesting. The former is classified into Absorption Pit Method, Absorption Well Method, Well cum Bore Method and Recharge trench cum injection well. The later is categorised into Individual Houses and Grouped Houses which are further classified into Percolation Pit Method, Bore Well with Settlement Tank, Open Well Method with filter bed Sump and percolation Pit with Bore Method.

Bamboo method of rainwater harvesting

In Meghalaya (one of the seven northeastern states in India), an indegenious system of tapping of stream and springwater by using bamboo pipes to irrigate plantations is widely prevalent. It is so perfected that about 18-20 litres of water entering the bamboo pipe system per minute gets transported over several hundred metres and finally gets reduced to 20-80 drops per minute at the site of the plant. The tribal farmers of Khasi and Jaintia hills use the 200-year-old system.

The bamboo drip irrigation system is normally used to irrigate the betel leaf or black pepper crops planted in arecanut orchards or in mixed orchards. Bamboo pipes are used to divert perennial springs on the hilltops to the lower reaches by gravity. The channel sections, made of bamboo, divert and convey water to the plot site where it is distributed without leakage into branches, again made and laid out with different forms of bamboo pipes. Manipulating the intake pipe positions also controls the flow of water into the lateral pipes. Reduced channel sections and diversion units are used at the last stage of water application. The last channel section enables the water to be dropped near the roots of the plant.

Kunds of Thar Desert

In the sandier tracts, the villagers of the Thar Desert had evolved an indegenious system of rainwater harvesting known as kunds or kundis. Kund, the local name given to a covered underground tank, was developed primarily for tackling drinking water problems. Usually constructed with local materials or cement, kunds were more prevalent in the western arid regions of Rajasthan, and in areas where the limited groundwater available is moderate to highly saline. Groundwater in Barmer, for instance, in nearly 76 per cent of the district's area, has total dissolved salts (TDS) ranging from 1,500-10,000 parts per million (ppm). Under such conditions, kunds provide convenient, clean and sweetwater for drinking. Kunds were owned by communities or privately, with the rich having one or more kunds of their own. Community kunds were built through village cooperation or by a rich man for the entire community.

Traditional Rain water harvesting

The traditional rainwater harvesting methods in North India is surface water harvesting methods are viz., Tanka, Nada, Nadi, Talai, Talab, Khadin Sar, Sagar and Samend. Depending upon rainfall, topography of area, type of soil, the water harvesting methods are different from region to region.

Tanka

It is one of the ancient, common and relatively hygenic methods of water storage. It is constructed of on farm, country yard and fort. The shape is normally circular / square. Dimension is 2 m dia. 3 m deep capacity 10000 lit. It is made on sloping land to arrest run off water in the farm; however in houses the construction is made on an elevated place to avoid entry of dirty water in to it.

Talai

Similar to Tanka, still deeper (2-3cm depth). Special attention paid for selection of location such that there is adequate flow of rain water into Talai. Care is also taken so that loose soil does not flow along with water stream.

Nada

In this method, low lying areas in between hillocks is excavated as pit and provided embankment to arrest rain water from these hillocks. The catchment area of Nada is 5 to 10 ha. The Nada is constructed on rangeland, barren land pastureland and agriculture field. It provides short-term storage of rainwater and mainly used for animals.

Nadi

Compared to Nada. the Nadi is bigger in size. A village or group of Villages uses the run off water collected in the Nadi. Depth is 6-8m, catchment area 10-150 ha. In the Nadi, water is available for whole of the year as a result it provides shelter for many wild animals and birds.

Talab

It is relatively shallow and spread over to more area compared to Nadi. It is generally constructed in rangeland. The catchment area of Talab is 480 ha, when it is filled its fullest capacity can lost for many years.

Khadin

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

Sar, Sagar and Samand

It is used to harvest rainwater for irrigation purpose. Even today this structure provides excellent source of reservoir and also tourist spot.

Practices of irrigation and rainwater harvesting adopted in ancient period were more relevant in Indian agriculture today.

- ❒ Water is elixir or life and kingpin of successful agriculture.
- ❒ Priority to be given for water conservation for efficient use for agriculture and-for domestic needs.

- Sustainability of irrigation system was very much stressed where the tanks, wells or canals must ensure continuous supply of water.
- Avoidance of problems of salinization/alkalinization and water logging which become features of canal irrigation system of today.

10. PLANT PROTECTION IN ANCIENT PERIOD – ITK – HARVESTING – THRESHING AND STORAGE

In the past when Indians were gaining knowledge on the prediction of rainfall, management of agriculture, farm operations, harvesting, and storage, nothing was known about plant protection. The only methods to protect the crop were prayers and mantras. It was believed that the crop is protected if the mantra was written with red lac-dye and tied to the crop. But it cannot be said that the people of that time were unaware of insects and other pests and their damage. Some of the pests (in Sanskrit) affecting crops were gandhi, Shankhi, Pandarmundi, dhuli, and shringari. It is certain that gandhi (offensive odour) is what is called today the gandhi bug (Leptocorisa varicornis F.); shankhi must be a snail (Pila sp.); and pandarmundi means white head which is the typical symptom of the attack of rice stem borer (Tryporyza incertulus Walker). It is certain that they knew the rice stem borer and its symptom of attack. Dhuli means powder and it is possible that this word must have been used for powdery mildew of wheat and barley. The word “shringari” in Sanskrit indicates something adorned with red colour and it is possible that the term was used for rust diseases.

Besides these pests, goats, rats, wild boars, pigs, deers, parrots, and sparrows were mentioned as destroyers of crops. In fact when the damage to crops due to different pests reached the economic injury level, they might have started thinking about plant protection and diverted their efforts to develop protection technology. It is significant that people at that time considered that plants and human beings have similar physiology. Therefore, they divided the diseases of plants into two categories: (1) internal; and (2) external. The internal diseases were those which were caused by “vata”, “pitta”, and “kafa” and external diseases were those which were caused by insects, birds, and weather. These categories can be attributed today to fungi,

bacteria, viruses, and nematodes-internal diseases; and insects, non-insect pests, frost, waterlogging, and drought-external diseases.

Information contained in Surapala's Vrikshayurveda , related to kinds of internal disorders observed in trees, causes and symptoms attributed, and remedies suggested.

Cause given	**Symptoms**	**Cause elaborated**	**Possible causes2**
Vata	Trunk slender and crooked; knots on trunk or leaves; hard fruits (less juicy and sweet); gradual defoliation; flower and fruit drop; generally yellowing of leaves and fruits.	Arid land on account of excessive supply of dry and pungent matters.	Underground mechanical barrier, leaf-galling insects; root-infecting fungi or ematodes;viruses ; saline or alkaline soils.
Pitta	Leaf yellowing; premature drop; decay of flowers and fruits	Occur at the end of summer if trees are excessively watered with bitter, sour,salty and strong materials	Viral disease; salinity in irrigation water; predisposal to blossom blight; fruit decays due to fungal/bacterial infections

Kapha	Fruit-bearing delayed and fruits are tasteless and ripen prematurely; oozing without wounds	Appear in winter and spring if trees are excessively watered with sweet, oily,sour or cold materials	Fungal gummosis / rot;nutrient deficiencies or toxicities ; excessive watering

Today integrated pest management (IPM) is considered a recent approach for plant protection but the so called recent approach was conceptualized and practised centuries ago in India. Some of the practices adopted in those days are given below.

Seed treatment : Seed treatment which is considered an important component of IPM to ensure better germination was given a lot of importance in ancient times. The seed was treated with milk, mustard, sesame-ash, and cowdung for better germination and protection against insect pests.

Fumigation : Fumigation methods were not as developed in those days as they are today but the concept of fumigation was prevalent. For example, diseases of cucurbits were controlled by smoking the bones of cow and dog mixed with the excreta of cat.

Field application : The plant protection appliances of the present era were not developed at that time; sprinkling of aqueous suspension and hand-dusting of various materials were used. For the control of insect pests several ancient recommendations are available. Some of them are as follows:

- Insects infesting trees can be removed by smoking a mixture of white mustard, black peper, asafoetida, vidanga (Embelia ribes), vaca (Zingiberzerumbet), and water mixed with beef, horn of a buffalo, flesh of pigeon, and the powder of bhillata (Semecarpus anacardium).

- Insects infesting creepers can be controlled by sprinkling water mixed with oilcake.
- Leaf-eating insects can be destroyed by dusting cowdung-ash and brick-dust.
- Trees are watered with cold water for 7 days to remove insects from the roots and branches.
- A wound caused by insects is healed if sprinkled with milk after being anointed with mixture of vidanga, sesame, cow's urine, ghee, and mustard.

A new term, eco-friendly pesticides, has been coined recently. In IPM more emphasis is laid on this term and botanicals are being used instead of chemical pesticides. In fact this is not new. Years ago several botanicals and other materials which have biocidal properties were identified and recommended by Surapala to control plant diseases. The famous "panchamula" (roots of five plants) which was commonly used at that time has antifungal, antiviral, antibacterial, and antifeeding properties. Likewise, mustard had been used for all kinds of diseases caused by "kafa". We now know that mustard causes antibiosis in insects; in addition it is antifungal and has nematicidal activity.

Some important products used in pest management during Ancient and Medieval periods in India.

Material	**Author/Period**	**Properties**
Root of vasika (Justicia adhatodaa)	Varahamihira (505-587 AD)	Soothing effect, insecticidal, antifungal, antibacterial, anthelmintic.

Branches and leaves of atimuktaka(Hiptage enghalensis)	Varahamihira (505-587 AD)	Leaf juice insecticidal; bark contains glucoside (hiptagin) and tannins `
Mustard (Sinapis alba = Brassica alba)	Surapala (1000AD)	Insect antixenosis and antibiosis; acaricidal; nematicidal; antifungal
Bidanga (vidanga) (Embelia ribes)	Surapala (1000AD) Someshwara Deva (1126 AD)	Anthemintic; antibacterial insecticidal
Ash	Someshwara Deva (1126 AD)	Dessicates insect eggs on seed; speeds up germination by softening seed coat through mild alkalinity; provides micronutrients
Sesame (Sesamum indicum)	Surapala (1000 AD)	Allelopathic to rice; insect repellent; insecticidal
Mahua (Madhuca spp.)	Surapala (1000 AD)	Insecticidal oil; piscicidal; antibacterial
Kusta (costus) (Saussurea lappa)	Surapala (1000 AD)	Insecticidal (repellents, anti-feedant); antiseptic
Bhillata (Bhallataka) (Semecarpus anarcardium	Surapala (1000 AD)	Insecticidal; antiseptic' termite-repellent;mildew moth-proofing of cloth anthelmintic; antibacterial
Cotton(Gossypium spp) seed oil		

Materials and practices that need our early attention

Milk and milk products : Milk and ghee have been used for centuries. Even buttermilk was found useful. About 40% of total aminoacids in milk are glutamate, leucine, and proline. Milk is reported to contain plant growth promoters. A recent report claimed that milk sprays induced systemically acquired resistance in chilli against leaf curl, a viral disease. Milk (10% aqueous suspension) also has been effectively used for controlling powdery mildews. Besides, milk has excellent sticker-spreader properties.

The aminoacid proline has been found to systemically induce resistance in plants. It stimulates production of antimicrobial phenolics. High amounts of endogenous proline increase contents of cytokinin and auxins. Besides milk, proline is present in the connective tissues of animals including fish.

Application of cowdung : Use of cowdung for dressing seeds, plastering cut ends of vegetatively propagating units such as sugarcane setts, dressing wounds, sprinkling diluted suspension on plants, and applying to soil has been indicated since the time of Kautilya (c.300 BC). Indian farmers continue to use cowdung in various ways, but the agricultural scientists have ignored its use for other purposes except manure.

Briefly speaking cowdung from the cattleshed is a mixture of dung and urine, generally in a ratio of 3:1. Cowdung consists of crude fiber, crude protein, and materials that can be obtained in nitrogen-free extracts and ether extracts. Cellulose along with lignin makes up most of the crude fiber; hemicellulose and pentosans (poly saccharides based on pentose sugars) are also present. Micronutrients too are present in cowdung. The urine portion of cowdung contains nitrogen, potash, and sulfur and only traces of phosphorus. The nitrogenous compounds excreted in fecal matter consist in part undigested or unabsorbed food nitrogen and

in part another fraction called metabolic nitrogen. The metabolic fraction comprises substances originating in the body such as residues of the bile and other digestive juices, epithelial cells from the alimentary tract, and the bacterial residues. In short, fecal residues comprise undigested fiber, debris from sloughed-off intestinal epithelium, some excreted products derived from bile (eg. pigments), intestinal bacteria, and mucus. There are more than 60 species of bacteria and over 100 species of protozoa encountered in the rumen of a cow. A majority of the bacteria are cellulose, hemicellulose, and pectin fermenters. The bile constituents are bile salts, bile acids, and bile pigments. Bile salts confer hydrophilic coat to otherwise hydrophobic droplets, thus acting as emulsifying agents. No bile salt is supposed to be present in the dung because these are reabsorbed through the intestine and are put back in the bile. However, in each such cycle (enterohepatic circulation) involving bile salts, a small part is lost through bacterial degradation in the feces as dyslysin which is the slimy material. Bile salts have antiseptic properties. Two chief bile pigments are bilirubin (reddish / golden yellow) and biliverdin (green). It is the biliverdin ($C_{33}H_{36}N_4O_8$) which is chiefly present in herbivorous animals and gives greenish color to the dung.

Materials recommended by Surapala to control tree disorders and their currently known properties.

Materials	**Properties**
Plant species	
Acorus calamus L.	Antibacterial
Brassica alba (L.) Rabenh/Sinapis alba L.(white mustard)	Insect antixenosis;antifungal;acaricidal; nematicidal;glucosinolate sinalbin “anti-insect” and “anti-nematode” allyl isothiosinate antifungal

Curcuma longa Koenig non L. Curcuma domestica Val. (turmeric)	Antioxidative curcuminoids; antimicrobial
Embelia ribes Burm. F	Anthelmintic; antibacterial; insecticidal (embelinbenzoquinone)
Emblica officinalis Gaertn. (triphala)2	Anthelmintic with other two species of triphala.
Ficus benghalensis L. (banyan)	Latex with good sealing property; tannin
Ficus glomerata Roxb.	Latex; bark 14% tannin; some Ficus spp. are antibacterial.
Piper nigrum L. (black pepper)	Oleoresin antibacterial/antifungal;alkaloid piperin is insecticidal.

Sesamum indicum L. (sesame)	Insecticidal and repellent; oil synergistic to pyrethrums; antioxidative lignins in seed; 17% protein; 800 mg per 100g calcium, phosphorous, and potassium; 14% iron (ash) - highest.
Solanum indicum L.	Fruits/leaves antifungal /antibacterial; glyco-alkaloid solasonine present.

Animal products and other materials

Ash	Particles hygroscopic; absorb moisture from insect eggs and spores; interfere with insect feeding; ash potassium interacts with surface fats.
Cowdung	With urine it is antiseptic; rich in bacteria which compete with pathogens; good medium for biocontrol agents; beneficial to Rhizobium and Azotobacter.
Fish meal	Rich in protein; releases aminoacids including proline.
Ghee	Same as animal fat
Honey	Antimicrobial; protects wounds in plants / animals; proline present; honeybee peptide apidaecin is antibacterial.
Liquid manure (kunapa)	Effects would include : healthy crop/tree; crop tolerance to abiotic stresses such as frost, heat, etc. as well as to insect pests and disease; high yields; high quality produce.

Harvesting and Threshing

Kautilya Arthasasthra states “Grains and other crops shall be collected as often as they are harvested. The threshing of different fields shall be in close proximity. In Sangam literature it is mentioned that paddy was removed from the stalks by beating them on ground or by making

the bullocks to tread on them. Cleaned paddy was collected, measured and stored in proper places. Sickles and swords were used for harvesting millet. For threshing, buffaloes were made to tread or men are used to tread ears with feet. Blackgram was threshed with sticks. Women considerably contributed to threshing and cleaning. A common vessel for measuring grain was referred as “ambanam”

Festivals were celebrated before the commencement of harvest and during the time of harvest. For threshing, Parashara mentioned a levelled threshing “pit” and installation of threshing pillar called “medhi” are mentioned. The wood for the pillar was obtained from a tree that produces milky sap, preferably by silk cotton, Ficus bengalensis, F. glomerata.

Measurement :

`Adhaka’ is wooden vessel made of mango, punnaga (Callophyllum inophyllum) is used to measure grains which is equal to approx. 11 oz or 3.5 Kg.

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

Since time immemorial, cereals, particularly wheat, rice, and maize are considered to be life sustaining crops for humans. Even in future these crops will play a pivotal role in food security system of several nations across the world. The utilization of cereals as food and feed, and for industrial purpose is around 1792 million out of which wheat, rice, and coarse grains contribute nearly 35.4%, 20.8%, and 53.7% respectively. In the past fifty years the world has witnessed structural change in cereal economics:

Long run trend towards wheat and rice and to some extent for maize, while replacement of coarse grain crops occurred.

Developing countries achieved higher growth in production and consumption and at the same time recorded rise in deficits.

Rapid expansion of cereals as feed in developing countries and increased share of cereals in world trade.

It has been projected that world demand for cereals will increase by 2-3% per annum in the next 25 years mainly due to increase in population as well as change in taste and income of the people. This projection clearly suggests that despite impressive growth the world community is still facing the daunting task to maintain adequate food supply for larger sections of population and this will further aggravate in future

History of agricultural development and food production.

Agricultural system	**Cultural stage/time**	**Cereal yield (t ha^{-1})**	**World Population (million)**	**Land holding (ha person^{-1})**
Hunting and gathering	Paleolithic	-	7	-
Shifting agriculture	Neolithic (10000 years ago)	1	35	40.0
Medieval rotation	500-1450 AD	1	900	1.5
Livestock farming	Late 1700s	2	1800	0.7
Improved farming	20th century	4	4200	0.3

1. Use of fertilizers, pesticides, and improved crop varieties.

Source: Tisdale et al. (1993).

In recent years, the concept of “sustainable agriculture development” has been introduced to the world community by the “Bruntland Commission”, which has been accepted by all the countries. It ensures that “long-term effects of development do not damage the rightful heritage of future generations.” More specifically referring to food security, it calls for “increasing production to satisfy growing demands while at the same time preserving basic ecological

integrity of production system." Such sustainable development in agriculture emphasizes conservation of land, water, plant, and animal genetic resources through technically appropriate, economically viable, socially acceptable methods. Presently, utilization and access to genetic resources have become an increasingly important issue because:

Technological advancement in molecular biology and biotechnology have opened new avenues for widening gene pool of several crops.

Legal situation concerning ownership of genetic resources have changed (patent law, state ownership)

The decline/less recognition in value of biological diversity has made risk of their extinction/shortages.

Agricultural development in the recent past has markedly accelerated erosion of plant genetic material, loss of genetic diversity, or heterogeneity on one hand while on the other hand it has increased uniformity and genetic vulnerability of cultivated species to diseases and pests. This necessitates indepth knowledge of the history of cereals involving the origin, process of domestication, and morpho-physiological changes that occurred during the evolutionary process. These aspects can help in conservation of primitive types and further improvement in genetic capabilities of these crops.

Rice

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

are endemic to North America, where it is the staple food of Indians.

Origin

The place of major diversity where rice might have domesticated is roughly the east west belt along the Himalayas and adjoining Asia mainland (from Assam, Bangladesh, Burma, Thailand, southern China, and northeren Vietnam). The archaeological evidence suggests that Asian rice culture was established around 7000 years ago. In India carbonized grains excavated from Hastinapur (New Delhi) suggest that it was in cultivation during 1100-800 BC. Subsequently, the grain samples collected at Atrankikar (Uttar Pradesh) were oldest (1500-1100 BC). It has been inferred from the excavation of rice samples belonging to 5000-4000 BC in Thailand that from this place rice spread to other countries.

Evolutionary history

The evidences from diverse disciplines including biosystematic and paleogeology suggest that the genus Oryza arose from a common ancestor. The evolutionary path was from wild perennial to wild annual to cultivated annual, and the closely related wild relatives contributed differentiation of two cultigens. In oryza sativa, the evolution of different geographical races, i.e., japonica, javanica, and indica (the latter forming aman, aus, and indica types in the Ganges belt) took place assisted strongly by human selecton. There is general agreement that in both Asia and Africa elongation and floating ability in two cultigens was derived from their wild relatives. Regarding transformation from perenial to annual types, a theory has been advanced which suggest that climatic changes during the Pleistocene period induced physiological stress in herbaceous flora, which accelerated evolution of annuals from perennials. In rice, change might have occurred in the following sequence:

Perennial->climatic stress->seasonal->human selection-> cultivated rice.

Future strategies

The primitive cultivars and allied wild species of cultivated rice constitute a store house of rare and valuable genes but their use in the breeding programme is limited because these possess many undesirable characters such as shattering of grains, sterility, and red grains.In recent years, the precise elimination of undesirable characters while maintaining vital characteristics has been found possible as evident from the fact that:

Four different spontanea types (O.rufipogon) subjected to different chemical mutagens treatment, produced short plants with thick, erect leaves, and profuse tillering and possessed a different source of dwarfening gene.

Short culm mutants induced in the Assam type of O. rufipogon produced higher yield and proved more adaptable under waterlogged conditions during the monsoon compared to the variety IR 8.

Rice species growing under marshy areas provide excellent sources of resistance to drought and waterlogged conditions.

Agri-history of Cotton in India : An Overview

The antiquity of cotton in the Indian subcontinent has been traced to the 4th millenium BC. The fabrics dated approximately 3000 BC , recovered from the Mohenjo-daro excavations in Sind (Pakistan), were identified to have originated from cotton plants, closely related to the Gossypium arboreum species. The lint-bearing species of the genus Gossypium, the true cottons, are four, out of which the diploid (2n=26) species G. arboreum and G. herbaceum are indigenous in Asia and Africa.

The history of introduction into India of the new world cottons (tetraploid species of G. hirsutum and G. barbadense with 2n=52) dates back to the 18th century AD. By the last decade of the 20th century, India had gained a pride of place in the global cotton statistics with the largest cropped area of 8.9 million in 1996-97, growing the most diverse cultivars in terms of botanical species and composition, producing the widest range of cotton fiber quality suitable for

spinning 6's to 120's counts yarn, and supporting the largest agrobased national industry of the country.

Origin of the indigenous cottons

The cotton textiles of the Harappan civilization (2300-1750BC) were produced by sophisticated textile craftsmanship. Thus at the earliest agricultural levels yet discovered, true cottons were already present in the Indian subcontinent.

Wild and weedy types have been found to be associated with primitive cultivated types in both the old world species of G. herbaceum and G. arboreum.

Species of G. herbaceum, have been found from the coastal strip northwest of Karachi (Pakistan), through northern Baluchistan to south Yemen, Ethiopia, and Sudan and even in West Africa south of the Sahara. Species of G. arboreum. have been recorded by in Kathiawar, Gujarat, Khandesh, and the Deccan in India. It seems likely that it was in Gujarat (India) or Sind (Pakistan) that G. arboreum cottons were first brought into cultivation (Hutchinson, 1971).

It may further be surmised that the differentiation of the three perennial races of G. arboreum, namely burmanicum of northeastern India, indicum of western India and the Penninsula, and sudanense of northern Africa, ante-dated domestication and that each contributed separately to the cultivated cottons in Asia and Africa.

Agri-history of cotton production development

Until the middle of the 18th century, only indigenous arboreum and herbaceum varieties of cotton were grown in different regions of the country. Due to the human skills and dexterity of the local artisans, very fine yarns were produced by them, from even the short staple and coarse cottons grown in India.

In 1788, the Governor General (at Calcutta) was requested by London to encourage growth and improvement of Indian cottons to meet the requirements of the Lancashire textile

industry. The figures for exact area under indigenous cottons and production in India during this period are not available, although it is reported that the local production had stabilized by 1900 AD.

Sugarcane

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

List of major plant species domesticated, introduced and cultivated in India.

Crops domesticated in Indian sub-continent	
Cereals	Oryza sativa (Rice)
Millets and Forages	Cenhrus ciliaris (bunch grass), Coix lacrymz-jobi (job's tears), Digitaria cruciata (Digitaria), Echinochloa colona (Deccan grass), Echinochloa crus-galli (cockspur grass), Panicum arntidotale (blue panicum), Panicum miliaceum (french millet), Panicum sumatrense (little millet), Paspalum scrobiculatum (kodo-millet), Sesbania bispinosa syn. Sesbania aculeata (dhaincha)
Grain legumes	Cajanus cajan (pigeonpea), Dolichos biflorus syn. Macrotyloma uniflorum (horse gram/kulthi), Dolichos lablab (hyacinth bean), Mucuna utilis (velvet bean), Psophocarpus tetragonolobus (Goa bean), Vigna aconitifolia (moth bean), Vigna angularis (adzuki bean), Vigna mungo (black gram), Vigna radiata (green gram), Vigna triloba (jungi bean), Vigna umbellata (rice bean)

Oilseeds	Brassica juncea (indian mustard), Brassica rapa ssp. trilocularis (yellow sarson or Indian Colza), Brassica rapa var. toria (Indian rape), Brassica rapa var. dichotoma (brown sarson), Sesamum indicum (sesame)
Fibre crops	Agave cantala (kantala), Bombax malabaricum (red silk cotton), Corchorus capsularis (white jute), Corchorus olitorius (tossa jute), Crotolaria juncea (sun-hemp), Gossypium arboreum (tree-cotton), Gossypium obustifolium (Asiatic cotton), Hibiscus cannabinus (Deccan hemp), Hibiscus sabdariffa (Jamaica sorrel)
Vegetables	Abelmoschus esculentus (okra), Amaranthus blitum (sag chulai), Amaranthus tricolour (lal sag), Amorphophallus campanulatus (elephant-foot yam), Chenopodium album (common pigwheat), Coccinia indica (kovai fruit), Colocasia esculenta (taro), Cucumis sativus (cucumber), (Indian lett) (ridge gourd), Luffa cylindrica (sponge gourd), Momordica charantia (bitter gourd), Momordic cochinchinesis (kakora), Momoridica dioica (balsam apple), Moringa oleifera (drumstick), Praecitrullus fistulosus (round gourd), Raphanus caudatus (rat-tail Radish), Rumex vesicarius (bladder dock), Sesbania grandiflora (agathi), Solanum melomgena (brinjal), Spinacia oleracea (spinach), Trichosanthes anguina (snake gourd), Trichosoanthes dioica (pointed gourd)
Fruits	Aegle marmelos (Bengal quince), Areca catechu (areca nut), Artocarpus heteophyllus (jack fruit). Carissa congesta (karaunda), Citrus limon (lemon), Mangifera indica (mango), Musa paradisiaca (plantain/banana), Phoenix sylvestris (date sugar palm, Indian palm), Zizyphus jujuba (Indian jujube), Zizyphus nummularia (wild jujube)

Some important medicinal and aromatic plants	Abelmoschus moschatus (muskmallow), Atropa acuminata (Indian belladona), Azadirachta indica (margosa tree), cassia fistula (Indian laburnum), Cymbopogon marini (palmarosa), Cymbopogon nardus (citronella grass), Cymbopogon pendulus (lemon grass), Cynodon dactylon (Bermuda grass), Datura metel (datura), Emblica officinale (Indian gooseberry), Patchouli (patchouli), Rauvolfia serpentina (serpentine root), (costus), Vetiveria zizanioides (vetiver)
Narcotics Spices and condiments	Cannabis sativa (hemp) Cinnamomum tamale (Indian cassis) Cinnamomum verum (cinnamon), Crocus sativus (saffron), Curcuma amada (mango ginger), Curcuma caesia (black turmeric), Curcuma domestica syn. C. longa (turmeric), Curcuma zedoaria (zedoary), Elettaria cardamomum (small cardamom), Kaempferia galanga (chandramula), Mentha piperita (mint), Murraya koenigii
Spices and Condiments	(curry leaf tree), Myristica malabaricum (nutmeg), Piper betel (betel pepper), Piper longum (long pepper), piper nigrum (black pepper), Trigonella foenum-graecum (fenugreek), Zingiber officinale (ginger)

Others	Acacia catechu (kattha), Acacia nilotica (India acacia), Bambusa arundinacea (thorny/spiny bamboo), Bambusa tuldo (Bengal bamboo), Bauhinia purpurea (camel foot tree), Borassus flabellifer (palmyra-palm), Caesalpinia sappan (Indian redwood), Camellia sinensis var. assamica (tea), Cedrela toona (red cedar), Cordia myxa (Indian cherry), Coffea bengalense (coffee), Curcum angustifolia (Indian arrowroot), Dendrocalamus hamiltonii (Dendrocalamus), Dendrocalamus strictus (Calcutta bamboo), Dioscorea alata (greater yam), Dioscorea esculenta (lesser yam), Ficus bengalensis (banyan tree), Ficus elastica (Indian rubber), Ficus religiosa (peepal), Garcinia sylvestris (wild mangosteen), Indigofera tinctoria (indigo), kochia indica (bui), Lawsonia alba (henna), Maoutia puya (pua, poi), Marsdenia tinctoria (rion), Morinda angustifolia (ban haldi), Morinda citrifolia (Indian mulberry), Nephelium longana (anshaphal), Nerium indicum (kaner), Nyctanthes arbortristis (Tree of Sadness), Ochlandra travancorica (elephant grass), Oroxylum indicum (sonapatha), Pluchea indica (pludina), Rubia cordifolia (Indian madder), Saccharum officinarum (sugarcane), Saccharum sinense (sugarcane), Sapindustrifoliatus (soap nut tree), Sida rhombifolia (Cuba jute), Sinocalamus giganteus (Sinocalamus), Tamarindus indica (tamarind)

Crops introduced by Portuguese

Pseudo cereals Amaranthus caudatus (amaranth)

Oilseeds Arachis hypogeae (groundnut)

Vegetables Cucurbita moschata (pumpkin), Ipomoea batatas (sweet potato), Solanum tuberosum (potato)

Fruits	Anacardium occidentale (cashew nut), Anona squamosa (custard apple), Psidium guajava (guava)
Narcotics	Nicotiana tabaccum (tobacco)
Spices and condiments	Capsicum annuum (chilli)

Crops introduced by Britishers

Pseudo cereals	Avena sativa (oat)
Grain legumes	Castanospermum australe (black bean), Pisum sativum (pea)
Fiber crops	Gossypium barbadense (cotton)
Vegetables	Allium tuberosum (leek), Asparagus racemosus (satawar), Beta vulgaris (beet root), Brassica oleracea var. botrytis (cauliflower), Brassica oleracea var. gemmifer (Brussels pekinensis (celery), Capsicum frutescens (sweet pepper), Cichorium intybus (chicory), Cucurbita maxima (squash), Daucas carota (carrot, orange type), Lactuca sativa (lettuce), Lycopersicon esculentum (tomato), Pisum sativum (sweet pea)
Fruits	Averrhoa bilimbi (bilimbi), Averrohoa carambola (carambola), Carica papaya (papaya), Eugenia jambos (rose apple), Fragaria ananassa (strawberry), Garcinia mangostana (mangosteen), Helianthus tuberosus (artichoke), Manihot esculenta (cassava), Malus pumila (apple), Prunus armeniaca (apricot), Prunus avium (cherry), Prunus communis syn. P. domestica (plum), Prunus persica (peach), pyrus communis (pear), Ribes rubrum (red currant)

Medicinal and aromatic plants: Cinchona officinalis (quinine), Origanum vulgare (majoram), Papaver somniferum (opium poppy), Pelargonium capaitatium (Geranium), Salvia officinalis (sage), Thymus vulgaris (thyme), Vanilla aromatica (vanilla)

Crops introduced from West and Central Asia by Mughals or Arabs

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

Crops introduced by Spaniards

Phaseolus vulgaris (French bean)

Crops introduced from China

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

Crops introduced from Latin America

Hevea brasiliensis (Rubber), Ananas comosus (pineapple)

Crops introduced from Southeast Asia and Pacific islands

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

Some recent introductions

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

12. GARDENING IN ANCIENT AND MEDIEVAL PERIOD – ARBORI HORTICULTURE - ORCHARDS

Man is inseparable from nature. Since prehistoric times, the Indian people have had close relationship with nature, particularly plants and flowers. The cult of tree worship has been a tradition and faith in India through the ages. Trees and flowers have been sanctified in Indian mythology, history, art and socio-religious culture. The pre-historic and proto-historic man in the Indus Valley had great reverence for trees and worshipped them during the chalcolithic period. Tree was worshipped in its natural form and as tree spirit personified as human attributes in Mohenjo-daro and Harappa. The divine character of the trees has been depicted in a number of seals, sealings, potteries, potsherds and some rock paintings as archeological evidences of the Mohenjodaro and Harappa period (2500-1750 BC). A few trees, such as pipal or asvattha (Ficus religosa), neem (Azadirachta indica), katha or khadira (Acacia catechu) and jhand or sami (Prosopis cineraria) were held sacred by the ancient people of the Indus Valley. In the Indus Valley Civilization, the belief was that trees were symbolic of gods and goddesses, which dwelt in them (vriksha devata or vriksha devi). In ancient India trees were considered to be divine and spiritual as the tree knowledge (brahma tarn), the tree of life Uivan tarn) and also as medicinal tree (rogu tarn).

Mauryan period

After the rise of the Mauryas in the 4th to 3rd century BC, there has been vast secular literature and texts, both Vedic and post-Vedic, like Vedas, Brahamanas, Aranyakas, Upanishadas, Sutras, Smritis, Mahakavyas, Puranas, Buddhists texts (Jataka) and Jain literature (Sutras). The sages of the Upanishadas have described the Cosmic Tree rooted in the Brahman, the ultimate, whose branches are space, wind, fire, water and earth. The cosmic tree

is the World Mother, the Goddess of nature, which nourishes all Life. Kalpavrksa (wish-fulfilling tree) and kalpalata (wish-fulfilling creeper) are mythological tree and creeper, not mentioned in the Vedic literature, which have been a part of folk cult in Hindu mythology. Kalpavrksa is mentioned in Ramayana, Mahabharata, Jatakas, Divyavadana and the Jain Sutras. In Brahamanical religion, vata (Ficus benghalensis) was identified with Shiva, asvattha (Ficus religiosa) with Vishnu, lotus with Surya (Sun) and nine leaves of nine trees (navapatrika) with nine different aspects of Durga.

There are vivid descriptions of trees in the Rigveda (3700-2000 BC), the Ramayana (1200-1000 BC), The Mahabharata as well as other literature by Shudraka (100 BC), Kalidasa (c. 57 BC), Ashvaghosha (100 AD), Vatsyayana (300-400 AD) and Sarangdhara (1300 AD). The art of gardening and kinds of gardens were described by Sarangdhara and Vatsyayana, respectively.

In the Ramayana, mention is made of Ashokavana or Panchavati, in which Sita was held captive. Ashoka trees (Saraca asoca) were predominant in this garden. In the Panchavati, five trees were planted, asvattha (Ficus religiosa) on the,east side, bilva (Aegle marmelos) on the north, the banyan (Ficus benghalensis) on the west, amla (Emblica officinalis) on the south and the ashoka (Saraca asoca) on the southeast. A description of the layout of gardens and parks and artificial lakes in the city of Indraprastha is given in the Sabha-Parva of the Mahabharata. Several trees, such as Saraca asoca, Terminalia arjuna, Mesua ferrea, Ficus benghalensis, F. religosa, Michelia champaka, Butea monosperma and Cassia fistula, have been mentioned in the Ramayana. Almost all of them also have been described in the Mahabharat. It is said that Lord Buddha was born under the pipal tree in a garden. The bodhi tree, under which the Buddha attained nirvana, is sacred to Buddhists. The trees and plants mentioned in Buddhist texts include asvattha (Ficus religiosa), banyan (Ficus benghalensis), udumbara (Ficus glomerata), patali (Bignonia suaveolens), sala (Shorea robusta) and sirisa (Acacia sarisa). The

planting of roadside avenue trees (margeshuvriksha) was an important contribution of the king Ashoka (233 BC).

Vedic times

The trees and the plants mentioned in the Vedic times were, soma (Sarcostemma acidum), pipal/asvanha (Ficus religiosa), sami (Prosopis ceneraria), banyan (Ficus benghalensis), udumbara (Ficus glome rata) , bilva (Agele marmelos); khadira (Acacia catechu), neem (Azadirachta indica), palasa/plpksa (Butea monosperma), tulsi (Ocimum sanctum) and lotus (Nelumbo nucifera). The other trees and plants of the Vedic and post-Vedic period include salmalilsilk cotton tree (Bombax ceiba), coconut (Cocos nucifera), rudraksha (Elacocarpus sphaericus), snuhi (Euphorbia neriifolia), madhavi lata (Hiptage madablota), amalka (Emblica officinalis; syn. Phyllanthus emblica), mango, amra (Mangifera indica), banana, plantain / kadali or rambha (Musa paradisiacal), ber / vadari (Zizyphus mauritina), sala/shal (Shorea robusta), asoka (Saraca asoca), kadamba (Anthocephalus cadamba), bahira (Terminalia belli rica), arjuna (Terminalia arjuna), nagavalli, tambula or paan (Piper betle), nalaka (Arundo donax), jivaka(Putranjiva roxburghii), mandara (Erythrina variegata), tili/tila (Sesamum indicum), amarphal (Monstera deliciosa), Ficus krishnae, gaduchi (Cocculus cordifolius), ketaki (Pandanus odoratissimus), imli/tintrini (Tamarindus indica), parijata (Nycanthes arbortristis) and tinduku (Diospyros peregrina).

Tree worship and trees and environment

Tree motifs have been found in the art of Indus Valley, Mauryan ring stones, and gateways and railings of stupas at Bharhut, Bodhgaya, Sanchi, Amaravati and Nagajunakonda, Mauryan relief sculptures, particularly on the Ashokan Pillar Capitals and Rampura Bull Capital of Ashoka. Old sculptures and architecture of Mathura (Kanishka period, AD 78-101) and Ajanta frescoes (AD 100-600) also bear testimony to the importance of plants and flowers in ancient India. The relationship of trees with the Brahamanical and Buddhist gods and goddesses and

Jain Tirthankaras in Indian art date back from the 151 century AD to 1200 AD. Trees and flowers have been also delineated in ancient coins found at the pre-Mauryan site, Sugh, Taxila, Ayodhya during Mitra Kings, Kausambi and Mathura and also of the Andhra dynasty and Pandyan territory. The ancient Sanskrit and other literature and texts, mythological epics and legends, paintings, cave murals and frescoes, sculptures, architecture, folklores and tribal arts and crafts provide evidences of the kind of plants and trees and flowers growing in the forests and gardens. The science of plant life, (Vrikshayurveda) and arbori-horticulture, and usefulness of forests and gardens were well-known in ancient India. The utilitarian qualities of trees and plants for food, medicine, shelter, shadow and fuel, and the relationship of trees with fertility were also known to ancient Indians. They were concerned with the conservation of trees and biodiversity in nature and ecological balance in environment. Their concept of identifying trees with gods and goddesses, and threats and punishments against the destruction of useful trees helped to save the trees and flora, which is a remarkable contribution of our ancient people.

Mughal period

With the renaissance of gardening in India by the Mughal rulers beginning with Babur, many plant species were brought by them from Persia and Central Asia where herbaceous and bulbous flowers were already under cultivation. Many of these have been mentioned in autobiographies and other books written during those days. Besides, in Mughal paintings also we find illustrations of many flowers. These have also been used to illustrate the borders of those paintings. In the book Bagh-I- Wafa. Babur has presented a description of gardening in India.

During the 16th and 17th centuries AD, Mughal gardens were developed in Agra, Delhi, Pinjore (near Shimla) , Srinagar, Kashmir and a few other places. The most important Mughal gardens are the Taj Mahal Garden, Agra; Shalimar and Nishat Gardens, Srinagar; Pinjore

Gardens, Pinjore and the garden at Hamayun's tomb, Delhi. The rose was introduced into our country via the port of Bussorah by Babur in around 1526. Jehangir and Nurjehan were ardent lovers of the rose and encouraged rose growing in gardens. The most important plants introduced in Kashmir from Persia by the Mughal ruler, Jehangir in 1619 when he laid out the famous Shalimar Bagh in Srinagar, were the majestic Chinar tree (Platanus orientalis), the cypress (Cupresus sempervirens) and the weeping willow (Salix babylonica), and flowers like rose, narcissus, daffodil, iris, lilies, tulip and carnation.

European period

Later, mainly Englishmen and the Portuguese introduced many species. Missionaries and priests, civil servants and individual amateur, gardeners mostly brought these in. One of the important missionaries who introduced a number of exotic plants was Dr Firminger, an Englishman, who wrote a book on gardening, giving descriptions of various species of flowers in 1863. The book titled 'Firminger's Manual of Gardening in India' is an authoritative reference book on ornamental flowering plants even today.

With the establishment of Government Botanic Gardens by the British rulers during 18th and 19th centuries, such as Lalbagh Botanical Garden, Bangalore (1760); the Government Botanic Garden, Saharan pur (1779); the Indian Botanic Garden, Sibpur, Calcutta (1787); the Lloyd Botanic Garden, Darjeeling (1878); and the Government Botanic Garden, Oatacamund (1884), numerous economic plants as well as ornamentals were introduced in these gardens.

Among the noteworthy introductions of that period are the mahogany (Swietenia mahogany) from Jamaica in 1795 and the Giant Amazon lily, Victoria regia, into Sibpur garden followed by Grevillea robusta and Araucaria exceLsa in 1857 and Amherstia nobiLis in] 859 in the Lalbagh Botanical Garden, Bangalore. A few important and rare flowers of India are Agapetes auriculata. Corydalis govaniana. Dendrobium chrysanthum, D. nobile. Geranium wallichianum, Katherinea ampla, Meconopsis aculeate. Notholirion thomsonianum, Nepenthes

khasiana, Rhododendron macabeanum, R. hodgsonii. and R. thomsonii.

Native Indian Ornamental Plants

Trees

Albizzia lebbeck, Alstonia scholaris, Anthocephalus cadamba, Azadirachta indica, Bauhinia variegata, Bombax malabaricum, Butea monosperma, Cassia fistula, C. nodosa, C. siamea, Erythriana indica var. parcellii, E. Variegata var. orientalis, Ficus religiosa, F. benghalensis, F. benjamina, F. elastica, F. infectoria, F. retusa, Lagerstroemia speciosa, Michelia champaka, Milletia ovalifolia, Millingtonia hortensis, Mimpusops elengi, Polyalthia longifolia, Pongamia pinnata, Pterospermum acerifolium, Putranjiva roxburghii, Rhododendron arboreum, Saraca asoca, Tecomella undulata, Terminalia arjuna, Thespesia populnea.

Shrubs

Barleria cristata, Buddleia asiatica, Daedalacanthus nervosus, Dombeya spectabilis, Holmskioldia sanguinea, Jasminum sambac, J. grandiflorum, J. humile, J. officinale, Nyctanthes arbortristis, Russellia juncea, Spermadictyon suaveolens.

Climbers

Clematis paniculata, Clitoria ternatea, Ficus repens, Hiptage benghalensis, Jasminum grandiflorum, J. humile, J. officinale, Porana paniculata, Thunbergia grandiflorum.

Seasonal Flowers

Amaranthus spp., Celosia, Gomphrena, Lady's lace (Pimpinella monoica), Torenia.

Bulbous Flowers

Allium giganteum, Canna, Gloriosa superba, Iris spp., Tulip spp., Orchids (Aerides, Anoectochilus, Arachnis, Arundina, Calanthe, Coelogyne, Cymbidium, Dendrobium, Paphiopedilum).

Other Plants

Lotus (Nelumbo nucifera), Nymphaea spp. (N. pubescens, N. rubra, N. stellata)

Indoor Foliage Plants

Aglaonema, Asplenium nidus, Begonia rex, Coleus blumei, Pilea cadieri, Pteris cretica var. crispate.

Indoor Flowering Plants

Crossandra infundibuliformis, Gynura aurantiiaca, Kalanchoe blossfeldiana.

13. TRADITIONAL TECHNICAL KNOWLEDGE

With the spectacular achievement in the field of agricultural sciences, India has been able to reach the stage of self-sufficiency in the agricultural production. But, in this change, we overlooked and rejected sustainable natural farming systems and moved towards “exploitative” agriculture with increased dependency on farm machinery and chemicals (fertilizers, pesticides, etc.), which proved counter productive and resulted in depletion of soil and water resources, increase in desert and climatic disturbances, natural calamities, deterioration of environment, and unprecedented fuel wood cries. Among many challenges in the coming years, the basic issue will/be to find ways for sustainable development which are environmentally sound and make the earth a better place to live in.

The best solution of this problem could be to blend the modern technology with the traditional one. The integration of scientific and traditional knowledge would help, to develop technologies, which are need-based, better problem-solving, locally available, easily acceptable, cost-effective, convincing and credible to the rural clientele.

There is a lot of indigenous agricultural know-how available with the farming communities specially the tribals. These traditional farming systems are products of centuries of accumulated experiences. Farmers all over the world have developed their own indigenous systems of farming with local inputs. In India the traditional system of farming is being practiced since the Vedic age (3700 BC).

This traditional wisdom can disappear unless their understanding values are promoted. Many of the practices, which were beneficial and were being used since generations have been lost because of lack of appreciation. Therefore, there is a need to explore the indigenous practices being used by the tribals and to get these scientifically validated for wider use by the farming community.

Crop Protection

Traditional systems of crop protection, rooted in the simple practices that farmers have learnt from their long association with the land, its flora and fauna, were based on ecofriendly systems of suitable cultural practices, judicious rotation of crops, and knowledge of pests and their life cycles. Some of the traditional methods of cultivation, which has direct bearing on pest control, are:

1. Maize seeds are soaked in cow urine for 10-12 hours before sowing. According to farmers, this treatment increases resistance against insect pests.
2. Rice seedlings raised from seed treated with extract of neem kernel are vigorous and resistant to leafhopper.
3. In paddy, spraying a solution of 4 l of cow urine and 10 g asafoetida in 10 l of water, repel the sucking pests (aphids,jassids).
4. In paddy, spraying a solution of cow dung prepared by mixing 3 kg cow dung in 3 l of water was observed in the study area against the control of paddy blast and bacterial blight.
5. In case of insect holes made by shoot borer and bark eaters in mango tree, jaggery is placed in the holes to attract other predators (ants), so that they will feed upon the insects present in the hole. Similarly the practices of pouring kerosene in holes and 'blocking holes with cow dung were also observed in the area.
6. For prevention of infestation of shoot borer in mango tree, common salt is mixed with soil near the collar region of the tree.
7. In case of 'bunchy top' disease in chilies dusting of ash; use of gugul (Commiphora wightii) smoke; spray of sour butter milk; spray of liquid waste of tanned leather, and spray of cow/goat urine was recorded in the tribal areas.

8. A peculiar method of controlling diseases in chilli was observed in which the twigs of aak (Calotropis spp.) are placed in chilli field in between rows. Similarly some farmers placed fresh cow dung near the collar region of plant to prevent it from fungal diseases viz., damping off and die back.
9. In case of soil-borne diseases viz., root rot, collar rot, etc. and termites, the castor cake, karanj cake, or neem cake were used as a control measure.
10. In case of sugarcane crop, use of common salt (100-125 kg/ha) during intercultural operations was found to be common. According to farmers, the salt is effective against termite problem.
11. During sprouting of sets in sugarcane crop, putting stems of aak (Calotropis spp.) in the irrigation channels is effective against control of termites, white grub, and borers.
12. Use of kerosene was also common against control of termites in the field.

Weather Forecast

In recent times, there has been a growing demand for more accurate and reliable weather forecasts. Modern scientific knowledge and modern methods of weather forecasting have originated recently. But, ancient indigenous knowledge is unique to our culture. India had a glorious scientific and technological tradition in the past. Our ancient astronomers and astrologers made a scientific study of meteorology. Even today, it is common that village astrologers (Pundits) are correct in surprisingly high percentage of their weather predictions. Unfortunately, with the evident of so-called scientific technologies during the past one-century, even if these are reductional and uni-dimensional in nature, the ancient knowledge, which is holistic and multidimensional in nature, has been sidelined and totally neglected by today's so-called scientific minded rationalists.

The most common methods of predicting rainfall are :

1. Rain bird; if the rain bird gives eggs at the ground level then, there will be less rain however; if the eggs are laid at higher elevation then it is the indication of more rains. The local people assume that eggs of rain bird are laid on such a height that in case of more or less rains, the eggs will not be submerged in rainwater. Similarly, if the nanow ends of all the four eggs of rain bird are downwards, then it is the indication of good rainfall through out the season.

2. When the adventitious roots of the banyan tree (Ficus bengalensis) start sprouting (tillering), then the local people assume that the rains will appear within 2-4 days.

3. In castor (Ricinus spp.) and ber (Ziziphus nummularia) when the buds start sprouting, then it is predicted that rains will appear within 10-15 days.

4. The rains will appear after 10-15 days of flowering in babul tree (Acacia nilotica).

5. As soon as the neem kernels ripen and start falling, it is expected that there will be rains after 10-15 days.

6. Rain may come if damsel fly flies at ground surface, frogs make noise and ants move in line from one place to another.

The farmers were also forecasting rains by observing the direction of wind/clouds. According to them Westerly winds/clouds meant good rainfall. Similarly Northwesterly clouds will bring hailstorm and meager rains.

Animal Management

Some of the indigenous practices used by the tribals in the area of animal management are as under :

1. Castration in males is done by destroying the spermatic cord with a stone/hammer and applying cow dung / karanj oil as an antiseptic.
2. In case of respiratory distress, animals are branded with hot iron rod on the neck.
3. Treatment of bloat is done by drenching indigenous materials like;

- A mixture of 0.5 of buttermilk + 100 g mustard oil + 100 g ground rapseed.
- Bark of roheda tree (Tecomella undulata) ground and mixed with water.
- A mixture of meerchu (local herb) ground 25 g + 0.5 I buttermilk + 25 g of rapeseed + 1 small onion + 50 g of mustard oil + 25 g of common salt.
- Bark of haru tree ground and soaked in water.
- A mixture of butter milk + common salt + onion + raw custard apple
- Roots of date palm tree 200 g (ground) and mixed with water.
- 5-10 leaves of custard apple (ground) and black cumin (50 g) mixed with buttermilk.

4. In case of FMD (foot and mouth disease). a small fish wrapped with a piece of bread is fed to the diseased animal till the animal is not completely cured.
5. For deworming the following measures are taken:
   - Drenching with copper sulfate 25 g in one litre of water.
   - Dilute neem solution
   - Sesame leaves crushed, mixed with water. and strained, are drenched.
6. For control of external parasites. kerosene is applied on the body of animal with the help of cotton gauze.
7. To facilitate normal pasturition, cows buffaloes are fed crushed wheat soaked in water and mixed with jaggery and ghee oil for one month prior to calving.
8. For treatment of anestrus in buffaloes, following measures are taken:
   - Match stick (two match boxes) wrapped in a piece of bread is fed to animals.
   - Seeds of datura (Datura fastuosa) 4-5 are fed
   - Dry flowers of mahua tree (Madhuca indica) 250 g boiled in llitre are fed for 5 days.
   - 250 g flowers of khakra (Butea monosperma) boiled in llitre of water are fed for 4-5

days.

- ❖ Crushed sorghum (2 kg) soaked in water is fed for 2-3 days.
- ❖ Droppings of poultry mixed with bread or concentrate is fed.

9. In case of pneumonia, cactus (used for fencing) is burnt and the ash mixed with water is drenched twice to the animal.
10. In case of fractures, (a) leaves of khakra (Butea monosperma) are bandaged all over the affected part and splints of bamboo are tied around it. (b) eggs of local poultry breed given.
11. In case of excessive salivation (FMD) a tuber sooran (Amorphallus campanulatus) is ground and drenched with water.
12. To increase milk production the following methods are adopted:
    - ❖ Feeding of boiled crushed maize 1/2 kg to a cow and I kg to a buffalo for about one month.
    - ❖ Feeding leaves of sem (Dolichos purpureus) and chan ber (Ziziphus nummularia) increases milk production.
    - ❖ After calving, the milk left after sucking of calves is again fed to the cow/buffalo for 15-20 days.
13. Disease Management : Dipping the foot of animal in its urine for the control of foot and mouth disease; dipping the tail in hot water or by applying powdered camphor for overcoming tail neurosis; feeding ground neem leaves for internal parasites; feeding sprouted whole wheat for 10-15 days continuously for anoestrus, etc. The findings portray that a lot of wisdom still exists in rural areas but there is uncertainty about theirexpert validation.

14. VEGETABLE FARMING – FLORICULTURE – PERFUMES and MEDICINAL PLANTS

Vegetable farming

- The Indian sub continent, one of the Vavilovian centres of crop plant, is endowed with diversity in several vegetable crops.

- Egg plant, cucumber, ridge and sponge gourd have been identified native to this country.

- Around 80 species of major and minor vegetables occur here apart from several wild edible species.

Distribution of major vegetable crops variability in different agro ecological regions of India

Sl.No.	Agro Ecological region	Geographical Ranges	Variability in major crops
1.	Humid western Himalayan Region	J&K, H.P and Parts of UP	Cucurbits, radish carrot, turnip, cowpea, fenugreek, amaranthus
2.	Humid Bengal / Assam Basin	WB and Assam	Cucurbits, radish, cowpea, chillies, brinjal, Abelmoschus manihot Momordica chodinchinensis sechium edule

3.	Humid Eastern Himalayan Region and Bay islands	Arunachal Nagaland, Manipur Mizoram, Tripura and Meghalaya	Solanum torvum S.sisymbrifolium
4.	Sub-humid sutlej, Ganga alluvial plains	Punjab, UP and Bihar	Febugreek, onion garlic Solumum hispidum S.Surattense
5.	Humid Eastern and south eastern uplands	East Madhya Pradesh, Orissa and Andhra Pradesh	S.torvum Cucurbits, radish carrot, cowpea, chillies brinjal, okra, spinach
6.	Arid Western plains	Haryana, Rajasthan and Gujarat	Cucurbit, cauliflower, carrot, peas, fenugreek, onion, garlic, citrullus sp.
7.	Semi Arid Lava plateau and central highlands	Maharashtra and West Madhya Pradesh	Cucurbits, Cauliflower, radish, fenugreek Solanum torvum S.nigrum S.kharianum
8.	Humid to semiarid western Ghats and Karnataka plateau	Karnataka, Tamil Nadu, Kerala and lakshadweep	Cucurbits, chillies brinjal, okra, amaranthus, Solanum trilobatun S.indicum Luffa, acutaugula Basella Basella rubra

Floriculture in Ancient India

Plants were also featured in personal adornment and beautification of the home. Of the climbers, Madhavilata (*Hiptage madhablata*) received frequent mention in Kalidasa's play (5th century) and among sweet scented shrubs the mask-mallow (Hibiscus abelmoschus) and the garland flower (Hedichium coronarium). Description of flowers and gardens and the garland flower (Hedichium corononarium). Description of flowers and gardens had been presented in ancient Sanskrit classics like Rig Veda (3000-2000 B.C), Ramayana (1200-1000 B.C) and Mahabharata (500 B.C). Other Sanskrit books of early days wirtten by Shudraka (100 B.C.), (Asvaghosha (100 A.D) and Sarnghara (1283-1301 A.D) also mentioned about flowers and gardens.

Among the flowers the sacred lotus (*Nelumbo mucifera*) was the most important and numerous references to it occur in Sanskrit literature. Int he days of Moahendjadaro, lotus blossoms were wreathed over the head of Sun-God.

During the Buddhist period gardens were laid out around the monasteries and stupas and there were beautiful gardens in Nalanada the Taxila.

The Hindus were so fond of ornamental plants that some of them were actualy worhsipped. **During the Mughal period (16th and 17th centuries AD) and the British period (18th and 19th centuries) several ornamental plants were introduced into India. Indian native flora has made significant contributions to the gardens of the world and also to the improvement of a few flowers like orchids and Rhododendrons.**

Mughal period

- The concept of developing a garden in an enclosed space was introduced by the Mughals in India during 16th and 17th centuries.
- Babur is credited with the introduction of scented Persian rose in India.
- Akbar the Great (1556-1605), the Mogul emperor of India was the garden lover.
- Abu-i- Fazi provided a list of 21 fragrant flowering plants along with flower colour and season of flowering in Ain-i-Akbari.
- He also gave another list of 29 plants with flowers notable for their beauty.
- From the Tuzuk-i-Jahangiri it appears that Jahangir was familiar with nearly all important fragrant palnts of India like Michelia champaca, Pendanus odoratissimum, Mimusops elengi, Jasminum officinale. **Mughal gardens were developed in Agra, Delhi, Pinjore (near Shimala), Srinagar, Karhmir and a few places during the 16th and 17th centuries AD.**

European period

- Missionary priests, Englishmen, Portuguese, amateur and professional gardeners from Europe, Asia and Africa, introduced a large number of plants into Indian gardens.

- Several botanical gardens were established during 18th and 19th centuries in various parts of India, where indigenous and exotic plants were introduced and maintained.
- With the establishment of Government Botanic Gardens by the British rulers during 18th and 19th centuries such as Lalbagh Botanical Garden, Bangalore (1760); the government Botanic Garden, Saharanpur (1779); the Indian Botanic Garden, Sipbur

Calcatta (1783); the Lloyd Botanic Garden, Darjeeling (1878) and the Government Botanic Garden, Oatacamud (1884), numerous economic plants as well as ornamentals were introduced in these gardens.

PERFUMES

India has a perfumery tradition that dates back to over 5,000 years to Indus Valley civilization. The roots, flowers and leaves were used in perfumery. The Sanskrit Encyclopedia 'Manasollasa' composed by Someshwara in AD 1127 deals with the blending of perfumes which were used in royal baths and for the rituals and worship. The Ain -1- Akbari (17th century) provides a list of twenty one fragrant flowering plants along with season and colours.

Preparation of Perfumes (Brhat Samhita):

The word '*yukti*' means combination and composition. Perfumes and scents are manufactured for the benefit of royal personages and inmates of harems.

Medicinal plants and their relevance today

Medicinal plants in ancient India

- Medicinal and aromatic plants have been used for a long time for their medicinal properties.
- About 2000 native plants species have curative properties and 1300 species are known for their aroma and flavour.
- The Indian systems of medicines, popularly known as Ayurveda, unani and sidha drugs are of great demand in the country.
- There is already spurt in demand of plant based drugs and of late may such native species of medicinal values are being brought under systematic cultivation.

- Saffron, opium poppy have been under cultivation for many years.
- Opium poppy is perhaps the exotic plant brought under cultivation in the later part of 16th century through introduction from West Asia. It is one of the cultivated crops where the selection pressure has played a major role in developing new varieties and land races.
- Cinchona has been introduced in India mainly to fight the menace of malaria and diahorrea respectively, while belladonna, ergot, pyrethrum, henbane and toxglove were introduced in India during second world war to meet the demand of raw materials for vital drugs.
- India is blessed with a wide variety of soils and agro-climatic situation that supports a large variety of plants.
- Out of these, about 65 plants have large and consistent demand in world trade.
- India however produces only limited quantities of these materials.
- Interms of market share in production value, India holds only the 6th place with a mere 7% share.
- At present, about 90% collection of medicinal plants is from the forests and since 70% of the plant collections involve destructive harvesting many useful plant species are endangered or threatened.
- In India, more than 15 lakh practitioners use medicinal plants in preventive and curative application.

There are two ancient systems of medicine in India, the Siddha that flourished in the South and the Ayurveda prevalent in the North. Instead of giving the name of any one individual as the founder of either system, our ancients wisely attributed their origin to the Creator. According to tradition, it was Shiva who unfolded the knowledge of Siddha system of medicine

to his consort, Parvati, who handed it down to Nandideva and he, to Siddhars. Therefore it is called 'Saiva Sampradayam' (tradition of Shive), or 'Siddha Sampradayam'. In the case of Ayurveda it was Brahma, the Creator of the Universe, who taught the science to Prajapati, he to Aswini Devatas and they, in their turn, to Atreya etc. So this tradition is called the Brahma or Arsha Sampradaya (the tradition of Rishis). The inference to be drawn from these traditions is that, there is no exact point of time to which the beginning of these systems could be traced. They are eternal, without a beginning or end; they began with man.

Origin of Siddha Medicine: Siddha system is one of the oldest systems of medicine in India. The term ‘Siddha’ means achievement and the ‘Siddhars’ were saintly figures who achieved results in medicine through the practice of Yoga. Eighteen ‘Siddhars’ seem to have contributed towards the development of this medical system. Siddha system’s literature is in Tamil and it is practiced in Tamil speaking parts of India. The system is also called Agasthyar system in the name of its famous exponent sage Agasthya. A number of medical works of this system are ascribed to him but it may be difficult at this time to say the exact number that can be credited to him. This system of medicine developed within the Dravidian culture, which is of the pre-vedic period. The Siddha system is largely therapeutic in nature.

The Siddhars: The ancient Tamils in their quest for knowledge for longevity developed two ways by which man can achieve mastery over nature. One is the Yogic way and the other is through medicines. The persons who dedicated themselves to this task were themselves great yogis known as Siddhars. Hence the system of medicine propounded by them came out be known as Siddhars system of Medicine.

The Neem Tree: The Neem tree was regarded as sacred in Mohenjo-daro Civilization. In the annals of the ancient Siddha System of Medicine, the first medicinal plant mentioned as well as found a place, in ancient Tamil literature is Margosa or Neem. This has been used by Tamils

from time immemorial as a deterrent for smallpox and other infectious diseases and also considered to possess powers to ward off evil spirits.

Kalpa Treatment: Ancient Siddha devoted time in finding out suitable remedies rather than describing the causes of a disease in detail. The scope of 'Kaya Kalpa' treatment is two-fold; one is to cure degenerative diseases and the other is to prolong the life span. Kalpa serves as an anti-degenerative elixir -- that can cure cancer and heart diseases is itself rejuvenation.

Timeline of Indian Medicine

1000 BC - Atharva Veda.

600 BC – Codification of medical knowledge into Ayurveda.

400 BC – Caraka Samhita by Caraka.

400 BC - Susruta Samhita by Susruta.

700 AD - Ashtanga Samgraha by Vagbhata.

700 AD - Ashtanga Hridya Samhita by Vaghbata.

800 AD - Rasaratnakara by Nagarjuna.

900 AD - Rug Vinishchaya by Madhakara.

1000 AD - Siddha Yoga by Vrinda.

1000 AD - Nava Nitaka by Navanita.

1300 AD - Sharangadhar Samhiti by Sharangadhar.

1550 AD - Bhavaprakasha by Bhava Misra.

1563 AD - Garcia da Orta`s Coloquios dos simples e Drogas e cousas medicineis da India (A.D 1563) includes description of many Indian medicinal plants.

1591 AD - Christophoras Acosta`s Aromaticum et medicametorum in Orientali Indian nascentium liber and Historia Natural R moral de las Indias scuilla (Barcelona, A.D. 1591) are important works on medicinal plants of India.

Medical Education in Ancient India: Medicinal knowledge has been systematized thousands of years ago in a system of medicine called Ayurveda. Ayurveda is a Sanskrit word, derived from two roots: ayur, which means life, and veda, knowledge. It has its root in ancient Vedic literature and encompasses our entire life, the body, mind and spirit. In ancient India, Medical education was available in in the larger cities such as Taxila, Kasi (Varanasi) and Nalanda. The plant wealth of forest was utilized through 'Ayurveda' for the welfare of human beings. **The city of Ayodhya was inhabited by a good number of vaidyas or physicians. Proficient and skilled surgeons known as 'salyakrt' (v. 28.6) existed at the time of Ramayana. Physicians accompanied royal well developed and surgeons were in special demand. Surgeons of the structure of the human body as can be inferred from the many anatomical terms used in the epic.**

Relevance of medicinal plants today

The World Health Organisation (WHO) estimated that 80 % of the population of developing countries still relies on traditional medicines, mostly plant drugs, for their primary health care needs. Also, modern pharmacopoeia contains at least 25% drugs derived from plants. Many other are synthetic analogues built on prototype compounds isolated from plants. Demand for medicinal plant is increasing in both developing and developed countries due to growing recognition of natural products, being non-toxic, having no side-effects, easily available at affordable prices. There has been resurgence in the consumption and demand for medicinal plants. These plants are finding use as pharmaceuticals, neutraceuticals, cosmetics and food supplements. According to an all India ethno-biological survey carried out by the Ministry of Environment and Forests, Government of India, there are over 8000 species of plants being used for medicine in India.

15 . Role of cattle and other domestic animals- management of cattle for draught and milk – indigenous breeds

India has a distinguished livestock heritage and a place of pride in the history of livestock development in the world. It has shared its livestock resources with many countries all over the world, thus contributing immensely to livestock development on a global scale. It ranks first in cattle and buffalo population with 15% and 52% respectively and together making up 28% of the large ruminant population of the world. Likewise, India ranks first in goat population (19%) and fifth in sheep population (45%), the two together making up 26% of small ruminant population of the world. India has the largest number of breeds of cattle (26), buffaloes (7), goats (20), and sheep (40) in the world. Thus livestock wealth of India constitutes the richest livestock bank of the world. In India the zebu are much prized for their heat tolerance, disease resistance, and capacity to thrive under harsh environments. They have been exported to countries in Asia. Africa, the Americas, and Australia, where they have adapted well.

Animals are sources of food, fibre, power, manure, hides. skins, bones, and recreation. Besides being an integral part of agriculture and rural life. their contribution to the national income is invaluable. The contribution of animal husbandry is 26.4% and that of the latter is 36% of the gross national product. The annual growth rate of animal husbandry is 6.2% and that of agriculture is 3.42%. Thus the growth rate of livestock products in India has been comparable to that achieved by any other important sectors of economy. Today, the country ranks first in milk production in the world.

The present glory of animal husbandry has a long historical background. The history of animal husbandry is interwoven with the progress of agriculture and ultimately the progress of civilization. In developing crop husbandry, man learned to supplement his own capabilities with

that of domestic animals. The importance of livestock was well known since time immemorial. In prehistoric and ancient India animal husbandry has been an integral part of agriculture. Written documents and old civilization manifestations suggest that animal husbandry in ancient and medieval India was of high order. Several references exist on importance of livestock and their rearing; e.g., Vedas, Upanishads, Ramayana, Mahabharata, Buddhist and Jain literature, Kautilya's Artha-sastra. Puranas, Krishi-Parashara. and Ain-i-Akbari. According to some scholars the Vedas are dated 5000-3000 BC, Puranas 2000-1000 BC, and Artha-sastra 300-600 AD; Ramayana is considered 9000 years old, Mahabharata 5000 years old, and Jain and Buddhist literature about 2500 years old.

Domestication of animals

Dog, a domestic pet, was the first animal to be domesticated in the Old Stone Age (10,000 BC) and other farm animals were domesticated in the New Stone Age (7500-6500 BC). Different animals have been domesticated in different periods in Europe, Central and West Asia, and India. It is considered that horse, cow, sheep and goat were domesticated first in Europe and Asia. pig in China. and poultry, elephant, and buffalo in India. The order of domestication was dog. goal. sheep. cow, buffalo, pig, elephant. horse. camel. and ass. However. evidence from Mohenjo-daro excavation amply suggests that indigenous breeds of cattle had originated in India and not brought by Aryans in India. The present-day cattle of Sind, Gujarat, and Rajputana are similar to those that existed in Mohenjo-daro.

Animal husbandry in Vedic literature

Many uses of animals and birds for the human society arc mentioned in the Vedas. These include food items such as milk and milk products; medicines from milk, ghee (clarified butter), and urine of cows; wool; skin and hides; manure; and fuel and animal power in agriculture and transportation. The sound of animals and birds are indicators of future events such as rains, lightning. and earthquakes; presence of poisons in food; and location of lurking dangerous

animals. Therefore, Vedas have directed to raise and protect animals.

Cow is referred as “aghnya” which means not to be killed but to be raised and protected. Likewise, Vedas have directed to protect other animals too. A lot of emphasis has been given to rearing and protecting cows as they produce milk and manure (dung and urine), and bullocks for draught power.

The Aryans, in the Vedic Age, knew the importance of pasture and forests . They used to graze their cattle by taking them to the grasslands in the morning and bring them back in the evening.This practice still survives in villages all over India. A number of hymns in Vedas are addressed to God for gifts of cattle and other animals. The vocabulary of Aryans is rich in names for every aspect of herds with special words for cows with strange calves; a cow barren after calving; and red, black, and light coloured cows; also herds were differentiated by distinct names. Cuts in the ears were made for identification. The cows were milked three times daily suggesting their high milk-yielding capacity. Castration was practised and oxen were used for their normal purpose of farm transport:’Cows which gave abundant milk and which could be milked easily are prayed for. The quality of some cows which let down milk merely on the sight of their calves has been well observed and referred to.

Avi, the Sanskrit word for sheep, is used by transference for wool. Sheep wool was mainly used but there is evidence of use of goat’s wool (hair) from long-haired animals such as those from Kashmir. The wool when spun was woven on a loom.

Animal husbandry during 200-300 BC

The Buddhist text (Suttanipata) declares cattle to be givers of food, beauty, and happinessand pleads their protection. There used to be superintendents of cows who supervised herds of milch cattle, cow herdsman, buffalo herdsman, milkers, and churners. The superintendent ensured that calves were not starved but fed well. The herds included equal number of milch cows, pregnant cows, aged cows, heifers, and calves. Crippled cows and cows

difficult to milk were kept in special herds. The superintendent branded the cows to indicate that their calves were more than two months old. He registered them and also noted their natural marks, colour, and distance between horns. Thus herd registration and marking for identification was in practice. The cattle were allowed to graze in fields after harvesting of crops. However, during the cropping season they were sent under normal charge of a herdsman, hired by the village collectively, to grazing land. The herdsman knew each animal under his charge by general appearance and marks upon it. He was experienced in removing eggs of flies from their hide, to heal sores, knew places of availability of food and water, and clever in choosing pastures.

Kautilya's Artha-sastra also mentions importance of cows and states, 'The killing of cows is a deadly sin." The king will daily visit the cows, observe them, and salute both cows with her calf and bull by circling round them, before going to the court.

In the Mauryan age, buffaloes were also recognized as dairy animals. The rations for buffaloes were prescribed. It is stated that buffalo milk is richer in butter fat than cow's milk, the fact established very well today. Kautilya clearly mentions for providing breeding bulls in herds of cows.

During the reign of Ashoka, veterinary hospitals were state institutions and functioned all over the empire. Herbs and medicinal plants used for healing ailments of beasts were grown and those lacking at a particular place were imported and planted. Thus, there was a provision for care and treatment of cattle, horses. and elephants.

Animal husbandry in medieval India

Abdur Razzak, a foreign visitor in South India, observed that Devendra II of Vijayanagar empire had many elephants. The king also had a white elephant. He described in detail the' procedure for catching, taming, feeding, and breeding of elephants. Cows and oxen were not slaughtered in that empire but were worshipped on certain occasions. Mention has been made

of Hallikar cattle breed which was poor in milk production but one of the best draught type cattle that was available in South India. Bullocks were strong and quick, covering 30-40 miles a day on rough road. In the field, the animal was fast and yet a steady worker, being useful for all types of cultivation. Males were castrated when broken to yoke, i.e., around 3 years. Giving a historical record, Kristnasamienger and Pease mentioned that the Hallikar cattle breed was taken to Mysore between 1500 and 1600 AD. It was bred and developed into Amritmahal breed.

Akbar had 12000 horses in his stables. He collected horses from Iraq, Iran, Turkey, Arabia. Central Asia, and Tibel. Much attention was given to breeding of horses in Mughal India for which skilful and experienced men were kept. India ranked higher than Arabia in this regard writes Abul Fazal, Kachhi horses being equal to Arabian horses. Goat breeds of Bengal and Coach Bihar are also mentioned. Feed and fodder for horses were described; e.g., in winter boiled grains or vetch and in summer 2 seers (about 2 kg) flour, 1 1/2 seers jaggery. and fresh grass or hay feeding is suggested. It has heen mentioned to keep 3 bighas land for grass.

Cattle of Gujarat were stated to be the best. Bullocks travelled 80 miles a day and some even surpassed horses. The life span of cow was stated to be 25 years. Various classes of cows have been mentioned, e.g. ‘Khas’ class and first class. Khas class were fed 61 1/4 seers grain and 1 1/2 dams grass whereas the other category was fed 3 seers grain and I dam grass. Molasses was also used for feeding. Female buffaloes were fed 8 seers wheat flour, 1/2 seer molasses, 1 1/2seers grain, and 2 dams grass. Milk yield of cows varied and was 1 - 15 seers day-1 and that of buffalo was 2-30 seers day-1. Buffaloes of Punjab were best. One man was kept for looking after 4 adult cattle with their followers.

Thus it can be observed that importance of animals was very well known in ancient and

medieval India. The husbandry of animals was well established. Norms of feeding, breeding, housing, and health care were also very wen established and practised. The present-day animal husbandry development is an outcome of the gradual enhancement in knowledge in this field for thousands of years.

Dairy production systems

In ancient India, number of cows that were kept by the people is amazing. There are instances that people possessed lakhs (one hundred thousand is one lakh) of cows and one King used to donate drive away the entire cow herd of other kings when there used to be any conflict between them. We can imagine that in such an endeavor the tremendous human power that would be required to drive away such a large herd from one place to another. This indicates that the number of animals in those days was far more than the total livestock population existing today. Not only this, the husbandry practices and grazing facilities for cows were very good and in abundance. Lord Krishna used to call his cows by name (a method of identification of animals). In Garg Sarnhita (Golok Khand) three titles, which used to be conferred upon persons possessing cowherds are mentioned below.

Brakh - the person who reared 10 lakh (one million) cows,

Nand - the person who reared 9 lakh cows,

Upnand - the person who reared 5 lakh cows,

The existing thumb rule of feeding concentrate ration to the animals was based on the feeding standards of ancient days, which by and large approximate to the present-day feeding standards of animals.

Evidently, ancient India has thus remained traditionally a “dairying” country and the prosperity and social status of a person was judged not by the landholding but by the number of cows he possessed. Hence, the present day sciences by no means can estimate vast utility and purpose of cows, which our ancient visionaries had realized, propounded and established.

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

Indus valley civilization: Allchins, relying on Lambrick, who, according to them, had personal knowledge of Sind, describe as follows how crops were grown in the riverain tract of the Indus. "The principal food grains, that is wheat and barley, would have been grown as spring *(rabi)* crops: that is to say, sown at the end of the inundation upon land which had been submerged by spill from the river or one of its natural flood channels, and reaped in March or April.

The Greek writers highly praised the fertility of Indian soil and favourable climate condition describing the principal agricultural products of the land.

The Greek writers also affirm that India has a double rainfall and the Indians generally gather two harvests. - Megasthenes witnesses - the sowing of wheat in early, winter rains and of rice, 'bosporum', sesamum and millets in the summer solstice (Diodorus, II, 36). **Megasthenes** adds further to the winter crops, viz., "wheat, barley, pulse and other esculent fruits unknown to us".

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

Protection of cultivators: Sher Shah had genuine concern for the peasantry and safety of their crops. One of the regulations made by Sher shah was this: That his victorious standards

should cause no injury to the cultivations of the people; and when he marched he personally examined into the state of the cultivation, and stationed horsemen round it to prevent people from trespassing on any one`s field. As regards the peasantry and their condition, there is reliable evidence in the observations of the European travellers who travelled in India in the seventeenth century.

Evidence of the structure of the Mughal gardens and plants grown in them is in the Persian classics illustrated during the reign of Akbar. Among them is *Diwan-i-Anwari,* a collection of poems by the Persian poet Anwari, who flourished in the latter part of twelfth century. It contains some excellent paintings on gardens and gardening. **Abu-l-Fazl** mentions three kinds of sugarcane, viz. *paunda,* black and ordinary. **Abu-l-Fazl** provides a list of twenty-one fragrant flowering plants along with the colour of their flowers and the season of flowering in the **Ain-iAkbari**.

Terry, an English traveler, writes, 'The country was abounding with musk-melons. One could also find water-melons, pomegranates, lemons, oranges, dates, figs, grapes, coconut, plantains, mangoes, pineapples, pears, apples, etc.' Terry also mentions the use of coffee by some people. He writes, 'Many religious people drank a "wholesome liquor" which they called coffee. Black seeds were boiled in water, which also become black. It altered the taste of water very little. It quickened the spirit and cleansed the blood.

Francois Bernier: Of the European travelers who come to India during the Mughal rule, the most intelligent and learned was Francois Bernier a Frenchman. Bernier gives a vivid description of Bengal its landscape people and its plant and animals products. With extensive

fields of rice, sugar, corn, three or four sorts of vegetables, mustured, seasems for oils and small mulberry trees two or three feet (61 to 91 cm) in height, for the food of silk worms.

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

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

17. OUR JOURNEY IN AGRICULTURE AND VISION FOR THE FUTURE

The famine from 1876-78 led to institution of Famine Commission of 1880. The horrors of Famine (1889-90) convinced Lord Curzon that urgent attention must be paid agriculture. Lord Curzon passed the Land Alienation Act (1900) and Cooperative Societies Act (1904). Lord Curzon, the Viceroy of India with the generous donations from Henry Phipps of the USA had founded the Imperial Agriculture Research Institute in 1905 at Pusa, a village in the Darabhanga district of Bihar. The main building at Pusa was named after its donor as the Phipps Laboratory. [PUSA stands for the donor of the Institute, Phipps of the USA]. There was a disastrous earthquake in 1936 and Pusa suffered heavily. After careful consideration the Government of India rebuilt the institute at New Delhi. The transfer to New Delhi was completed by October, 1936. The Marquees of Linlithgo, the then Viceroy of India, opened this Institutes in November, 1936. This Institute (IARI) in Delhi is popularly known as the Pusa Institute. Under the University Grants Commission Act 1956, the Institute (at New Delhi) got the status of the Deemed University and Teaching and Research activities were intensified from 1958. In 1947, India had about 27 Agricultural and Veterinary Colleges including the Indian Agricultural Research Institutes, Indian Veterinary Research Institute and five other Agricultural Colleges established during the first decade of the century.

Agriculture Colleges were started at Poona (Pune) and Kanpur. Teaching was the main mandate. The Indian Central Cotton Committee (ICCC) (1921) was formed as per recommendation of the Indian Central Cotton Commission (1917-18).

The Government of India appointed a Royal Commission in 1926 to examine the condition of agricultural and rural economy in India. The Imperial Council of Agricultural

Research (ICAR) was established in 1929 as a Society under the Societies Registration Act, 1860. The Society was registered on July 16, 1929. [After Independence, the name of the society was changed to Indian Council of Agricultural Research (ICAR)]. The food crisis created by the Second World War and the Bengal famine in 1943 deepened and became the matters of great concern to Government of India. To meet the food shortage the Grow More Food campaign was started in 1943.

The Indian Central Coconut Committee and the Indian Central Tobacco Committee were formed in 1945. The Indian Central Arecanut Committee was formed in 1949 and the Indian Central Spices and Cashewnut Committee were formed in 1958. Regional stations\sub-station on cotton, Jowar, Finger millet, setaria, castor, groundnut, linseed, bajra were established and the PIRRCOM (Project for Identification of Regional Research on Cotton, Oilseeds and Millets) were started.

All India Coordinated Research Projects: The AICRPs were born from the coordinated project on maize developed with the Rockefeller Foundation's assistance in 1957, ICAR has now about 70 All India Coordinated Research projects covering various disciplines and commodity crops, livestock, fisheries, home science, and agricultural engineering. An AICRP enables effective utilization of the resources in man and material anywhere in the country to tackle some of the important national problems.

ICAR Institutes: The ICAR is directly responsible for administering 32 research institutes in the fields of agriculture, animal sciences and fisheries. Some of these are single commodity-oriented crop institutions while a few of them undertake work on a number of crops. The Indian Agricultural Research Institute (IARI), New Delhi, the Indian Veterinary Research Institute (IVRI), Izatnagar, and the National Dairy Research Institute (NDRI), Karnal are the three

national institutions which have responsibilities both for research and post-graduate education. The recent establishment of the National Academy of Agricultural Management at Hyderabad as a constituent unit of the Council is an important landmark in institution building. This Academy would be responsible for providing quality training to various categories of personnel involved in agricultural research all over the country. Establishment of an Agricultural Research Service (ARS) started on October 1st, 1975 marks yet another landmark in the history of research management of ICAR.

Agricultural Universities: The responsibility for research in most of the States is now with the 21 agricultural universities, which perform in an integrated way the functions of teaching, research and extension education. The ICAR has recently taken major steps to further strengthen the agricultural research capabilities of the agricultural universities through the National Agricultural Research Project (NARP), which is being implemented through the assistance of IBRD.

Krishi Vigyan Kendras (KVKs): The ICAR has sponsored a programme known as the Krishi Vigyan Kendras, designed to provide skill oriented vocational training to practicing farmers, in-service field level extension Workers or those who intend to go in for self-employment.

Other ICAR schemes:

i. National demonstrations and Operational Research Projects :In 1964-65,

ii. Scheme of Professors of Eminence/ National Fellows

iii. National Research Centres

iv. Advanced Centres of post-Graduate Education and Research

VISION FOR AGRICULTURE IN 2020 AD

President APJ Abdul Kalam in 2003 opined that that there is need for India to launch a new vision, which he called "Vision - 2020". To achieve this, they should concentrate on two mantras: Effective Implementation with People's Participation; and Effective Communication for People's Participation. A key element of "Vision 2020" would be "*Providing Urban amenities in Rural Areas* (PURA)". The Biological Diversity Bill 2002, passed in the Winter Session, marked a major milestone in India's commitment to conservation and sustainable utilization of our bio-resources.

Agricultural Research in India

The research thrust areas identified for immediate future are:

i. Increasing the productivity of crops

ii. Micro-propagation of agricultural and horticultural plants though tissue culture techniques, biotechnology, etc.

iii. Forage crops for various agroclimatic regions

iv. Achieving sustainable agriculture through integrated farming systems, integrated nutrient management, biofertilizers, etc.

v. Optimal cropping system in accordance with resource base in dryland agriculture

vi. Organic farming

vii. Wasteland development through agroforestry, agri-horticulture, silvipasture, insitu soil moisture conservation, and technologies for problem soils

viii. Evolving eco-friendly, low cost technologies including biopesticides and biocontrol agents

ix. Production of quality seeds of agricultural and horticultural crops including hybrids seeds

x. Strengthening post harvest research and protected cultivation from crop produce losses

xi. Developing suitable farm machineries and tools to manage labour scarcity in farm operations

xii. Strengthening research on new irrigation methods, developing drought tolerant crop varieties to manage water scarcity

xiii. Developing low cost packing and processing technologies to agricultural and horticultural commodities

xiv. Non-conventional energy resources

xv. Research on productivity and processing of medicinal plants. Commercial exploitation of medicinal plants in domestic and foreign markets

xvi. Setting of agri-clinics and agri-business centres in areas such as soil, water quality and input laboratory service centre, plant protection, horticulture, marketing, farm machinery and primary processing, etc.

Agricultural Extension in India

The farming community needs to increase their productivity through the mission Second Green Revolution using technological advances. Also dry land cultivation needs a thrust. The technology is the base item for the action plan to bring India into a developed nation in reality. Grooming **'**technology**'** from seed up to a fruit-bearing tree is an art, science and a specialised enterprise in itself. The key to success lies in assessing where, when and how to facilitate entry for money in the process of technological project realization. There are many other prior activities, which need to be done if technology development can mature into a good business activity. Another important development was that in addition to rapid spreading of interest within the actual farmers, the whole community (in the benefited areas) got involved. For example, a women 'Self Help Group' is being formed for certain joint cooperative efforts for better quality of life.

Farmers get considerable earnings (and substantial returns on their investment in Agro processing) per hectare. Stabilizing the agro technologies for the well chosen (market share wise) medicinal herbs and placing them in the correct places of value chain. Ever since the Agreement on Agriculture of the World Trade Organisation (WTO) began to be debated in the

country, increasing agricultural productivity and improving food quality are being tossed as the only solutions for farmers' survival. Invariably, at every conference and seminar on WTO, the common refrain is that farmers are left with no choice but to increase productivity and thereby reduce the cost of production to remain competitive in a globalised world. The productivity bug has bitten not only the agricultural scientists but also the policy-makers, planners and, of course, the politicians.

India'a Agricultural Heritage Status in Press

World heritage status for India's farming techniques - The Hindu, FEB 13, 2010

India's locally developed farming techniques look set to take their place on the world heritage map alongside the country's national parks of outstanding beauty and its grand monuments to culture.

The rice crop of Koraput, the salt water farms of Kuttanad, and the paddy fields of Thanjavur could join the likes of Konarak, Kaziranga and the Taj Mahal, under an initiative of the UN Food and Agriculture Organisation (FAO) designed to safeguard unique agricultural systems in an era of climate change.

"These sites are protecting our food security. They are our heritage… The techniques were developed by farmers, not by scientists or anything else. The technology is their own," said M.S. Swaminathan, Chairman MSSRF, who was speaking to reporters ahead of an international conference on biodiversity at the Research Foundation next week.

Globally Important Agricultural Heritage Systems (GIAHS) are regions of outstanding biodiversity that reflect the natural evolution of farming and may help provide natural solutions to changing climates in the future.

Orissa's Koraput region, India's first candidate for GIAHS status, has been nominated for the variety of rice, millets, pulses, and medicinal plants developed using traditional cultivation practices by tribal groups.

Papers for Kuttanad in Allapuzha, Kerala, where farmers have produced crops in sea water, have been submitted to the FAO and the 2,000-year-old system of irrigating paddy in Thanjavur should follow, Dr. Ajay Parida, Executive Director, MSSRF said.

Thus far, systems from just five countries have been identified as GIAHS: Andean agriculture in Peru, Chiloe agriculture in Chile, the Ifuago rice terraces of the Philippines, the Magreb Oases in Algeria and the Upland pastures that cross the borders of Kenya and Tanzania

Kudos for Koraputs Agricultural Heritage - Indian Express Jan 08, 2012

United Nation's Food and Agriculture Organisation (FAO) has recognised the efforts of the tribal community of Koraput to conserve biodiversity and develop climate resilient farm practices as a Globally Important Agricultural Heritage System (GIAHS).

✤The recognition of the Koraput traditional agricultural system as a GIAHS site is expected to guarantee local and international efforts for the conservation of biodiversity and sustainable use of its genetic resources.

✤GIAHS is defined as a 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.

✤Mentioning this at the inauguration of the 99th Indian Science Congress here, Prime Minister Manmohan Singh lauded the Koraput tribals for the achievement.

✤The Koraput region is famous for its rich agricultural biodiversity of global importance. The agro-biodiversity recorded in the Koraput region includes, 340 landraces of paddy, eight species of minor millets, nine species of pulses, five species of oilseeds, three species of fibrous plants and seven species of vegetables.

✤The Jeypore region is rich in genetic resources of medicinal plants. More than 1,200 medicinal plant species are available there. Some of the endemic plant species of the region are used for curing different diseases including gastrointestinal disorders, malaria and bone fracture.

✤The tribal groups have rich traditional knowledge about forest species too. It is also seen as the recognition of tribal people's contribution to biodiversity and knowledge systems, whilst increasing attention to their natural and cultural heritage.

✤The genetic diversity of Asian cultivated rice has been considered as the centre of origin of aus ecotype of rice. The landraces or traditional varieties growing here are

thought to be harbouring dominant genes for biotic and abiotic stresses, aroma and palatability, and hold promise for their utilisation in future plant breeding and biotechnology programmes, an FAO official said.

✤The tribal and rural families of this area have been developing and conserving these genetic resources from time immemorial with their traditional knowledge. Today's landraces, evolved naturally with the changing environment and agricultural practices, are the products of careful and continuous selection by tribal women and men, whose merits have not yet received the recognition they deserve, he said.