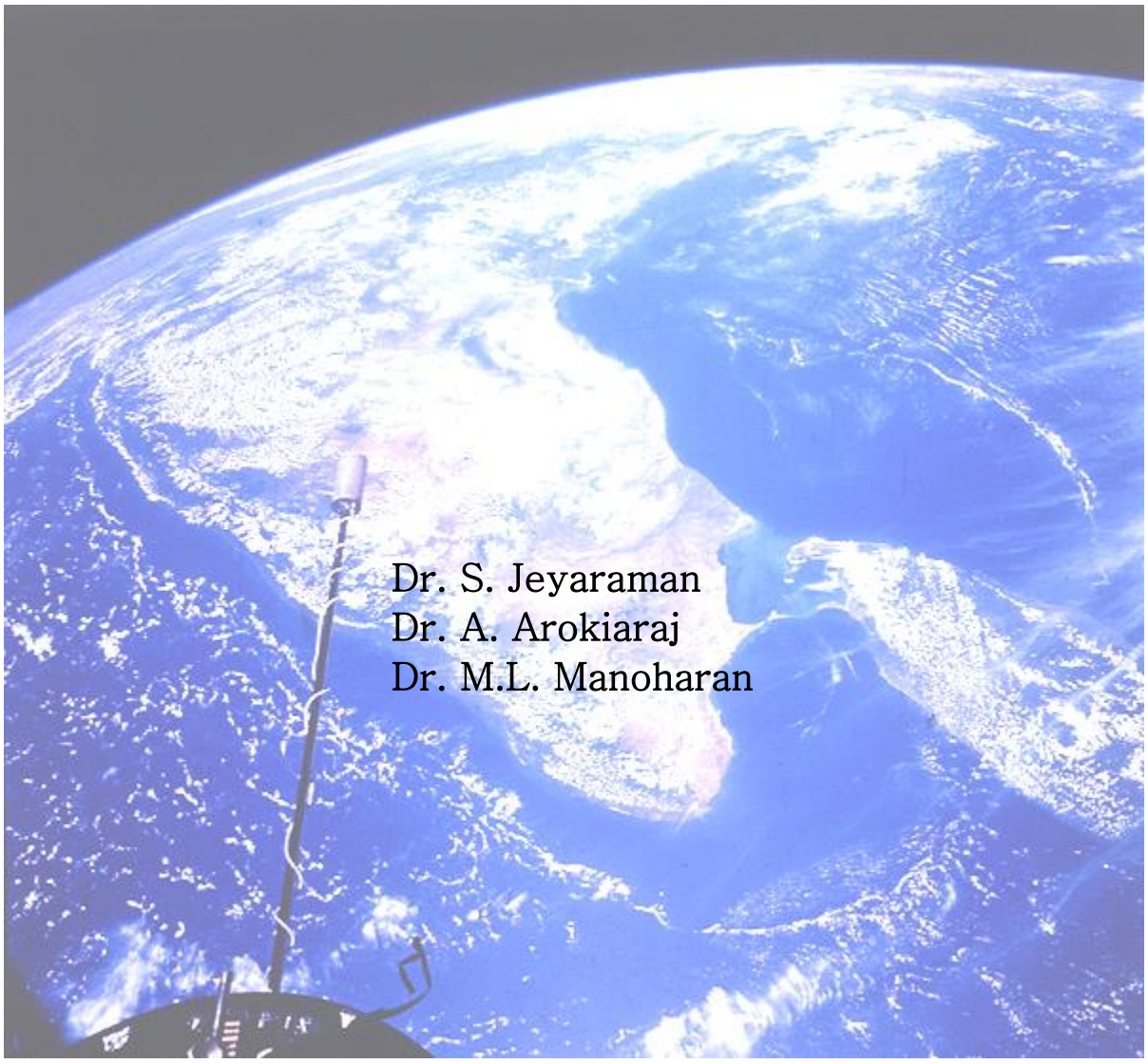
# AGRICULTURAL HERITAGE OF INDIA



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# Preface

Agriculture is an age old practice. Many developments in agriculture have been taken place throughout the world. Mostly the agricultural technologies are location specific, season specific, soil specific, crop and variety specific. Some of technologies developed in western countries lead to the unsustainable agriculture. Now the scientists are looking for the study of traditional, indigenous farming system. Experiences gained at various stages in different parts of the world especially in India need not be tested again and again and can be used directly to the field condition if one knows what is the development occurred in different periods. A course on 'Agricultural heritage of India' is newly introduced to the students of Agriculture. Information on ancient agricultural practices are brought together as per syllabus which will be very useful to the students of Agriculture as well as the personnel involved in various aspects of Agriculture.

The authors request the readers to kindly offer their valuable suggestions to improve the contents in future.

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**CONTENTS**

## Chapter 01 Geology of Indian sub continent-Agricultural Heritage- early history: Archaeological and historical facts

Ancient History time scale is measured in terms of Before Christ (B.C.) or Before the Common Era (B.C.E.).

**Timeline of Mesozoic Era** ( ~251 Ma to ~66 Ma)

1. **Triassic period** ( ~251 Ma to ~204 Ma) was the earliest period of the Mesozoic era,
   or the corresponding system of rocks, marked by the first appearance of the dinosaurs.

2. **Jurassic** (~204 Ma to ~136 Ma) is the period of the Mesozoic era, between the Triassic and the Cretaceous or the corresponding system of rocks, marked by the presence of dinosaurs, and the first appearance of birds.

3. **Cretaceous period** (~136 Ma to ~66 Ma) was marked by the presence of dinosaurs, marine and flying reptiles, ammonites, ferns, and gymosperms and the appearance of angiosperms, mammals and birds. With the disintegration of the Godwanaland towards the end of the Cretaceous, the continents acquired their present features, their shapes, the great mountain systems, the courses of the rivers, the Great Plains, and the climatic zones. The Cenozoic Era that followed the Mesozoic is continued up to the present. It began about 60 million years ago.

**Timeline of Cenozoic Era (~66Ma to 10000 years)**

**Cenozoic Era** (~66Ma to 10000 years): The Cenozoic Era is divided into two periods – the Tertiary and the Quaternary. The Tertiary is subdivided into five epochs. The name of each epoch ends with the suffix one (Greek, recent) and refers to the progress of life. The Tertiary period has been studied in greater detail than any other period, partly because its flora and fauna bear close similarities to the living forms, but mainly because of economic reasons, viz, search for petroleum, of which more than 50 per cent of the world production comes from the Tertiary rocks.

| | | | |
|---|---|---|---|
| Quaternary | | Years | sub period |

| | | | |
|---|---|---|---|
| period | Oligocene Epoch (little recent)<br>Eocene Epoch (dawn recent)<br>Paleocene Epoch (ancient recent) | 15 million years<br>15 million years<br>10million years | Paleogene period or Nummulitic period |
| Tertiary period | Miocene Epoch (less recent)<br>Pliocene Epoch (more recent)<br>Pleistocene Epoch (most recent)<br>Recent Epoch | 12 million years<br>10 million years<br>1 million years<br>10, 000 years | Neogene period |

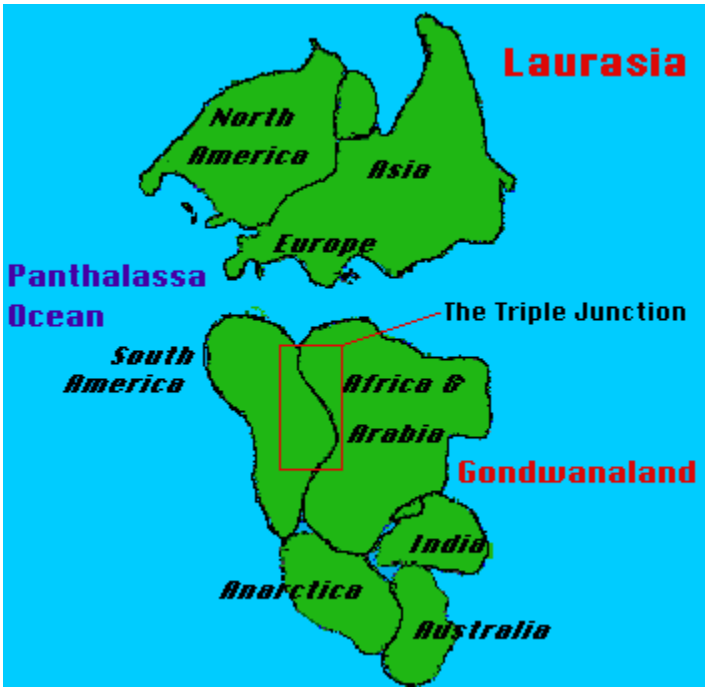
**Pangea, the super-continent**

The Earth is a *dynamic* or constantly changing planet. The Earth's crust is broken into many pieces, which are called ***plates***. These plates are in constant motion causing earthquakes, mountain building, volcanism, the production of "new" crust and the destruction of "old" crust. There are three kinds of plate boundaries:

1. ***Convergent boundary*** -where two plates collide to form mountains or a subduction zone.
2. ***Divergent boundary*** -where two plates are moving in opposite directions as in a mid-ocean ridge.
3. ***Transform boundary*** -where two plates are sliding past each other as in the San Andreas fault of California.

The Earth's plates are in constant, but very, very slow motion. They move at only 1/2 to 4 inches (1.3 to 10 centimeters) per year!! This does not seem like much, but over millions of years it adds up to great distances of movement. In 1912, ***Alfred Wegener*** introduced the '***Continental Drift Theory***' which states that the continents have moved and are still moving today. Scientists believe these plates have been moving for millions of years. In fact, 250 millions years ago the Earth's seven continents were all grouped together into a supercontinent (one huge landmass) called '**Pangea**'. This huge supercontinent was surrounded by one gigantic ocean called ***Panthalassa***.

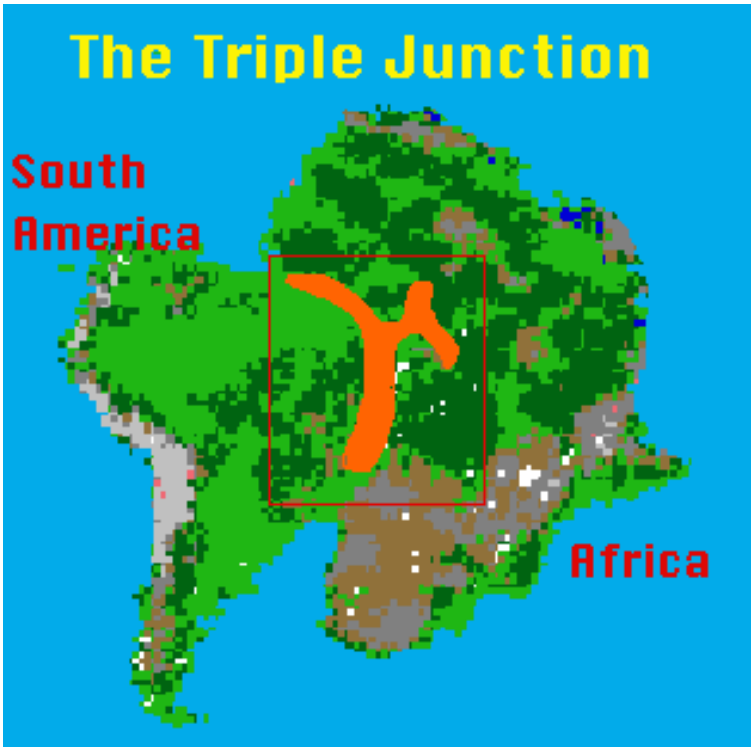

The postion of the continents of Antarctica was far north of its current position; Australia lipped sideways and far west of its current position and the subcontinent of India was hundreds of miles from Asia. North American continent was located much farther south and east of it's position today. North America was in or near the tropics. Fossils of tropical plants and animals found in cold regions like North Dakota and Greenland.



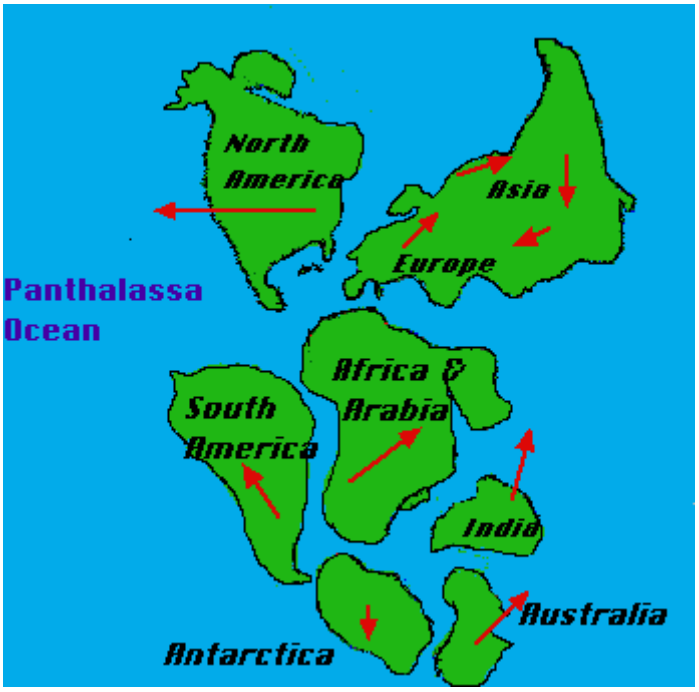
**180 Million Years Ago**

About 180 million years ago the super continent Pangea began to break up in the Mesozoic Era. Scientists believe that Pangea broke apart for the same reason that the plates are moving today. The movement is caused by the convection currents that roll over in the upper zone of the mantle. This movement in the mantle causes the plates to move slowly across the surface of the Earth. Pangea broke up in four stages. In the first stage during the Triassic about 200 million years ago, rifting occurred between Laurasia and Gondwanaland. ***Laurasia*** was made of the present day continents of North America (Greenland), Europe, Angara land comprising Russia, Siberia and China in the north. ***Gondwanaland*** was made of the present day continents of South America, Africa, India, Australia, and Antarctica. Notice that at this time India was not connected to Asia. The huge ocean of Panthalassa remained but the Atlantic Ocean was going to be born soon with the splitting of North America from the Eurasian Plate.

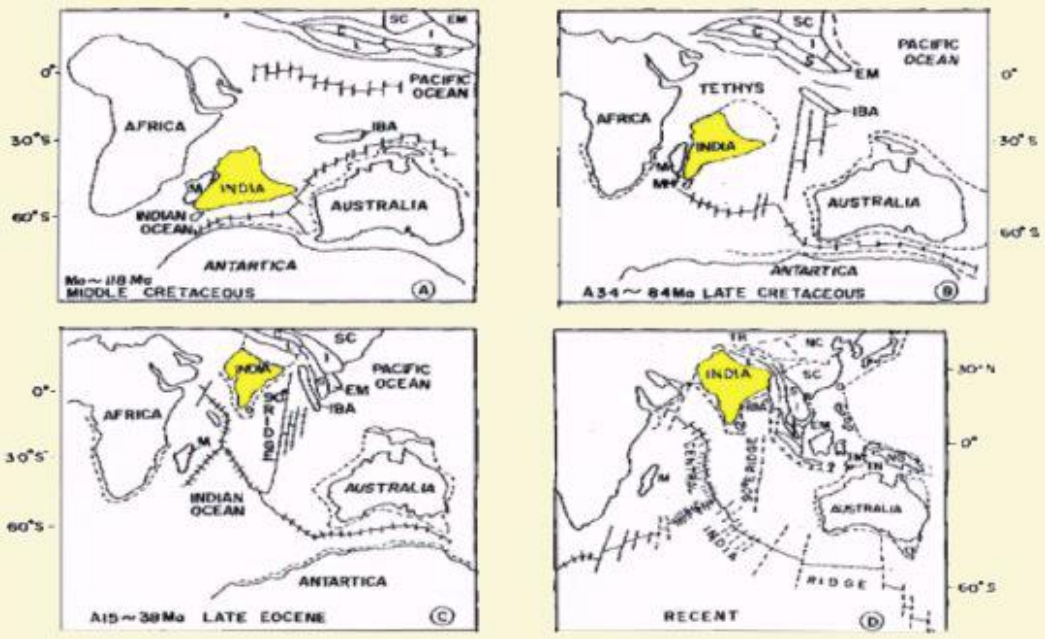
**'The Triple Junction'** was formed because of a three-way split in the crust allowing massive lava flows in three directions and poured out lava over hundreds of square miles of Africa and South America. The rocks of the triple junction, which today is the west central portion of Africa and the east central portion of South America, are identical matches for age and mineral make up. In other words the rocks in these areas of the 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.




**135 Million Years Ago**



In the Jurassic period about 135 million years ago, 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. In stage three, the Atlantic extended north, and Eurasia rotated clockwise to close the eastern end of the Tethys Sea, the precursor to the Mediterranean. 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.



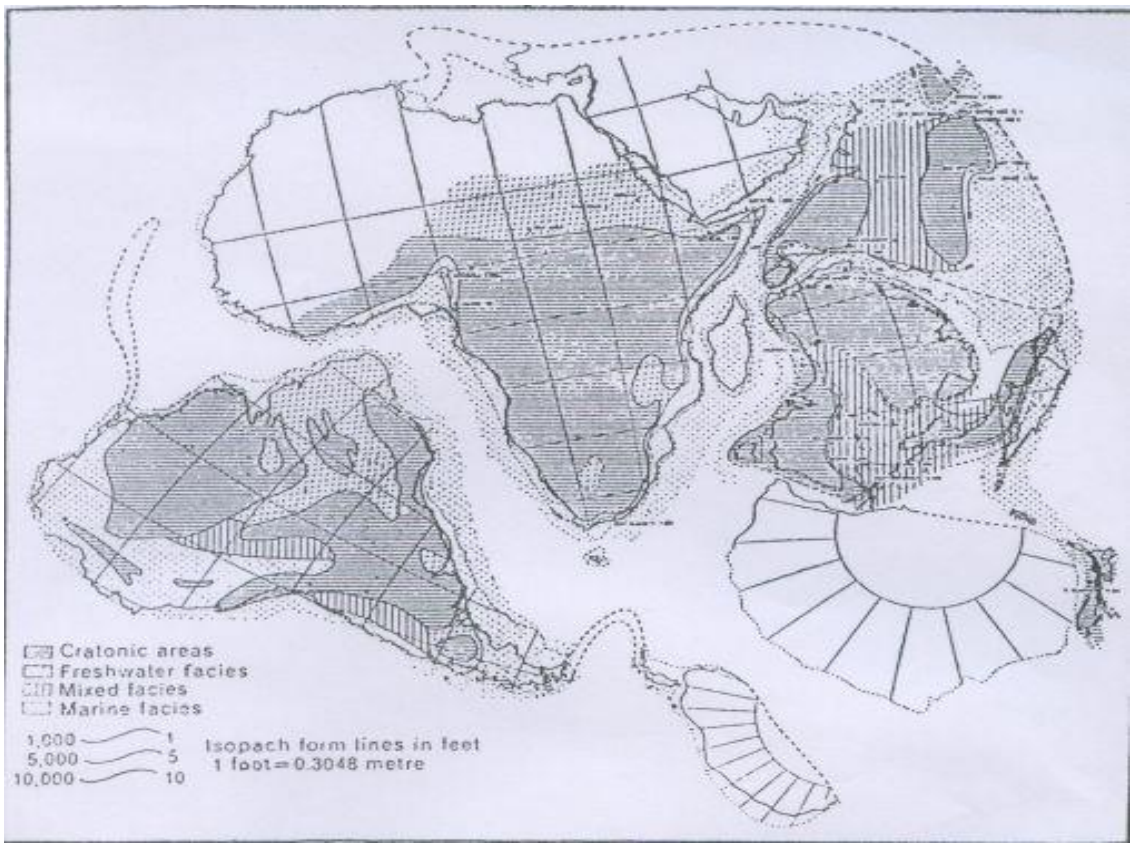

The Himalayas mountain-together with vast amounts of sediment eroded from them—were so heavy that the Indian-Australian Plate just south of the range was forced downward, creating a zone of crystal subsidence, or geosynclines into Malagasy (Madagascar) and Australia. Indian coal resource is mainly in the Permian Gondwana sediments. Indian continent being a crystal neighbour of mineral-rich South Africa and West Australia is also rated high for its potential future mineral prospects. Arabia started to separate from Africa as the Red Sea opened up. The red arrows indicate the direction of the continental movements. As a result of the earth movements, considerable parts of the marginal areas of the Gondwanaland

broke off and sank into the oceans. Rifting occurred between Africa and Antarctica, with this rift extending northeastward to India. In the early Cenozoic, Antarctica and Australia separated. The final stage of the dismemberment of Pangea occurred in the early Cenozoic. The North Atlantic rift continued north until North America and Eurasia (Europe) separated. During this stage, Antarctica and Australia separated. The final separation of the continents occurred about 45 Ma. The fragmentation of Pangea took about 150 million years.

**Geography of India**

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. The land area of peninsular India has never been submerged under the sea. The western ghats form the western edge, and the eastern ghats the eastern edge of the plateau, which slopes towards the east whereas the Himalayas and the Indo-Gangetic plain are comparatively young. Marine sediment occurs at the roof of the Everest.

The Cretaceous period began 110 million years ago and lasted for 50 million years. During the middle and the upper Cretaceous, the land areas especially in the Pondicherry, Tiruchirappalli sector, are mainly littoral. The fauna of this sector is similar to that of Malagasy (Madagascar) and South Africa and to that of the southern flank of the Assam range. Along the Narmada Valley on the west coast are some marine fossil ferrous beds with fossils showing greater affinity with those of the Cretaceous of southern Arabia and Europe than with those of Assam and Tiruchirappalli regions. The dissimilarity indicates that there was still a sort of land barrier that separated the Bay of Bengal from the Arabian Sea. This land barrier has been called Lel11uria, which included Peninsular India and Malagasy (Madagasgar). The middle and the upper Cretaceous were periods, volcanic outbursts overwhelmed a vast area, comprising the present Gujarat, Maharastra and Madhya Pradesh. Several hundred thousand square kilometers were flooded by the outpourings of extremely mobile lava from fissures. The hills formed by the lava are in some places over 1,200 meters high and are known as the Deccan traps. The formation of the Deccan trap continued in the Tertiary Period. Deccan trap covers Sind, Kutch, Bihar, and the coastal areas of Andhra Pradesh.



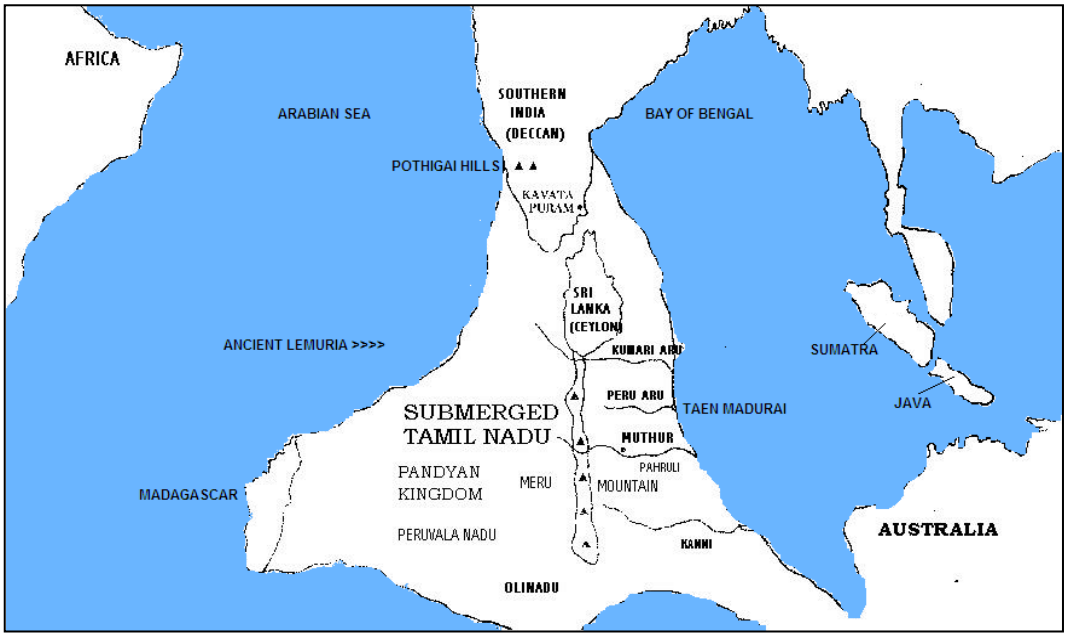

The uplift of the Himalayan system of mountain ranges was due to movements of two solid continental masses on two sides of the Tethys ocean, directed towards one another. The Central Asian continental mass, Angaraland, slowly moved from the north to the south under pressure from the floor of the Arctic Ocean, and the northern edge of the Indian continental mass, the Gondwanaland, became down warped by the northward compressive force from the Indian Ocean. The Himalayan portion of the Tethys gradually shifted southward and became narrower, assuming its present trend in the early Eocene time. The presence of tongue like projections of the Gondwanaland: one in the Kashmir- Hazara region (the Punjab wedge) and the other in the north-eastern extremity of Assam (the Assam wedge) have moulded the pattern of the Himalayan chain. The effects of these two wedges can be clearly seen in any relief map of India. It will be seen that the Himalayan chain occurs as a huge arc between Nanga Parbat in the west and Namcha Barwa in the east. The convexity of the arc points south towards the Indian peninsula. Below the Himalayas are the Siwalik Hills, extending from Jammu in the west to Assam in the east. The Siwalik Hills are mainly river deposits of the middle Miocene to the lower Pleistocene Age, folded into arches (anticlines) and troughs (synclines). The fault planes steeply sloping into the hills have given rise to steep scarps facing the plains. Immediately adjacent to and on the north of the Siwalik Hills lies the sub-Himalayan zone or lesser Himalayas, 65 to 80 kilometres wide and of an average

altitude of about 3,000 metres. The rocks here are mostly non fossiliferous. Farther north is the central Himalayan zone of high ranges with snow-clad peaks. It consists mainly of metamorphosed sedimentary rocks.

The Indo-Gangetic plains, which lie at the foot of the Himalayas from Hazara to Assam, mark the side of a deep basin of estimated depth of 1,050 to 6,000 metres which resulted from the compression exerted on the peninsular margin against the advancing crustal waves from the north. The basin has been filled up with the river alluvium derived from the rising Himalayas as well as from the plateau on the south.

## 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. is presented in Figure 7.




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 name "Lemuria" was actually invented by an English Zoologist, Phillip L. Schlater, back in the early days of Darwinism, in order to explain the fossilized remains of lemurs similar to those that live in Madagascar only today. The last surviving 'Lemurs' exist on Madagascar. This is why 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 first Tamil Sangam was believed to have occurred in the so-called lost continent known as Kumari Kandam. The great flood would have sunk Lemuria or Kumari Kandam before the Ramayana period (10,000 BC) since there the existence of an island, Sri Lanka, in the Indian Ocean during the Ramayana period was mentioned.

**Agriculture Heritage in India**

Agriculture in India is not of recent origin, but has a long history dating back to Neolithic age of 7500-6500 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. The modern society has lost sight of the importance of the traditional knowledge which had been subjected to a process of refinement through generations of experience. The ecological considerations shown by the traditional farmers in their farming activities are now-a-days is reflected in the resurgence of organic agriculture.

The available ancient literature includes the four Vedas, nine Brahnanas, Aranyakas, Sutra literature, Susruta Samhita, Charaka Samhita, Upanishads, the epices Ramayana and Mahabharata, eighteeen Puranas, Buddhist and Jain literature, and texts such as Krishi-Parashara, Kautilya's, Artha-sastra, Panini's Ashtadhyahi, Sangam literature of Tamils, Manusmirit, Varahamihira's Brhat Samhita, Amarkosha, Kashyapiya-Krishisukti and Surapala's Vriskshayurveda. This literature was most likely to have been composed between 6000 BC to 1000 AD. The information related to the biodiversity and agriculture (including animal husbandry) are available in these texts.

Rigveda is the most ancient literary work of India. It believed that Gods were the foremost among agriculturists. According to 'Amarakosha', Aryans were agriculturists. Manu and Kautilya prescribed agriculture, cattle rearing and commerce as essential subjects, which the king must learn. According to Patanjali the economy of the country depended on agriculture and cattle-breeding. Plenty of information is available in 'Puranas', which reveals that ancient Indians had intimate knowledge on all agricultural operations. Some of the well known ancient classics of India are namely, Kautilya's'Arthashastra'; Panini's 'Astadhyayi'; Patanjali's 'Mahabhasya'; Varahamihira's 'Brahat Samhita'; Amarsimha's 'Amarkosha' and Encyclopaedic works of Manasollasa. These classics testify the knowledge and wisdom of the people of ancient period. Technical books dealing exclusively with agriculture was Sage Parashara's 'Krishiparashara' in 1000 A.D. Other important texts are Agni Purana and Krishi Sukti attributed to Kashyap (500

A.D.). Ancient Tamil and Kannada works contain lot of useful information on agriculture in ancient India. Agriculture in India made tremendous progress in the rearing of sheep and goats, cows and buffaloes, trees and shrubs, spices and condiments, food and non-food crops, fruits and vegetables and developed nature friendly farming practices. These practices had social and religious undertones and became the way of life for the people. Domestic rites and festivals often synchronised with the four main agricultural operations of ploughing, sowing, reaping and harvesting.

In the *Rigveda,* there is reference to hundreds and thousands of cows; to horses yoked to chariots; to race courses where chariot races were held; to camels yoked to the chariots; to sheep and goats offered as sacrificial victims, and to the use of wool for clothing. The famous Cow Sukta (Rv. 6.28) indicates that the cow had already become the very basis of rural economy. In another sukta, she is difined as the mother of the Vasus, the Rudras and the Adityas, as also the pivot of Immortality. The Vedic Aryans appear to have large forests at their disposal for securing timber, and plants and herbs for medicinal purposes appear to have been reared by the physicians of the age, as appears in the *Atharva Veda*. The farmers' vocation was held in high regard, though agriculture solely depended upon the favours of Parjanya, the god of rain. His thunders are described as food-bringing.

The four Vedas mention more than 75 plant species, Satapatha Bhrahamna mentions over 25 species, and Charkaa Samhita (C. 300 BC) an Aayurvedic (Indian medicine) treatise-mentions more than 320 plants. Susruta (C. 400 BC) records over 750 medicinal plant species. The oldest book, Rigveda (C. 4000 BC) mentions a large number of poisonous and non poisonous aquatic and terrestrial, and domestic and wild creatures and animals. Puranas mention about 500 species of plants. The science of arbori-horticulture had developed well and has been documented in Surapala's Vrikshayurveda. Forests were very important in ancient times. From the age of Vedas, protection of forests was emphasized for ecological balance. Kautilya in his Artha sastra (321-296 BC) mentions that superintendent of forests had to collect forest produce through the forest guards. He provides a long list of trees, varieties, of bamboos, creepers, fibrous plants, drugs and poisons, skins of various animals, etc., that come under the purview of this officer.

The preservation of wild animals was encouraged and hunting as a sport was regarded as detrimental to proper development of the character and personality of the ruler, according to Manu (Manusmriti, 2$^{nd}$ Century BC). Specifically, in the Puranas (300-750 AD) the names of Shalihotra on horses, and Palakapya on elephants have been found as experts in animal husbandry. For instance, Garudapurana is a text dealing with treatment of animal disorders while the classical work on the treatment of horses is Aswashastra. One chapter in Agnipurana deals with the treatment of livestock and another on treatment of trees.

## Chapter 02 Development of Human Culture- Stone Age- Bronze age- Iron Age and beginning of Agriculture

The traditional classification of human social evolution is into pre-history and recorded history. The latter follows the invention of writing and therefore written historical records. The large number of primitive stone tools found in the Soan Valley and South India suggests that the earliest races of human existence in India go back to the period between 400,000 and 200,000 BC. He learnt to control fire, which helped him to improve his way of living. At the end of this age, the modern human being (*Homo sapiens*) first appeared - around 36,000 BC.

**Genetic History of modern man:**

During the early Paleolithic period, at least four species of genus *Homo* (man) inhabited earth:

i) *Homo habilis* - parts of skull, hands, legs and feet were discovered in 1960-64 by Louis S B Leakey in Tanzania, E. Africa. He was 4 feet tall and used crude tools (bones, limbs from trees, chunks of stone). *Homo habilis* is morphologically too primitive to be an ancestor of *homo erectus*.

ii) *Homo erectus* – There were two groups viz., i) Java man remains were discovered dating ca. 1.5 million-500,000 BC on the island of Java in 1891. They were 5 feet tall and used group hunting techniques and ii) Peking man remains were found between 1926-30 who knew the use of fire (around 500,000 BC) to cook food and kept warm; evidence of the first true hand-ax was also found.

iii) *Homo ergaster* is morphologically closer to *Homo sapiens* than *H. erectus*.

iv) *Homo sapiens* – the modern man was 5'4" tall with a receding chin and heavy eyebrow ridges. He cooked his food, but no houses yet but only semi-nomadic.

Some nuclear DNA sequences (including Y-chromosome data) and mtDNA indicate that modern humans originated and migrated relatively recently from a subset of the African population, putting Africa as the home of modern humanity. A study of human Y-chromosome variation in a worldwide sample of over 1,000 men determined that Africans and non-Africans shared a common ancestor 59,000 years ago and that the non-African branch of humanity left Africa about 44,000 years ago. Other data shows that Africans and non-Africans split about 156,000 years ago. The true migration date is some time between these dates There seems to be some correlation between these dates and the appearance of modern humans as a species. The last common ancestor of all non-African human Y-chromosomes is estimated to be about 40,000 years (31,000-79,000) ago. Another study of the Y-chromosome of Europeans used 22 markers in 1,007 men across Europe Over 80 percent of the European genes were traced to two migrations of

Paleolithic ancestors around 40,000 and 22,000 years ago, respectively. Twenty percent of the European genes were from Neolithic farmers who entered the continent about 10,000 years ago.

Early or primitive *Homo sapiens* were adaptable, leading to the adoption of diverse lifestyles based on locally available food resources. Early Europeans hunted reindeer as did the Eskimo. Hunters met migratory herds in autumn on their return from summer tundra pastures to winter forest shelters. This meat could be frozen and used throughout the winter. Modern Eskimos, Australian aborigines and primitive inhabitants of Glacial Europe use a type of spear-thrower, an early technological innovation. Early Europeans had to contend with lions, bears, bison, mammoths, woolly rhinoceros and wild ox. Wood for cave fires was collected from conifer forests. On the southern steppes there was less fuel, so bone served as fuel. *Homo erectus* remains in Sundaland (Java, Sumatra and Borneo), of between 600,000 and 900,000 years old, represent the earliest evidence of our pre-human ancestors in this region. The Australoid colonists of this area are represented today by the Aborigines of Australia, the Highlanders of New Guinea, the Negritos of Malaya and the Philippines.

**Development of Human Culture**

The Pre-history **Stone Age** is broken down onto three periods, according to the materiel used for making tools:

i) The **Paleolithic Period or Old / Ancient Stone Age** (2.5 million-12,000 BC): The age in human culture characterized by the use of rough or chipped stone tools. Man was essentially a food gatherer and depended on nature for food. He learnt to control fire, which helped him to improve his way of living. At the end of this age, the modern human being (*Homo sapiens*) first appeared around 36,000 BC.

ii) **Mesolithic period or Meso Stone Age** (12,000 to 7,500 BC): The Mesolithic age began and continued up to 4000 BC in India. It is characterized by tiny store implements called microliths. During this time, sharp and pointed tools were used for killing fast-moving animals. The beginning of plant cultivation also appeared. The human beings learned to produce higher quality tools around 10,000 BC and to farm around 8,000 BC.
Semi-permanent agricultural settlements took place in Old World.

iii) **Neolithic or New Stone Age** (7500 BC to 6500 BC): The word ‘lithium’ comes from a Greek word, "lithos", which means stone while ‘Neo’ means ‘new’. Human settlement in the Indian sub-continent is from 7500 to 4000 BC. Man began to domesticate animals and cultivate plants, settling down in villages to form farming communities. Beginning or discovery of Agriculture takes place in Neolithic period. Agricultural Revolution has occured in western Asia during the same period. Invention of polished store implements has taken place.

The **Bronze Age** (4000 to 2000 BC): Chalcolithic culture prevailed in Bronze Age. The term Chalcolithic is applied to the communities using store implements along with copper or bronze ones. Invention of plough, wheel and metallurgy has taken place. Earliest recorded date in Egyptian calendar was 4241 B.C. First year of Jewish calendar was 3760 B.C. First phonetic writing appears in 3500 B.C. Sumerians develop a city-state civilization during 3000 B.C. Copper used by Egyptians and Sumerians. The most ancient civilization on the Indian subcontinent, the sophisticated and extensive Indus Valley civilization, flourishes in what is today Pakistan.

The **Iron Age** (1500 BC onwards).

The **Paleolithic Period** (Old Stone Age) is from 2.5 million-12,000 BC with earliest tool-making human beings and ends when people learned to produce higher quality tools around 12,000 BC and to farm around 8,000 BC. The Old Stone Age is the '*Age of food-gatherers*', while the New Stone Age (the New Stone Age or the Neolithic Age (12000 to 4000 BC)) is referred to as the '*Age of food producers*'. This puts the Bornze age onwards as the '*Age of civilization*', starting towards the end of the Neolithic Age. There are three major lifestyle groupings viz., i) Hunter gatherer, ii) Agriculture and iii) Technological civilisation. Civilization requires, or may be defined by, settlement in definite territories, the building of towns and cities, the evolution of defined systems of government and the development of trade and commerce. This social system has and does exist together with the first two.

**Hunter gatherers:** Over the period called the Middle Palaeolithic (called the Middle Stone Age in Africa), 200,000 to 40,000 years ago, stone tools found are quite similar, representing a uniform technology world-wide. The oldest site of tool use comes from East Africa where pebble tools were in use 1.7 million years ago. Tool and fire are ancient "landmarks" on the path to humanity. There is evidence that fire was first used by *Homo erectus* at Ghoukoutien, China 300,000 to 400,000 years ago. Hunter-gatherers had a practical, but excellent knowledge of their natural environment, be it plants animals or the physical conditions. In productive areas, Australian aborigines had up to 250 food plants from which to choose. Poorer areas had about 50 food plants. Paleolithic (Stone) Age lasted up to 12,000 BC. Primitive man used tools and implements of rough stone. Man was essentially a food gatherer and depended on nature for food.

During the Ice Age (Upper Palaeolithic: 35,000 to 8,000 B.C.), a culture of mammoth hunters lived in eastern Europe and Siberia. These hunting nomads had a diet mostly of meat as did the Eskimos until recently. All their requirements would have come from their prey which also included bison, horses, reindeer, birds, fish, arctic foxes and hares. Vegetable foods would have formed a minor supplement. They even built huts from carefully interlocked mammoth bones covered with skins. A typical Australian aborigine's catch for the day may include

snakes, lizards, anteaters, frogs and grubs, and a wallaby or two. Semang people of Malaysia rely on small creatures (fish, birds, rats, squirrels, lizards and sometimes wild pigs, tapirs and deer), wild plants (nuts, berries, fruit, leaves, shoots, and tubers) and honey collected from the forest. They use a poisoned dart propelled from a two-metre long bamboo blowpipe to kill some animals.

**Mesolithic period (Meso Stone Age)** is from c. 12,000 to 8,000 years ago. The human culture characterized by cultures moving from a food-gathering society to a food-production society. Tools in this age often had "barbs" or hooks, or interchangeable. The beginning of plant cultivation also appeared. Chotanagpur plateau, central India and south of the river Krishna are some of the various Mesolithic sites.

Table 1. gives an idea about the type of economy and culture during the Mesolithic period to the Bronze Age.

| Period | Type of economy | Type of culture |
|---|---|---|
| 12000-8500 BC | Hunter / gathering economy with more intense use of animals planting s | Nomadic culture |
| 8500-7600 BC | Exploitation of cattle, pigs, sheep, goats, wheat, barley, peas, lentil, etc., cultivated. | Village development at Jericho barter began burial of dead. |
| 7600-6000 BC | Domestication of sheep, goat, expansion range of cultivated crops. | Increase in settlement size. More varied artifacts. |
| 6000-5000BC | Increasing concentration on agriculture and harding as hunting diminished in importance. Cattle and pigs domesticated. | Pottery making began, use of Plough. |
| 5000-3700BC | More productive agriculture and herding economy. | Development of copper culture, wider range of pottery styles. Increased population. |

**Beginning of Agriculture:** Demographic pressure probably led to the adoption of crop cultivation and animal husbandry, leading to modern civilisation. As the population grew, there was an increased dependence upon plants. Next, consumer demand within a constrained space forced the adoption of some form of intensive agriculture. Other evidence for this trend is found in Peru where people domesticated camelids and guinea pigs 2,000 years before crop cultivation. Agriculture would have been started with the end of the last Ice Age between 15,000 and 8,000 years ago. Before this, people living the hunter-gatherer lifestyle

depended upon what was available. Historical evidences showed that agriculture started around 8,500 years ago from the Near East, reaching Britain around 6,000 years ago and Spain and Portugal by 5,000 years ago. American Indians of central Brazil, called, the Kayapo are a modern version of hunter gatherer people. With chickens, crops such as corn, sweet potatoes, sweet manioc and yams and a hunting lifestyle they represent a transition from a hunter-gathering lifestyle to an agricultural lifestyle. What they caught by hunting, be it a tortoise, deer, fish or a wild pig, they had to share and they discouraged selfishness. Women worked in groups to gather fruit, nuts and plants from the same forest where the men hunt. Ironically, on finding a high fruit tree, they cut it down with a metal axe to harvest the ripe fruit. Domestic crops and animals become more important as food than wild animals and plants. Agriculture is relatively new, only emerging between 12,000 and 8,000 years ago and has often caused environmental damage, but has led to the social changes that have allowed the formation of our modern civilisation. The domestication of dogs and turkeys followed agriculture. People made tools such as bone reaping knives with flint cutting teeth.

**Table 1. History of agriculture development and food production**

| Agriculture system | Cultural stage / time | Cereal yield (t/ha) | World population (million) | Land holding (ha person) |
|---|---|---|---|---|
| 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 | 20$^{th}$ century | 4 | 4200 | 0.3 |

**Neolithic period (New Stone Age):** The age in human culture characterized by the use of arrows, *polished* stone tools used in farming, the creation of pottery, weaving cloth and making baskets. In Neolithic period, two major periods were covered viz.,

I. 8000-6000 B.C.--early agricultural settlement with domestic architecture and variety of crafts.

- 8000-7000 B.C.: first phase lacked pottery; people used mostly stone blades, a few ground-stone hand-axes; wheat, barley--staple crops; domesticated sheep and goats; agriculture supplemented by hunting; mud-brick huts; simple burial rituals.

- 7000-6000 B.C.: pottery appears during second phase; domestic cattle replace game animals, sheep, and goats; granaries appear (indicate crop surpluses); more elaborate burial rituals; human figurines modeled in clay.

II. 5000-3000 B.C.--c. 5500 B.C., a major geologic event took place (earthquake, flood, or shift of tectonic plates)--original site almost completely buried in silt. Original culture persisted, but with alterations: increased use of pottery; granaries larger/more numerous; appearance of several new crafts--use of copper and ivory; size of settlement enlarged. The Chalcolithic period lasted from 4,000 to 2,500 years B.C.

**Bronze Age** is the period of ancient human culture characterized by the use of bronze; that began between 4000 and 3000 B.C., and ended with the advent of the Iron Age. According to a variety of religious traditions, about 3800 BC was the tragic expulsion of "*Adam and Eve*" from the Garden of Eden - sent to practice agriculture.

**Technological Civilization**

The development of a technological civilisation is a matter of degree rather than a moment in time. Early Egyptian societies were technological, enabling complex engineering such as the pyramids. Technology has been with humans from the first use of a stone as a tool, as it is with some chimpanzee groups today. With the introduction of agriculture, villages and cities became possible as people did not have to travel in search of food. (*Civilisation* comes from the Latin word " *civitas* " meaning city.) This sedentary way of life formed the basis for modern civilization.

Egypt and Mesopotamia had established irrigation systems by 5,000 years ago. In China, people developed the iron plough by 2,600 years ago, replacing wood and stone ploughs as a more effective tool. They had also developed the mould board plough by 2,100 years ago. Ancient people are responsible for the basic inventions such as the use of fire, the use of metals such as gold and copper, bows and arrows, the fish hook, spinning and weaving, agriculture, animal domestication, sail boats and ships, wells and irrigation, pottery, clothing, language, arithmetic, the alphabet and written communication in prehistoric times. The oldest evidence for the bow and arrow, at 20,000 years old, comes from North Africa. Other agricultural inventions such as seed drills have older origins, in use in Mesopotamia 5,500 years ago.

People built the pyramid at Saqqara over 4,600 years ago. Architects designed complex architectural concepts such as domes, built in Ancient Cyprus 5,000 years ago.

The discovery and use of '*metals*' was an important aspect of our cultural evolution. Malleable metals allowed creations limited only by human imagination and so the invention of a far wider range of implements, tools and instruments than could be made with wood and bone. Copper was found in almost pure form in

some areas and so was one of the first metals used around 10,000 years ago by the people living along the Euphrates and Tigris rivers in what is now Iraq. Gold was in use by 5,500 years ago. Roman dentists were using gold as tooth fillings 2,000 years ago. Silver was in use 6,000 years ago. Egyptians produced iron, the most difficult metal to separate from its ore, 4,000 years ago. Assyrians had an advanced technology for iron smelting, even making steel from iron. Labour saving devices were commonly used in ancient Greece. They used the wedge, the lever, the block with pulleys, the winch or windlass and the screw. Scientists such as Archimedes (2,300 years ago) were involved in these developments, but were not the inventors. The screw was used to move water in the Middle East and probably originated in ancient Egypt.

Before A.D. 1,000, two important innovations became established in Europe, the rotation of crops and the horse-drawn and wheeled Saxon plough. Water wheels were in use in England for various purposes such as grinding corn or sawing wood in 1066 A.D.

At the end of the middle ages and the beginning of the Renaissance the German, Johan Gutenberg invented printing with movable type. His Gutenberg Bible of 1455 was the first known printed book. In the medieval period, mechanical clock and the watch with balance wheel was invented during 1286.

During the fifteenth century Europeans started exploring and discovering the rest of the world. Columbus reached the Americas in 1492. Bartholomew Diaz reached the Cape of Good Hope on Africa in 1494. Vasco De Gama sailed around the Cape to India in 1497. In 1543, the "De Revolutionibus Orbium Coelestium" of Copernicus established that the earth orbited around the sun. according to Marco Polo, the Chinese inventions include coal as fuel, the use of paper money, printing technology, firearms and the compass during 1271-1292 and none of which was in use in Europe

Our technological era began with the invention of the steam engine and automated regulator devices in the mid-eighteenth century. Water mills remained the main source of mechanical power in England throughout the Industrial Revolution and up to 1830. A wheat thresher was invented in Scotland during 1784. A horse-drawn combine harvester that reaped, separated the chaff and poured the grain into bags was in use in 1830's.

Paper was invented in China around A.D. 100. A practical typewriter was patented in 1868. Blaise Pascal, a French mathematician invented the first automatic calculator in 1642. George Boole, a mathematician developed this into Boolean Algebra and Boolean Logic. This formed the basis for computer logic and computer languages.
Fabric weaving was automated in 1801 by J.M. Jacquard, using punched cards. Charles Babbage (1791-1871) tried to develop a mechanical computer, or "analytical engine" using punched cards in the 1830's. In 1888, an American inventor, Herman Hollerith, developed a successful computer, using punched cards

and electricity. This was the first step in automated data processing, generating tabulated results from payroll, census and other data. In 1911 he sold his company, the Tabulating Machine Company, which then became the Computing-Tabulating-Recording Company. They formed IBM from this company in 1924.

**Indian history: A timeline (Ancient)**

| | |
|---|---|
| 2700 BC | Harappa Civilisation |
| 1000 BC | Aryans expand into the Ganga valley |
| 900 BC | Mahabharata War |
| 800 BC | Aryans expand into Bengal; Beginning of the Epic Age: Mahabharata composed, first version of Ramayana |
| 550 BC | Composition of the Upanishads |
| 544 BC | Buddha's Nirvana |
| 327 BC | Alexander's Invasion |
| 325 BC | Alexander marches ahead |
| 324 BC | Chandragupta Maurya defeats Seleacus Nicator |
| 322 BC | Rise of the Mauryas; Chandragupta establishes first Indian Empire |
| 298 BC | Bindusara Coronated |
| 272 BC | Ashoka begins reign ; Exclusive Interview with Ashoka |
| 180 BC | Fall of the Mauryas ; Rise of the Sungas |
| 145 BC | Chola king conquers Ceylon |
| 58 BC | Epoch of the Krita-Malava-Vikram Era |
| 30 BC | Rise of the Satvahana Dynasty in the Deccan |
| 40 AD | Sakas in power in Indus Valley and Western India |
| 50 AD | The Kushans and Kanishkas |
| 78 AD | Saka Era begins |
| 320 AD | Chandragupta I establishes the Gupta dynasty |
| 360 AD | Samudragupta conquers the North and most of the Deccan |
| 380 AD | Chandragupta II comes to power; Golden Age of Gupta Literary Renaissance |
| 405 AD | Fa-hein begins his travels through the Gupta Empire |
| 415 AD | Accession of Kumara Gupta I |
| 467 AD | Skanda Gupta assumes power |
| 476 AD | Birth of astronomer Aryabhatta |
| 606 AD | Accession of Harshavardhan Gupta |
| 622 AD | Era of the Hejira begins |
| 711 AD | Invasion of Sind by Muhammad Bin Qasim |
| 892 AD | |
| 985 AD | The Chola Dynasty: Accession of Rajaraja, the Great |
| 1001 AD | Defeat of Jaipal by Sultan Mahumd |

**Indian history: A timeline (Medieval)**

| **Year** | **Particulars** |
|---|---|
| 1026 | Mahmud Ghazni sacks Somnath Temple |
| 1191 | Prithviraj Chauhan routs Muhammad Ghori: the first battle of |

| | |
|---|---|
| | Tarain |
| 1192 | Qutbuddin establishes the Slave Dynasty |
| 1221 | Mongol invasion under Genghis Khan |
| 1232 | Foundation of the Qutub Minar |
| 1290 | Jalaludin Firuz Khalji establishes the Khalji dynasty |
| 1320 | Ghiyasuddin Tughluk founds the Tughluk dynasty |
| 1325 | Accession of Muhammad-bin-Tughluk |
| 1336 | Foundation of Vijayanagar (Deccan) |
| 1398 | Timur invades India |
| 1424 | Rise of the Bahmani dynasty (Deccan) |
| 1451 | The Lodi dynasty established in Delhi |
| 1489 | Adil Shah dynasty at Bijapur |
| 1490 | Nizam Shahi dynasty at Ahmednagar |
| 1498 | First voyage of Vasco da gama |
| 1510 | Portuguese capture Goa |
| 1518 | Kutub Shahi dynasty at Golconda |
| 1526 | Establishment of the Mughul Dynasty; First Battle of Panipat: Babur defeats Lodis |
| 1526-1530 | Reign of Babur |
| 1530 | Humayun succeeds Babur |
| 1538 | Death of Guru Nanak |
| 1539 | Sher Shah Suri defeats Humayan and becomes Emperor of Delhi |
| 1555 | Humayun recovers the throne of Delhi |
| 1556 | Death of Humayun; Accession of Akbar; Interview with Akbar |
| 1564 | Akbar abolishes poll tax on Hindus |
| 1565 | Battle of Talikota: Muslim rulers in Deccan defeats and destroys Vijaynagar Empire |
| 1568 | Fall of Chittor |
| 1571 | Foundation of Fatehpur Sikri by Akbar |
| 1572 | Akbar annexes Gujarat |
| 1573 | Surat surrenders to Akbar |
| 1575 | Battle of Tukaroi |
| 1576 | Battle of Haldighat: Akbar defeats Rana Pratap; Subjugation of Bengal |
| 1577 | Akbar troops invade Khandesh |
| 1580 | Accession of Ibrahim Adil Shah II in Bengal; Rebellion in Bihar and Bengal |
| 1581 | Akbar's march against Muhammad Hakim and reconciliation with him |
| 1582 | Divine Faith promulagated |
| 1586 | Annexation of Kashmir |
| 1591 | Mughul conquest of Sind |
| 1592 | Annexation of Orissa |
| 1595 | Siege of Ahmednagar; Annexation of Baluchistan |
| 1597 | Akbar completes his conquests |

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|---|---|
| 1600 | Charter to the English East India Company |
| 1602 | Formation of the United East India Company of Netherlands |
| 1605 | Death of Akbar and Accession of Jahangir |
| 1606 | Rebellion of Khusrav; Execution of the Fifth Sikh Guru, Arjan |
| 1607 | Sher Afghan first, husband of Nur Jahan, killed |
| 1608 | Malik Ambar takes Ahmednagar |
| 1609 | The Dutch open a factory at Pulicat |
| 1611 | The English establish a factory at Masulipatnam |
| 1612 | The Mughul Governor of Bengal defeats the rebellious Afghans; Mughuls annex Kuch Hajo |
| 1615 | Submission of Mewar to the Mughuls; Arrival of Sir Thomas Roe in India |
| 1616 | The Dutch establish a factory at Surat |
| 1620 | Capture of Kangra Fort; Malik Ambar revolts in the Deccan |
| 1622 | Shah Abbas of Persia beseiges and takes Qandahar |
| 1623 | Shah Jahan revolts against Jahangir |
| 1624 | Suppression of Shah Jahan's rebellion |
| 1626 | Rebellion of Mahabat Khan |
| 1627 | Death of Jahangir; Accession of Shah Jahan |
| 1628 | Shah Jahan proclaimed Emperor |
| 1631 | Death of Shah Jahan's wife Mumtaz Mahal; The construction of Taj Mahal |
| 1632 | Mughul invasion of Bijapur; Grant of the "Golden Firman" o the English Company by the Sultan of Golkunda |
| 1633 | End of Ahmednagar Dynasty |
| 1636 | Aurangzeb appointed Viceroy of Deccan |
| 1639 | Foundation of Fort St. George at Madras by the English |
| 1646 | Shivaji captures Torna |
| 1656 | The Mughuls attack Hyderabad and Golkunda; Annexation of Javli by Shivaji |
| 1657 | Invasion of Bijapur by Aurangzeb; Aurangzeb captures Bidar and Kalyani |
| 1658 | Coronation of Aurangzeb |
| 1659 | Battles of Khajwah and Deorai |
| 1661 | Cession of Bombay to the English; Mughul capture of Cooch Bihar |
| 1664 | Shivaji sacks Surat and assumes royal title |
| 1666 | Death of Shah Jahan; Shivaji's visit to Agra and escape |
| 1674 | Shivaji assumes the title of Chhatrapati |
| 1678 | Marwar occupied by the Mughuls |
| 1680 | Death of Shivaji; Rebellion of Prince Akbar |
| 1686 | English war with the Mughuls; Fall of Bijapur |
| 1689 | Execution of Sambhaji |
| 1690 | Peace between the Mughuls and the English |
| 1691 | Aurangzeb at the zenith of his power |
| 1698 | The new English company trading to the East Indies |

| | |
|---|---|
| 1699 | First Maratha raid on Malwa |
| 1700 | Death of Rajaram and regency of his widow Tara Bai |
| 1702 | Amalgamation of English and the London East India Companies |
| 1707 | Death of Aurangzeb; Battle of Jajau |
| 1714 | Husain Ali appointed Viceroy of the Deccan; The treaty of the Marathas with Husain Ali |
| 1720 | Accession of Baji Rao Peshwa at Poona |
| 1739 | Nadir Shah conquers Delhi; The Marathas capture Salsette and Bassein |
| 1740 | Accession of Balaji Rao Peshwa; The Marathas invade Arcot |
| 1742 | Marathas invade Bengal |
| 1748 | First Anglo-French war |
| 1750 | War of the Deccan and Carnatic Succession; Death of Nasir Jang |
| 1751 | Treaty of Alivadi with the Marathas |
| 1756 | Siraj-ud-daulah captures Calcutta |

**The Little Ice Age** (1450AD-1870AD): Beginning about 1450AD is a marked return to colder conditions, often called The Little Ice Age, a term used to describe an epoch of renewed glacial advance. Glaciers advanced in Europe, Asia and North America, whilst sea ice in the North Atlantic expanded with detrimental effects for the colonies of Greenland and Iceland.

**Indian history: A timeline (Modern)**

| | |
|---|---|
| 1757 | Battle of Plassey: The British defeat Siraj-ud-daulah |
| 1760 | Battle of Wandiwash: The British defeat the French |
| 1761 | Third battle of Panipat: Ahmed Shah Abdali defeats the Marathas; Accession of Madhava Rao Peshwa; Rise of Hyder Ali |
| 1764 | Battle of Buxar: The British defeat Mir Kasim |
| 1765 | The British get Diwani Rights in Bengal, Bihar and Orissa |
| 1767-1769 | First Mysore War: The British conclude a humiliating peace pact with Hyder Ali |
| 1772 | Death of Madhava Rao Peshwa; Warren Hastings appointed as Governor of Bengal |
| 1773 | The Regulating Act passed by the British Parliament |
| 1774 | Warren Hastings appointed as Governor-General |
| 1775-1782 | The First Anglo-Maratha war |
| 1780-1784 | Second Mysore War : The British defeat Hyder Ali |
| 1784 | Pitt's India Act |
| 1790-1792 | Third Mysore War between the British and Tipu |
| 1793 | Permanent Settlement of Bengal |
| 1794 | Death of Mahadaji Sindhia |
| 1799 | Fourth Mysore War: The British defeat Tipu; Death of Tipu; |

| | |
|---|---|
| | Partition of Mysore |
| 1802 | Treaty of Bassein |
| 1803-1805 | The Second Anglo-Maratha war: The British defeat the Marathas at Assaye: Treaty of Amritsar |
| 1814-1816 | The Anglo-Gurkha war |
| 1817-1818 | The Pindari war |
| 1817-1819 | The last Anglo-Maratha war: Marathas finally crushed by the British |
| 1824-1826 | The First Burmese war |
| 1829 | Prohibition of Sati |
| 1829-1837 | Suppression of Thuggee |
| 1831 | Raja of Mysore deposed and its administration taken over by East India Company |
| 1833 | Renewal of Company's Charter; Abolition of company's trading rights |
| 1835 | Education Resolution |
| 1838 | Tripartite treaty between Shah Shuja, Ranjit Singh and the British |
| 1839-1842 | First Afghan war |
| 1843 | Gwalior war |
| 1845-1846 | First Anglo-Sikh war |
| 1848 | Lord Dalhousie becomes the Governor-General |
| 1848-1849 | Second Anglo-Sikh war : (Rise of Sikh Power) British annex Punjab as Sikhs are defeated |
| 1852 | Second Anglo-Burmese war |
| 1853 | Railway opened from Bombay to Thane; Telegraph line from Calcutta to Agra |
| 1857 | First War of Indian Independence: The Sepoy Mutiny |
| 1858 | British Crown takes over the Indian Government |
| 1861 | Indian Councils Act; Indian High Courts Act; Introduction of the Penal Code |
| 1868 | Punjab Tenancy Act; Railway opened from Ambala to Delhi |
| 1874 | The Bihar Famine |
| 1877 | Delhi Durbar: The Queen of England proclaimed Empress of India |
| 1878 | Vernacular Press Act |
| 1881 | Factory Act; Rendition of Mysore |
| 1885 | First meeting of the Indian National Congress; Bengal Tenancy Act |
| 1891 | Indian Factory Act |
| 1892 | Indian Councils Act to regulate Indian administration |
| 1897 | Plague in Bombay; Famine Commission |

| | |
|---|---|
| 1899 | Lord Curzon becomes Governor-General and Viceroy |
| 1905 | The First Partition of Bengal |
| 1906 | Formation of Muslim League; Congress declaration regarding Swaraj |
| 1908 | Newspaper Act |
| 1911 | Delhi Durbar; Partition of Bengal modified to create the Presidency of Bengal |
| 1912 | The Imperial capital shifted from Calcutta to Delhi |
| 1913 | Educational Resolution of the Government of India |
| 1915 | Defence of India Act |
| 1916 | Home Rule League founded; Foundation of Women's University at Poona |
| 1919 | Rowlatt Act evokes protests; Jalianwalla Bagh massacre; The Montague-Chelmsford Reforms offer limited autonomy |
| 1920 | The Khilafat Movement started; Mahatma Gandhi leads the Congress; Non-co-operation Movement |
| 1921 | Moplah (Muslim) rebellion in Malabar; Census of India |
| 1922 | Civil Disobedience Movement; Chauri-Chaura violence leads to Gandhi suspending movement |
| 1923 | Swarajists in Indian Councils; Certification of Salt Tax; Hindu-Muslim riots |
| 1925 | Reforms Enquiry committee Report |
| 1926 | Royal Commission on Agriculture; Factories Act |
| 1927 | Indian Navy Act; Simon Commission Appointed |
| 1928 | Simon Commission comes to India: Boycott by all parties; All Parties Conference |
| 1929 | Lord Irwin promises Dominion Status for India; Trade Union split; Jawaharlal Nehru hoists the National Flag at Lahore |
| 1930 | Civil Disobedience movement continues; Salt Satyagraha: Gandhiji's Dandi March; First Round Table Conference |
| 1931 | Second Round Table Conference; Irwin-Gandhi Pact; Census of India |
| 1932 | Suppression of the Congress movement; Third Round Table Conference; The Communal Award; Poona Pact |
| 1933 | Publication of White Paper on Indian reforms |
| 1934 | Civil Disobedience Movement called off; Bihar Earthquake |
| 1935 | Government of India Act |
| 1937 | Inauguration of Provincial Autonomy; Congress ministries formed in a majority of Indian provinces |
| 1939 | Political deadlock in India as Congress ministries resign |
| 1942 | Cripps Mission to India; Congress adopts Quit India Resolution; Congress leaders arrested; Subhash Chandra Bose forms Indian National Army |
| 1944 | Gandhi-Jinnah Talks break down on Pakistan issue |
| 1945 | First trial of the Indian Army men opened |
| 1946 | Mutiny in Royal Indian Navy; Cabinet Mission's plan announced; |

| | |
|---|---|
| | Muslim League decides to participate in the Interim Government; Interim Government formed; Constituent Assembly's first meeting |
| 3-6-1947 | Announcement of Lord Mountbatten's plan for partition of India |
| 15-8-1947 | Partition of India and Independence |

## Chapter 03 INDUS CIVILIZATION

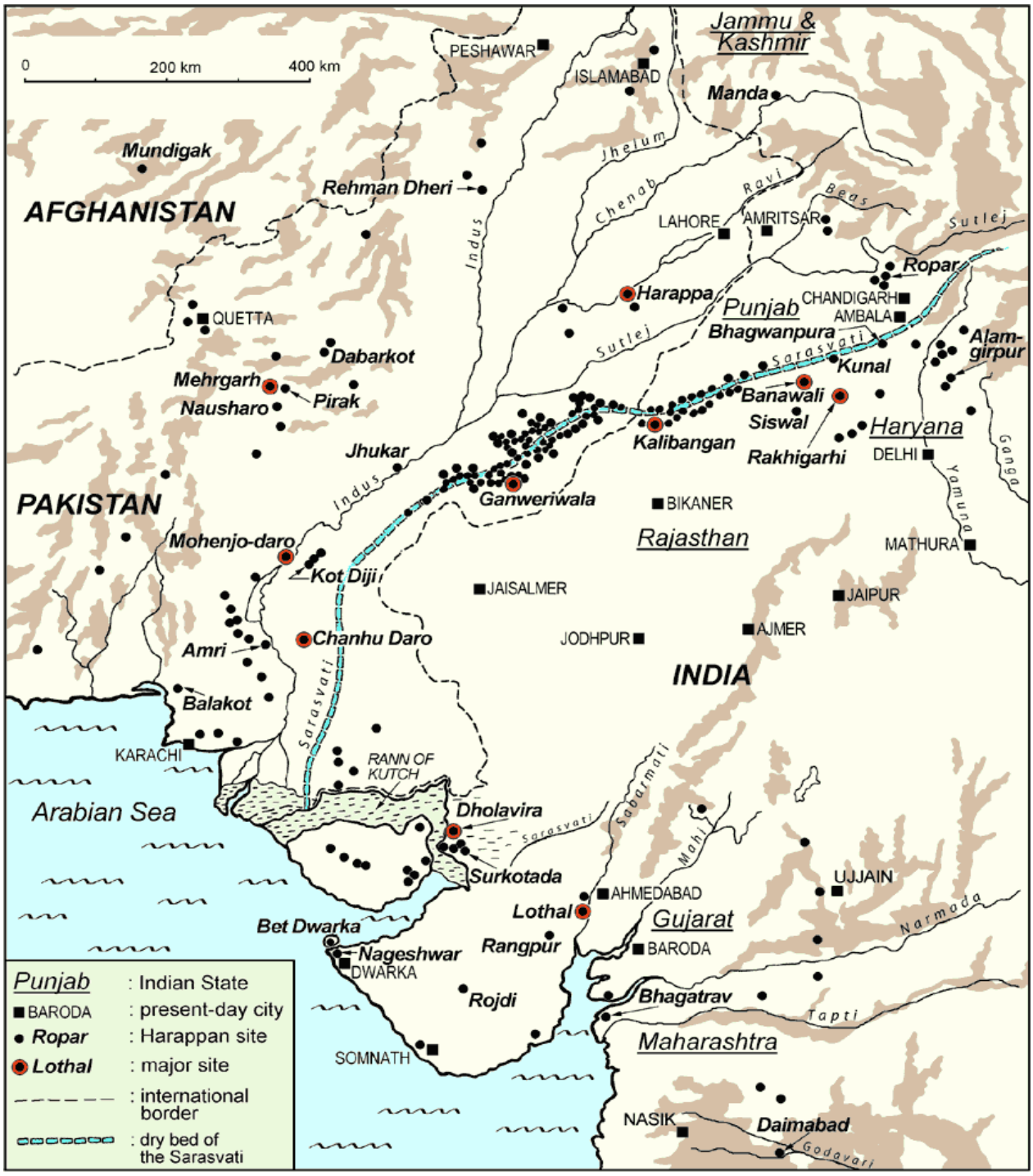
{Indus civilization- Vedic civilization- current debate- civilization in other parts of India- developments in Agriculture}

The great civilizations of the ancient world are Mesopotamia and ancient Egypt; then come, in mixed order, ancient China, Greece, Central and South America, and the Indus Valley civilization, also called the Harappan civilization. Indian civilization, its ancientness and great cultural traditions go back to the dawn of ages. This civilization was thought to have been confined to the valley of the river Indus, hence the name given to it was Indus Valley civilization. This civilization was a highly developed urban one and two of its towns, Mohenjo-daro and Harappa, represent the high watermark of the settlements. Subsequent archaeological excavations established that the contours of this civilization were not restricted to the Indus valley but spread to a wide area in northwestern and western India. Thus this civilization is now better known as the Harappan civilization. Mohenjo-daro and Harappa are now in Pakistan and the principal sites in India include Ropar in Punjab, Lothal in Gujarat and Kalibangan in Rajasthan. Recent research has shown Sutkagen Dor in Baluchistan next to Iran is the westernmost known Harappan site. The Indus Valley Civilization stretched across the whole of Sindh, Baluchistan, Punjab, Northern Rajasthan, Kathiawar and Gujarat. This civilization is one of the three great early civilizations that arose in the late fourth and third millennia BC around the three large alluvial systems of the Tigris-Euphrates, Nile and Indus rivers.

India laid stress on a deep culture without neglected material life. Indian can be pride comparing with Americans or Australians civilization which has taken two centuries old and material achievements.

### Physical Data

The Harappan civilization comprises of more than 1,500 settlements, most of them small villages or towns, with only a few large cities. Some of the “villages” covered more than twenty hectares ; the cities, in comparison, often extended over some eighty hectares — Mohenjo-daro up to 250 hectares. The southern limit was between the Tapti and the Godavari rivers, while the northern limit was some 1,400 kilometres away in Kashmir (at Manda) — though one site, Shortughai, is found still farther up, in Afghanistan ; as of now, the easternmost settlement stands at Alamgirpur in Western Uttar Pradesh, and the western limits were the Arabian sea and the whole Makran coast, almost all the way to the present Pakistan-Iran border. Harappa is a site on the west bank of Ravi; Kalibangan is a site on the right bank of Sutlej; Amri is a site on the west bank of Indus (close to the Arabian sea); Banawali is located 15 km northwest of Fatehbad, near the Sarasvati river and about 120 km east of Kalibangan; Lothal and Rangpur are sites below the Rann of Kutch.




Note: Some of the main sites of the Harappan civilization along the dry bed of the Sarasvati

Indus or 'Sindhu' civilization comprising the settlements, Mohenjo-daro and Harappa, were found along the river, Ravi and its tributary and on the both sides

of the Indo-Pakistan border along the dry bed of a huge river, Sarasvati in the Ghaggar-Hakra valley. The giant sites of Ganweriwala and Lakhmirwala are the known settlements of Kalibangan and Banawali. There are a number of sites in Gujarat, such as Lothal. Satellite photography and recently by radioisotope dating of the water still found under the river's dry bed in the Rajasthan desert. Since the sites found along the Sarasvati far outnumber those in the Indus basin, some scholars have made the point that the Harappan civilization would be better named the '***Indus-Sarasvati civilization***'. The origins of the Indus-Sarasvati civilization are to be found on the subcontinent itself. It no doubt had extensive cultural and commercial contacts with other civilizations, but its identity was distinct.

Sarasvati-Sindhu civilization flourished circa 3000 to 1700 BC on the river valleys of Indus and Sarasvati rivers. The drying-up of the Sarasvati river led to migrations of people eastwards to the Ganga-Yamuna doab and southwards from the Rann of Kutch and Pravara (feeder into the Godavari river near Daimabad in Maharashtra) river valley, along the Arabian sea coast. The old Sarasvati river courses from the Sutlej, flowed through Northern Rajasthan, Bahawalpur and Sind found its way into the Arabian Sea via Rann of Kutch in the third to second millennium BC. Etymologically, sarasvati means `abundance of lakes (saras)'. The synonym of sarasvati (goddess of vak = speech or language) is brahmI which is the name given to the early scripts used in Asoka's epigraphs of circa 300 B.C. Jonathan Mark Kenoyer, a U.S. archaeologist, who has worked on many Indus sites, dated 5000-2600 BC.

**River migrations in Western India**

The dried-up bed of Sarasvati might have constituted the great road between Hastinapur and Dwaraka. Geographically, the sarasvatI basin can be traced to the currently known: ghaggar channels. Ghaggar might have been a stream that rose in the Siwaliks and that joined the sarasvati. This network runs parallel to the Indus across Sind. The river flowed from the Himalayas to the Rann of Kutch.

Geologically, the entire Sarasvati river bed, and the arm of the Arabian sea (formerly spanning into saline Ranns of kutch) into which the river fell are on an earth-quake belt; an earthquake could have upraised this entire river-sea-bed profile, drying up the river. This may explain the formation of the Thar desert on the left banks of the river in earlier earthquakes; also, perhaps of the Thal desert in Pakistan. Did some tracts of the thar desert support cultivation in ancient times? Geological surveys do indicate subsoil water in some tracts. Even today, over 2 million people in Rajasthan live in these tracts! The Sanskrit name is maru-sthalI. cf. Tamil maruta-nilam].

The Indus river has a very wide flood plain on either side of its course up to a maximum width of 100-120 km in the east and south-east. To have such a wide flood plain on only one side shows that the Indus river has preferentially migrated towards the north-west in the northern parts and towards the west in the central

and southern parts. The study of remotely sensed data in the desert tract of Rajastan shows that there are plenty of paleochannels with well sprung-up tentacles throughout the desert. On the northern edge of the Thar-Great Indian desert at the Ganganagar-Anupgarh plains a well-developed set of palaeochannels are clearly discernible in satellite photographs. The Saraswati river once flowed close to the Aravalli hill ranges and met the Arabian sea in the Rann of Kutch, that it has migrated towards the west, the north-west and the north and has ultimately got lost in the Anupgarh plains.

" ... Remote sensing study of the Great Indian Desert reveals that the Saraswati river, which is believed to be lost in the desert, could be traced through these palaeochannels as a migratory river. Its initial course flowed close to the Aravalli ranges and successive six stages took west and northwesterly shifts till it coincides with the dry bed of Ghaggar river. The groundwater, archaeological and pedological data with selected ground truths also corroborate these findings. The migration of river Saraswati seems to be caused by tectonic disturbances in Hardwar-Delhi ridge zone, Luni-Surki lineament, Cambay Graben and Kutch fault facilitated by contrasting climatic variations. The stream piracy by Yamuna river at later stage is responsible for the ultimate loss of water and drying up of the Saraswati river ..."

**Climate change**

The Indus Valley Culture seen in the context of post-glacial climatic and ecological studies in North-West India: suggests that `` ... the significant increase in rainfall at the beginning of the third millennium BC, attested by palaeoecological evidence, played an important part in the sudden expansion of the Neolithic-Chalcolithic cultures in north-west India, ultimately leading to the prosperity of the Indus culture ... The present evidence would suggest that the onset of aridity in the region around 1800 BC probably resulted in the weakening of the Harappan culture in the arid and semi-arid parts of north-west India ... "

**What is the saraswati river civilization?**

After the discovery of the first archaeological site at Harappa in 1920, the civilization was referred to as Harappan culture. With the discovery of another major site at Mohenjo-daro in the same decade, it was re-christened as Indus civilization. Since 1950's a number of new type sites have been located. In particular, the sites of Rupar, Kalibangan, Lothal, Dholavira and Banawali. The characteristic feature of the location of these sites is that these are on the banks of or very close to the `lost' sarasvati river. Hence, the civilization should be re-christened as Indus-Sarasvati civilization. Sarasvati river is extolled in the Rigvedas. Kalibangan and Lothal may not be as grandiose as the urban Harappa but are typical Indus / Sarasvati civilization sites.

**Does the river exist in part and rest of it has disappeared?**

The lost Saraswati river course have established the existence of a river flowing down from the Siwalik ranges and also the changes in the courses of the Indus tributaries and the Yamuna rivers. As Yamuna and Sutlej captured the water sources, Sarasvati might have dried up, aided by the upraisings of land caused by earthquakes. A part of the river exists as Ghaggar in Haryana; the rest of it has disappeared in the fringes of the maru-sthall or the thar desert.

**The Cities**

Harappan cities displayed the most sophisticated town-planning. Geometrically designed, the towns had fortifications (for protection against both intruders and floods), several distinct quarters, assembly halls, and manufacturing units of various types ; some bigger cities had furnaces for the production of copper tools, weapons or ornaments ; public baths (probably often part of temples), private baths for most inhabitants, sewerage through underground drains built with precisely laid bricks, and an efficient water management with numerous reservoirs and wells show that the ordinary inhabitant was well taken care of. Mohenjo-daro, for instance, is thought to have had over 700 wells, some of them fifteen metres deep, built with special trapezoid bricks (to prevent collapse by the pressure of the surrounding soil). The Indian archaeologist, B. B. Lal, writes in a recent comprehensive study of this civilization : *"Well-regulated streets [were] oriented almost invariably along with the cardinal directions, thus forming a grid-iron pattern, even the widths of these streets were in a set ratio, i.e. if the narrowest lane was one unit in width, the other streets were twice, thrice and so on. Such a town-planning was unknown in contemporary West Asia.*

**Agriculture, Technology and Trade in Harappa duringn 1600 BC.**

In the Chalcolithic period, Harappans had reached a high state of culture. They wore cotton garments and used ivory combs and copper mirrors. The women wore ornaments of bronze and gold. They used implements such as sickles, saws, knife blades, spears, axes, arrowheads and daggers made of bronze, and copper fish-hooks. Specialized occupation besides agriculture developed and these articles were produced by skilled craftsman such as coppersmiths, carpenters, jewelers, goldsmiths, stone cutters and potters. Trade with other countries especially with Mesopotamia flourished and some items such as metals timber and precious stones were imported. Harappans cultivated bread wheat, barley, sesame, pea, melon, date palm and Brassica spp. Gossypium arboretum was an important crop, the centre of its origin the Indus Valley. Harappan culture covered a very vast area in north India with very strong settlements at various sites in Jammu and Kashmir, Punjab, Haryana, Rajasthan, Gujarat, Uttar Pradesh and Madhya Pradesh. The rice cultivated in Harappa had long seeded grain and perhaps was the ancestor of the fragrant basmati rice. Wheat and jowar were the other food crops.

**Neolithic (7500-6500 BC) and Chalcolithic (2295-1300 BC)**

The main crops under cultivation were jowar, bajra, and ragi (Eleusine coracana ). Minor millets such as kangni (*Setaia italica*) kndon (*Paspalum milliaceum*) and sannuk (*Enchinochloa frumentocea*) were also cultivated. Others crops were kulthi (Dolichos bifiorus), mung (Vigna radiate), mash (urd; black gram; *Vigna mungo*) masur (*Lens culinaris*), linseed (*Linum usitatissimum*) and castor (*Ricinus communis*), Ber (*Ziziphus nummularia*) and amla (*Emblica offocinalis*) were also grown. Wood of teak (*Tectona grandis*) Acacia sp., Albizia sp, and *Ziziphus mauritiana* were used for making agriculture implements and for timber. The wood of *Zizphus mauritian* was used for marking moosal (mortar).

The plant domestication, diffusion development in ancient India and borderlands was a gradual transition from full time hunting-foraging practices which took place in several geographical regions and chronological settings, viz., the north western sector, Baluchistan, Pakistan and its borderlands with Iran and Afghanistan during Neolithic period between 8000 and 5500 BC. In the early Calcholithic phase (4700-4300 BC) wheat, hulled and naked barley was cultivated. Fruits of jujube, prunus and cotton were added to the plant economy besides dates.Practice of high yielding hexaploid wheat (bread, club and dwarf) and barley (hulled and naked) also continued. Crop remains of wheat (emmer, bread, club and dwarf) and hulled barley in from 3500 to 3200 BC along with apricots. During 3200-2500 BC, barley (6 row hulled, 6 row naked, 6 row shot) lentil, chickpea, flax/linseed, jujube, grape, cotton and dates were grown. Besides rice. indigenous people of India had domesticated several species of minor millets grain legumes oil seed crops fiber crops fruits vegetables and other economic plant species in the Indus –Saraswati Yamuna Ganga valleys. Farmers practiced barely and rice rotation at Atranjikhera (e.g 2000-1500 BC) in association with grass pea and chickpea. Farmers cultivated rice, black gram and gram and green gram in the rainy season and bread and lentil in winter. The people ate, besides cereals, vegetables and fruits, fish, fowl, mutton, beef and pork. Perhaps the most remarkable achievement was the cultivation of cotton. There was an extensive network of canals for irrigation.

The Sumerians developed the plough about 2900 B.C. Possibly, the Harappans learnt the use of the plough from the Sumerians. All primitive ploughs were made of wood, and wood is a perishable material. A terracotta model of a plough, 7 cm x 19.7 cm has been discovered from Mohenjo-daro. This toy plough is kept in the Prince of Wales Museum, Bombay. There is a longish beam and the plough breast terminates in a rectangular manner. There is no indication that it had a handle *(munna)* for the ploughman to hold. The people of Kalibangan had domesticated cattle, and carried on agriculture. To the southeast of the pre-Harappan settlement a ploughed field was discovered. It showed a grid of furrows, with one set more closely spaced (about 30 cm apart) running east-west, and the other widely spaced (about 1.90 metres apart), running north south. This pattern bears a remarkable resemblance to ploughing as is now carried, where mustard and gram are grown in two sets of furrows in the same field.

S.R. Rao in his monograph, *Lothal and the'Indus Civilization,* has reproduced a photograph *of* a seal from Lothal, which he feels depicts a seeddrill. But its shape is rather unusual for a seed-drill. Ox-drawn sledges were still being used about 3000 B.C. at Dr to convey royal corpses to their final resting-place. But long before that date, the sledge had been transformed by an invention that revolutionized locomotion on land. The wheel was the crowning achievement of prehistoric carpentry; it is the pre-condition of modern machinery, and, applied to transport, it converted the sledge into a cart or wagon. Wheeled vehicles are represented in the Sumerian art as early as 3500 B.C., and in northern Syria perhaps even earlier. By 3000 B.C., carts, wagons, and even chariots were in general use in Elam, Mesopotamia and Syria. In the Indus Valley, wheeled carts were in use when the archaeologic record begins about 2300 B.C. and at about the same date in Turkestan too. Children's toys from Mohenjo-daro, Harappa, Lothal and Chandigarh include some wheeled carts, which indicates that they were in use in ordinary t-life (Fig. 81). Bronze models of carts have also been found at Harappa. The people made extensive use of the wooden plough. Kalibangan even yielded a field ploughed with two perpendicular networks of furrows, in which higher crops (such as mustard) were grown in the spaced-out north-south furrows, thus casting shorter shadows, while shorter crops (such as gram) filled the contiguous east-west furrows. This is a technique still used today in the same region. There is also evidence of the domestication of cats, dogs, goats, sheep and perhaps, the elephant.

Indus civilization society capable of town-planning, shipping, refined arts and crafts, writing, sustained trading, necessarily has to master a good deal of technology. *Symbols of Indus religion and culture were incorporated into pottery, ornaments and everyday tools in a way that helped to unite people within the urban centers and link them with distant rural communities.* The cotton textiles, ivory and copper were exported to Mesopotamia, and possibly China and Burma in exchange for silver and other commodities. Production of several metals such as copper, bronze, lead and tin was also undertaken. The Indus people did not know iron. The people were very artistic in the pottery, stone sculpture and seal making. The discovery of kilns to make bricks support the fact that burnt bricks were used extensively in domestic and public buildings. The people had commercial links with Afghanistan, Persia, Egypt, Mesopotamia and the Samaritans. Trade was in the form of 'barter '. There was a cleverly organized system of weights and measures.

**Government and Social Evolution**

The Harappan political organization as an empire, with Mohenjo-daro as the seat of the emperor and a number of “governors” in the regional capitals, others are in favour of regional states. Mohenjo-daro is thought to have sheltered at least 50,000 inhabitants.

**The Aryan Problem**

The relationship of the Indus-Saraswati civilization with the later Indian civilization remains a subject of debate. The ancient dwellers in India were Dravidians, and in fact, their culture had developed a highly sophisticated way of life. The existence of the Brahui tribe in Baluchistan, to the west of the Indus, who speak a Dravidian language like South Indian Tamil, gives evidence that a migration of people or culture did occur. The language of Indus Valley civilization appears to be Dravidian akin to Old Tamil, presently spoken throughout the southern part of the Indian Peninsula. Maru is the Sanskrit name of the desert that lies between the Indus-Sarasvati river valleys of south Asia. It is also called '*thar*' in India and '*thal*' in Pakistan. The habitation 'Maru' land was once marsh, the Indus-Sarasvati river valley inundated area which supported agriculture. Similarly the word 'Maru' as marsh-land, river valley is used as 'marutam' indicating the agricultural tracts in Tamil language. A study of the evolution of scripts in India indicates that the Dravidians, over the centuries, have made the key contributions to the development of language and literature in India.

**The theory of an Aryan invasion or even migration into India is as follows:**

1. The Aryans migrated from their original home in Europe or Central Asia. The Harappan towns were destroyed by semi-barbarian Aryans rushing down on their horse chariots. The Aryans are said to have entered India through the Khyber Pass and invaded or perhaps more peacefully intermingled with the Indus Valley peoples at least since 1600 BCE, and perhaps earlier. The Aryans cross the River Sindhu and settled in a region called Saptsindu, or the land of seven rivers (now known as the Punjab, the land of five rivers). The Aryans were Indo-European warlike herders from Asian steppes. Bronze users and horse handlers, Aryans had a superior military and their cavalry warfare enabled them to spread their culture from the Punjab across northern India, preparing the way for emergence of large empires. The Aryans had a complex cosmology and knowledge of astral sciences--astronomy considered central to Aryan statecraft. Aryans spoke the Sanskrit language (the basis of a majority of Indian languages today), had a polytheist religion (one basis of Hinduism) with a rich pantheon of deities, and a stratified class system: with Kshatriyas (warriors) to rule, and Brahmins (priests and teachers) at the top of the social hierarchy, supported by Vaisyas (farmers) and the Sudras (outcasts). Aryans driven the inhabitants Dravidians of Saptsindu to South India. These ancient dwellers in India were Dravidians, and in fact, their culture had developed a highly sophisticated way of life. The existence of the Brahui tribe in Baluchistan, to the west of the Indus, who speak a Dravidian language like South Indian Tamil, gives evidence that a migration of people or culture did occur. Also the Harappa religion shows many similarities with those elements of Hinduism which are specially popular in the present Dravidian culture.

2. Raymond and Bridget Allchin, archaeologists, now admit that the arrival of Indo-Aryans in Northwest India is "*scarcely attested in the archaeological record,*

*presumably because their material culture and life-style were already virtually indistinguishable from those of the existing population*."

3. British anthropologist, Edmund Leach also termed the Aryan invasion theory as being born out of European racism.

4. Jim Shaffer, 1984 wrote: "*Current archaeological data do not support the existence of an Indo-Aryan or European invasion into South Asia any time in the pre- or protohistoric periods. Instead, it is possible to document archaeologically a series of cultural changes reflecting indigenous cultural developments from prehistoric to historic periods.*"

5. Kenoyer, whom I quoted earlier, concludes in his recent beautiful book : " *Many scholars have tried to correct this absurd theory [of an Aryan invasion], by pointing out misinterpreted basic facts, inappropriate models and an uncritical reading of Vedic texts. However, until recently, these scientific and well-reasoned arguments were unsuccessful in rooting out the misinterpretations entrenched in the popular literature. [...] But there is no archaeological or biological evidence for invasions or mass migrations into the Indus Valley between the end of the Harappan Phase, about 1900 BC and the beginning of the Early Historic period around 600 BC.*"

6. Kenneth A. R. Kennedy, a U.S. expert who has extensively studied such skeletal remains, observes : "*All prehistoric human remains recovered thus far from the Indian subcontinent are phenotypically identifiable as ancient South Asians. [...] In short, there is no evidence of demographic disruptions in the north-western sector of the subcontinent during and immediately after the decline of the Harappan culture*".

7. No invasion or migration caused or followed the collapse of the urban phase of the Indus-Sarasvati civilization around 1900 BC. The Harappans were just Northwestern Indians of the time and continued to live there even after the end of the urban phase (with some of them migrating towards the Ganga plains in search of greener pastures).

8. Dr. B. R. Ambedkar, famous for his work on the Indian Constitution, as well as his campaign in support of the nation's dalit community noticed the racial overtones underlying the theory and described the British espousal of the Aryan Invasion theory in the following words: *"The theory of invasion is an invention. This invention is necessary because of a gratuitous assumption that the Indo-Germanic people are the purest of the modern representation of the original Aryan race. The theory is a perversion of scientific investigation. It is not allowed to evolve out of facts. On the contrary, the theory is preconceived and facts are selected to prove it. It falls to the ground at every point."*

**The Aryans, or Vedic civilization:**

Pre-Vedic Period (Before 3100 B.C.)
Vedic Period (1st Phase 3100 B.C.)
Vedic Period (2nd Phase 2150 B.C.)
Vedic Period (3rd Phase 2150 B.C.-1400 B.C.)
Vedic Jyotish Period (1400 B.C. -1200 B.C.)

The Aryans called themselves the "noble ones" or the "superior ones" to distinguish themselves from the people they conquered. Their name is derived from the Indo-European root word, "ar," meaning "noble." In Sanskrit, they were the "Aryas" ("Aryans"); but that root, "ar," would also serve as the foundation of the name of the conquered Persian territories, "Iran." This concept of nobility, in fact, seems to lie at the heart of Indo-European consciousness, for it appears in another country's name, "Ireland," or "Eire." The Aryans were a tribal and nomadic peoples living in the steppe lands of Euro-Asia. They were a tough people, fierce and war-like. Their culture was oriented around warfare. They were ruled over by a war-chief, or 'raja' (the Latin word "rex" (king) comes from the same root word, along with the English "regal"). They travel on horseback and rushed into battle in chariots. They began to migrate southwards in waves of steady conquest across the face of Persia and the lands of India in 2000 BC.
They swept over Persia with lightening speed, and spread across the northern river plains of India. They penetrated India from the north-west, settling first in the Indus valley and then along the Ganges floodplain. The Aryans, or Vedic civilization (Rigvedic Period -1700-1000 BC) were a new start in Indian culture. These tribes spread quickly over northern India and the Deccan. Rig Veda is believed to represent the Indo-European religion and have many characteristics in common with Persian religion since the two peoples are closely related in time. In this early period, their population was restricted to the Punjab in the northern reaches of the Indus River and the Yamuna River near the Ganges. They maintained the Aryan tribal structure, with a *raja* ruling over the tribal group in tandem with a council. Each *jana* seems to have had a chief priest; the religion was focused almost entirely on a series of sacrifices to the gods. The Rigvedic peoples originally had only two social classes: nobles and commoners. Eventually, they added a third: *Dasas* , or "darks." These were the darker-skinned people they had conquered. The word '*Varna*' is used in the Rig Veda never refer to the *Brahmana* or *Kshatriya*.

By the end of the Rigvedic period, social class had settled into four rigid castes: the '*caturvarnas*', '*Varna*' or "*four colours*." At the top of the *caturvarnas* were the priests, or '*Brahmans*'. Below the priests were the warriors or nobles (*Kshatriya*), the craftspeople and merchants (*Vaishya*), and the servants (*Shudra*), who made up the bulk of society. In the early centuries of '*Later Vedic Period*' or '*Brahmanic Period*' (1000-500 BC), the Aryans migrated across the Doab, which is a large plain which separates the Yamuna River from the Ganges. The Later Vedic Period is the 'Epic Age'; the great literary, heroic epics of Indian culture, the

'*Ramayana*' and the '*Mahabharata*', though they were composed between 500 and 200 BC, were probably originally formulated and told in the Later Vedic Period. The most ancient scared Aryan literature of Hinduism is called the *Vedas*. The *Vedas* consist of four collections called the *Rig-Veda*, the *Sama-Veda*, the *Yajur-Veda*, and the *Atharva-Veda*. Collectively, these are referred to as the Samhitas. The *Rig-Veda* mentioned 'Indra', the god of war and weather, 'Agni', the god of fire. The hierarchy of the gods was from Indra and Varuna to the two current sects of Hinduism which worship Vishnu and Shiva. The best of the Vedic *Shlokas* refer to a common life-spirit that links all living creatures, to human social-interconnectedness, to the notion of unity in diversity and how different sections of society might have different prayers and different wishes. The *Upanishads,* the *Sankhya*, and the *Nyaya-Vaisheshika* schools, the numerous treatises on medicine, ethics, scientific method, logic and mathematics clearly developed on Indian soil as a result of Indian experiences and intellectual efforts. Siddhartha Gautama (c. 563 BC-483 BC) founded the religion which is known as Buddhism. Western scholars frequently list Vardhamana Mahavira (c. 540 BC- 468 BC), as the founder of Jainism.

In 331 BC, Alexander the Great of Macedon began one of the greatest conquests in human history. After conquering Egypt, Persian Empire, Mesopotamians, Gandhara (Afganisthan), he came into contact with cultures to the east, such as Pakistan and India. The plain region of Gandhara lies directly west of the Indus River. When he tried to push on past Pakistan, his army grew tired, and he abandoned the eastward conquest in 327 BC. Alexander had literally no effect on Indian history and he left as soon as he reached the Indus. Two important results arose because of Alexander's conquests: first, from this point onwards Greek and Indian culture would intermix. Secondly, the conquest of Alexander may have set the stage for the first great conqueror of Indian history, Chandragupta Maurya (reigned 321-297 BC), who, shortly after Alexander left, united all the kingdoms of northern India into a single empire. While Chadragupta Maurya built his empire by the force of his arm, Kautilya, a shrewd and calculating Brahman, designed the government. Together they created the first unified state in Indian history.

The Vedic period is a period of cultural mixing of Aryans and indigenous people. Vedic culture was native to the Indian subcontinent. Rig-Veda mentions a few symbols used in later Indian culture, such as the trishul or the swastika, the pipal tree or the endless-knot design, are found in the Indus-Saraswati cities. Kalibangan also shows a ploughed field and fire-altars. The vedic period had weavers; the words sirI and vayitrI denote a female weaver. Gold was highly valued. Rigveda refers to niskagriva which is a golden ornament on the neck and necklaces of gold reaching down to the chest. The vedic people had used ships to cross oceans. The Sarasvati-Sindhu rivers supported the cultivation of wheat and barley. The ploughshare ploughing makes the food and feeds the people. Many vedic people were herdsmen, pastoralists on Sarasvati, the mother of the Sindhu. The river flows copiously and fertilizing, bestowing abundance of food, and nourishing (the people) by their waters.

*(Clockwise from top left :) A terracotta figurine from Harappa, in a yoga posture ; seals depicting a Shiva-like deity, a unicorn, and a bull.*

Rig-Veda praised the hundreds of settlements along the Sarasvati river confirms again the identification between Harappans and Vedic people. The Vedic homeland was the *Saptasindhu*, which is precisely the core of the Harappan territory. As for the Sangam tradition, it is equally silent about any northern origin of the Tamil people ; its only reference is to a now submerged island to the south of India, *Kumari Kandam*, and initial findings at Poompuhar show that, without our having to accept this legend literally, we may indeed find a few submerged cities along Tamil Nadu's coast ; especially at Poompuhar and Kanyakumari, where fishermen have long reported submerged structures.

**Status of Agriculture in the Vedic period (1600 BC -1000 BC)**

The early home of Aryans was in south Russia in the steppes between the Danube the Volga, and the Urals. There was another verse that the homeland of Aryans was Germany. The Aryans left this home-land during 1600 BC, and dispersed east and west in large groups. Early vedic Aryans were primarily pastoral and settled in Indus valley. They cut jungles, built their villages, grazed their cattle in jungles and planted barley in the land close to their habitation. Vedic Aryans were accustomed to cows, horses; buffalo was a new animal which they called gouri or govala which appears to be an extension of the word gau (cow). Indus valley is the land of seven rivers was called 'Saptasindhavah'. The seven rivers included the five rivers of the Punjab (meaning land of five rivers) viz., the Sutudri (Sutlej), the Vipas, (Beas), the Parushini (Ravi) and the Askini (Chenab) and the remaining two includes the Indus and Saraswathi. Aryans began to move in search of water when the river Saraswati dried up. It was king Bhahirath whose efforts brought the Ganga into the plains of India and storage cultures in the Indo-Gangetic plains developed. The Aryans have been identified as nomads they always moved in search of pasture lands for their animals. Their culture has been based on met, camped and departed. This culture is superior than that of the people who were already living for millennia in India and had developed agriculture. Domesticated animals made strong settlements and created a class of artisans and craftsman. One of the strong arguments in the favour of Aryan invasion from the steppes in Russia is the introduction of horse in India by them. When during the Chalcolithic period, trade with Mesopotamia and other cultures was being carried out, the horse could have been brought to India while cotton cloth and other articles were exported. Even during the time of Chandragupta Mayurya, in the bazaars, horses brought by traders from the Middle East were on sale.

**Rigveda:** Rigveda the oldest book which was complied around 3700 BC. At the beginning of the cropping season, the ploughing was done with great fanfare associated with several rituals. There are several hymns address to Shuna, Sita and Shunshira. Sita has been referred to as the goddess of the early and also the share of the plough. Barley (yava), sesame and sugarcane were the main crops. As a husbandman repeatedly ploughs the early for barley; causing the barley to be sown in fields properly by the plough; and the cattle feed upon the barley. Harvesting proceeded with prayers. It was mostly done with a sickle by cutting the crops at the ground level or by cutting the ear heads only.

**Environment** (Rigveda): The sun destroys all non-visible poisonous creatures is a reference to nocturnal poisonous creature such as snakes and scorpions. The sun is the protector, the purifier and the source of prosperity. The water cycle is described as water going up form earth in the summer through evaporation, cloud formation and water coming down again in the from of rain. Loss of surface water in summer must have been easy to observe. There are six seasons in a year; namely Grishma (May –June), Varsha (July-August), Hemant (September-October), Sharad (November-December), Shishir (January-February) and Vasant (March-April). The beginning of the rainy season (obviously in Pakistan North-West India) is

after 21 June when the sun starts 'moving south'. There existed of dams on the seven rives. Constructing dams on rivers must have meant cutting off water to Vedic people to irrigate lands and to provide water to people and animals after the rains the contribution of rivers to increasing the food production.

**Farming resources and practices** (Rigveda): A farmer plows his fields repeatedly. Sun brought six seasons which repeat in a sequence. Bullock cart and chariot were used for crossing Sutlej and Vyas rivers. Tie bullocks to the plow, join yokes, sow the seed, let the food produced be sufficient and let the sickle fall on the ripe crop. Sumps were constructed to provide drinking water for animals, leather ropes and irrigation from never-drying pits. Field operations to raise crops were well-established. Using a plow to cultivate land and raise barley was already an "ancient practice" for the Vedic Aryans. Soils of different kinds and productive and non–productive fields were recognized. Soil preparation was done through repeated plowings. Classification of seasons into six different kinds as is followed even today was done. A bamboo stick of a specific size was used for measuring land. Soaking of soil profile with water was carried out to facilitate plowing and sowing operations. Well water was used for drinking purpos but irrigation from shallow wells was practiced. Reference to irrigation possibly from rivers was found. Bullock power was used for plowing and for pulling bullock carts and chariots to cross rivers such as sutlej and vyas undoubtedly in the postrainy season. Labourers were available for work. Other farm operations included bird scaring, harvesting with sickle, threshing, winnowing with titau (suba), storing gains in storage bins and burning of trash / wastes. Barley was ratooned on residual moisture possibly for fodder after harvest of grain crop. Apart from barley, other cereals were consumed. Barley was roasted obviously to make saktu (sattu or flour from roasted barley grain).

**Forestry** (Rigveda): Trees such as pippala (peepal), khadir, shisham palasa shalmali and urvaruka are mentioned. Pippala is treated as sacred tree. Urvaruka fruits are edible. Khadir and shisham wood used for making chariots are used even today to make furniture. Several grasses are mentioned. Some of which are still used in religious ceremonies and in making rope, mats cottage roofs etc.

**Animal husbandry (Rigveda):** A cow having a copious stream of milk yields it coming into the presence of their calf. Do not kill a cow who is mother of Rudras, daughter or Vasus, sister of Aditya, milk-bearing innocent and without any complex. Various animals referred in Rigveda include cows and horses, sheep and goats, donkey and camel. Two colours of cows are mentioned black and red. Cows with a long nose seem to have been preferred. Camels, donkeys and horses were used for riding and possibly for carrying loads. Stealing cows is referred in Rigveda considering the fact that cattle meant wealth. Cows belonging to enemies were looted. Chickpea was used as a horse feed because even today water-soaked chickpea is considered to be a good feed for horses. Cleaning of horses was obviously preferred. On management of cows, grazing in forests seems to have been common practice. Cows were permitted to graze in barley fields and cattle owners apparently knew the benefits of providing clean safe water from ponds.

Dogs were used for managing herds of cows and for recovering stolen cows. Calling cows for milking with some grass in hand is mentioned boys obviously looked after cows while they grazed. Burning of dried cowdung is practiced as fuel for fire. Killing of cows was clearly discouraged not only because it played an important part in human subsistence, but also for the cow's innocence.

In the later vedic period (1000-600 BC), agriculture implements were improved. Iron plough shares were used.

**End of the Indus civilization:** After 1750 BC, the Mohenjo-daro and Harappan culture slowly declined and gradually faded out. The cause or causes of the end of the Indus civilization are not easy to determine. Some ascribe this to the decreasing fertility of the soil on account of the increasing salinity, caused by the expansion of the neighboring desert. Others attribute it to some kind of depression in the land, which caused floods. At Mohenjo-daro groups of sprawling skeletons in this period suggests some sort of massacre or invasion. The destroyers of the Indus cities were members of the group of tribes whose priests composed the Rig Veda. The Indus Valley culture moved from west to east of Ganga-Jamuna- Doab region, with sites towards central and southern India flourishing after Harappa and Mohenjo-daro had declined. The Ramayan partly unfolded the tale of the Aryan advent into the south. Even though there are various theories for the downfall of this civilization, there is no clear picture as to how or why it came to an end.

## Chapter 4. Status of Farmers in Society- advice by sages to kings on their duties towards farmers

Agriculture and Animal Husbandry began to be developed in India from pre-Vedic times. In *Rigveda,* there was reference to hundreds and thousands of cows; to horses yoked to chariots; to racecourses where chariot races were held; to camels yoked to the chariots; to sheep and goat-offered as sacrificial victims, and to the use of wool for clothing. The famous Cow-Sukta indicates that the cow had already become the very basis of rural economy. In another Sukta, she is deified as the mother of the Vasus, the Rudras and the Adityas, as also the pivot of immortality. The Vedic Aryans appear to have large forests at their disposal for securing timber, and plants and herbs for medicinal purposes appear to have been reared by the physicians of the age, as appears in the *Atharva Veda*. The farmers' vocation was held in high regards though agriculture solely depended upon the favours of Parjanya, the god of rain. His thunders are prescribed as food-bringing. Tree planting and preservation was one of the fundamental articles of Hindu religion, for the Indian culture from its inception grew under the shades of trees

where the Rishis dwelt. Different kinds of trees and their importance in life, for use as well as beauty, were studied with great care. In social rank, the farmers were considered next to Brahmans, and the entire village administration appears to have been in the hands of leading farmers who were known as "**Kutumbin**", from which the word "**Kunbi**" is derived.

Even in the **medieval period** under the Hindu rulers, ample evidence for testifying to the expert skill in raising crops such as wheat, gram, pulses, barley, sugarcane, indigo, cotton, pepper and ginger, and in the rearing of fruits like pineapple, oranges and mangoes. The farmers only paid 1/6th to 1/12th of their agricultural products to the State.

***References in epics**: "Are large and swelling lakes excavated all over the kingdom at proper intervals without agriculture being in thy realm entirely dependent on the showers of heaven?" So says Narada to Yadhisthira in his discourse on administrative principles. Rama's land of Kosala were cultivated under irrigation and not on rainfall.*

***Arthasastra** uses the same epithet to describe the qualities of a good country. The advance made in irrigation may be imagined from the anecdote that when a teacher sent his pupil to stop a breach in the water-course of a certain field, the latter had to lie down to stop the flood and prevent vital injury to the crops. The position is confirmed by a parable the implication of which is that guards were employed at the vital spots of embankments, the rupture whereof would cause a great flood and damage. The King should be vigilant at danger-gates as at the dam of a large water-work.*

Arthasastra significantly recommends upland (sthala) and low-land (kedara) to be entered separately in the field register of the *gopa* and enjoins a three fold gradation of villages after the manner of Gautama and Manu upon the revenue officer (Samahartar ; Sukraniti). This together with a similar reference in Sukraniti, indicates that differential rates for different classes of soils are intended. The Agnipurana again mentioned revenue rates for different kinds of paddy crops. Thus the land assessment varied according to the quality of land and the nature of the crop, the *sadbhaga* was only a traditional or average rate, not the fixed or universal rate, in this respect resembling somewhat the 'tithe' in European fiscal terminology. A careful gradation of land, survey and measurement, calculation of outturn as well as expenses per unit of land was mentioned in Manu, the Arthasastra and the Sumaniti. The king's share did not necessarily mean a fixed share. It was determined by consideration of fertility of the soil and by the needs

of the State or of the cultivator. The system of measurement and survey and differentiation of soil according to productivity also indicates that land revenue assessment was not permanent but revised at intervals although a constant revision was not necessary.

In Buddha's time irrigation contrivances hardly excelled the old Vedic mechanisms; water was drawn by means of the lever, (tulam), the bullock-team.

**Peasant's under Mughal rule:**

The Arabs were also innovators in agriculture. They had improved systems of

irrigation. They wrote scientific treatises on farming. They excelled in

horticulture, knowing how to graft and how to produce new varieties of fruits and

flowers. **Ibn Battuta** (The Traveller of Islam): He traveled over the greater part of

Asia, and visited India in the regime of Muhammad-bin-Thghlak.

**Peasant Economy:** Of the produce of land, a large share went to the State in the form of the land-tax and various perquisites. Of the remainder, a customary share was fixed for various classes of domestic and other laboures. The peasant and his family kept the rest for their own use. A certain proportion went to the share of the priest and the temple. The carpenters, the smiths, the potters, the washer man, the scavengers, etc., were better off as they had to incur no expenditure, e.g on feeding of livestock, and payment in cash and kind to agricultural labourers.

**Trade:** The official weights under the Sultans of Delhi were fixed at an average of 28.78 lb (13.05 kg) to a maund.

**Land revenue cesses and taxes:** The land-tax during Arab rulers was usually rated at two-fifths of the produce of wheat and barley, if the fields were watered by public canals; three-tenths, if irrigated by wheels or other artificial means; and one-fourth, if altogether unirrigated. If arable land was left uncultivated, one-tenth of the probable produce has to be paid. Of dates, grapes and garden produce, one-third was taken, either in kind or money; and one-fifth (khums) of the yield of wines, fishing, pearls, and generally of any product not derived from cultivation, was to be delivered in kind, or paid in value, even before the expenses had been defrayed. The Land-tax was the main source of revenue in Mughal India.

**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.

**Zehir-ud-din Muhammad**, the author of **BABUR-NAMA** –An Autobiography and A Book on Natural History: Babur, the founder of the Mughal dynasty in India, is regarded as one of the most romantic and interesting personally of Asian history. Describing the appearance and dress of the peasants, Babur noted that they were not over-burdened with clothes. 'Their peasants and the lower classes all go about naked'. 'They tie on a thing which they call a langoti, which is a piece of clout that hangs down two spans from the navel, as a cover to their nakedness. Below this pendent modesty-clout is another slip of cloth, one end of which they fasten before to a string that ties on the langoti, and then passing the slip of cloth between the two legs, bring it up and fix it to the string of the langoti behind. The women too, have a lang-one of tit they tie about their waist and the other they throw over their head.

**Protection of cultivators:** Sher Shah (1540-1545 AD.) who came from Afghanistan had genuine concern for the peasantry and safety of their crops. Abbas Khan states, One of the regulations Sher shah made was this: That his victorious standards should cause no injury to the cultivations of the 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. I have heard from Khan-i` Azam Muzaffar Khan, who said he often accompanied Sher Shah, that he used to look out right and left, and if he saw any man injuring a field, he would cut his ears with his neck, would have him to be paraded through the camp. And if farm the narrowness of the road any cultivations was unavoidably destroyed and give compensation in money to the cultivations. If he enters an enemy's country, he did not enslave or plunder the peasantry of that country nor destroy their cultivation. For, said he, the cultivators are blameless, they submit to those in power; and if I oppress them they will abandon their villages, and the country will be ruined and deserted, and it will be a long time before it again becomes prosperous.

The objects of **Akbar`s revenue system** were firstly to obtain a correct measurement of the land. Secondly, the amount of the produce of each bigha of the land was too ascertained and to fix the proportion of that amount that the cultivator should pay to the government. Thirdly, to settle an equivalent for the proportion so fixed, in money. The Land-tax was the main source of revenue in Mughal India.

Status of farmers, however, changed with the establishment of the Turkish rule.' "If an Empire has to stay, farmers should be exploited", said **Allaudin Khilji**, who used to collect half of the earnings of the farmers. Except during the short period under Akbar, who elaborated the land reforms outlined by Sher Shah, exploitation of the farmers became the rule. Naturally, the status of the farmers suffered and his skill came to be restricted to traditional methods.

European traveller, **Peter Mundy** stated that the peasants near Agra were treated 'as Turks treat Christians', 'taking from them all they can get by their labour, leaving them nothing but their bad, mud-walled, ill-thatched houses and a few cattle to till the ground, besides other miseries'. **Pelsaert,** who was in Agra during the rule of Jahangir, observed: 'The land would give a plentiful, or even an extraordinary, yield if the peasants were not so cruelly and pitilessly oppressed; for villages which, owing to some small shortage of produce, are unable to pay the full amount of the revenue-farm, are made prize, so to speak, by their masters or governors, and wives and children sold on the pretext of a charge of rebellion. Peasants abscond to escape their tyranny, and take refuge with rajas who are in rebellion, and consequently the fields lie empty and unsown, and grow into wildernesses. Such oppression is exceedingly prevalent in this country.'. **Bernier**, commenting on the state of the northern part of the country, its agriculture and peasantry, states: 'Of the vast tracts of country constituting the empire of Hindustan, many are little more than sand, or barren mountains, badly cultivated, and thinly peopled; and even a considerable portion of the good land remains untilled from want of labourers, many of whom perish in consequence of the bad treatment they experience from the Governors. These poor people, when incapable of discharging the demands of their rapacious lords, are not only often deprived of the means of subsistence, but are bereft of their children, who are carried away as slaves. Thus it happens that many of the peasantry, driven to despair by so execrable a tyranny, abandon the country and seek a more tolerable mode of existence, either in the towns or camps, as bearers of burdens, carriers of water, or servants to horsemen. Sometimes, they' fly to the territories of a Raja, because there they find less oppression, and are allowed a greater degree of comfort.'(Bernier ).

**Jeane-Baptiste Tavernier**, a French jeweller and merchant, visited India six times, between the years 1638 and 1688. He corroborates the account given by Bernier. He states: 'The peasants have for their sole garment a scrap of cloth to cover those parts which natural modesty requires should be concealed; and that they are reduced to great poverty, because if the Governors become aware that they possess any property they seize it straightaway by right or by force. You may see in India whole provinces like deserts from whence the peasants have fled on account of the oppression of the Governors.'(Tavernier )

The flight of peasants from the land intensified during the reign of Aurangzeb. As the peasants number decreased, the income of the assignees, the *jagirdars,* was reduced. The *jagirdars,* to make good their loss, put increased pressure on the working peasants. Moreover, the practice developed of selling governments of provinces for immense sums in hard cash. Hence, it naturally became the principal object of the individual thus appointed Governor, to obtain repayment of the purchase-money, which he had borrowed at a ruinous rate of interest. This in turn resulted in more repression on the cultivators.

**Status of Farmers in Southern India**

The Indian Council of Agricultural Research published a book entitled 'Sons of the Soil' in 1941 in which status of the farmers of the different States of India .had been discussed. The southern states of India, Andhra Pradesh, Karnataka (Mysore), Tamil Nadu (Madras) and Kerala are separated from the Indo-Gangetic alluvial area of North India by the forest-covered, rocky and comparatively barren and dry forest land, of central India, now called Madhya Pradesh. People from the North, who have not traveled in south India, can have no idea of the beauty of the landscape, the fertility of the soil, and the rich cultural background of the population of South India. Here the ancient Hindu cultural, which has largely disappeared from North India, lies preserved in its pristine beauty. The ancient mountain systems of the Western and Eastern Ghats represent the most ancient mountain system of the world, dating back to the beginning of life itself in the Archazoic period. It lacks the snow peaks and glaciers of the Himalayas. These blue purple hills, studded with rich plantations of tea, coffee and rubber. In the foot hills areca palms are cultivated. As proceed towards the sea coast, coconut plantations, paddy, plantains and sugarcane are being grown. The State of Kerala is known as the '*Land of the Coconut Palm*' while Tamil Nadu can rightly be called the '*Land of Palmyra Palm*'. The Blue hills of the Eastern Ghats provide a heavenly contrast with emerald green of paddy fields, and in between them are rows and rows of Palmyra palms with dark trunks bearing clusters of palmate leaves. The women carried out most of agriculture operations like transplanting of paddy, weeding and hoeing, digging groundnut, or scraping grass, etc. As compared with North India, the villages in South India are comparatively much

more clean. The district of Coimbatore can claim to be one of the most progressive districts in India. The Agricultural College, with its longstanding tradition of good research, has made a contribution to the progressive agriculture of this area. However, the credit mainly goes to the farmers themselves, the Naidus and the Gounders, who are always ready to adopt some useful improvements. Agriculture in this district really represents the triumph of man over adverse circumstances and is hence all the more praise – worthy. They dig tank – like wells, boring through the hard rock to provide irrigation to their fields the siphon system of irrigation with concrete towers for storage of water located in different parts of their of their farms interconnected with under ground cement pipes enables them to irrigate land at different levels. Line sowing is common and application of green manures, tank mud, and fertilizers is very popular. Give a Naidu a barren piece of land, and by careful soil management he will convert. Most of the well-to-do farmers are also industrialists who have set up small spinning mills. They not only invest the savings from industry in agriculture, but also apply techniques of industry in their farms, which are run on commercial lines. Even small farmers have adopted a diversified system of agriculture combining cultivation of plantains, sugarcane and cotton with paddy. Gliricidia and Sesbania are grown as hedge plants in many farms. All operations in the cultivation of paddy can be seen going on at the same time in the same village. While in one field nursery is being raised, in another transplanting is being done, and in yet another harvesting is going on. This is on account of the tropical climate with more or less the same temperature all the year round. The land being usually wet, the roads arc commonly used for' drying paddy and millets. As one travels in the districts of

Madurai and Ramanathapuram one can see paddy drying on the road with a woman keeping a watch. The passing vehicles are usually careful not to trample over the drying grain. Leaving aside the huts of the landless labourers, which are thatched with Palmyra leaves, the houses of the landowners arc pucca, roofed with red tiles, and usually white washed. Near the entrance of the village enormous images of horses are seen. These are the ride of the guardian deity of the village known as Ayanar. Near some of the villages arc sometimes hundreds of baked clay images of horses; these are the offerings of the grateful villagers who have benefited from the grace of Ayanar who has saved the suffering bullock from disease, or a child from a serious malady. Scare-crows with ugly human races are also common in the fields. Apart from saving the crop row herds and jackals, they are also said to be efficacious against the evil eye of jealous neighbors. The most interesting festival in Tamil Nadu is the festival of Pongal, when the farmers wash their cattle and decorate the horns of their bullocks. A crowd of villagers dressed in their best cloths proceeding in groups to the village temples. A distinctive feature of the landscape of Karnataka is of with plantations of coconut and arecanut and numerous irrigation tanks. The evergreen forests of Western Ghats in Karnataka have bamboos and coffee gardens.  While the people of Mohenjodaro print or carve their special breeds on their seals, the people of Karnataka built a gigantic memorial in honor of the Nandi bull, the ride of Shiva. In the famous temple of Halalebid, Krishna is shown playing the flute while a herd of Hallikars breed with elongated pointed horns surround Him spell bound by the music of the flute. Andhra Pradesh is one of the young States of India. The Kammas and Reddys are intelligent farmers who knew the use of fertilizers and line sowing long ago.

Tobacco, chillies, turmeric and groundnut are being cultivated on scientific lines adopting all the improved methods, which the agricultural scientists are advocating. Their soil management is so good that by the application of green manures, organic manures and fertilizers. It is the Naidus and Reddies from Andhra area who migrated in ancient times to Karnataka and parts of Tamil Nadu, and wherever they settled, they raised the level of agriculture. One of their distinctive traits is sincerity and boldness with which they express their views. In fact, their frankness is really refreshing in this age of hypocrisy. The State of Kerala is unique in India in its landscape as well as crops. The homes of the people even in the towns arc surrounded by a patch of land in which coconut palms are grown as well as vegetables for home consumption. The red soil of Kerala and its vast plantation of coconut palms give it a distinctive character. Beautiful temples and neatly built churches studded all over the countryside are a testimony of the culture of the people. Farmers of Punjab are really the best farmers in India and were responsible for developing the colonies in the canal-irrigated areas of West Punjab.

## ADVICE BY SAGES TO KINGS

**What practical argument does Kautilya offer the king for supporting poor farmers?**

Lands may be confiscated from those who do not cultivate them and given to others; or may be cultivated by village labourers and traders, lest those owners who do not properly cultivate the land might pay less (to the government). If cultivators pay their taxes easily, they may be favorably supplied with grains, cattle, and money. The king shall bestow on cultivators only such favor and remission as will tend to swell the treasury, and shall avoid such as deplete it. He shall regard with fatherly kindness those who have passed the period of remission of taxes. He shall offer facilities for cattle breeding and commerce, construct roads for traffic both by land and water, and set up market towns. He shall also

construct reservoirs (sétu) filled with water either perennial or drawn from some other source. Whoever stays away from any kind of cooperative construction (sambhúya setubhandhát) shall send his servants and bullocks to carry on his work, shall have a share in the expenditure, but shall have no claim to the profit. The king shall exercise his right of ownership with regard to fishing in reservoirs or lakes, ferrying and trading in vegetables. He shall protect agriculture from the molestation of oppressive fines, free labour, and taxes; herds of cattle from thieves, tigers, poisonous creatures and cattle-disease. He shall keep the herds of cattle from being destroyed by robbers. The king shall make provision for pasture grounds on uncultivable tracts.

***Advice to the Sage Kadshyapa to the king**: Kashyapa has repeatedly stressed the need for a genuine support to farm activities by the king or ruler concerned. In the modern context, this would mean support from the central and state governments. The ruler's support is required in identifying land for agriculture, building water reservoirs, planting trees on the banks of water reservoirs, constructing canals and wells, water harvesting, making seed available, ensuring sustenance to people giving donation of land and subsidies to weaker people, arranging markets, standardizing weights and measures, afforestation, locating mines producing metals such as iron, copper, and zinc (brass?) gold, and silver and collecting taxes. Kashyapa has thus strongly suggested a very major role for the ruler (governments today) in fully supporting various agricultural activities. He has emphasized that happiness all around can be felt only if there was food security. The king should appoint officers to search and acquire the best land who know the way to scrutinize the (quality of the land). Land selection is based on scientific examination of the soil. It is stated to be the king's duty to get the entire land examined by experts and identify land that is good for agriculture, is suitable for horticulture, should be of constructing permanent water reservoirs. The location could be villages, other parts of the country like towns or cities, mountains or the premises of forts and palaces. So long as good soil and supply of water were assured any location was considered good. Especially in the rainy season, keeping a vigil on hundreds of canals (or trenches), wells, and lakes will be beneficial. King should take care on prevention of diseases and alleviation of danger from fire, guarantees best welfare, all round nourishment, and protection for both the bipeds and the quadrupeds.*

**Terminology in Relation to Agriculture**

**Cultivator:** A person is considered as cultivator if he or she has been engaged in cultivation either as employer, single worker or family worker. A cultivator is different from an agriculture labourer who works on another person's land for wages in cash, kind or share. The cultivativator has no risk in cultivation but merely works on another persons land for wages. An agriculture labourer has no right of lease or contract on land which he/she works.

**Farmer:** Etymologically a farmer is a person who cultivations a farm which is basically pertaining to agriculture. The Ministry of Agriculture and Irrigation,

Government of India, defined marginal, small, semi-medium, medium and large farmers as the households having <1 acre (1 acre =0.4047 ha),1-2 acres, 2-4 acres, 4-10 acres and >10 acres of land respectively (Ministry of Agriculture and Irrigation, Government of India, 1970-71). However in West Bengal, marginal, small, medium and large farmers are considered as those who posses <2.5 acres. 2.5-5 acres: 5-10 acres and >10 acres of land respectably.

**Peasant:** Peasants are rural cultivators. They raise crops and livestock in the countryside, not in greenhouses in the midst of cities.

**Landlord**: Landlords do not physically participate in major agriculture operations but get their land cultivated by landless tenants. Landlords are mostly share-croppers of farm servants. They can be classified as feudal transitional and commercial. The feudal landlords are those who have underutilized bond through the same in not only unnecessary but positively undesirable. The traditional landlords are those who utilize both dependent and free wages labour although are those who free wage labour although they find too advantageous to maintain pre-capitalist labour force.

**Agriculture Labourer:** Basically they own neither land nor farm implements although some may own to a negligible extent. The make a living mainly or wholly by selling their labour in agriculture of allied activities as free or attached or share-cropper for a very low wage in without much security of tenure.

## Chapter 05. KAUTILYA'S ARTHASASTRA

Kautilya's Artha-Sastra (250 BC): Agriculture, Animal husbandry, Commodity trade,

etc,.-features of village

**Background on Arthasastra**: Kautilya's Artha-Sastra (250 BC) is a detailed manual on statecraft and the science of of classical times. Kautilya is also known as '***Chanakya***' and Vishnu gupta. Arthashastra deals with the science of politics, economics and the art of government in its widest sense—the maintenance of law and order as also of an efficient administrative machinery. Artha, literally means 'wealth', is one of four supreme aims prescribed by Hindu tradition. In accordance with this, Kautilya's Arthashastra maintains that the state or government of a country has a vital role to play in maintaining the material status of both the nation and its people.

**Features of villages:** Villages consisting each of not less than a hundred families and of not more than five-hundred families of agricultural people of súdra caste, with boundaries extending as far as a krósa (2250 yds.) or two, and capable of protecting each other shall be formed. Boundaries shall be denoted by a river, a mountain, forests, bulbous plants, caves, artificial buildings, or by trees such as silk cotton tree, Acacia suma, and kshíravriksha (milky trees). There shall be set up a sthániya (a fortress of that name) in the centre of eight-hundred villages, a drónamukha in the centre of four-hundred villages, a khárvátika in the centre of two-hundred villages and sangrahana in the midst of a collection of ten villages.

**Agriculture:** The superintendent of agriculture should possess the knowledge of the science of agriculture. Seeds of grains, flowers, fruits, vegetables, bulbous roots, roots, fibre-producing plants, and cotton may be collected in time. Sow the seeds on lands ploughed often and satisfactorily. Ploughs (karshanayantra) and other necessary instruments or bullocks are made available with the assistance of blacksmiths, carpenters, borers (medaka), ropemakers, as well as those who catch snakes, and similar persons. Any loss due to the above persons shall be punished with a fine equal to the loss.

**Rainfall:** The quantity of rain that falls in the country of jángala is 16 dronas; half as much more in moist countries (***anúpánám***); as to the countries which are fit for agriculture (***désavápánam***);--13½ dronas in the country of asmakas; 23 dronas in avantí; and an immense quantity in western countries (aparántánám), the borders of the Himalayas, and the countries where water channels are made use of in agriculture.

A forecast of such rainfall can be made by observing the position, motion, and pregnancy (garbhádána) of the Jupiter (Brihaspati), the rise and set and motion of the Venus, and the natural or unnatural aspect of the sun. From the sun, the sprouting of the seeds can be inferred; from (the position of) the Jupiter, the formation of grains (stambakarita) can be inferred; and from the movements of the Venus, rainfall can be inferred.

When one-third of the requisite quantity of rain falls both during the commencement and closing months of the rainy season and two-thirds in the middle, then the rainfall is considered as very even.

If rain falls three times free from wind and unmingled with sunshine, ploughing is possible. Hence sow the seeds depending on the rainfall.

**Seasons:** Two months make one ritu (season).

Srávana and Proshthapada make the rainy season (Varshá).

Asvayuja and Kárthíka make the autumn (Sarad).

Márgasírsha and Phausha make the winter (Hemanta).

Mágha and Phalguna make the dewy season (Sisira).

Chaitra and Vaisákha make the spring (Vasanta).

Jyeshthámúlíya and Ashádha make the summer (Grishma).

**Division of land:** Lands on the banks of rivers, etc., are suitable for growing vallíphala (pumpkin, gourd and the like); lands that are frequently overflown by water (paríváhánta) for long pepper, grapes, and sugarcane; the vicinity of wells for vegetables and roots; low grounds (hariníparyantáh) for green crops; and marginal furrows between any two rows of crops are suitable for the plantation of fragrant plants, medicinal herbs, cascus roots and lac. Medicinal herbs suited to grow in marshy grounds can also be grown in pots.

A forest provided with only one entrance rendered inaccessible by the construction of ditches all round, with plantations of delicious fruit trees, bushes, bowers, and thornless trees, with an expansive lake of water full of harmless animals, and with tigers (vyála), beasts of prey (márgáyuka), male and female elephants, young elephants, and bisons—all deprived of their claws and teeth—shall be formed for the king's sports. On the extreme limit of the country or in any other suitable locality, another game-forest with game-beasts; open to all, shall also be made. In view of procuring all kinds of forest-produce described elsewhere, one or several forests shall be specially reserved. Manufactories to prepare commodities from forest produce shall also be set up. Wild tracts shall be separated from timber-forests. In the extreme limit of the country, elephant forests, separated from wild tracts, shall be formed.

**Seeds and sowing:** Sáli (a kind of rice), vríhi (rice), kodo millet (***Paspalum scrobiculatum***), tila (sesamum), common millet (panic seeds), and varaka (***Phaseolus trilobus***) are to be sown at the commencement (púrvávápah) of the rainy season. Blackgram (*Phaseolus mungo*), greengram (*Phaseolus radiatus*), and saibya (?) are to be sown in the middle of the season. Kusumbha (safflower), masúra (Ervum hirsutum), horsegram (Dolichos uniflorus), yava (barley), godhúma (wheat), kaláya (leguminus seeds), linseed, and mustard are to be sown last or seeds may be sown according to the changes of the season.

**Choice of crops:** The farmer shall grow wet crops (kedára), winter-crops (haimana), or summer crops (graishmika) according to the supply of workmen and water. Rice crop is the best to grow); vegetables are of intermediate nature; and sugarcane is the worst and very difficult to grow as it require much care and expenditure.

**Seed treatment:** The seeds of grains are to be exposed to mist and heat for seven nights; the seeds of kosi are treated similarly for three nights; the setts of sugarcane are plastered at the cut end with the mixture of honey, clarified butter, the fat of hogs, and cowdung; the seeds of bulbous roots with honey and clarified butter; cotton seeds with cow-dung; and water pits at the root of trees are to be burnt and manured with the bones and dung of cows on proper occasions. The sprouts of seeds, when grown, are to be manured with a fresh haul of minute fishes and irrigated with the milk of snuhi (***Euphorbia antiquorum***). Where there is the smoke caused by burning the essence of cotton seeds and the slough of a snake, there snakes will not stay. Always while sowing seeds, a handful of seeds bathed in water with a piece of gold shall be sown first and the following mantra recited:--

“Prajápatye Kasyapáya déváya namah.

Sadá Sítá medhyatám dévi bíjéshu cha

dhanéshu cha. Chandaváta hé."

“Salutation to God Prajápati Kasyapa. Agriculture may always flourish and the Goddess (may reside) in seeds and wealth. Channdavata he."

**Harvest:** Grains and other crops shall be collected as often as they are harvested. No wise man shall leave anything in the fields, nor even chaff. Crops, when reaped, shall be heaped up in high piles or in the form of turrets. The piles of crops shall not be kept close, nor shall their tops be small or low. The threshing floors of different fields shall be situated close to each other.

**Post harvest technology:** Clarified butter, oil, serum of flesh, and pith or sap (of plants, etc.)., are termed oils (sneha). Decoction (phánita), jaggory, granulated sugar, and sugar-candy are termed kshára. The honey of the bee as well as the juice extracted from grapes are called madhu. Mixture made by combining any one of the substances, such as the juice of sugar-cane, jaggory, honey,. the, juice of grapes, the essence of the fruits of jambu (Euginia Jambolana) and of jaka tree—with the essence of meshasringa (a kind of plant) and long pepper, with or without the addition of the essence of chirbhita (a kind of gourd), cucumber, sugar-cane, mango-fruit and the fruit of myrobalam, the mixture being prepared so as to last for a month, or six months, or a year, constitute the group of astringents (sukta-varga).

The fruits of those trees which bear acid fruits, those of karamarda (Carissa Carandas), those of vidalámalka (myrobalam), those of matulanga (citron tree), those of kola (small jujuba), those of badara (Flacourtia Cataphracta), those of sauvíra (big jujuba), and those of parushaka (Grewia Asiatica) and the like come under the group of acid fruits. Long pepper, black pepper, ginger, cumin seed, kiratatikta (Agathotes Chirayta), white mustard, coriander, choraka (a plant), damanaka (Artemisia Indica), maruvaka (Vangueria Spinosa), sigru (Hyperanthera

Moringa), and the like together with their roots (kánda) come under the group of pungent substances (tiktavarga). Dried fish, bulbous roots (kándamúla), fruits and vegetables form the group of edibles (sakavarga).

Raw flour and boiled and forced rice will be as much as one and a half of the original quantity of the grains. Barley gruel as well as its flour baked will be twice the original quantity. Kodo millet (*Paspalam scrobiculatum*), varaka (Phaseolus trilobus) and common millet (*Panicum* sp) will increase three times the original quantity when cooked. Vríhi (rice) will increase four times when cooked. Sáli (a kind of rice) will increase five times when cooked. Grains will increase twice the original quantity when moistened; and two and a half times when soaked to sprouting condition. Grains fried will increase by one-fifth the original quantity; leguminous seeds (kaláya), when fried, will increase twice the original; likewise rice when fried.

Oil extracted from atasi (linseed) will be one-sixth (of the quantity of the seed); that extracted from the seeds, nimba (Azadirachta indica), kusámra (?), and Kapittha (Feronia elephantum) will be one-fifth; and that extracted from tila (sesame), kusumba (safflower), madhúka (Bassia latifolia), and ingudi (Terminalia catappa) will be one-fourth. Five palas of kárpása (cotton) and of kshauma (flax) will yield one pala of threads.

**Storehouse:** Grains are heaped up on the floor; jaggary (kshára) is bound round in grass-rope (múta); oils are kept in earthenware or wooden vessels; and salt is heaped up on the surface of the ground. Of the store, thus, collected, half shall be kept in reserve to ward off the calamities of the people and only the other half shall be used. Old collection shall be replaced by new supply.

**Agricultural workers:** Workmen in the fields shall always have water but no fire. Watchmen, slaves and labourers shall be paid a pana-and-a-quarter per mensem in proportion to the amount of work done by them. Artisans shall be provided with wages and provision in proportion to the amount of work done by them.

**Food requirements:** One prastha of rice, pure and unsplit, one-fourth prastha of súpa, and clarified butter or oil equal to one-fourth part of (súpa) will suffice to form one meal of an Arya. One-sixth prastha of súpa for a man; and half the above quantity of oil will form one meal for low castes (avara). The same rations less by one-fourth the above quantities will form one meal for a woman; and half the above rations for children. Bran and flour (kánika) may be given to slaves, labourers, and cooks. The surplus of the above may be given to those who prepare cooked rice, and rice-cakes. For dressing twenty palas of flesh, half a kutumba of oil, one pala of salt, one pala of sugar (kshára), two dharanas of pungent substances (katuka, spices), and half a prastha of curd (will be necessary). For dressing greater quantities of flesh, the same ingredients can be proportionally increased. For cooking sákas (dried fish and vegetables), the above substances are to be added one and a half times as much. For dressing dried fish, the above ingredients are to be added twice as much.

Rice prepared in such a way that five dróna of sáli yield ten ádhakas of rice will be fit to be the food of young elephants; eleven ádhakas from five drónas for elephants of bad temper (vyála); ten ádhakas from the same quantity for elephants trained for riding; nine ádhakas from the same quantity for elephants used in war; eight ádhakas from the same for infantry; eleven ádhakas from the same for chiefs of the army; six ádhakas from the same for queens and princes and five ádhakas from the same quantity for kings.

**Taxation:** Fields that are left unsown (vápátiriktam, i.e., owing to the inadequacy of hands) may be brought under cultivation by employing those who cultivate for half the share in the produce (ardhasítiká); or those who live by their own physical exertion may cultivate such fields for ¼th or 1/5th of the produce grown; or they may pay (to the king) as much as they can without entailing any hardship upon themselves, with the exception of their own private lands that are difficult to cultivate. Those who cultivate irrigating by manual labour shall pay 1/5th of the produce as water-rate; by carrying water on shoulders ¼th of the produce; by water-lifts, ⅓rd of the produce; and by raising water from rivers, lakes, tanks, and wells,⅓rd or ¼th of the produce.

**Commodity trade:** The Superintendent of Commerce shall ascertain demand or absence of demand for, and rise or fall in the price of, various kinds of merchandise which may be the products either of land or of water and which may have been brought in either by land or by water path. He shall also ascertain the time suitable for their distribution, centralisation, purchase, and sale. Sale proceeds of grains, grains purchased and the collection of interest in kind or grain debts are termed commerce. Profitable exchange of grains for grains is termed barter (parivarthana). Grains borrowed with promise to repay the same is termed ápamityaka. Pounding (rice, etc.), dividing (pulses, etc.), frying (corns and beans), manufacture of beverages (suktakarma), manufacture of flour by employing those persons who live upon such works, extracting oil by employing shepherds and oil-makers, and manufacture of sugar from the juice of sugar-cane are termed simhanika.

The superintendent shall also personally supervise the increase or diminution sustained in grains when they are pounded (kshunna), or frayed (ghrishta), or reduced to flour (pishta), or fried (bhrashta), or dried after soaking in water.

**Forest produce:** The Superintendent of Forest Produce shall collect timber and other products of forests by employing those who guard productive forests. He shall not only start productive works in forests, but also fix adequate fines and compensations to be levied from those who cause any damage to productive forests except in calamities.

**Animal Husbandry**

A herd of 100 heads of asses and mules shall contain 5 male animals; that of goats and sheep ten; and a herd of ten heads of either cows or buffaloes shall contain

four male animals. Herds are maintained for wages, a fixed amount of dairy produce, 1/10th of the dairy produce, etc. 'Class of herds'- cattle is classified as calves, steers, tameable ones, draught oxen, bulls that are to be trained to yoke, bulls kept for crossing cows, cattle that are fit only for the supply of flesh, buffaloes and draught buffaloes; female calves, female steer, heifer, pregnant cows, milch cattle, barren cattle---either cows or buffaloes. Cowherds shall apply remedies to calves or aged cows or cows suffering from diseases. Cows and cattle shall graze the herds in forests which are severally allotted as pasture grounds for various. Cowherds shall allow their cattle to enter into such rivers or lakes as are of equal depth. The cowherds may sell either fresh flesh or dried flesh.

The cowherds shall milk the cows both the times (morning and evening) during the rainy, autumnal, and the first part of winter (hemanta) seasons and only once (i.e., only in the morning during the latter part of winter and the whole of the spring and summer seasons. The cowherd who milks a cow a second time during these seasons shall have his thumb cut off. If he allows the time of milking to lapse, he shall forfeit the profit thereof (i.e., the milk).

The cowherds shall give buttermilk as drink to dogs and hogs, and reserve a little (buttermilk) in a bronze vessel to prepare their own dish: they may also make use of coagulated milk or cheese (kíláta) to render their oilcakes relishing (ghánapinyáka-kledartha). He who sells his cow (from among the herds) shall pay (to the king) ¼th rúpa (value of the cow).

One drona of a cow's milk will, when churned, yield one prastha of butter; the same quantity of a buffalo's milk will yield 1/7th prastha more; and the same quantity of milk of goats and sheep will produce ½ prastha more.

According to the protective strength of the cowherds the capacity of the cattle to go far and wide to graze, cowherds shall take their cattle either far or near. Once in six months, sheep and other animals shall be shorn of their wool.

**Rations for Livestocks**

For bullocks, one drona of greengram (*Phaseolus radiatus*) or one drona of barley cooked with other things, as prescribed for horses, is the requisite quantity of food, besides the special and additional provision of one tula of oilcakes or ten ádhakas of bran; twice the above quantity for buffaloes; Half an ádhaka or one ádhaka of grain together with bran for a goat, a ram and a boar; one prastha of cooked rice for dogs; Half a prastha for a hamsa (goose), a krauncha (heron) and a peacock.

For bulls which are provided with nose-rings, and which equal horses in speed and in carrying loads, half a bhára of meadow grass (yavasa), twice the above quantity of ordinary grass (trina), one tulá (100 palas) of oil cakes, 10 ádhakas of bran, 5 palas of salt (mukhalavanam), one kudumba of oil for rubbing over the nose (nasya), 1 prastha of drink (pána), one tulá of flesh, 1 ádhaka of curis, 1 drona of

barley or of cooked másha (Phraseolus Radiatus), 1 drona of milk; or half an ádhaka of surá (liquor), 1 prastha of oil or ghi (sneha) 10 palas of sugar or jaggery, 1 pala of the fruit of sringibera (ginger) may be substituted for milk (pratipána).

**Remedies against National calamities:**

The king shall always protect the afflicted among his people as a father his sons from eight kinds of calamities viz., fire, floods, pestilential diseases, famine, rats, tigers, serpents, and demons.

**Fire:** King and superintendents of villages shall protect from fire on ordinary days, but also on full-moon days.

**Floods:** Villagers living on the banks of rivers shall be provided protection from floods during the rainy reason. They shall provide themselves with wooden planks, bamboos, and boats. On new and full-moon days shall rivers be worshipped. Experts in sacred magic and mysticism and persons learned in the Vedas, shall perform, incantations against rain. During drought shall Indra (sachínátha), the Ganges, mountains, and Mahákachchha be worshipped.

**Pestilences:** Protection against epidemics with auspicious and purificatory ceremonials, milking the cows on cremation or burial grounds, burning the trunk of a corpse, and spending nights in devotion to gods, worship of family-gods shall also be observed.

**Famines:** The king shall show favour to his people by providing them with seeds and provision during famine or the king with his subjects may emigrate to another kingdom with abundant harvest. He may cause his subjects to grow grains, vegetables, roots, and fruits wherever water is available.

**Rats:** Cats and mongooses may be let loose to control rats. On new and full-moon days rats may be worshipped.

**Snakes:** Auspicious rites may perform from Atharvaveda. On new and full moon days, (snakes) may be worshipped.

**Tigers:** Catch tigers by entrapping them in nets The juice of madana and kodrava plants may be thrown in tiger living places to destroy tigers. On new and full moon days mountains may be worshipped.

**Demons:** Ceremonials shall be performed with the rituals of the Atharvaveda to ward off the danger from demons. Such ascetics as are experts in magical arts, and being endowed with supernatural powers, can ward off providential visitations, shall, therefore, be honoured by the king and made to live in his kingdom.

**Weights and measures**

10 seeds of másha (*Phaseolus radiatus*) or

5 seeds gunja (*Cabrus precatorius*) = 1 suvarna-másha.

16 máshas = 1 suvarna or karsha.

4 karshas = 1 pala.

88 white mustard seeds = 1 silver-másha.

16 silver mashas or 20 saibya seeds = 1 dharana.

20 grains of rice = 1 dharana of a diamond.

20 tulas == 1 bhára.

10 dharanas == 1 pala.

100 such palas == 1 áyamání (measure of royal income).

Public balance (vyávahárikā), servants' balance (bhájiní), and harem balance (antahpurabhájiní) successively decrease by five palas (compared with áyamáni).

Twenty-five palas of firewood will cook one prastha of rice. This is the unit (for the calculation) of any greater or less quantity (of firewood).

Thus weighing balance and weights are commented upon.

Then, 200 palas in the grains of másha 1 drona which is an áyamána, a measure of royal income.

187½ palas, 1 public drona.

175 palas, 1 bhájaníya, servants' measure

162½ palas, 1 antahpurabhájaníya, harem measure.

Adhaka, prastha, and kudumba, are each ¼ of the one previously mentioned.

16 dronas == 1 várí.

20 dronas, == 1 kumbha.

10 kumbhas == 1 vaha.

Cubic measures shall be so made of dry and strong wood that when filled with grains, the conically heaped-up portion of the grains standing on the mouth of the

measure is equal to ¼th of the quantity of the grains (so measured); or the measures may also be so made that a quantity equal to the heaped-up portion can be contained within (the measure).

But liquids shall always be measured level to the mouth of the measure.

With regard to wine, flowers, fruits, bran, charcoal and slaked lime, twice the quantity of the heaped-up portion (i.e., ¼th of the measure) shall be given in excess.

1¼ panas is the price of a drona.

¾ pana ,, an ádhaka.

6 máshas ,, a prastha.

1 másha ,, a kudumba.

The price of similar liquid-measures is double the above.

20 panas is the price of a set of counter-weights.

6⅔ panas ,, of a tulá (balance).

84 kudumbas of clarified butter are held to be equal to a wáraka of the same;

64 kudumbas of clarified butter are held to be equal to make one wáraka of oil (taila); and ¼ of a wáraka is called ghatika, either of ghi or of oil.

**SPACE AND TIME MEASUREMENT**

**Linear and square measurements were made with the following units:**

8 atoms (paramánavah) are equal to 1 particle thrown off by the wheel of a chariot.

8 particles are equal to 1 likshá.

8 likshás are equal to the middle of a yúka (louse) or a yúka of medium size.

8 yúkas are equal to 1 yava (barley) of middle size.

8 yavas are equal to 1 angula (¾ of an English inch) or the middlemost joint of the middle finger of a man of medium size may be taken to be equal to an angula.

4 angulas are equal to 1 dhanurgraha.

8 angulas are equal to 1 dhanurmushti.

12 angulas are equal to 1 vitasti, or 1 chháyápaurusha.

14 angulas are equal to 1 sama, sala, pariraya, or pada.

2 vitastis are equal to 1 aratni or 1 prájápatya hasta

2 vitastis plus 1 dhanurgraha are equal to 1 hasta used in measuring balances and cubic measures, and pasture lands.

2 vitastis plus 1 dhanurmusti 1 kishku or 1 kamsa.

42 angulas are equal to 1 kishku according to sawyers and blacksmiths and used in measuring the grounds for the encampment of the army, for forts and palaces.

54 angulas are equal to 1 hasta used in measuring timber forests.

84 angulas are equal to 1 vyáma, used in measuring ropes and the depth of digging, in terms of a man's height.

4 aratnis are equal to 1 danda, 1 dhanus, 1 nálika and 1 paurusha.

108 angulas are equal to 1 garhapatya dhanus (i.e., a measure used by carpenters called grihapati). This measure is used in measuring roads and fort-walls.

The same (108 angulas) are equal to 1 paurusha, a measure used in building sacrificial altars.

6 kamsas or 192 angulas are equal to 1 danda, used in measuring such lands as are gifted to Bráhmans.

10 dandas are equal to 1 rajju.

2 rajjus are equal to 1 paridesa (square measure).

3 rajjus are equal to 1 nivartana (square measure).

The same (3 rajjus) plus 2 dandas on one side only are equal to 1 báhu (arm).

1000 dhanus are equal to 1 goruta (sound of a cow). 4 gorutas are equal to 1 yojana.

**Measurements with time**

(The divisions of time are) a truti, lava, nimesha, káshthá, kalá, náliká, muhúrta, forenoon, afternoon, day, night, paksha, month, ritu (season), ayana (solstice); samvatsara (year), and yuga.

2 trutis are equal to 1 lava.

2 lavas are equal to 1 nimesha.

5 nimeshas are equal to 1 káshthá.

30 káshthás are equal to 1 kalá.

40 kalás are equal to 1 náliká, or the time during which one ádhaka of water passes out of a pot through an aperture of the same diameter as that of a wire of 4 angulas in length and made of 4 máshas of gold.

2 nálikas are equal to 1 muhúrta.

15 muhúrtas are equal to 1 day or 1 night.

Such a day and night happen in the months of Chaitra and Asvayuja. Then after the period of six months it increases or diminishes by three muhúrtas.

When the length of shadow is eight paurushas (96 angulas), it is 1/18th part of the day.

When it is 6 paurushas (72 angulas), it is 1/14th part of the day; when 4 paurushas, 1/8th part; when 2 paurushas, 1/6th part; when 1 paurusha, ¼th part; when it is 8 angulas, 3/10th part (trayodasabhágah); when 4 angulas, 3/8th part; and when no shadow is cast, it is to be considered midday.

Likewise when the day declines, the same process in reverse order shall be observed.

It is in the month of Ashádha that no shadow is cast in midday. After Ashádha, during the six months from Srávana upwards, the length of shadow successively increases by two angulas and during the next six months from Mágha upwards, it successively decreases by two angulas.

Fifteen days and nights together make up one paksha. That paksha during which the moon waxes is white (sukla) and that paksha during which the moon wanes is bahula.

Two pakshas make one month (mása). Thirty days and nights together make one work-a-month (prakarmamásah). The same (30 days and nights) with an additional half a day makes one solar month (saura).

The same (30) less by half a day makes one lunar month (chandramása).

Twenty-seven (days and nights) make a sidereal month (nakshatramása).

Once in thirty-two months there comes one malamása profane month, i.e., an extra month added to lunar year to harmonise it with the solar.

Once in thirty-five months there comes a malamása for Asvaváhas.

Once in forty months there comes a malamása for hastiváhas.

Two months make one ritu (season).

Srávana and proshthapada make the rainy season (varshá).

Asvayuja and Kárthíka make the autumn (sarad).

Márgasírsha and Phausha make the winter (hemanta).

Mágha and Phalguna make the dewy season (sisira).

Chaitra and Vaisákha make the spring (vasanta).

Jyeshthámúlíya and Ashádha make the summer (grishma).

Seasons from sisira and upwards are the summer-solstice (uttaráyana), and (those) from varshá and upwards are the winter solstice (dakshináyana). Two solstices (ayanas) make one year (samvatsara). Five years make one yuga. The sun carries off (harati) 1/60th of a whole day every day and thus makes one complete day in every two months (ritau). Likewise the moon (falls behind by 1/60th of a whole day every day and falls behind one day in every two months). Thus in the middle of every third year, they (the sun and the moon) make one adhimása, additional month, first in the summer season and second at the end of five years.

## Chapter 06 AGRICULTURE AND SANGAM LITERATURE OF TAMIL

### SANGAM AND ITS HISTORY

'Sangam' is a Sanskrit word which means as 'association'
'Sangam poets' is an association of poets

Tamil Sangam was a body of Tamil Scholars or poets, a literary academy which was established by the Pandia Kings
Sangam was known as ‘Avaiyam’, Kudal or its variant ‘Kuttu’ before 700 A.D.
In Purananuru the expression of ‘Kudal’ was used
Kudal was also used to indicate the Madurai city
Thirunavukarasar (Appar) in his ‘Tewaram’ had used the word, ‘Sangam’ while Thiruzhanasambandar used the word ‘Togai’ means a collection
This showed that the institution was known as ‘Kudal’ or ‘Togai’ during Sangam period itself
Literature / poems is said to have been compared by the members of that body of poets

A system of literary censorship was exercised in Tamil language during early days of their literary history, which is known as ‘Avaiyam’ and not ‘Sangam’.

There were three Tamil Sangam constituted one after another and were called

- ✓ First Sangam or Thalai Sangam;
- ✓ Middle Sangam or Idai Sangam and
- ✓ Last Sangam or Kadai Sangam.

These periods was comprised of about 1000 years from 500 B.C to 500 A.D. as the extreme limits.

Dravida Sangam in Madurai around fourth and fifth century was not a Tamil Sangam.

**Tamil Literature - A Bird's View**

The Sangam literature provides very valuable information on the social, economic and political life of the people living in deltaic Tamil Nadu. Sanga kaalam is considered to be the Golden Age of Tamil Literature. The Ancient Sangam Age around 1000 B.C to 200 B.C was considered as the era of Tholkappiar. Tholkappiam is the oldest Tamil book. 'Tolkappiyar' whose age is generally placed in the 5th century B.C. gives us a lot of information for tracing the heritage of the Tamils. The land was treated as five regions viz. mountains, forests, fields, coasts and deserts and the theme of love in five aspects viz. union, patience, sulking, wailing and separation. The poet dealing with a certain aspect of love restricted himself to a particular region, season, hour, flora and fauna. These literary conventions are explained in Tolkappiyam. The third Sangam period, the most notable is Tiruvalluvar's Tirukkural or Kural, which deals with philosophy and wise maxims. It is the *second* great work with 1330 couplets (133 topics each having 10 couplets). It has been translated into English and several other languages.

The Late Sangam Age around 200 B.C to 200 A.D. is considered as an era of Thiruvalluvar. The *third* outstanding work in old Tamil is Silappathikaram around 200 A.D as the era of Ilango. During the middle Sangam, the Pandia kings had the capital in Thenmadurai on the shores of the Indian ocean, which was later, destroyed by sea deluge. Then the capital and Sangam were shifted to Kapatapuram on the east coast. The sea too engulfed Kapatapuram. Then the capital and Sangam was shifted to the Madurai, an inland city. Thus the present Madurai on the bank of river Vaigai became the third capital and the seat of Third Sangam of poets. There were references in Silapathigaram and in Kalithogai.

The Dark Age or the Kalabhra Interoregnum period witnesses the growth of Buddhism and Jainism in the now shrinked Tamil country. The Kalabhra, of the Kannada soil, invasion during 250 A.D. alters the shape of Tamil literature and Tamil way of life. The post-Sangam period (200-600 AD) is notable for the composition of five great Tamil epics -- Silappadikaram, Manimekalai, Jivaka-cintamani, Valaiyapati and Kundalakesi.

In 400 A.D., Ten Idylls (Pattuppattu) and the Eight Anthologies (Ettuttohai) are classified into Akam or esoteric dealing with love and Puram or exoteric dealing with war. The literature of the third Sangam period mainly comprises of poems which are arranged in eight anthologies called Ettuttokoi and ten idylls called Pattuppattu. Ettuttokoi consists of Narrinai, Kuruntogai, Ainkurunuru, Padirruppattu, Paripadal, Kalittogai, Ahanuru and Purananuru. Pattuppattu consists of Tirumurugarruppadai, Porunararruppadai, Cirupanarruppadai, Pattinappalai, Kurincippattu, Nedunalvadai, Maduraikkanci, Malaipadukadam, Mullaippattu and Perumpanarruppadai.

Bakthi or The Pallava Period: The suppression of the alien Kalabhra clan by Pandiyan Kadumkon by the end of the 6th century had helped a revival of the ancient orthodox religions of the land. Besides these, the Jain authors have produced five minor works -- Yasodhara-kaviyam, Chulamani, Perunkathai, Nagakumara-kaviyamand, Nilakesi. Besides these, the Jain authors have produced five minor works -- Yasodhara-kaviyam, Chulamani, Perunkathai, Nagakumara-kaviyam and Nilakesi. The Chola Period or the Epic period: Kamba Ramayana in the 9th century A.D. Kamban, belonged to this period. He was the greatest of the court poets of Kulottunga Chola III (1178-1218 AD). He adapted Valmiki's Ramayana in Tamil in his Ramakatai or Kamba Ramayanam, Another noble off spring of this period is Periapuranam.

**The age of Tamilised Epic**: Between 600-900 AD, the Tamil literature came under the influence of Saiva and Vaisnava saints called Nayanmars and Alvars respectively. The Saiva saints first compiled their hymns into the Devaram. The hymns of the Saiva saints were later collected into twelve anthologies called Tirumurais. The Periya Puranam or Tiruttondar Puranam, considered as the twelfth Tirumurai, was composed by Sekkizhar (12th century AD). The Vaishnavaite saint

Nathamuni (824-924 AD) compiled the Vaishnava hymns into four books called Divya Prabandham or Nalayira Divya Prabandham. The other Alvar saints who contributed to the Tamil religious literature include Periyalivar, Poigaialvar, Bhutattalvar, Andal (the only woman saint among Alvars) and Nammalvar. Nammalvar's Tiruvaymozhi, the third book of Divya Prabandham, is said to be a quintessence of the Upanishads.

**Modern Literature**: The modern period witnessed the impact of Islam and Christianity on Tamil literature. Mohammedians rule during the 13th and 14th century. Umaruppulavar (1605-1703 AD) was the earliest among the Muslim Tamil poets. He composed the Sirappuranam, which is a verse narrative on the life of Prophet Muhammad. Another work dealing with the Islamic faith was Muhaidin Puranam (1845 AD) by Mohammad Ibrahim. Constanzio Beschi (1680-1747 AD), who adopted the pseudonym of 'Viramamunivar', wrote a classic Tembavani, on the life of Jesus Christ. Paramartta Gurukathai written by Viramamunivar in the 18th century affords the earliest specimen in novel writing in Tamil. Subramanya Bharati (1882-1921 AD) was one of the greatest of Tamil litterateurs of the modern times. He is renowned for his patriotic and devotional songs and intense prose writings on contemporary social affairs. His 'Panchali Sabadam' is an epic poem based on a single episode of the Mahabharata.

***Agriculture**: Agriculture was the Principal occupation of Tamils. The Agriculturalists were called ' Ulavar' and their women the 'Ulattiyar' (Tolporul, 20). The classes of people owning land and the class of people actually tilling the land were 'Velalas' the farmer known as the superior 'Vellalas' and the latter known on inferior 'Vellalas. Ulavar was also known as Valnar. Ulutunbar or Yerin. Purananuru calls Ulavar as Kalamar. The term Ulavar itself indicates the use of the plough and the term Vellalar denotes the propertiership of the soil. The cowherd community counted the cattle as wealth while among agriculturalists the number of plough was the standard of measurement of wealth. A poet in Karuntogai speaks of 'Orerulavar' a peasant with one ploughshare. Thiruvalluvar had highlighted the importance of Agriculture in Chapter- 104, Thirukural. Agriculture is considered as an esteemed profession (Kural, Chap 104). Valluvar had described the desirable feature of a territory or country. A country should have good agriculturalists and learned and wealthy men. It must be free from hunger, disease, and enmity. A country should not be under the influence of famine. In whatever occupation others might be engaged they might engaged, they must all depend finally on the farmer (Kural, 1031), even the ascetics will become helpless if presents do not till the lands Kural, 1036). Agriculture is not as*

*dignified as other professions; on the other hand, the agriculturalists are positively the support of whole world (Kural, 1032). Agriculturalists alone lead a truly useful life, the rest being only parasites and sycophants (Kural, 1033). According to Thiruvalluvar an agriculturalist must: i) plough the land; ii) manure it; iii) transplant the seedlings; iv) ensure an unfailing supply of channel water and vi) protect the cultivated farm from the stray cattle (Kural, 1038). He warns the farmer against lethargy, he lids him be active and never despond (Kural, 1040). The farmer is to guard against absentee-landlordism (Kural, 1039).*

**Farmers, the founders of civilization:** Thiruvalluvar had high lightened the agriculture profession in chapter 104 as follows: Behind the plough in the whole world and is the prime of all professions (Kural 1031). Tillers of the soil are the axle-pin of the revolving world because they sustain all others who have the plough and take to other occupations (Kural, 1032). Farmers only live by right that till the soil and raise their own food, rest are parasites, who live upon them (Kural, 1033). The state of green fields, waving in fullness with sheaves of corn, will surely bring many countries around them under the influence (Kural, 1034). Trade increases the wealth and glory of a country; but its real strength and stamina are to be looked for among the cultivators of the land. The farmers, who eat only the fruits of their own toil, will never beg, nor will they deny alms to a mendicant at their door (Kural, 1035). If the tillers of the soil withdraw their labour, even those who have renounced the world will lose their serenity and concentration of sprit (Kural, 1036). If the tillers of the soil withdraw their labour, the householders support to the ascetics will naturally be affected and loose their concentration (Kural, 42). If the ploughed soil is left to dry to a fourth of its bulk, there will be plenteous crop, without even a handful of manure being put in (Kural, 1037). Valluvar considers the preparation of the soil as the first and for the most step while effective aeration and purposeful nitrogenisation are incidental to it. Manuring is more important than ploughing, then, after proper weeding; plant protection is more important than water management. (Kural 1038). If the husband-man does not pay personal attention to his land like the neglected wife that field will turn it face away in loving anger. (Kural, 1039). The good earth will laugh derisively at those, who pleading poverty, sit idle and neglect their productive land.

**Climate:** Rain is respected as the axil for the world and basic need of the people (Nartrinai, 139). World cannot exist in absence of the water (Natrinai 1: 6). Rain bearing clouds under shrouding darkness with lightning gives cool showers, the clouds that of a beating drum with short thick sticks and thunder again and again gives heavy rains (Kurunthogai 270). Thiruvalluvar had stressed the need and importance of rain not only for agriculture but to the wealth and spiritual life of people in Chapter III of Thirukural. Valluvar praised the rain as follows: As the

falling rain sustains the world, it must be deemed as the Amuta (the drink of immortal Gods) or the nectar of life (Kural, 11). From food come fourth begins, from rain food is produced. All food is produced because of rain, which itself is food again (Kural, 12). If rain fail, hunger will cause infinite misery to the world, even though it is surrounded by the wide oceans (Kural, 13). If there is diminution in the bounty of rain, the ploughmen will be forced into idleness (Kural, 14). Want of rain, spell ruin the prosperity, sufficiency of rain in farm, will lead to renewed prosperity. Even excess rain and cyclonic flood sometimes bring disaster (Kural, 15). If the clouds do not shed drops of rain, even blades of grass cannot shoot up (Kural, 16). If the clouds produced by the sea fail in their bounty, even the wealth of the seas will shrink (Kural, 17). The pearl formation would suffer due to the failure of rain in summer season. If rain failure occurs in October-November, coral conception would be affected. If rain fails, there will be neither festivals nor rituals for the Gods themselves (Kural, 18). If heavens will not give up of their bounty to give rain to this world, Alms to the needy and penance for the spiritual uplift cannot be sustained (Kural, 19). Even as life on earth cannot sustain without water, Virtue too depends ultimately on rain (Kural, 20).

***Seasons**: Seasons were broadly classified into Ilavenil –(Chitrai – Vaigasi); Mudhuvenil – (Aani-Adi); Karkalam - (Avani-Puratassi); Kuuthgirkalam – (Ipachi-Karthigai); Munpanikalam - (Marghali-Thai) and Pinpanikalam - (Masi-Panguni). Vengai flowers bloom with loosened petals and the fallen petals beautify the river bed's black sand locks in the spring (Early summer) season (Kalithogai, 32). The agriculture of the delta fell into two divisions: a double crop and a single crop economy. The former consisted of growing a short crop of rice first, and a longer duration crop afterwards. The rice growing seasons of Tamil Nadu varies from region to region. The short crop in turn, consisted of two varieties-a four months variety called 'Kar' and a hundred days variety called 'Kuruvai'. The former was confined to the first reaches of the delta. Where the seedlings could be raised before the advent of the freshes and in reasonable anticipation of its certainty, and the latter was the more common variety. The second crop grown on double crop land was known as 'Thaladi', as distinguished from 'Mudladi' which was the first crop. The major crop economy, growing five months crop called 'Samba'. The first crop season was from June to October. The second crop October to February. The single crop season was spread over from June to January.*

***Landscapes classification of Tamil Nadu in Tholkappiam**: Tamil Nadu is bounded by Thirupathi in the North and Cape Comorin (Kumari) on the south and seas in the east and west (Kakaipadiniyar). Landscapes in corresponding to a flower, time of day, and stage of love-relationship in Table 1.*

Table 1. Features of Landscapes in Ancient Tamil Nadu

| **Landscapes** | **Mullai** | **Kurinji, Punam** | **Marudham, Vayal, Kalani, Palanam** | **Neithal, (Adaikarai-Nattrinai)** | **Palai** |
|---|---|---|---|---|---|
| Land type | Forest and pasture (shrubbery) | mountain, hilly tract | Agricultural areas; plains and valleys | Coastal areas, marine tract | Barenland (desert and sandy tract, vegetation sparse) |
| Soil | Red soil | Red and black soils with stones andpebbles | Alluvial | sandy soil, saline soil | salt affectedsoil |
| crop | Tenai, varagu, cotton | cotton,Rice var Kulanel, Thoppinel, Thorainel | Sugarcane, Rice var. Vennel;Mudandainel | ------ | ------ |
| Flower | Mullai (white jasmine) | Kurinchi (blooms once every twelve years) | Marutam | Water lily | Paalai |
| Stage of love | Heroine expresses patient waiting over separation | Union of lovers | Lovers' quarrels, wife's irritability (husband accused of visiting a courtesan) | Heroine expresses grief over separation | Longest separation; dangerous journey by the hero |
| Season of year | Cloudy (Aug-Oct) | Cool and moist (Nov-Dec) | No specific season | No specific season | Hot and dry (April-Sept) |
| Time of day | Evening | Midnight | Shortly before sunrise | Sunset | Midday |
| Livestocks/ Fish | goats, cattles | ----- | Buffaloes, penning with goats or cattles | Fish culture | Sheep, goats |
| God | Vishnu, Mayan | Murugan, Subramanian | Indra, the rain god | Varuna | Durga, Korravai |

Tholkappiar further classified the land as Vanpulam (Kurinchi, mullai) and Menpulam (Marutham, Neithal). Since Mullai land is located by the side or next to Kurinchi land, it is known as 'Puravu'. The cultivation of fruit trees and crops for

cattle was undertaken in Mullai lands. Tholkappiar refereed the Mullai land as 'Kadurai Ulagam' since the trees occur in predominant areas. It has grasslands on in larger areas. Growing sheep and weaving wool clothes was yet another profession. Tenai and paddy was cultivated in Kurinji. 'Palai' is really a non descript mixture or medley of Mullai and Kurinji tracts rather than a mere sandy tract (Silapathigaram). It must be remembered that there is no desert in Tamil Nadu. Marudam land is fit for agricultural operations. In Marutham, rice in the staple food. Cattle were their-favourate beasts, Vanji, Kandri and Marudam were Chief trees of the Marudam lands. In fact, the land Marudam was delivered its name from the tree Marudam. Their occupation was agriculture and the lotus was their sacred flower (Tor Porul, 18). There is no separate Palai land in Tamil Nadu. If rain fails, the Mullai and Kurinchi lands turns into Palai land (Silapathigaram). Thiruvalluvar mentions two chief characteristics of an ideal state / country viz., i) ***talla vilaiyal***: fertility of the land ensuring perennial supply of food to the population (Kural, 41) and ii) ***Vallaran***: Suitability of the terrain for purposes of defense against foreign attacks (Kural, 40).

**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.

**Land preparation:** Thiruvalluvar gives a few ideas about agricultural operations. If an agriculturalist would allow the ploughed land to dry up so that one todi (one palam) of dust dries down to one kashi (1/4 palam) i.e., if it is reduced to one fourth (1/4) of the original quantity, there will be no need to put into the land even one handful of eru, ie. manure (Kural, 1037). Ploughing was carried out many times instead of single time (Ahananuru,26:24-25). Agriculture can be practiced easily when the cultivator has his own ploughs, Iniyavainarpathu, 3:3). Ploughing one time was referred as Orusal ulavu; twice as Irusal vualu and many times as Chensal vualu. Plough the land deeper than wider. Cattle were used for ploughing. Cyperus weeds and crab cavities were destroyed during land preparation and levelled in wetlands (Perumpanattrupadai). Crops had been raised in beds and channels (Nanmanikaddigai, 16).

***Crops and varieties:*** *Ancient Tamils cultivated paddy, blackgram, horsegram, varagu, Tenai, Sesame, Sugarcane, Banana, Coconut, Palmgrab, bamboo grasses, jack fruit, tamarind and mango. Varagu was cultivated in Mullai lands (Purananuru, 120). Tenai and field bean*

*(Mochai) were cultivated mixed crop in Kurinchi lands (Kurunthogai, 72.240). Cotton and Tenai were cultivated an mixed crops (Kurunthogai, 72). Rice varieties such as Chennel, Vennel, Salinel, Mudandainel, Ivananel, Kulanel, thoppinel, Pudunel, Varnel, Aviananel, Torainel were cultivated (Purananuru, Pattinapalai, Kurunthogai,277). Mungil nel or Mungil arisi obtained from bamboo. It was taken as food at the time of king Pari (Purananuru, 109).*

*Redgram, Blackgram was cultivated in Marutham lands (Aaga nanuru, 339: Natrinai 28, Purananuru, 297). Sugarcane was cultivated with check basin in Method at the foot hills (Kurunthogai, 262). Sugarcane var. Kalik karumbu) was cultivated in Thagadur region during the king Adiyaman period. (Purananuru, 99). Banana was cultivated. Its terminal loft's medicinal properties was mentioned in (Kurunthogai, 308). Rice, sugarcane, coconut, plantains, areca palm, turmeric, mango, palmyra, Sembu (*Colocasia antiquolam*) and ginger were grown in Cauvery river valley. A 'Veli' of land produced a round thousands kalams of paddy. Farmer enjoys on seeing the first freshes and hearing the sound of Cauvery flow and of the eddying water scouring the bunds (Silappadikaram).*

**Seeds and sowing:** 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. Sowing tenai seeds without ploughing was also practiced. Cyperus weeds were removed through feeding with pigs and then in such lands seeds were sown without ploughing (Purananuru, 168-6). Seeds were sown with adequate spacing (Narrinai). Seed germination happens with adequate moisture (Nanmanikadigai,67)

**Cropping systems:** Crop rotation was practised by raising black gram (urd) after rice. They also practised mixed cropping; e.g., foxtail millet with lablab or cotton. Ginger and turmeric were grown as intercrops in coconut and jack fruit plantations. Rice fallow cultivation with other crops such as pulses had been reported in 'Ingurununu'. Cultivation of sugarcane was reported in 'Pathittrupattu'. Mixed cropping of cotton and tenai were also practiced. Pepper was grown as mixed crop in mango plantation (Inthinai,8:1-2).

**Weed Management:** Weeds were removed from the fields (Madurai kanchi). Tools were used for weed control (Ahananuru). weeds hamper the growth of crops (Nanmanikadigai).

**Soil fertility:** Thiruvalluvar stated that fertile land alone is entitled to be called territory (Nadu) which yield wealth unsought for (Kural, 739). The fertility of the land especially in Chola Kingdom finds proud mention in contemporary literature. Organic manures were applied in ploughed lands (Narrinai). Avur Mulankilar in a short poem addressed to Killivalavan says, " The land is so fertile that a tiny piece there of, where a she-elephant might rest, can produce enough food to nourish seven bull elephants (Purananur, 40). The fertility of the land even in hilly areas like the Palakunrakottam (land between Tirupathi and Tiruvannamalai) was such that the sesame crop was so healthy and full grown that a handful could contain no more than seven grains of sesame (Malaipadu, 102 to 106). Even without ploughing, merely sowing deep in turned sod made mustard grown in great quantities (Malaipadu, 122 to 123). In a fairly fertile farm, a veli of land produced a full thousand kalams of paddy (Porunnar, 246 to 248). The silt carried by the flood water was a major source of fertilization, and the greater the volume of water, the greater the valuable silt deposit. Some of the more favourably situated fields were known as "Erikkattu" meaning tank reservoir. This was an ingenious system of "field insurance" against the risk of floods.

***Irrigation Management**: Water quality depends on land type (Nanmanikadigai, 80). Moisture stressed crops grow well on receipt of rains (Iniyavainarpathu15:2); construction of ponds for others use is essential (Iniyavainarpathu1, 23:1).*

**Art of well divining:** The Cankam art works speak of the art of well-divining practice of the Tamils to wells on the highways for the weary travellers (Naririnai,240; Purananuru, 306). The didactic work Tirikatukam (14) refers to the virtuous act of digging 'drinking water wells' bounteously. Tivakaram and Kayatara Nikantu refer to those well-versed in well-divining as 'ulliyar' and calliyar' respectively. Although 'Kuval, Acumpu, Kupam, Kuli, Puval, Keni, Turavu are used synonymously to denote well, cankam classic speak of kuval only. Patirrupattu (51) and Ainkurununu (203) revealed that the wells of those days, generally, were of shallow depth only. According to two manuscripts, rocky lands were classed as 'Kurinchi'; the land with coarse sand, 'Neytal'; the land abounding in scattered minor rocks, 'Mullai'; muddy land, 'Marutam' and the unused tract 'Palai', of which the Neytal tract was supposed to have moisture. The depths of the water source in different lands differed from the surface land. In Kurinchi springs will be found at a depth of 33 cans, in Palai 30 cans, in Mullai 36 cans, in Neytal 35 cans and in Marutam 22 cans. The soil fit for the growth of banyan tree, tamarind, mango and so on might have water springs at different depths. The places where white rats, scorpion, the double-tongued lizard, toad and so on inhabit might have

water sources. Another manuscript talks about the brownishness of Mullai water, whiteness of Palai water, Kurinchi's blackish water, Marutam's potable water and saltish water of Neytal. A well, which had disappeared due to human or natural calamities, can be traced on the basis of certain varieties of grass getting withered in winter and flourishing in summer season. In such places, there would be a swarm of flies and ants; also anthills appearing in places where certain grassy plants grow and such trees as 'Vanci' and 'Nocci' flourishing during the hot summer season, would be sure indications of the existence of wells-now disappeared in such places.

***Major Irrigation system of ancient Tamil Nadu**: In Purananur (18), Kudapula-Vianar says that a large irrigation system has relieved the peasants from dependence on the monsoon. The Pallavas, whose capital was in Tondaimandalam, constructed several irrigation tanks, and practically all of them are functioning to this day. The Cholas, besides constructing tanks, tamed the Cauvery river, an achivement of which any monarch and his people may be proud. The Pandyan country was divided between fringe irrigation alongside of the rivers and the utilization of tanks. The two major rivers of Tamil Nadu are the Cauvery and the Tamiraparani. The Vaigai has at no time been a source of great importance. The Cauvery river rises in the western ghats near Coorg and after a course of nearly 500 miles, enters the Bay of Bengal, draining an area of about 31,000 square miles in route. In the Cholamandala Satakam ther eis mention of the Kallanai or the Grand Anicut being constructed. Karikala is said to have employed several thousands of Ceylonese for this purpose. According to the "Mahavamsa", one hears of an aged woman complaining to Gajabahu that amongst the twelve thousand persons taken away by Karikala for making the embankment of the Cauvery was her only son. According the Pattinathupalai, Karikala was known as "Kaaverinaadan" due to his taming the violent river. His raising of the flood banks of the Cauvery was mentioned in the Malepadu plates of Punayakumara, a Telegu Choda king of the seventh or eighth century. A list of some of the major irrigation works are furnished in Table 2.*

Table 2. Major irrigation works in Ancient Tamil Nadu

| Name of the work | King to whom attributed | Date |
|---|---|---|
| Grand Anicut | Karikala Chola | 1st Century |
| Thirayan Eri | Thirayan | 6th Century |
| Mahendra Tataka | Mahendravarman I | 7th Century |
| Parameswar Tataka | Parmaeswara Varman | 7th Century |

| | | |
|---|---|---|
| Vairammega Tataka | Vairamega Pallava | 8th Century |
| Marpidigu Eri | Vairamega Pallava | 8th Century |
| Valian Eri | Dandivarman | 8th Century |
| Kaveripakkam tank | Nandivarman | 8th Century |
| Kilavan Ari | Nedumaran Srivallabha | 8th Century |
| Maraneri | Maran | 8th Century |
| Kudimallam Tank | Tandikramavarman | 8th Century |
| Maruthadu | Vijayanripatunga | 9th Century |
| Dharmapuri Tank | Mahendra Pallava | 9th Century |
| Ukkal Tank | Kampavarman | 9th Century |
| Chola Varuthi | Parantaka I | 10th Century |
| Chodiumbakan Tank | Parantaka I | 10th Century |
| Nangavaram Tank | Arunjaya | 10th Century |
| Veeranam Eri | Veeranarayana | 10th Century |
| Uyyakondan Channel | Raja Raja I | 10th Century |
| Bahur Tank | Raja Raja I | 10th Century |
| Periya Vaikal | Raja Raja I | 10th Century |
| Chola Ganga | Rajendra | 10th Century |
| Parakara Kallanai | Jayadeven Srivallabha | 11th Century |

The anicuts on the Tamiraparani are noticed separately. Seven anicuts were constructed across the Tamiraparani. The exact dates when they were constructed are not known. The usual local legends have grown around each of them. That they are ancient, how ever is evident. They are in order namely, Kodaimelalagiyan, Nadiyunni, Kannadiyan, Ariyanayakapuram, Palavur, Suttamalli, and Marudur.

**Tank systems:** The Tamils constructed two types of tanks; large tanks, such as those referred to in the early part of this paper, and innumerable smaller ones scattered all over the undulating interior of the Tamil country. Both kinds of tanks were largely looked after by the people themselves. The inscriptions in some of the tanks make mention of this resposibility. “The primary care of the village assemblies was to get the silt removed (Every year before the rains set in) from the tanks under their control in time for them to secure the proper depth needed to store the full supply for the next year. Often special endowments were created or the penury of village authorities. In some instances a cess called ‘Eriayan’ was collected from the villages for this purpose. The Cauvery system is very ancient is evident from Sangam literature. The Grand Anicut, constructed by Karikala in the first century is still in effective use.

**Plant protection:** Fencing had been laid out around the fields to protect from the animals. Fencing was done with bamboo (Kurunthogai); Karuvel (*Acacia* sp.-in Ahananuru).

**Harvesting and Threshing:** Harvesting was carried out in night time with beating drums to protect from the wild animals (Kunthogai, 375;3; Madurai kanchi, 259-260); Malaipattu, 471). Rice crop was harvested using a tool 'Kuyam' (Narrinai, 195: 5-6). Rice was threshed using cattle and elephants (Malaipadukadam, Perunaruttrupaadai). Gardenland bean (Avarai) was cultivated in Tenai stubbles (Ingurununu: 284:1-2); sowing of tenai and cotton in harvested tenai lands (Malaipadukadam, 122-123).

A tool called 'senyam' was used for harvesting 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 stagnate to facilitate roting of stubble 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 , the 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 grains bazaar where 18 kinds of cereals, millets, and pulses were sold. Each shop had a banner hoisted high so that it cloud be seen from a distance indicating the grains sold. Whar a novel method instead of neon signals and name boards. Customs duty was collected on imports and exports.

Revenue from Agriculture: Tamil kings collected land tax, which was known as 'irai' or 'karai', tols and custom duties. Revenue collection was known as 'ulgu' and 'sungam'. The duties paid by the king (King's share were known as 'Kadamai', 'Paduvadu' or 'Padu'. 'Vari' was a generic term meaning income, i.e., revenue. Extra demands or forced fits were called 'iravu' 'vari' refers to tax, 'Variam' refers to the tax collecting service and 'Variyar referred to an officer collecting tax. One sixth (1/6) of produce from land was paid as land revenue to the kings. King assigns tax-free lands to certain persons or institutions. Such lands were called 'Puravu' or 'iraiyili nilam'. Revenue relief was given due to unexpected poor harvests because of failure of rains. The poet Iraiyanar Ahapporul mentioned a long period (twelve years) of failure in the Pandia kingdom. On such occasions of extreme famine, the farmer lived consuming the seeds normally intended for sowing.

## Chapter 07. Astronomy- Prediction of monsoon rains; Parasara, Varahimira, Panchanga - comparison with modern methods

**Astronomy:** The path of the Sun being a fixed circle among the fixed stars is called ecliptic. The relative Sun moves along the ecliptic from West to East. To mark the movement of the sun., Moon and Planets, the ecliptic is divided into 27 equal parts called "Nakshatras" (fixed stars) and also 12 equal parts called 'Rashis' (Signs). The time taken by the Sun to complete one round along the ecliptic is a fixed period, called Sidereal Year. The Sidereal year, Calendar year or Julian Year is made up to 365.2568 days and the Tropical year made up to 365.2422 days. There was excess 0.0078-day i.e. 3 days in 400 years. The Sidereal day is shorter than the apparent Solar Time by 4 minutes. The earth goes round the sun in 24 hours, but with reference to a Star, it goes round the sun within 23 hours and 56 minutes. Julius Caesar introduced the concept of leap year once in four years and was made equal to 365.25 days. Axis of rotation causes the appearance of the sun oscillating slowly north south wards and south-north wards. When the sun comes exactly above the equator twice a year one is called the beginning of Vasantha (spring) ruthu and the other, the beginning of Sharad (Autumn) ruthu. The Sun has another motion-North to South and South to North. He crosses the East-West line twice a year. He goes 23 ½ to South-East and 23 ½ North-East (Similarly of Western Zenith). But, the period between the two crossing of each point (From South to North and from North to South) is not always constant and the Sun does not cross the ecliptic at the same point. This is called Precession. In other Words, the Period from one Vernal Equinox to another Vernal Equinox may be called the Tropical Year. The duration of the 'tropical year' is accounted on the basis of the movement of the Earth around the Sun. In order to cover all the seasons, its duration per year is 365.2422 days. The tropical calendar was spread to the different parts of the world by Sage Vasishta and his brother sage Agastya. That is why we find Sun temples all over the world.

Distance to be covered in the southernly direction is known as Dakshinaayana (summer solstice). Dakshina + Ayana it means the southern + latitudinal distance to be traversed. When the sun is in the north, it is called, Dakshinaayana (summer solstice). Dakshinaayana (Summer Solstice) us of 6 months duration tropically and so too is Uttaraayana (winter solstice). When the rays change their directions and it will be found to do so either on June 21$^{st}$ or 22$^{nd}$ or December 21$^{st}$ or 22$^{nd}$ depending on whether it is Dakshiaayana (summer solstice) or Uttaraayana (winter solstice) respectively. Eqinoctical points are those on the orbits of the earth on which equal days and nights will appear and this happens twice a year on June 21$^{st}$ or 22$^{nd}$ or December 21$^{st}$ or 22$^{nd}$.

**The Zodiac:** Zodiac is the division of the heavens into twelve astrology signs, each comprising exactly one-twelfth of the heavenly circle or 30º and totalling 360º. The Zodiac is a circle of space surrounding the Earth. It may be imagined as a belt in the heavens about 15 degrees wide in which the planets travel. It is the Sun's

apparent path that is called ecliptic. The zodiacal circle is divided into twelve parts, each part containing thirty degrees of space called the signs of the Zodiac. Thus a sign is one twelfth division of the zodiacal circle and is defined as containing 30 degrees of celestial longitude: 12 signs each measuring 30 degrees constitute the circle of the Zodiac or 360 degrees. In this circle the planets travel each in its own orbit, one outlaying beyond the other. The twelve signs of the Zodiac are Aries (Mesha), Taurus (Vrishabh), Gemini (Mithuna), Cancer (Kataka), Leo (Simha), Virgo (Kanya), Libra (Thula), Scorpio (Vrischika), Sagittarius (Dhanus), Capricorn (Makara), Aquarius (Kumbha) and Pisces (Meena). It is the twelve signs through which the planets travel or transit from west to east, going through one sign after another in their order from Aries to Pisces. Each sign possesses a specific influence. The planets also as they travel around the Zodiac exert an influence according to their separate nature and position in the Zodiac. Although according to modern Astrology there are twelve planets viz., Sun, Moon, Mars, Mercury, Jupiter, Venus, Saturn, Rahu, Kethu, Uranus, Neptune and Pluto, Hindu Astrology recognises only the first nine. Each sign of the Zodiac is owned by a planet who is termed as its 'ruler' of the sign. Sun and Moon rule one sign each viz., Leo and Cancer respectively. Mars rules Aries and Scorpio, Mercury rules Gemini and Virgo, Jupiter rules Sagitarius and Pisces, Venus rules Taurus and Libra and Saturn rules Capricorn and Aquarius. Sun is the king of the solar kingdom. He is also called the 'Father of Stars". Westerners call the Sun Apollo. The sun takes exactly one year to go round the ecpliptic or zodiac.

Quadruplicity: Each sign belongs to one of four groups of signs based on their elemental tendencies to be either fiery, earthy, airy, or watery in temperament.

| Elements | Rasi / zodiac / Signs |
|---|---|
| Fire | Aries, Leo, Sgittarius |
| Earth | Taurus, Virgo, Capricorn |
| Air | Gemini, Libra, Aquarius |
| Water | Cancer, Scorpio, Pisces |

Note: Capricorn is half-watery and half-earthy

**Seasons and Equinoxes**

Sun, the latter's rays fall equally only on two days in a year i.e. the day and nights are equal on two days a year when the Sun enters the Equator. These two days are March 21$^{st}$ and September 21$^{st}$**.** One is called autumnal equinox and the other is called vernal equinox. In Sanskrit autumnal is known as the first day of Sarad Ruthu and the vernal equinox is known as first day of Vasantha Ruthu. These points are also known as equinoctical points or Vishu bindus. There are basically six seasons. Each of the above six seasons has been divided into two parts.

| Seasons | Parts | Period |
|---|---|---|
| Vansantha Rithu | Madhu | March 21$^{st}$ to April 21$^{st}$ |

| | | |
|---|---|---|
| | Madhava | April 21st to May 21st |
| Greehma Ruthu | Sukra | May 21st to June 21st |
| | Suchi | June 21st to July 21st |
| Varsha Ruthu | Nabhas | July 21st to August 21st |
| | Nabhasya | August 21st to September 21st |
| Shard Ruthu | Lsa | September 21st to October 21st |
| | Urija | October 21st to November 21st |
| Hemantha Ruthu | Sahas | November 21st to December 21st |
| | Sahasya | December 21st to January 21st |
| Sisira Ruthu | Tapas | January 21st to February 21st |
| | Tapasya | February 21st to March 21st |

The Moon which is a natural satellite of the Earth moves around the Earth once is about 28 days, i.e. it takes about 28 days to come to the some star, after going around the earth. This is called the Sidereal Movement of the Moon. There is another way of recognizing the movement of the Moon around the Earth and that is with respect to the Sun. On Amavaya (New Moon) Day Poornima (Full Moon) Day, the Sun, the Moon, the Earth are on the same line longitudinally. From one Amavasya (New Moon) to another Amavasya (New Moon) it takes about 30 days. Each of these divisions (of 30) is called a Thithi (phase). This division of months is called Luni-solar Months. This is recognized in the Panchanga (Caiendar) as Prathma (1st day), Dwithiya (2nd day) etc. Sukla prathama (1st day of Bright half) or Krishna Prathama etc. (1st day of Dark half) depending on the bright or dark fortnight.

Sukala Paksham / Krishna Paksham

| S.No. | Sukala Paksham Thithi | S.No. | Krishna Paksham Thithi |
|---|---|---|---|
| 1 | Prathama | 1 | Prathama |
| 2 | Dwithiya | 2 | Dwithiya |
| 3 | Thrityiya | 3 | Thrityiya |
| 4 | Chaturthi | 4 | Chaturthi |
| 5 | Panchami | 5 | Panchami |
| 6 | Sashti | 6 | Sashti |
| 7 | Sapthami | 7 | Sapthami |
| 8 | Ashtami | 8 | Ashtami |
| 9 | Navami | 9 | Navami |
| 10 | Dasami | 10 | Dasami |
| 11 | Ekaadasi | 11 | Ekaadasi |
| 12 | Dwaadasi | 12 | Dwaadasi |
| 13 | Thryodasi | 13 | Thryodasi |

| | | | |
|---|---|---|---|
| 14 | Chaturidasi | 14 | Chaturidasi |
| 15 | Poornima or Full Moon | 15 | Amavasya or new moon |

**Planetary movement:** There are five planets moving around the sun. They are Mercury, Venus, Mars, Jupiter and Saturn. By the time mercury, goes round the sun, approximately 88 days. Would have elapsed (4 rounds a year); by the time venus moves round the sun, it will be 224 days; for mars it is 686 days, for Jupiter 4332 days; and for Saturn 10,759 days.

**Ancient systems of time:** Our ancient calculated time is an follows : one day = 60 Naligais 1 Naligai =60 vikalas. Therefore a day = 60 x 60 x 60 x vikalas = 2,16,000. The Rig veda contains 4,32,000 units of sounds therefore 1 vikala = 2 units of sound.

## Ancient Hindu calendar

**Samavatsara:** Samavatsara corresponds to a year. Vikrama Smavat starting from 57 BC and Shalivahana Saka starting from 79 AD were the two systems used in ancient India. The references in Krishi Parashara are to Saka. There is a cycle of sixty years called Jupiter cycle and all the sixty years have individual names and characteristics. Parashara's reference to Saka year is currently 1920 (i.e.,1998 AD). In the Panchang or Almanac system in whole of India, rainfall forecasting / prediction based on ruling planet and minister planet is worked from a base year Salivahan Saka from 1920 (i.e.,1998 AD). Datye's Marathi Panchang using the base year Salivahan Saka (Shaka) from 1919 or 1997 AD refers to adhaka as the measure of water in land area of 240 kroshas in width (768 km) and 400 kroshas (1280 km) in length.

**Seasons:** Six seasons in Rigveda: Grishma (Jyestha-Aashadha or May-June ), Varsha (Sharavana-Bharapada or July-August), Hemant (Margashirsha-Pausha or September-October), Sharad (Ashwin-Kartika or November-December), Shishir (Magha-Phalguna or January-February) and Vasanta (Chaitra-Vaishakha or March-April).

**Months** (Masa) **of a year:** Pausha (January), Magha (February), Phalguna (March), Chaitra (April), Vaishakkha (May), Jeyshtha (June), Aashadha (July), Shravana (August), Bhadrapada (September), Ashwin (October), Kartika (November), Maragashirsha (December).

**Paksha:** Each month is dived into two fortnights called Shukla Paksha corresponding to the bright fortnight and Krishna Paksha corresponding to the dark fortnight.

The ancient /indigenous methods of weather forecast may be broadly classified into two categories:

1. **Observational methods**
    - 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 plants and stars
    - Study of solar ingress and particulars dates of months
    - Study of Nakshatra Chakras
    - Study of Nadi Chakras
    - Dashatapa Siddhana

**Prediction of monsoon rains**

**1.Parashara's technique** of '*rain forecast'* is based on the positions of the Sun and the Moon.

| Sign of the Sun | Sign of moon | Predicted annual rainfall |
|---|---|---|
| Cancer | Gemini, Aries, Taurus, or Pisces | 100 adhakas |
| Leo or Sagittarius | Gemini, Aries | 50 adhakas |
| Virgo or Leo | Gemini, Aries, Taurus or Pisces | 80 adhakas |
| Cancer, Aquarius, Scorpio, or Libra | Gemini Aries, Taurus or Pisces | 96 adhakas |

**Method for measurement of rainfall:** Varahimira defined one adhaka equivalent to 50 palas of water. Adhaka is a measure of rainwater quantity in a land expanse of 100 yojanas in length and 30 yojanas in depth. The following formula will help to understand this concept clearly. 1 yojana = 4 kroshas = 8 miles = 13 km. Hence ¼ yojana = 1 krosha = 3.2 km. If the rain water wets a land area of approximately 100 yojanas (or 100 x 13 = 1300 km) in length and 30 yojanas (or 30 x 13 = 390 km) in width (depth is interpreted as width), then it qualifies for an earthly measure of

one adhaka. For measurement of rainfall or rainwater the unit of rain-gauging was adhaka. An adhaka is the quantity of rainfall which fills to the brim of a vessel 20 inches in diameter and 8 inches deep. Four such adhaka constitute one drona. The method of measurement of rainfall is described by Varahamihira in Chapter 23 entitled "Pravarshan Adhyaya" (Chapter on rainfall) of his book. 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 (human) fingers and with a depth equal to the distance measurement 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 seer Parashara. Parashara's basic unit of measuring rainfall is adhaka. One drona = 4 adhakas = 6.4 cm.

According to Parashara the basic unit of rainfall is adhaka.

1 adhaka = 17600 ÷ 7 = 2514 cubic finger = ¼ drona [eq 1]

Volume of the vessel = $\pi r^2 d$ = 3.14 x $10^2$ x 8 = 314 x 8 = 2512 cubic fingers [eq 2]

Where p = 3.14, r = radius of the vessel = 10 fingers-width and d = depth of the vessel = 8 fingers-width
Three units were used to measure rainfall in ancient India are Pala, adhaka and drona (50 palas = 1 adhaka = ¼ drona). These ancient units can be related to the modern ones using the relation 2514 cubic fingers of rainwater or 1 adhaka is equal in weight to 11 oz or 311.85 g. As 1 cc of water weighs 1 g, so

1 adhaka = 2514 cubic fingers = 311.85 cc [eq 3]

In a modern rain-guage with a 200 $cm^2$ container, volume of 1 cm of rainwater collected is

200 cm x 1cm = 200 cc [eq 4]

Based on equation 3, rainfall measured using the ancient method could be related to modern units as:

1 adhaka = 311.85 ÷ 200 = 1.6 cm [eq 5]

[i.e., volume of rainwater ÷ area of container = amount of rainwater collected (see equation 4)

From equations 1 and 5

1 drona = 4 adhaka = 6.4 cm [eq 6]

**2. Parasara's Rainfall Prediction:** Every year has (a particular planet as) a ruler, (another planet as) a minister, a particular cloud, and (depending on that) an amount of rainfall which one has to study to acquire the knowledge of rains. The method of finding out the ruler (planet) of the year: Multiply the number denoting the Saka year by three. Add two; divide the result by the number of sages (i.e., seven). The remainder is the number indicating the ruling planet of that Saka year. The planet, which is fifth form the ruler planet, indicates the minister planet of that year. The minister plant of the year is Venus as it is the fifth from the Sun. 1920 x 3 = 5760

5760 + 2 = 5762

5762 / 7 = 823+ remainder 1

The Sun as the ruler of the year indicates average rainfall, the Moon heavy rains, Mars scanty rains, and Mercury goods rains. When Jupiter happens to be the king of the year the rainfall is satisfactory, Venus indicates excellent rainfall while Saturn as a king leaves the earth dry and dusty. Diseases of the eye, threat of fever, and all sorts of other calamities, scanty rainfall and continuous blowing of winds are the characteristics of a year ruled by the Sun. The year in which the Moon is the ruler is sure to enrich the earth with good harvest and bestow health on mankind. In the year ruled by Mars, damage is caused to the crops and diseases spread among people. The earth becomes benefit of crops. When Mercury happens to be the ruler, earth is free of diseases. Transportation is easy and there is plenty of harvest. The earth is blessed with all the varieties of crops. If Jupiter rules the year, Dharma prevails on earth, people enjoy peace of mind, There is good rainfall The whole earth enjoys prosperity. Venus the preceptor of demons, as a ruler of the year causes the kings to prosper without fail. Prosperity and plenty result. The earth is blessed with a variety of food grains. The year in which Saturn rules war, stormy rains and outburst of diseases are sure to occur. Rains rare scanty and winds are continuous.

*Table 1. Annual rainfall and crop yields depending on the ruling planets of the year*

| Name of the ruling plant of the year | Estimated rainfall for the year | Crop yield during the year |
|---|---|---|
| Sun | Average or scanty | Poor crop yield[1] |
| Moon | Heavy | Good harvest |
| Mars | Scanty | Damage to crops |
| Mercury | Good | Plenty of harvest |
| Jupiter | Satisfactory | Good harvest[1] |
| Venus | Excellent | Variety of food |

| | | |
|---|---|---|
| | | grains |
| Saturn * | Scanty | Poor yield |

- Saturn-The earth is dry and dusty, continuous winds occur during this period.

## 3. A model for forecasting seasonal rainfall recorded in Brhat Samhita

Varahamihira (600 AD) evolved or adapted a technique based on science. This techniques lays down that after the occurrence of the full-moon day of the month of Jyestha (approximately coinciding with June of Gregorian calendar) the asterism or lunar mansion or naksatra of the day on which the first rainfall of that yeara rainy season is received should be noted. This asterism provided the basic for the forecast of seasonal rains. The predicted amount of the season's total rainfall for each nakshatra or lunar mansion if it happens to be the nakshatra on the first rainfall of the season is listed (Table. 2). The first rainfall of the season that occurred after the full-moon day of the month of Jyestha (approimately June) is taken into account for forecasting the seasonal rainfall, but the amount of rainfall recorded on that day has hot been indicated. Modern meteorology defines a rainy day as a day on which a rainfall of 2.5 mm or more has been recorded.

**Table 2. Varahamihira's technique for forecasting seasonal rains**

| Lunar Mansion | Zodiac sign | | Predicted total seasonal rainfall | |
|---|---|---|---|---|
| | Sanskrit | English | Inancient units2 (drones) | In modern units (cm) |
| *Hasta* | *Kanya* | Virgo | 16 | 102.4 |
| *Purvashadha* | *Dhanu* | Sagittarius | 16 | 102.4 |
| *Mrigashirsha* | *Vrushabha* | Taurus | 16 | 102.4 |
| *Chitra* | *Kanya* | Virgo | 16 | 102.4 |

| | | | | |
|---|---|---|---|---|
| *Revati* | *Meena* | Pisces | 16 | 102.4 |
| *Dhantishtha* | *Makara* | Capricorn | 16 | 102.4 |
| *Shatabhisha* | *Kumbha* | Aquarius | 4 | 25.6 |
| *Jyeshtha* | *Vrushchika* | Scorpio | 4 | 25.6 |
| *Swati* | *Tula* | Libra | 4 | 25.6 |
| *Kritika* | *Vrushabha* | Taurus | 10 | 64.0 |
| *Shravana* | *Makara* | Capricorn | 14 | 89.6 |
| *Magha* | *Simla* | Leo | 14 | 89.6 |
| *Anuradha* | *Vrushchika* | Scorpio | 14 | 89.6 |
| *Bharani* | *Mesha* | Aries | 14 | 89.6 |
| *Mula* | *Dhanu* | Sagittarius | 14 | 89.6 |
| *Purvaphalguni* | *Simla* | Leo | 25 | 160.0 |
| *Punarvasa* | *Mithun* | Gemini | 20 | 128.0 |
| *Vishakha* | *Vrushchika* | Scorpio | 20 | 128.0 |
| *Uttarashadha* | *Makara* | Capricorn | 20 | 128.0 |
| *Aaslesha* | *Karka* | Cancer | 13 | 83.2 |
| *Uttarabhadrapada* | *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 |
| *Ashwini* | *Mesha* | Aries | 12 | 76.8 |
| *Aradra* | *Mithun* | Gemini | 18 | 115.2 |

1. On the day of the first rainfall of the season.
2. I drona=6.4cm.

**4. The method of ascertaining the type of cloud of the year:** Add the types of fire (which is three) to the number denoting the Saka year. Divide the sum by the number of vedas (which is four). The remainder of the division indicates the type of cloud, viz., Aavarta, etc., according to their order. Let the Saka year is 1920. The 1920+3 = 1923; 1923/ 4 = 480+ remainder 3. Hence the type of cloud is the one listed at number 3. Pushkara cloud is stated at number 3 in the order. Therefore the cloud of the Saka year 1920 is Pushkara. Aavarta, Samvarta, Pushkara, and Drona are the four types of clouds, Aavarta being the first in order. **Aavarta** rains at some parts while **Samvarta** rains everywhere. water is scanty in Pushkara cloud while drona makes the earth full of water. The rains from Aavarta cover some parts of the earth. The students of modern Indian science of meteorology will identify this type of cloud, Aavarta, with the present day *cumulonimbus*, which gives thundershowers over a limited area. It is a result of of the special feature of its build up in the sky with a base at about 2500-3000 ft (abotu 750-900 m) above ground and with a vertical ascent of 25,000-30,000 ft (about 7-9 km) above it base. The second type of cloud, samvarta, rains every where indicating that is is a sheet type of cloud, *an altostratus*, which is widely spread in the sky, at a height from 2.5 km to 6.0 km above seas level. The thickness of the sheet cloud can be considerable, rendering the Sun invisible during the period of its spread in the sky. The third type of cloud is Pushkara and

the year with this type cloud is known for scanty rainfall. The name Pushkara or Pushkal shows that it is a cloud of short duration as its buildup is a temporary phenomenon or a disturbance in the normal atmosphere. The last type, Drona, makes the earth full of water according to the sage Prarasha. It is the stratocumulus cloud type, which is a sheet-cloud at a height of approximately 2 km above ground. This type also gives steady, continuous rain. According to Varahamihira and other scholars the formation of clouds or pregnancy of clouds or Garbha Dharana takes place 195 days before fall or birth or delivery or 'Garbha Prasava'

**5. The method of determining the amount of rainfall:** Experts have fixed *adhaka* (jalaadhaka) as the measure of water which is the quantity of water contained in an expanse of a hundred *yojanas* and the depth of thirty *yojanas*. When the Sun enters the sign of cancer while the moon is in Pisces, Aries, Taurus or Gemini, the rainfall is a hundred adhakas. If the sun passes through Leo and Sagittarius it is half of that (i.e., fifty adhakas). when the sun is in the Virgo or Leo rainfall is stated to be eighty adhakas. When the Sun is in Cancer, Libra, Aquarius, the rainfall is said to be ninety-six adhakas. Farming should be planned after studying the quantity of rainwater.

**6. Sudden rainfall**: If an expert on predictions of rainfall is approached with query regarding rains while he is taking a dip in water or has water in his hand or is the variety of water, sudden rains can be predicted. Ants emerging (from the ant hill) carrying their eggs and a sudden croaking of frogs are also indications of sudden rains. Cats, mongooses, snakes, other creatures which live in holes as well as grasshoppers moving around freely as in a state intoxication are also sure signs of sudden rains. Children playing on the road and building bridges of mud, and peacocks dancing also indicates sudden rains without fail. People suffering from injury or vatadosha (human disorder similar to wind humor) complaining of body pain and snakes climbing on the treetops also bespeak of sudden rains. Water birds drying their wings in the hot sun and crickets chirping in the sky also signify sudden rains.

**7. Indications of famine**: Mar's transit through Dhruva (Uttaraphalguni, Uttarashadha and Uttarabhadrapada nakshadars), Vaishanava ( Shravana), Hasta, Mula, Shakra (the master of Jyeshtha), Krittika, and Magha indicates famine. The sun situated behind Mars evaporates even the ocean while in an opposite situation, he drenches mountains too. Obstruction to rain as soon as Venus reaches the middle of its path through Chitra. Mars passing through Leo turns the earth into a fireplace, and accompanied by the Sun can evaporate even the ocean.

**Kautilya's Artha-Sastra** (400 BC) describes the technique for measuring rainfall for a location. A circular vessel with a diameter equal to the length of human arm (which is equal to the distance measured by the width of twenty fingers of a human hand) and a depth equal to the distance measured by the width of eight fingers (in modern unit, the diameter and the depth would approximately 38 cm and 13 cm respectively) was used to collect the rainwater. When this vessel was

filled with rainwater collected open space, rainfall was measured to be 50 palas or one adhaka or ¼ drona. An adhaka of rainfall is equal to 1.6 cm rainfall in modern units of measurement and a drona is 6.4 cm. Kautilya gives the amounts of rainfall received in the rainy season over different regions of India (Table 2).

Table 2. Distribution of rainfall during the rainy season in the 4th century BC in India.

| Ancient name of the region | Modern name of the region | Amount of rainfall in ancient and modern units | |
|---|---|---|---|
| | | (dronas) | (cm) |
| Ashmaka | Marathwada | 13 | 83.2 |
| Aratta | Western Maharastra | 13 ½ | 86.4 |
| Avantika | Ujjain city in Madhya Pradesh | 23 | 147.2 |
| Malwa | Western Madhya Pradesh | 23 | 147.2 |
| Aparanta | Konkan (coastal Maharastra) | Unlimited | Unlimited |
| Hilly areas in North | Himachal Pradesh | Unlimited | Unlimited |

The beginning of the rainy season in north west India occur when the sun starts moving south, i,e., after 21 June. The rainy season extended over four months of the Hindu calendar viz., Shravana (August ), Bhadrapada (September ), Ashwin (October) and Kartika (November). Kautilya predicted excellent crop production if one third of the total rainfall is received in the first and the last months and two third in the intervening two months during the four moths of rainy season. Continuous rains for seven days, 80 days showering drops and sixty days intermittent showers alternating with sun shine were considered even and beneficial.

## *Varahamihira's Brihat Samhita on weather forecast*

In Brihat Samhita, Varahamihira devotes eight chapters to the science of forecasting rain. Weather forecast can be made with considerable accuracy only on the basis of observing process taking place in the Sun, which in their turn, are correlated to certain planetary juxtapositions. Changes in the weather are associated with the Sun, the Moon and other planets under certain conditions of positions, either when they act alone or in combination. Varahamihira had dealt the sunspots and their effects on earth. Periods of very heavy rainfall (flooding) also coincide with sunspot maxima. The appearance of these spots would bring thunderbolts, earthquakes and such unusual phenomena boding calamity. Every 11 years or so there are great bursts of solar activity. During the maximum periods, there is an acceleration of the "earth's heartbeats" causing a larger number of

earthquakes. Sunspots also cause the eruption of violent winds releasing charged corpuscles, which cause terrestrial magnetic storms. Sun's disc spot is in the form of wedge, there will be famine. The solar wind is more 'gusty' around the time of maximum solar activity. When the Sun is more active, producing flares and spots, the solar wind contains more high-speed streams. And these high-speed streams are very likely to affect the weather on the earth. Directs evidence linking sunspots and the weather comes from records of the occurrences of storms and lightning. The annual lightning incidence (which is a measure of the number of lightning flashes occurring in a given area each year) closely follows the mean sunspot index.

## *Principles of Astro-meteorology*

The Hindu astrological method of predicting rainfall a scientific method spread over a period of at least six months observation stage by stage. There is a need to study the garbha dharan (impregnation) of the clouds towards the fag end of Dakshninayan (July 17 to January 13) on the particular day when the when the moon enters a particular constellation (or nakshatra) this should be done to predict rains during the Indian monsoon. Similarly, for winter rains the garbha dharan is to be observed in the Uttarayana period (January 14 to July 16).

The following principles are being given for rainfall predictions:

**Principle No. 1:** According to **Varahamihira**, the formation of clouds or pregnancy of clouds or 'Garbha Dharana' takes place 195 days before their fall or birth or delivery or 'Garbha Prasava'. There are actually twenty seven nakshatras (constellations) for the purpose of astro-meteorology. Apart from these, the twenty eighth nakshatra 'abhijit' is also allotted a space towards the end of Uttarashadha. (no.21)

## *Sapta Nadi Chakra and its relation with rain occurrence*

| **Seven nadis** | **Nakshatra or asterism or constellation** | **Effect on weather** |
|---|---|---|
| Chandanadi, Prachand, (Fierce) | Krittika (3), Vishakha (16), Anuradha (17), Bharani (2) | Bright sunshine, No rainfall |
| Dahananadi or Vatanadi or Paman | Rohini (4), Swati (15), Jyeshta (18), Ashivini (1) | Sunshine and wind, Normal rainfall |

| | | |
|---|---|---|
| (windy) | | |
| Vayunadi, Vanhinadi, Dahan (hot) | Mrigashira (5), Chitra (14), Mula (19), Revati (27) | Strong hot wind (Westerlies) |
| Soumyanadi (weather changes) | Ardra (6), Hasta (13), Poorvashadha (20), Uttaraproshthapada (26) | Normal rainfall |
| Neeranadi (good rain) | Punarvasu (7), Uttarphalguni (12), Uttarashadha (21), Poovaproshthapada (25) | Very good rainfall |
| Jalanadi (better rain) | Pushya (8), Poovaphalguni (11), Abhiit, Satabhisha (24) | Abundant rainfall |
| Amritanadi (best rain) | Ashlesha (9), Magha (10), Sravana (22), Dhanista (23) | Heavy to very heavy rainfall causing flood |

**Planets and Nadi's impact on rain during winter solstice (Dakshinayana)**

| **Planets** | **Nadi** | **Effects on weather** |
|---|---|---|
| Sun, Mars, Saturn | Saumya | Ordinary rain |
| Jupiter, Venus, Mercury, Moon | Saumya | Good rain |
| Jupiter, Venus, Mercury, Moon | Vayu, Chada, Dhana | Ordinary showers |
| Sun, Mars, Saturn | Vayu, Chada, Dhana | No rain |

There are actually twenty seven nakshatras (constellations) for the purpose of astro-meteorology. Apart from these, the twenty eighth nakshatra 'abhijit' is also allotted a space towards the end of Uttarashadha. (no.21)

**How Asterisms Regulate Weather:** Aswini, Krittika, Rohini, Purvabhadra, Uttarabhadra, Anuradha, Sravana, Punarvasu, Pushya are masculine; Bharani, Hasta, Chitta, Swati, Visakha, Pubba, Uttara, Aslesha, Makha, Jyeshta, Aridra, Dhanishta, Purvashadha and Revati are feminine; Satabhisha, Mrigasira and Moola are neutral. When the Sun and the Moon are in neutral asterisms there will be winds; when they are in feminine asterisms there will be lightning and phosphorescence; and when the Sun occupies a feminine

asterism, and the Moon a masculine asterism, or vice-versa there will be rains.

***Principle No.2****. When many planets are in one Rashi preferably in one nakshatra, it affects the weather. When many planets gather in one rashi with Mars and Sun joining them and Mars is with Rahu, there can be a terrible downpour even if it is not regular monsoon season. When there is concentration of plants in one rashi. The weather begins to fluctuate and which moon joins them, there will be heavy downpour. Cancer, Pisces and Capricorn are full watery signs; Taurus, Leo and Aquarius are half watery signs; Aries, Libra and Scorpio are quarter watery signs while Gemini, Virgo and Sagittarius are not watery signs. Moon and Venus are full-blown watery planets. During Winter solstice (Dakshinayana) malefic planets (Saturn, Sun, and Mars) transiting through the Amrita, Jala and Neeranadis, would give rise to ordinary rains. If benefic planets transit the above constellations, there will be plenty of rain.*

**Principle No. 3.** Whatever may be the season, there must be weather-fluctuation when Moon joins Venus or when Moon is fifth or ninth from Venus in the rainy season it causes good rain unless there are factors preventing rains.

***Principle No 4****. When Mars transits from one Rashi into another within two days there is a perceptible change in weather and in the rainy season there must be a good rainfall. Mars is the most powerful planet causing rainfall.*

***Principle No. 5.*** *Similarly when a major planet (such as Jupiter, Saturn, Rahu and Ketu into a fiery, earthy, watery or airy sign) changes a Rashi, it causes momentous events. In case of weather, it must cause a very noticeable change in weather.*

***Principle No. 6****. When planets retrograde and on the days they direct there is a change in temperature, humidity and what the meteorologists describe as "disturbance" causing rainfall, etc.*

**Principles are used to predict the dates / occurrence of rainfall in India:**

a) After the sun has entered Mrigshira nakahatra towards the end of nay the south-west monsoon begins to strike Kerala coast. When sun enters Ardra (22-23$^{rd}$ june) every year monsoon advance towards northern India.

b) When sun reaches and crosses six degrees in Gemini, the monsoon arrives in North India (around June 22) and when sun reaches ten degrees in Virgo on September 26 the monsoon begins to withdraw in North India.

c) When the sun enters Hasta nakshatra, it causes rain in Bihar, which is known to an average Bihari farmar as Hathiya rain. But by that time monsoon withdraws from the rest of northern India.

d) When the sun enters Chitra, it continues to cause rain in Bihar particularly in north-East India.

e) When the sun enters Swati. It causes some occasional rain otherwise the south-west monsoon withdraws totally, in Indian tradition there is reference to the bird called chatak which supposedly waits for the rain-drop of swati.

f) The moon, in certain positions, 'nakshatras' (constellations / star) joining, with other planets or when aspected by them can cause or hinder rain. Planets will be placed in the nakshatras given above (in the Sapta Nadi Chakra Table).

g) There will be rain when Mercury transits Cancer and join Venus in the north India after August 3.

h) The presence of Jupiter and Venus together in Rohini star shows torrential and untimely down pour of rains.

i) Mars and Rahu together aspected by Saturn causes lightening and cloud bursts.

j) Cyclones on the Andhra Pradesh coast are likely to occur close to periods of sunspot maxima when the planets Jupiter, Saturn, Rahu (Ketu) and Uranus form even loose aspects of Kendra (square) and Samagama (conjunction) between themselves. These indications are strengthened whenever either Virgo or the 12$^{th}$ from it are afflicted.

**Rain gauging:** According to Varahamihira, rainfall should be collected in a vessel whose capacity is an adhaka. An adhaka has been defined as the quantity of rainfall, which falls to the brim of a vessel 20 inches in diameter and eight inches deep. Four such adhakas constitute a drona. If conception of clouds is due to all the five conditions of wind, rain, lighting, thunder and clouds, says Varahamihira, then the quantity of subsequent rainfall will be one drona and this will fall over an area of 400 square miles. If the conception of clouds has been due to wind alone, the resultant rainfall will be three adhakas. If due to lightning, the rain will be nine adhakas. If due to thunder and other factors affecting rainfall, twelve adhakas.

If there is rain on the day on which the Moon asterism is either Hastha or

Poorvasshadha or Mirgasira or Chittra or Revathi or Dhanistha, then on the

corresponding days of the next lunar month, there will be 16 dronas of rainfall.

If there is rain on the day on which the Moon asterism is either Sravana or Makha or Anuradha or Bharani or Moola, then on the corresponding days of the next lunar month, there will be 14 dronas of rainfall.

If the Moon resides in either satbhistha or Jyestha or Swathi, there would be 4 dronas of rainfall on the corresponding days of the rainy seasons. If in Kritthika, 10 dronas; If in Poorvaphalguni, 25 dronas; If in Vishakha or Uttarashadha, 20 dronas; If in Ayslesha, 13 dronas; If in Uttarabhadrapada or Uttaraphalguni or Rohini, 25 dronas; If in Aswini, 13 dronas; If in Aridra, 18 dronas.

If the moon in above asterism suffer from malefics influence either aspect or conjunction, there will be neither rain nor prosperity in the land. If the benefic planets pass through above asterism or the moon in above asterism should remain unaffected by malefics, rainfall would be good.

**Hour of Rainfall:** The very hour of the occurrence of rainfall can also be determined; for, says Varahamihira, clouds 'conceiving' during the day will be delivered at night and clouds 'conceiving' at night will be delivered during the day; clouds 'conceiving' in the twilight of the evening deliver during the morning twilight, and vice-versa. Again, if at the time of conception, clouds have appeared in the east, then at the time of birth, they will appear in the west; and so on with

the other quarters. Similarly, if at the time of conception the wind has blown from the east, then at the time of rain, it will blow the opposite quarter.

## Rain in the Immediate Future

While ancient meteorology can predict rain long in advance, is it no difficult thing to forecast rain in the immediate future. During the rainy season, immediate rainfall is indicated: If the sun at the time of rising is exceptionally bright and red, or If the taste of water is insipid, or the color of the sky or sunset rainbow is seen in the sky, or If salt begins to sweat, or If fish in tanks jump from water on the bank, or If metal vessels emit a fishy smell, or If ants, with their eggs, move from one place to another.

## Forecasting rainfall, floods and weather vagaries

Of the several methods recommended by classical writers for forecasting rainfall, floods and weather Vagaries, the most important ones are: (a) the lunar new year chart,(b) time of pregnancy of clouds, (c) entry of the Sun into the constellation of Aridra, (d) Sun's entry into Capricorn, (e) Rohini, Swati, and Ashadha Yogas, and (f) mutual dispositions of planets at a given time.

### Effect of Planets on weather parameters

The Sun in contact with Mercury gives windy spells. Similarly, Sun + Venus gives rain or snow; Sun + Mars gives warmer climate according to the season; Sun + Jupiter gives dry or drought; Sun + Saturn gives colder than normal in the season; Sun + Rahu gives local storms and Sun + Ketu gives very changeable climate within a short space of time.

According to Garga and other sages, the clouds become pregnant from the day the Moon reaches the constellation of Poorvashadha in the bright half of the lunar month Mirgasira (about 3$^{rd}$ November week each year).

While the Moon's varying distance from the sun, i.e., lunar day or *tithi* is a potent factor in weather changes, there is overwhelming evidence that the major planets have a powerful influence over atmospheric eventualities.

Many tropical storms have whirled to hurricane intensity on the three days centered at new Moon and full Moon. Heavy rain occurred most frequency about four days after full Moon and reached a secondary peak about four days after new

Moon. In other words the greatest amount of rain fell when the Moon is either 45 or 225 degrees from sun.

A clear correlation persists between the movements of the Moon and variations in quantities of rainfall. When a planet enters Cancer it well influence the weather more in the northern hemisphere while the southern hemisphere is more influenced when planets enter the sign Capricorn.

Mars and dry weather: Coming to the planet Mars, it raises the temperature, causing a dryness in the weather, especially when in Aries. Mars in conjunction with Jupiter exerts a disturbing effect on the weather, and storms of rain and thunder occur during the rainy season. Thunder, lightning and inundations are the outcome of Saturn-Mars influences.

When Mercury and Venus pass the Sun, usually wet and windily weather occurs. The position of the Sun at times of new Moon and season-changes will give the observer a clue as to the type of weather likely during a specified period of time. When Mercury and the Sun are in conjunction during the winter a blizzard or a cold wave occurs. When Mercury and the Sun are in superior conjunction followed by Mercury's conjunction with or opposition to Mars, and Rahu conjuncts Sun, a fast moving cold wave may be brought about. Temperatures may fall rapidly. Mercury and Saturn in mutual aspect may keep the area of rising temperatures limited. An aspect of Venus can bring moist warm air and a promise of moderate to heavy rain or even storms or tornadoes. Venus retrogression or direct motion does not singly affect weather unless it is accompanied by other plantes. A retrograde Jupiter is good for rains. A retrograde Saturn is not beneficial for rains.

How the winds are influenced: Mercury generates acute, sharp and whipping winds; Venus generates sunny weather consistent with the season; Mars gives rise to energetic watery winds and abnormally hot summers, and Saturn's action is frequently related to chronic cloudy skies and abnormal rainfall. Greatest numbers of fires observed at the time of the full Moon.

When the planet Jupiter is in perihelion there is a great drought and likewise when in aphelion there is more dampness and cold weather than usual. The slower moving planets (especially Jupiter and Saturn) exert a telling influence, because of their slow speed and their great masses for a longer period of time.

## *Role of planets on occurrence of rain or flood or drought or famine*

1. When sun is between Venus and Mercury there is a break in monsoon in the sense that for some days there is dry spell.

2. Sun being behind Mars in the rainy season, there will be poor rain or rain is delayed or will create dry spells. When the Sun was overtaking Mars, there will be heavy downpour of rains, causing flood in rivers.

3. Rain will not be timely when all quadrants being occupied by malefics.

4. Mars, affected by other malefics, will create dry spells till August.

5. If Jupiter and Mars are within 30 degrees (thirty degrees) of each other it prevents rains.

6. If the Moon is in the $7^{th}$ from Venus and within view of benefic planets, or be in the $5^{th}$, $7^{th}$ or $9^{th}$ house from Saturn there will be immediate rain.

7. When Venus is in constellations of Swathi, Vishakha and Anusha, unprececedent rainfall results in heavy floods.
8. Famine will break out for want of rains when Venus is in one of constellations from Jyestha to Sravana.

9. There will be drought condition when Venus sets in or retrogrades in makha or Uttarashadha.

10. Clouds become scattered and rainfall disturbed, when the sun, Mars and Venus transit the same sign.If Jupiter joins the above combinations, clouds will deliver rains in plenty.

11. When Jupiter retrogrades in Rohini, the year will have less rainfall.

12. Heavy rain results when Jupiter is in Pisces while Venus is in Cancer.

13. Droughts are noticed when Saturn is unaspected in Aries, Leo or Sagittarius.

14. When Mars and Saturn are in conjunction, rainfall will be very low.

**General signs that bring rain:**

1. Soft, white, deep halo round the Moon or the Sun.
2. Dark colored sky, dark as the crow's egg.

3. Sky overcast with huge, bright, dense clouds.
4. Needle-shaped clouds.
5. Blood-red clouds.
6. Rainbow in the morning or in the evening.
7. Low, rumbling roar of thunder.
8. Lightning.
9. The appearance of the mock-sun; and
10. Planets shine in full form and with soft light.

**Animal behaviour to make medium range forecasts**

The plants, birds and animal behaviour are used to predict medium and short- range forecasts.

i. In the rainy season when the sky is cloudy try to take your pet dog outdoor. If the dog shows a disinclination, it is a sign of coming rain.

ii. See if kites in flock are flying at a height of about 400 ft. It is an indication of rain or storm.

iii. See if any spider has started weaving its web outdoors. It indicates the departure of the monsoon.

iv. Those who are lucky to have some frogs alive Those who are lucky to have some frogs alive and croaking can get the indication from their croaking.

v. The exultant cry of the peacock is an indication of cloud formation.

vi. Early flowing of the gulmohur and amaltas was an indication of a good monsoon.

vii. Rain bird; if the rain bird gives eggs at the ground level then there will be less rain however if the indication of more rains the local people assume that eggs or 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 narrow ends of all the four eggs of rain bird are downwards, and then it is the indication of good rainfall thought out the season.

viii. When the adventitious roots of the banyan tree (*Ficus bangalensis*) start spouting (tillering), then the local people assume that the rains will appear within 2 to 4 days.

ix. when the buds start spouting in castor and ber, then rains will appear

within 10 to 15 days.

x. The rains will appear after 10-15 days of flowing in babul tree (*Acacia nilotica*).

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

**Almanac, Panchang and Krishi-Panchang:**

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 days and a record of various astronomical phenomena, often with weather prognostications and seasonal suggestions for the countrymen". In India, the classical Hindu astrological almanac is known as 'Panchang'. Panchang has been prepared for public use from Vedang Jyotish period 1400-1300 BC. The word 'Panchang' has derived from the Sanskrit words viz., 'panch' and 'ang', which mean 'five' and bodypart / limb' respectively. These parts are 1) Tithi or lunar day; 2) vara or week day; 3) Nakshatra or asterism or constellation; 4) Yoga or time during which the joint motion of the sun and the moon covers the space of a nakshatra and 5) Karana or half of a lunar day or half-tithi.

**Tithi:** The fifteenth day of the bright half is called Purnima, Paurnima, or Paurnamsasi. It is generally considered an auspicious day. The fifteenth day of the dark half is called Amavasya. It is called 'Kuhu' when the Moon is totally absent and 'Sinivali' when the moon is partially absent. It is generally considered an inauspicious day. The fourth, ninth, and the fourteenth days are called 'Rikta', i.e., empty days and are not recommended for commencing any new project.

**Vara:** There are seven days in a week named after the seven principal 'planets' (old concept) viz., Sun, Moon, Mars, Mercury, Jupiter, Venus and Saturn and they are believed generally to posses the characteristics of the respective planets.

**Nakshatra:** Nakshatra are constellations of stars. There are twenty seven (or twenty eight) nakshatras enumerated in a fixed order marking the Moon's heavenly path. Each nakshatra is divided into four padas, or charanas, i.e., quarters. Nine consecutive padas fall in one rashi, i.e., the zodiacal sign.

**Rashi:** Rashis are the twelve zodiacal signs that mark the imaginary or the apparent path of the sun through space. e.g. Mesha (Aries) and Vrishaba (Taurus). The sun takes approximately one month to pass through one sign (and takes thirteen to fourteen days to pass through one nakshatra).

**Rain Forecasting in Indian Almanacs (Panchangs):** According to the Encyclopaedia 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 ad saint's

days and a record of various astronomical phenomena, often with weather prognostications and seasonal suggestions for the countrymen". In India, the classical Hindu almanac is known as 'Panchang'. It is a very important book published yearly, and is the basic book of the society giving calenderical information on daily basis and is extensively used by the people all over India. For astrologers, it is one of' basic books for making astrological calculations, casting horoscopes, and for making predictions. For farmers, it is an astrological guide to start any farming activity. Hence, it is a fundamental book which is referred to by a large section of the people in this country various purposes. The word 'Panchang' has its roots in two Sanskrit words, viz., 'panch' and 'ang', which mean 'five' and 'bodypart / limb' respectively. These parts are: (1) Tithi or lunar day-there are a total of thirty tithis in a lunar month, fifteen in each fortnight; (2) Vara or week day-' there are seven varas, namely, Ravivara (Sunday), Somavara (Monday), Mangalavara (Tuesday), Budhavara (Wednesday), Guruvara (Thursday), Shukravara (Friday), and Shanivara (Saturday); (3) Nakshatra or asterism or constellation - there are a total of twenty seven nakshtras named according to the yogataras 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 a nakshatra (there are twenty-seven yoga) and (5) Karana or half of a lunar day or half-tithi.

**Krishi-Panchang:** Krishi-Panchang or Agro-almanac or Agro-panchang may be defined as “basic astro-agricultural guide book / calendar published annually, giving calendrical information on various aspects of agriculture and allied activities, basically suggesting region-wise, season-wise and crop-wise crop strategy based on astro-meteorological predictions, giving auspicious / inauspicious time for undertaking / avoiding various farm related operations, along with a list of performing religious rites, festivals, observing fasts and some non-astrological guidance, primarily useful for the farming communities and person having interest in agricultural development”.

**Making of Krishi-Panchang:** A *Krishi-Panchang* may be defined as “basic astro-agricultural guide book / calendar (that needs to be) published annually, giving calendrical information on various aspects of agricultural and allied activities, basically suggesting region-wise, season-wise, and crop-wise crop strategy based on astro-meteorological predictions, giving auspicious/inauspicious time for undertaking/avoiding 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".

**Content and coverage proposed:** The *Krishi-Panchang* should be basically different from the present-day *panchangs* in its content and coverage, method and approach of writing, composition of editorial boards, publication, and circulation. The *Krishi-Panchang*, being meant for meeting agricultural purposes, majority of its contents should relate to agricultural information. In addition to this, basic information such as annual date calendar, list of holidays, auspicious days/moments of the coming year should be given for the benefit of farming communities.

The contents of the proposed *Krishi-Panchang* can broadly be categorized in 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 sings
    - Daily/monthly/annual weather forecasting for the particular year
    - Crop prospects of that year based on planetary positions
    - Season-wise crop strategy based on anticipated weather

2. Information which remains same irrespective of any particular year
    - Theories relating to agricultural and meteorological forecasting
    - Auspicious moments for agricultural and allied activities
    - Some general agricultural guidance

In ancient India, success in agricultural operations was determined from the position and movement of heavenly phenomena at the time of commencement of the particular practices. The beneficial or malefic influences were mostly valued at the time of ploughing and sowing. On the basis of position of planets, *nakshatras*, and other celestial bodies at any particular moment, and their influence on both materials as well as non-materials, living as well as non-living, Hindu astrologers (*Jyotishis or Hyotishacharyas*) have written several "*Muthurta Granthas*" (books on auspicious / inauspicious moments) for starting or doing or disregarding any activity (both agricultural as well as non-agricultural). For example: For finding out auspicious moments / days for ploughing of farmalands, astrologers consider the "*Hala Chakra*" or "Ploughing Cycle". According to the cycle, the three *nakshatras* ahead of the *nakshatra* the sun leaves are inauspicious; three *nakshatras* ahead of those are auspicious; next three are inauspicious; next five are auspicious; next three are inauspicious; next five are auspicious; next three are inauspicious; and last three *nakshatras* are auspicious. This completes the cycle of 28 *nakshatras* (Ref: *Muhurta Jyotish Vigyan*; and

*Muhurta Chintaman*). In addition to the above, the "Beejopti Chakra" or "Seed Cycle" should also be considered. According to the cycle, eight *nakshatras* from the *nakshatra* at the position of the sun are inauspicious; in successive order next three *nakshatras* are auspicious; the next (one) *nakshatra* is inauspicious; next three *nakshatras* are auspicious; next (one nakshatra is inauspicious; next three *nakshatras* are auspicious: next one *nakshatra* is inauspicious; next three nakshatras are auspicious; and last four *nakshatras* are inauspicious (Ref.: *Brihat Jyotish Sara*; and *Muhurta Jyotish Vigyana*). Three '*Uttaras' -(Uttarashadha, Uttaraphalguni*, and *Uttarabhadrapada*), *Hasta, Chitra, Swati, Mula, Dhanishtha. Rohini, Mrigashira, Pushya, Anuradha, Ashwini*, and *Magha* are auspicious for crop transplanting and animal trade. Except *Magha* and *Hasta,* all other *nakshatras* are auspicious for irrigation (Ref.*: Mururta Chintamani*).

**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 least 1-2 months before the start of the agriculture year (July-June).

**Methods of rainfall forecasts**

Rainfall forecast is defined as "to tell before hand when" where and how it would rain".
For thousands of years India has been using astrology, study of clouds, examination of winds, observations of nature, animals, plants, birds for medium and short-range forecasts after the examination of the trends of rain astrologically for its overall long range forecasts.

**1. Short range forecasts** are forecasting monsoon rainfall developments, a few hours to 48 hours or 72 hours ahead.

**2. Medium range forecasts** are.. "preparation of scatter diagrams showing dispersal of rainfall classified as abnormal or normal or sub normal during the five-day period subsequent to the period to which the pressure height of a pair of selected stations refer".

**3. Long range forecasts** are issued twice in the year for the entire period of four months June to September and later for the second half of the monsoon season August and September".

**Artificial Rain-making Versus Yagna**

Artificial rain making is the technique of making the already existing cloud cause rain. The ancient Indian Vedic yagna technique is also used to cause rain.

In the 'Yagna', the ash gases released through the burning of certain combinations of wood and other materials during the yagna could result in ice-nucleating hygroscopic particulate matter. In the yagna experiment, the ash from the ingredients were claimed to have similar properties as the common salt used in seeding. Scientists do not believe seeding can be done without the presence of cloud first in that lies their difference with the yagna experiments where it is claimed clouds are first formed and then seeded by nuclei in the ash. (In USA, Red-Indians do rain-making dances and bishops to sprinkle water on fields).

Chemical cloud-seeding is a process for artificial rain-making destroying hail or making fog disappear. The cloud seeding is done with the spray of sodium chloride or silver iodide over the clouds through aeroplane. Chemical cloud-seeding is of two-types-warm clouding and cold clouding. Warm clouding is done in tropical country while cold cloud-seeding is done in hills such as Kerala. For cloud seeding, there must be a good cloud with a thickness of at least one kilometre. The clouds contain hygroscopic nuclei (water-vapour attracting particles) but the smaller nuclei travel faster than bigger ones. If bigger nuclei are introduced in the cloud, they will absorb the smaller nuclei already present. The process of seeding is to

"excite" the bigger nuclei already present the bigger nuclei and make them grow at a higher speed so that they drop down ad droplets of rain.

In *warm- seeding*, which is a process of coagulation, the clouds is seeded by common salt (NaCl) along with soapstone powder to prevent coagulation. The common salt nucleic are bigger than big nuclei and are hygroscopic in nature so they start precipitation and increase the efficiency of precipitation in a cloud from the usual 10 percent to a much higher count. The increase is compared with control cloud and the growth can be observed through radar.

In *cold-seeding* by a sublimating process, the cold cloud is already at a temperature below $0^{o}C$ Even in that state there are two nuclei, one in the ice state and the other in the water state at different pressures. The water nucleus, which is at higher pressure, goes over the ice nucleus. So here ice nucleus is introduced by seeding with silver iodide in a liquid state.

## Chapter 08 SOIL CLASSIFICATION, MAINTENANCE OF SOIL PRODUCTIVITY AND WATER MANAGEMENT

Physically, India may be divided more or less into three main regions v*iz*. (1) the mountainous borders of Himalayas in the north and of the Vindhyas in the south with the linings of Ghats in the south-eastern and south-western coasts and the traverse range or Aravalli hills; (2) the Deccan plateau or table land; and (3) the plains or low-lands, a rich Indo-Gangetic alluvium overflown by the rivers-the Ganges, Jamuna and Brahmaputra. Although primordial mountains remained inaccessible for human settlement, the foothills have been increasingly brought under cultivation and settlement and the upland valleys striking the Himalayas include some or the most fertile of Indian lowland formations. The whole Indo-Gangetic alluvium consists of rich fertile *soil* and has contributed materially to the growth of civilization.

### The Himalayas

The Himalayas (Sanskrit: hima, 'snow' and alaya, 'abode'), the loftiest mountain system in the world, form the northern limit of India. This great, geologically young mountain arc is about 1,550 miles (2,500 kilometres) long, stretching from the peak of Nanga Parbat in Pakistan-held Jammu and Kashmir to the Namcha Barwa peak in the Tibet Autonomous Region of China. Between these extremes the

mountains fall across India, southern Tibet, Nepal, and Bhutan. The width of the system varies between 125 and 250 miles.

**The Indo-Gangetic Plain**

The second great structural component of India, the Indo-Gangetic Plain (also called the North Indian Plain), lies between the Himalayas and the Deccan. The plain occupies the Himalayan foredeep, formerly a seabed but now filled with river-borne alluvium to depths of up to 6,000 feet. The plain stretches from the Pakistani provinces of Sind and Punjab in the west, where it is watered by the Indus and its tributaries, eastward to the Brahmaputra valley in Assam. The Ganges basin (mainly in Uttar Pradesh and Bihar) forms the central and principal part of this plain. The eastern part is made up of the combined delta of the Ganges and Brahmaputra rivers, which, though mainly in Bangladesh, also occupies a part of the adjacent Indian state of West Bengal. This deltaic area is characterized by annual flooding attributed to intense monsoon rainfall, an exceedingly gentle gradient, and an enormous discharge that the alluvium-choked rivers cannot contain within their channels. The Indus River basin, extending west from Delhi, forms the western part of the plain; the Indian portion is mainly in the states of Haryana and Punjab. The Great Indian, or Thar, Desert, forms an important southern extension of the Indo-Gangetic Plain. It is mostly in India but also extends into Pakistan and is mainly an area of gently undulating terrain, and within it are several areas dominated by shifting sand dunes and numerous isolated hills.

**The Deccan Plateau**

The remainder of India is designated, not altogether accurately, as either the Deccan Plateau or peninsular India. It is actually a topographically variegated region that extends well beyond the peninsula—that portion of the country lying between the Arabian Sea and the Bay of Bengal—and includes a substantial area to the north of the Vindhya Range, which has popularly been regarded as the divide between Hindustan (northern India) and the Deccan (Sanskrit: daksina, “south”).

> Agriculturists in ancient India were quite conscious of the nature of soil and its relation to the production of a specific crop of economic importance. The vast knowledge acquired by experience has been handed over from generation to generation. The available information collected from some eminent authors and from translation of old Sanskrit manuscripts is given below:

Rigveda identified productive and non-productive soils.

1) R. Gangopadhyay, in his book on ***"Some Materials for the Study** of **Agriculture and Agriculturists in Ancient India"*,** 1932, has given an account of 'Soil and Classification' as follows: "According to fertility, soil is mainly divided into two classes; *urvara* (fertile) and *anurvara* or *usara* (sterile). *Urvara* mrttika is again sub

divided into different kinds according to their peculiar fitness for the cultivation of different kinds of crops; for instance, the soil fit for barley, for sesamum, *urihi* (rice), *mung,* etc. *Anurvara mrttika* (Sterile) is also sub-divided into *usara* (salt ground) and *maru* (desert). The soil watered by river and that watered by rain are respectively called *nmdimrttika* and *deva-mrttika*.

2). Prof. G. P. Majumdar in his excellent translation of '*Upavana Vinoda*' published in 1935 by the Indian Research Institute, Calcutta, has shown that more elaborate attention was paid to the topic of classification of soils with characteristic flora in Charaka. The following excerpt is from the work of Prof. Majumdar. Charaka divides land into three classes, namely, arid (*Jangala),* wet (*Anupa*) and moderate, i.e., (neither too wet, nor too dry) *Sadharana* regions according to the nature of the soil (edaphic conditions) and climatic conditions). The land is again distinguished to be of six kinds each *from* its colour viz., black, pale, dark red, white and yellow and taste viz., sweet, sour, salt, pungent, bitter and stringent. The land which is vitiated by poison, stones, white-ants and holes (of vermin), or is saline or gravelly or has underground water too deep, is not good for the planting of trees.

i) Jangala Region (barren): The region called Jangala is full of unobstructed open spaces, where a steady and dry wind blows, pervaded with expansive mirages, rivers and rivulets scarce, abounding in artificial wells, also abounding in dry and rough sands and big sandy particles (kankars). This region presents a flat surface, and whose dull monotony is enlivened here and there by scanty growths of thorny shrubs, and tops of a few isolated hills, and in which the waters from springs and wells, accumulated during the rains, become nearly drained and strong gales of warm wind blow (during the greater part of the year).

ii) Anupa Region (literally marshy, or swampy and watery-plants littoral, or inland): "Mostly abounding in rivers and bordered by seas, swept by cold wind, i.e., charged with abundant moisture. Mountains are absent from this region. The land is covered with dense forests. This region contains a large number of pools, and is wooded and undulated with chains of lofty hills traversing its area, and which is impassable owing to its network of rivers and sheets of accumulated rainwater rippling before the currents of the gentle humid air.

iii) Sadharana region (ordinary plants -mesophytes): Charaka says that "the region which is endued with creepers, and plants and trees.

3). Kautilya in his '***Arthasastra'*** mentioned that lands on the banks of rivers are suitable for growing valliphala (pumpkin, gourd and the like); lands that are frequently over flown by water (parivahanta) for long pepper, rapes (mrdvika) and sugarcane; the vicinity of wells for vegetables and roots, ow grounds (hariniparyantah-moist bed of lakes) for green crops; and marginal furrows between any two rows of crops are suitable for the plantation of fragrant plants, medicinal herbs, cascus roots.

4). The Sage Kashyapa in ***'A Treatise on Agriculture'*** has given a division of the earth, according to its fitness for particular crops into hilly, river and stream irrigated, forest and pasture land etc. The land *(Bhumi*) should be clean, free from pieces of bone and stone, husk and glass, be amended to *kusa kasa* which are wild grasses, and its soil soft, strong, cohesive and moist, slightly reddish and dark in colour. Its surface should be level, without pits, chasms or mounds and the soil should emit the pleasant smell of jasmine, wine, or lotus or blossoms of date-palm or tinisa *(Dalbergia ujjeinensis)*. It may not be surcharged with water or may be watery at all times. It should be conducive to the rapid sprouting of seeds and be easy to plough. It may be covered with the cud of bulls *(Vrsa phena)* and may abound in (beneficent) beasts and insects. It should be compact, solid, heavy in weight fit for the luxuriant growth of herbs, and free from brambles and dry dung, etc. Land should have clear water and fertile soil both at the surface and deeper down. It should be pleasing to the eye, free from white ants and vermin and depredatory beasts but should harbour (beneficent) beasts and birds. It should not be exposed to storms, whirl-winds and wild fires. It should have an inexhaustible supply of underground water and should be favourable to the plantation of gardens and orchards and to the growth of thick shady trees and all sorts of seeds. It may have slight depressions, be soft to touch and be good for (the grazing of) cows and cattle. The soil should be suitable for digging wells and for the percolation of water. These are some of the good qualities of land in spite of some defects here and there like the patches of waste or desert land. The earth which is of uniform colour and tinge, compact and smooth is considered to be excellent by gods, kings, sages, Brahmanas and Vaisyas and, on account of its good qualities, is conducive to the prosperity and welfare of all. It promotes the health of the families and the growth of wealth, cattle and grain.

The Sage Kashyapa advised that the king should appoint officers to search and acquire the best land who know the way to scrutinize the (quality of the land). They should be equipped with the required eligibility. Either in the morning or in the evening (for the purpose of purifying the atmosphere) the land should then be sprinkled with the fivefold cow-products (milk, curd ghee) (clarified butter), urine, and dung) or may be simply with clean water, by Brahmins proficient in Vedas. This is known as 'Panchakowia'. Kashyapa divided the agricultural land into two categories: **shalibhu** (=land fir for rice cultivation) and **adhakadibhu** (=land suitable for cultivation of pulses and other grains). The wet lands for paddy fields, named variously *Shuli Bhumi, ala Bhumi* and *Sasya Bhumi,* and (2) Dry lands called Adhaka bhumi, Tara bhumi and *Usua bhumi*. Lands have also been classed according to their suitability for particular crops.

**5) Examination and classification of Land:** The classification and examination of lands as suggested by Shri Misra Cakrapani in "Visva-Vallabha" are described below: Land is of three kinds, viz., arid, wet (i.e., marsh) and moderate (i.e. neither too dry nor too wet). and is distinguished by six tastes, which can be known from the colour of the soil. Gray coloured, pale-white, black, white, red and yellow soils are sweet, sour, salt, bitter, pungent and astringent in taste respectively accord-

ing to the ancient tradition. Land that is littered with ant-hills, pits and stones is saline and gravelly and has water at great depth. It is poisonous as far as the planting of trees, etc. is concerned. In a region where trees and plants are blighted with frost and in a place littered with stumps, a garden should not be laid. Land in which the water is near the soil and is soft is best suited for planting trees.

**6) Krisi-sukti a comprehensive book on "Agriculture Science" attributed to Kasyapa** classified the land into (1) wet lands for paddy fields, named variously *Shuli Bhumi, ala Bhumi* and *Sasya Bhumi,* and (2) Dry lands called Adhaka bhumi, Tara bhumi and *Usua bhumi*.

7). The **Amarkosha** (c. 400 BC) described 12 types of lands in its chapter on Bhumivargha, depending upon the fertility of the soil, irrigation and physical characteritistics. These were urvara (fertile), ushara (barren), maru (desert), aparahata (fallow), shadvala (grassy), pankikala (muddy), jalaprayah (watery), kachachaha (land contiguous to water), sharkara (full of pebbles and pieces of limestone), sharakaravati (sandy), nadimarruka (land watered from a river), and devakarruka (rainfed). In the chapter on Vaisyavargaha, soils based on suitability for specific crops are mentioned. For example, Vraiheyam (Vrihi rice and corn), shaleyam (Kalama rice), yavyam (awned barley), yavakyam (awnless barley) tilyam (sesame), mashyam (blackgram).

8) Literature (200 BC to 100 AD) of Tamils in Southern India provides information on soil types (Bedekar, 1993). For example, in Tholkappiyam, written by a poet named Tholkappier (200 BC) for four types of land are mentioned. These are kurinji (hills), mullai (Forest), marutham (cultivable) and neithal (coastal land).

9) Surapala's Vrikshayurveda (c. 1000 AD) (Sadhale, 1996) mentions three types of land – jangala (arid) anupa (marshy), and samanya (ordinary)-further subdivided by colour into black, white, pale dark, red and yellow and by taste into sweet, sour, salty pungent, bitter, and astringent. Samanya land was considered suitable for all kinds of trees.

It is important to note that one of the most sustained land use practices, since the days of Kautilaya, has been the use of river beds for raising cucurbits throughout India.

7. In ancient works of Silpasastra of Visvakarman (architecture) [2] and in Kautilyas Arthasastra [3] as well as in Vasahamihira,s Brahat samhita [4] we come across sections dealing with agriculture, gardening and town-planning. in the Atharva Veda too, there are prayers for the sweet and juicy fruits of trees and creepers [5] Many ancient sages like Kasyapa, Gargya, and Parasara as well as medieval scholars like Cakrapanimisra, Surapala and King Somadeva III of the Chalukyan dynasty, have written on this subject. In the Ratnavali [6] there is the famoua verse, 'uddamokalikam, which speaks of the wondful appearance of abundant flowers on

the kings jasmine creeper as a result of the application of a Dohada, fertlilizer, supplied by a hermit There is also the case of the Dohadas coming under what are aclled "Kavisamayas" of poetic conventions. [1] As mentioned above, the subjects of Dohada is often met with in Sanskrit literature. In the Naisadhiyacarita of Sarharsa (12th cenrury A.D) who was well versed in many branches of learning, there is the reference to the fertilizer used for the pomegranate: while explaining the word Dohada-dhupini the commentator Narayana says that Dohada or fertilizer was fumigation. Dohada is that material evolved by competent persons for producing flowers etc., on trees, bushes, creepers and the like out of season" the next two verses of pomegranates the best procedure is to pour on the tree the liquid of mutton and to fumigate it by burning sheep's wool and mutton underneath. If the same tree smeared with a paste made of fish meal, ghee and Triphala as well as with the flesh of goats and sheep, and fumigated with the matter, its fruits will be big as those of the Tala tree.

***8. Soil types of India****: The investigations of Voelcker in 1893, and those of Leather in 1898, led to a classification if India soils into four major types and three minor types: (i) the Indo-Gangetic alluvium; (ii) the black cotton or regur soils (iii) the red soils lying on metamorphic rocks; and (iv) the lateritic soils.*

**i) Indo-Gengetic Alluvium:** The Indo-Gangetic alluvium is by far the largest and most important of the soil groups of India. The soils of this group cover about 777,000 square kilometers They are distributed mainly the Punjab, Haryana, Uttar Pradesh, Bihar, Bengal and parts of Assam and Orissa. They produce bumber crops of wheat and rice. Geologically the alluvium is divided into (i) *Khadar*, or new alluvium of sandy composition, generally light in colour, about 10,000 years old, and (ii) *Bhangar,* or the older alluvium. of Pleistocene elate, of more clayey com-position, generally of dark colour, and fun of pebbles or *kankar.* The soils differ in consistency from drift sand to loams, and from fine silts to stilts clays. A few pebble beds are also occasionally met with. The presence of imper-vious clays obstructs the drainage, and also promotes the accumulation of injurious salts of sodium arid magnesium, which make the soils sterile. The formation of hard pans at certain levels in the soil profile as a result of the binding of soil grains by the infiltrating silica or calcareous matter is often observed in these alluvial soils. A majority of the soils

are loams or sandy loams, with a soil crust of varying depth. Soluble salts are present in considerable quantities.

The alluvial soils of Tamil Nadu are transported soils, found mainly in the deltaic areas and on the coastal line, A section of the profile shows alternate layers of sand and silt, The composition of the strata varies with the nature of the silt brought by the rivers which, in turn, varies with the catchment areas and the tracts through which the streams flow.

ii) **Black Cotton Soils:** The typical soil of the Deccan Trap is the *regur* or black cotton soil. It is common in Maharashtra, in the western parts of Madhya Pradesh, Karnataka, and 'some parts of Tamil Nadu, including the districts of Ramnad and Tinnevelly in the extreme south, It is comparable with the chernozems of Russia and with the prairie soil of the cotton-growing tracts of the United States of America, especially the black adobe of California. It is derived from two types of rocks: the Deccan and Rajmahal Trap, and the ferruginous gneisses and schists occurring in Tamil Nadu under semi-arid conditions. The former attains sometimes considerable depths, whereas the latter are generally shallow. The black soil areas have, generally, a high degree of fertility, though some mainly in the uplands are of low producivity. The soils on the slopes and the uplands are somewhat sandy, but those in the broken country between the hills and the: plains are darker, deeper and richer, and arc constantly enriched by deposits washed down from the hills.

iii) **Red Soils:** Red soils extend practically over the whole Archaean basement of Peninsular India, from Bundelkhand to the extreme south, covering 2,072,000 square kilometres, embracing south Bengal, Orissa, parts of Madhya Pradesh eastern Andhra Pradesh Karnataka, and a major part of Tamil Nadu. These soils also occur in Santhal Parganas in Bihar, and in the Mirzapur, Jhansi and Hamirpur districts of Uttar Pradesh. They were produced as a result to meteoric weathering of ancient crystalline and metamorphic rocks. These soils started developing around the Mesozoic and Tertiary ages. The colour if these soils is generally red, grading sometimes into brown chocolate, yellow; grey and even black. The redness is due more to a general diffusion than to a high proportian of iran content. The soils grade from the poor thin gravelly and light coloured varieties of the uplands to the much more fertile deep dark varieties of the plains and the valleys. They are generally; poor in nitrogen phosphorus and humus. Compared with regur, they are poor in lime, potash and iron oxide, and are also uniformly Low in phosphorus The clay fraction of the soils is rich in kaolinite. More than two-thirds of the cultivated area in Tamil Nadu is covered by red soils they are in-situ formations produced from the rock below under the influence of climatic conditions. The rocks are acidic, consisting of mica or red granites. The soils are shallow and open in texture. They have a low exchange capacity and are deficient in organic matter and plant nutrients.

**iv) Laterites:** Laterite is a soil type peculiar to India and some other tropical countries, characterized by the intermittent occurrence of moist climate. In formation it varies from compact to vesicular rock composed essentially of a mixture of hydrated oxides of aluminium and iron with small quantities of manganse oxides, titania, etc. it is produced by the atmospheric weathering of several types of rocks. Laterites occur in Madhya Pradesh, the coastal region of Orissa, south Maharashtra, Malabar and part of Assam. All lateritic soils are generally very poor in lime and magnesia and deficiant in nitrogen. Occasionally, the $P^2$ $O_5$ content may be high, but there is deficient of $K_2O$. In Tamil Nadu, there are both high-level and low–level laterites which are formed from a variety of rock materials under certain climatic and weather conditions. The laterites at lower elevations grow rice whereas those at higher elevaions grow tea, cinchona rupper and coffee. The soils are rich in nutrients and contain 10 to 20 per cent organic matter.

v) **Forest and Hill Soils:** The soil formation is governed mainly by the character of the deposition of organic matter derived from the forest growth. Broadly, two conditions of soil formation may be distinguished: (i) soils formed under acid condition, with acid humus and low base status, and (ii) soils formed under slightly acid or .neutral condition with high base status, which is favourable to the formation of brown earths. Forest and Hill soils occur in Assam and in Uttar Pradesh, the Sub Himalayan tract comprises three distinct parts viz. *bhabar* area immediately below the hills, *tarai* and the plains. The *tarai* areas are characterized by extreme unhealthiness owing to excessive soil moisture and prolific growth *of* vegetation. The soils in Coorg has deep surface soil of great fertility, as it receives annually the decomposed products of the virgin forest. The areas towards the west are for the greater part reserved under forests and mountain areas. The land surface is full of pebbles, is easily drained, and has a laterite bed

**vi) Desert Soils:** A large part of the arid region *of* Rajasthan and the Punjab and Haryana, lying between the Satluj and the Aravallis, is affected by desert conditions, which geologically are *of* recent origin. This part is covered under a mantle of blown sand, and is dominated by conditions, which inhibit soil growth. Some of the soils contain a high percentage of soluble salts and varying

percentages of calcium carbonate, and possess high pH. They are, however, poor in organic matter. Reclamation is possible only if proper irrigation facilities are made available.

**vii) Saline and Alkaline Soils:** These soils are extensively distributed throughout India in all the climatic zones. These soils occur in Bihar, Uttar Pradesh, the Punjab, Haryana and Rajasthan. The injurious salts are confined to the top layers, being deposited there by the capillary transference of saline solutions from the lower strata. It has been estimated that nearly *850,000* hectares in Uttar Pradesh and over *200,000* hectares in the Punjab and Haryana have been affected by *usar*. Over 10,000 hectares are being affected every year in the Punjab and Haryana. Alkali soils are met with all over Maharashtra.

**MAINTENANCE OF SOIL PRODUCTIVITY**

Manures: Importance of manures in obtaining high crops yields was fully appreciated in ancient India. In Krishi-Parashara, it is stated that crops grown without manure will not give yield and a method of preparing manure from cowdung is described. Kautilya mentioned use of cowdung, animal bones, fishes, and milk as manure. Agnipurana recommends application of the excreta of sheep and goat and pulverized barely and sesame allowed to be soaked in meat and water for seven nights to increase flowering and fruiting of trees. In Varahamihira's Brhat Samhita growing of sesame to flowering stage and then incorporating it as green manure is recommended. The *Abhilasitarthacintamani* mentions a few such fertilisers - 1) the soil underneath a tree struck by lightning is good for warding off trouble for trees from snowfall. 2) Fumigation of trees by burning turmeric, Vidanga, white mustard, flowers of the Arjuna tree, mixed with fish and the flesh Rohita (a kind of deer) will not only help the growth of flowers and fruits but will destroy all worms and insects as well as diseases. Surapala (c. 1000 AD) describes the 'ancient' practice of preparing liquid manure (kunapa) prepared by boiling a mixture of animal excreta, bone marrow, flesh, and dead fish in an iron pot and then adding to it sesame oil cake, honey, soaked black gram, and a little ghee (or clarified butter). No fixed quantities of materials were required to prepare 'kunapa'. This liquid manure was mainly used in raising trees and shrubs. Traditional agriculture practised in the Himalayas regions of the sub continent involves used of green leaf manure as the main fertilizer for the rice crop. Surapala and Sarangadhara recommended the use of kunapa for properly nourishing trees. The preparation of kunapa is described by Sarangadhara as follows: "One should boil the flesh, fat and marrow of deer, pig, fish, sheep, goat, and rhinoceros in water and when it is properly boiled one should put the mixture in an earthen pot and add into the compound milk, powders of sesame oil cake, masa (black gram) boiled in honey, the decoction of pulses, ghee, and hot water. There is no fixity as to the amount of any of these elements; when the said pot is put in a warm place for about a fortnight, the compound becomes what is called kunapa water which is very nutritious for plants in general". Prior to Sarangadhara, Surapala had referred to kunapa and ingredients included excreta, bone marrow, flesh, brain, and blood of boar mixed with water and stored underground. Surapala

also referred to "available" materials and these could be animal fat, marrow, and the flesh of fish, ram, goat, and other homed animals. Other materials were more or less the same as mentioned by Sarangadhara, except that quantities of ghee and honey indicated were small. It should not be difficult to standardize and prepare kunapa water concentrates on mass scale and make these available in jars to users. Here is an opportunity for an enterprise to help farmers, especially the orchardists. Firminger (1864) who was a "Chaplain of the Bengal Establishment" mentions beneficial use of "liquid manure", prepared the way Kunapa was prepared, for vegetable cultivation. He has given no information about who first thought of liquid manure".

**Green leaf manures:** Farmers relied extensively on crop residues legumes and neem for enriching the soil fertility. Ancient Tamil texts, widely quoted the use of *Calotropis giganta*, *Morinda tinctoria*, *Thespesia populnea*, *Jatropha gossypifoila* and Adathoda sp. to be used as green leaf manure. Crop rotation and intercropping were practiced to restore soil fertility. Fauna such as ants, earthworms and frogs were used to improve soil physical properties. Composting practices have also been documented in ancient literature on ideal farming practices. The farmers of Tamil Nadu manure the soil with farmyard manure (FYM), oil cakes, compost and green manures or green leaf manures is an age-old practice.

Recycling of nutrients through pond excavation was achieved through tank silt or pond excavation in the foothill zones. The sediments from ponds coming from open spaces, field, etc., during the monsoon. The sewage slurry and dissolved minerals and nutrients in water coming from animal sheds and household washings are also diverted to the common village pond. All the flocculated clay and organic materials usually settle quickly to give clear water of the pond. Animals used to drink water from this pond. As soon as the ponds dry up in summer season, the farmers dig the pond base by lifting the soil and transport it to the fields. The surface layer of pond base usually removed is about 30 cm depth. This is a rich source of plant nutrients. The application of pond sludge to each field is done once in a span of 10-15 years. Tank silt increases clay content in light textured red soils which helps to increase soil moisture content and finally he crop yield. In Coimbatore district farmers apply tank silt to crops like banana turmeric and jasmine where as in Ramanathapuram farmers apply it to rice @ 25 t/ha. The excavation of pond basin and its application to field was abandoned with the introduction of chemical fertilizers. Farmers excavate ‘murrum’ a uppermost weathered basalt rock and apply to the fields.

The compost becomes ready to use in five to six months. This partially decomposed farmyard manure after spreading evenly in the field is worked into the soil by ploughing followed by planking.

| Crop<br>Straw | Grain to<br>Straw ratio |
|---|---|
| Rice | 1:1:5 |

| | |
|---|---|
| Pearl millet | 1:2:0 |
| Maize | 1:1:5 |
| Cotton | 1:6:0 |
| Wheat | 1:1:5 |
| Barley | 1:1:5 |
| Mustard | 1:2:0 |
| Pulses | 1:1:0 |
| Sugarcane | 1:0:2 |

Penning of sheep, goat, cattle and pig in the fallow fields is common. One or two fields by rotation are kept fallow to receive the animal dung and urine during summer ad well as winter months. Large herds of sheep, goat and cattle are kept in the fallow fields. The farmers used to feel obliged and usually come with a request to cattle herd owners for the night stays at their farm land. The litters of sheep get well mixed with soil during the period of penning. Light cultivation before the onset of monsoon makes it more effective. Sheep feed on the existing farm residue and drops litter in the same field during resting period. The excreta of sheep is acidic in reaction. On each piece of land, penning is continued for 2 to 4 days depending on the size of the flocks to gather or accumulate sufficient manure to improve the fertility status of the soil.

Rishi–krishi method of Vermiculture: The Amrit pani consists of 250 g ghee from cow milk + 500 g honey + 200 litre water + 10 kg cow dung. Firstly, ghee is mixed with cow dung thoroughly followed by honey and then water is added to it. Farmers collect 25 kg soil from the base of banian tree which is sufficient for sprinkling well–prepared Amrit pani on an acre uniformly. Normal earthworm count in an acre gets double (87120) due to enhanced energy and congenial soil environment. If the weight of one worm is 20 g which eats about the same quantity of soil, in 100 days, one worm can excrete 1kg excreta. Then 87 thousand worms will excreta 87 tonnes of excreta rich in mineral nutrients, organic carbon, microbial population, organic acids, growth hormones and growth promoting substances.

Dead animals (pet or domestic) were buried under the fruit trees such as mango tree. The dead animal contains large amount of biomass, mineral matter in the form of structure and bones specifically nitrogen in protein, phosphorus in bones etc.

Crop rotation helps in efficient use of nutrients. Farmers usually change crop rotation in every three or four years to have a better growth and performance of the cropping system. Stubble mulching is common in the high rainfall areas. Mulching raised the organic matter and nutritional status of soil.

## WATER MANAGEMENT

(Water management-water harvesting-storage-distribution and relevance to modern agriculture)

Rain is essential for cultivation and the latter is essential for life, so one should first acquire carefully the knowledge about rainfall. Over a large part of the country rain has always been unequally and irregularly distributed and that is why Indian cultivators have sought to supplement the rainfall by digging wells and conserve it by tanks and storage reservoirs.

**Ancient Irrigation:** Archaeological investigations in Inamagaon in Mahrastra, India (1300 BC), revealed a large mud embankment on a stone foundation for diverting flood water from the Ghod river through a channel. Rigveda mentions irrigation of crops by river water through channels as well as irrigation from wells. In the Rigveda, the word "well" frequently occurs (videante) and is described as "unfailing and full of water". Water was raised from the well by means of a wheel, a strap and water pails, and also perhaps by buckets tied by rope to one end of a long wooden pole, working about a fulcrum near the other end that carried a heavy weight. The same old crude method is still prevalent in some parts of Northern India. Another method largely employed is to raise water by a small canoe tied by four strings-two at each side and worked between two men standing on a wooden platform projecting over a shallow reservoir. The canoe is swung to and fro, and at each end of the swing, water rises and pours out into the main channel. Macdonell and Keith find clear references to artificial water channels used for irrigation as practised in the times of the Rigveda and Atharvaveda.

## References in epics, arthasastra, law-books and jatakas

Narada enunciates, "No grain is ever produced without water, but too much water tends to spoil the grain". An inundation is injurious to crops and drainage has to be provided. Definite sources from which water can he had on earth are the canals, wells, lakes, reservoirs, etc,. During the season of clouds rainfall is certain either accidentally or through the will power of the sages. The rain water 'poured down by clouds in rainy season should be stored by the king in ponds, reservoirs, etc., for the benefit of the people, and preserved by him with special care; for agriculture so1ely depends on water. Therefore all the water that can be gathered in the (rainy) season should be well preserved both by the kings as well as other prominent persons-this is the injunction of the great sage Kasyapa. Arthasastra of Kautilyas refers to sluice gates of tanks and mentions that 'persons letting out the water of tanks at any other place other than their sluice gate shall pay a fine of six

panas' and persons who obstruct the flow of water from the sluice gate of tanks shall also pay the same fine. It is further satated that ' the water of a lower tank, excavated later on, shall not irrigate the field already irrigated by a higher tank and the natural flow of water from a higher to a lower shall not be stopped, unless the lower tank has ceased to be useful for three consecutive years. Costs were levied on irrigated water regardless of the source. About the same time, 4th century BC, the large Sudarshan lake was constructed in Gujarat and it was subsequently provided with conduits. In western India, the tradition of constructing tanks for irrigation continued throughout the ancient period. Buddhist literature (500-300 BC) provides evidence of building small tanks for irrigation (Randhawawa, 1980).

Extensive tank irrigation systems were developed in Sri Lanka and southern India during the first two centuries of the Christian era. Availability of irrigation made it possible to extend cultivation of rice to large areas, and thus improve food security. Sri Lanka knowledge of tank irrigation technology was most advanced. They could build large tanks and control release of water by 3rd century BC (Brohier, 1934). It is most likely that the contemporary and subsequent kingdoms in southern India got the benefit of Sri Lanka expertise in building tanks. The philosophy about the efficient 12th century Sri Lankan king. He stated, " In such a country, let not even a small quantity of water obtained by rain, go to the sea, without benefiting man". As many as 14 large irrigation tanks existed in the northern half of Sri Lanka in the ancient times.

Topography of the Telangana region of Andhra Pradesh and Karnataka in India is ideally suited for the construction of tanks. A special feature of tanks in Telangana is their construction in series, by bunding the same valley at several points. Surplus water from one tank fed the tank at a lower elevation and so on. In Tamil Nadu, the Chola king Karikala (c. 190 AD) and his successors constructed irrigation tanks off the river Cauvery through canals and several of these exist to this day. For the maintenance of tanks, a committee of villagers called eri-variyam was appointed. The committee ensured repairs and desilting of tanks and distribution of water. During Pallava times (200-900 AD) arrangements were made for their repair and maintenance of building dams, embankments, tanks and aqua ducts in southern India.

Ancient dynasties from Mauryans to Mughals evolved various systems for soil water management such as anicuts, earthern dams field bunds check dams, canals tanks ponds wells and reservoirs. Babur observed two methods of irrigation from wells were with the aid of a wooden Persian Wheel and a leather bucket drawn over a pulley in northern India prior to Arab invasions.

## Locating water table - Keys to the finding of water source

**Chakrapani** in his ***'Visva Vallava'*** has dealt in detail as how one can have an approximate idea regarding water below the surface of different kinds of lands,

based on certain characteristics on the land. Generally water is found near or below a marshy place, at sea side, just by its shore, and in the desert, rocky and mountainous country far deep. From a mountain or from the root of a tree the underground artery (sometimes) goes below into a spring. At some places all the arteries are seen to terminate in caves. While digging if stone-like hard earth is reached and when struck it sounds like a thin slab of stone, then there is sure to be plenty of water beneath it. If in a place devoid of any water reservoir, there is found a rank growth of *Vetasa* (rattan), then there would be an artery of water two cubits below the surface flowing towards the west. If rattan plant is seen growing in a place where there is no pool of water, then three cubits towards the west of that plant an artery of water would be found after digging seven cubits deep. If the tree *Ficus oppositefolia* is seen growing in a place devoid of a water reservoir of any sort, then three cubits towards its west there will be found an artery of water two and a half man-lengths below the surface of the earth. (Note: Purusa is the height of a man with his arm raised, which is 120 digits or 5 cubits). Where there stands an *Udumbarika* tree, there three cubits towards its west will be found a dark artery of water two and a half man; lengths below the surface. If there is an ant-hill towards the north of an *Arjuna* tree, then three cubits towards the west of the tree, water is sure to be found at the depth of three and a half man-lengths. If a *Badari* (jujube) tree stands to the west of an ant-hill, then two cubits towards the west springs of water would certainly be found at the depth of three man-lengths. If there be the plant *Bhargi (Clerodendrum siphonantus)*, *Danti (Croton polyandrum) or Malika* (double jasmine), then there is water towards its south at the depth of three man-lengths.

## Locating water in arid areas

Agriculture in India mainly depended on rainfall since ancient times. People knew that much of the rain water percolates through the soil and flows under ground through aquifers. Observations about ground water and its exploration have been made by Saraswata Muni who was well versed with botany and zoology and Manava Muni who was a geologist. According to their observations, the presence of an ant hill or that of a serpent den was regarded as an indication of the underground water. A number of trees like Banyan, Gular, *Palas(Butea monosperma),* Bilwa *(Semicarpus anacardium)* has water at a particular depth in a particular direction. Manava Muni surmises presence of water by colour of the soil or of rocks and stones. He has given a list of the plants or trees which indicates presence of water. Varahamihira was the greatest astronomer of the 6th century A.D. who had made certain observations on water exploration. According to him water in the ground is available in an arid place near Vetasa plant (*Calamus rota/lg*); gular tree *(Ficus glomerata)*, where current of sweet water many be found; in place where bilwa and gular trees are found growing together; if there is an ant-hill to the north of arjuna *(Terminalia arjzma)* tree; if there is a coconut tree with ant hill; if nirgundi tree *(Vitex negzmdo)* is found with an ant hill; if ant hill is inhabited by a serpent and is near to the north side of Mahuwa tree

(*Madhuka indica*); near the milky trees having long branches; at spots where trees, shrubs and creepers are fresh and fine and leaves are untorn and near grasses of specific types. Digging of wells was not very common and people depended more on the monsoons and river water. Shallow wells were dug through human labour and water was lifted through indigenous devices which operated on man and animal power. These wells were dug after careful selection of site and after ascertaining availability of ground water through water diviners.

Ancient teachers have enumerated many methods of divining water in arid regions. If there is seen hot vapour (rising from the earth) then there would be found a stream of water at the depth of two man-lengths and underground vegetation. The two-man-deep water would turn pale-white and disappear. There are signs approved by (the astrologer) Sanmuni by which now it is possible to divine whether there is adequate supply of water underground or whether the water is sweet. For the felicity of people living in desert places there generally exists underground a rich stream of water as big as the trunk of an elephant. If to the north of a *Karira* shrub there is an ant-hill then there would be found sweet water towards the south at the depth of ten man-lengths, and at the depth of one man-length there would be yellow frogs. And if on the west of a *Rohita* tree then water would be found at a distance of three cubits and twelve man-lengths below the surface, and towards the west there would be a profuse stream of salt water. If there is an ant-hill of white colour then close to it towards the west there would be a water-vein at the depth of five man-lengths, and towards the west stones and yellow clay at the depth of one man-length. If there is an ant-hill to the east of which stands a *Pilu* tree, then at a distance of one man-length to the south there would be water at the depth of seven man-lengths. At the depth of first man-length there would be found a snake with black and white spots and plenty of salt (water) at the depth of three man-lengths. If an ant-hill stands to the east of *Indradru (Terminalia arjuna)* , then just at one cubit to the west there would be found water at the depth of twenty man-lengths and an iguana only at the depth of one man-length. If there be a group of five ant-hills at one place - the middle one being white in colour - then there would be water under a depth of fifty five man-lengths. If there be *Kusa* grass growing over an ant-hill or there be pale-white *adurva* then twenty one man-lengths below it would be found water.

## Locating water in marshy lands

In a marshy country there are green herbs and the land is wet and full of mosquitoes. There is *Andropogon muricatus*. There is plenty of sweet water underground at the depth of one man-length. Where there are succulent herbs such as *Ipomoea turpethum;* creepers (garuda), *Jyotismati (Cardiospermum halicacabum),* Cyperus, there water is found very near (the surface). Towards the south of a grove of thick trees and creepers there is plenty of water at the depth of four cubits. In a valley the land is low, covered with green turf, sandy, resonant and rich in water.

## Locating water in mountainous country

Sarasvata and Varaha described clear formulae with respect to the mountainous country. Where there is a cluster of the *Bodhi* tree, *Udumbarika, Palasa* and *Nyagrodha,* at one place, water would be found three man-lengths below them even in arid and marshy lands. The place where the trees have glossy and thick foliage and shrubs and creepers have milky juice has sweet water very near (the surface) and is inhabited by sweet-voiced birds. In a place where there grow *Kharjuri, Jambu, Sata-patra, Nipa, Sinduvara, Vata,* N*aktamala, Andumbari, Kakaranva*, and *Vibhitaka,* there water would be found at a depth of three man-lengths.

Water is said to exist underground in a place where flowering trees and plants like J*ati, Kusthaka, Campaka,* etc. and fruit-bearing trees like the pomegranate, lime *(Citrus acida)* and citron are found to grow. Where on a hilly place the *Tala* tree, the coconut, tree, *Kancanara, Vetasa* or any other trees are found to grow, sweet water is found there in plenty. What has been previously described as a *Nirjahara* (water-fall or cascade) is found in a mountainous country issuing from the crevices between the rocks or from the roots of the trees.

In a wet mountainous country a stream with a copious flow of water is generally found to flow from under the vegetation. Sometimes such a stream is also found to exist underground at holy places with shrines. Near the rocks that glisten like a copper vessel facing the east (i.e. sun), or like glass and *Vaidurya* (eat's eye) or are bright like the pearls, or grey like the *Patasa,* or brown in colour, there is plenty of water. Where the dark blue soil or the black soil is found in conjunction with gravel, or where there is white coloured soil and sand or where there is yellowish soil, there exists sweet water. In brown soil the water is acrid in taste and in polish soil (of smooth surface) it is salt.

**Construction of reservoirs**

After the location of underground water, **Chakrapani** describes in his book ***"Visva Vallabha"*** the construction of reservoirs in the following paragraphs: "When water has been located, reservoirs of various shapes and sizes should be constructed outside the villages, their sites and measurements being determined by the availability of space. An artificial reservoir may be of six shapes, *viz.* circular, quadrangular (i.e. square), triangular, polygonal, oblong and semi-circular (half-moon-shaped). Its capacity may be ascertained after it is dug. The best reservoir should measure one thousand poles (or 4000 cubits) in length, medium-sized would be half of it and the smallest one quarter. The size of other reservoirs is determined by the availability of space. A big reservoir, in which there will always remain a large store of water, can be constructed at a lesser cost by constructing a dam between two hills, or in a mountain valley or on a spacious place at the top of a hill. If there be a wide and high table land on all sides with

great influx of water and a. narrow outlet for the exit of water, then a big reservoir can be made by constructing a dam there. A wise person should provide a descent of steps from the top of the dam to the bottom of the reservoir and for making the dam strong he should have it plastered with lime cement both on the inner as well as outer face.

A land low from all sides when full of water turns into a pond and becomes a natural reservoir. There can be no prescribed measurements for it...small...pits etc. In the middle of the lakes and on their banks, there are pleasure houses of the kings. For the purpose of pleasure-trip or frolicking in water a boat should be kept there or an approach to the pleasure-house be made by means of a bridge (or causeway). A tank with three peaks (? angles) and one opening is called *Nanda,* that with *Bhadra,* the one with nine peaks and three openings is *Jaya* and that with twelve peaks and four openings is called *Vijaya*

If at the bottom of the well there is found to be sand, a foundation pedestal made of hard wood should be placed below in a manner that it does not block its springs of water.

A *Kunda* (pit) is of four kinds, viz., *Bhadra, Subhadra, Parigha* a:pd Nanda. The first is four-sided, the second is Bhadra, the third Subhadra and in the middle the fourth connected with Peatibhadra. They (i.e. the Kundas) should measure one hundred and eight cubits on each side with four openings, one in each direction, and a half in one corner provided with a quadrangular courtyard and ventilators inside. A very deep natural pool which has come into existence of itself may be of various shapes. Its embankments may be paved as they are with stone and lime mortar.

## Water unit: a thousand poles equals 4000 cubits.

**Changing water quality**

**Chakrapani** in his book ***"Visva Vallabha"*** describes the methods to change water quality. If the powder of *Khadira* is poured into a well whose water is saline or acrid in taste, the water would be turned sweet. The turbid and pungent smelling water of pools etc. would turn sweet and pellucid if the powder as well as the juice of *Kakubha, Musta, Usira,* fruits of *Dhatri* and *Kanaka* and of *Rodhra (Symplocos racemosa)* and Rajasana (?) is poured into them. The juice of *Abhaya (Terminalia chebula)* and the powder of *Pathya Terminalia citrina)* , *Kustha,* Cardamom, *Kugaudhma* (?) and *Kataka* fruit *(Strychnos potatorum)* along with the essence of Khadira and the fruit of wood-apple, if thrown in the turbid water or the salt water of well, they would at once turn the water (clear) and sweet.

**Ancient irrigation systems**

Devices for irrigation water lifting range from age-old indigenous water lifts to highly efficient pumps. Pumps operated by electric motors or engines have come into prominence in all large scale lift irrigation schemes. There are several types of indigenous water lifts are in use in India. They may be manual\y-operated or animal-operated. Based on the optimum range in the height of lift, they may be grouped under devices for low lift, medium lift and high lift.

i) Low Head Water Lifts: The swing basket, *don,* Archemedian screw, and water wheel are suitable when the depth to water surface does not exceed 1.2 m.

ii) Medium Head Water Lifts: Medium head lifts are suitable when the height of lift is within the range of 1.2 to 10m. The Persian wheel, chain pump, leather bucket lift with self emptying bucket, circular two-bucket lift and the counterpoise-bucket lift fall in this category.

iii) High Head Water Lifts: *Rope-and-bucket lift*. The only indigenous water lift suitable for deep wells is the rope-and-bucket lift *(Charasa)* operated by bullocks.

**Rain water harvesting techniques:**
The most common practices followed by the farmers to conserve the soil moisture are summer tillage, field boundary bund with vegetative cover, use of farm yard manure and intercultural operation with hand / bullock drawn equipments.

Farmers have followed the surface water harvesting rainwater harvesting techniques such as local percolation tank, farm pond, Tanka, Nada, Nadi, Talai, Talba, Khadin, Sar, Sagar and Samand. The water-harvesting methods differ from region depending upon rainfall, topography and soil type.

**Tanka** is constructed on farm in courtyard fort, etc, The shape of the Tanka is generally kept circular; however square Tankas are also constructed in buildings, forts and palatial buildings etc, for harvesting roof water, A2 m diameter and 3 m deep Tanka (capacity 10000 liter) is common on farmers. The Tanka is made on sloping land to arrest run off water in the farm however in house the construction is made on an elevated place to avoid entry water into it.

**Talai** is about 2-3 m deep the soil out from the Talai is spread around to make catchments area keeping its slope in mind special attention is paid for selection of

locations such that there is adequate flow of rainwater into the Talai. care is also taken so that loose soil does not flow along with water stream into the Talai. In contrast to the Tanka, the Talai is kept open from the top. A pucca masonry ram entrance is also provided on one side of the Talai to facilitate distribution of water using camel, donkey, bullock cart, etc,. The stored water is generally used for animals.

**Nada:** Nada is a common method of conserving rainwater in villages. Low-lying area in between hillocks the catchments area of the Nada is 5 to 10ha. The Nada is constructed on rangeland barren land pasture land and agricultural field. It provides short-term storage of rainwater and mainly used for animals.

**Nadi:** Compared to Nada high embankment is provided around the Nadi. Depth of Nadi is kept up to 6-8 m. Catchments area of 10 to 150 ha is common for a Nadi. However area as high as 200 ha is found in certain specific cases. Nadi is generally constructed on sloppy area so that excess runoff water flows out without causing any damage to the embankment. Adequate cleanliness is maintained in the watershed to maintain purity or stored water. Bath is prohibited inside the Nadi. In the Nadi, water is available for whole of the year as a result it is shelter home for many wild animals and birds.

**Talab**: Talab is relatively shallow and spread over to more area compared to Nadi Runoff from hillocks is channels to a low-lying area in the vicinity and adequately bunded to from a Talab. It is generally constructed on rangeland.

**Khadin:** Khadin is the ancient indigenous rainwater harvesting method mainly found in jaisalmer district. Accumulation of runoff water in between hillocks is known as khadin khadin means cultivation of crops in about 60-70 ha area. The khandi water is generally used for crop cultivation under preserved moisture conditions and animals consumption.

**Sar, Sagar And Samand:** In certain district of Thar Dessert sar, sagar and samand are used to harvest rainwater for irrigation purposes.

## History of Salinization in India – A lesson for the Future

Thought the dug wells and constructed canals to supply water for crop production (2000-6000 BC) no record of the rise of salinity irrigated tracts is documented with the development of canal irrigation from the era of sultan Feroz Shah Tughlak (1351-88) to the fall of mughal empire (1857) the salty patches in the soil said to have developed due to canal irrigation. disappeared when the canals went into disuse. Irrigation is a mixed blessing water-logging and salinity closely follow. in

the past. all such lands that used to be unfit for agriculture were called as ushtra in Sanskrit meaning sterile or barren also called usar. Usar lands were adversely affected with arid climate or scarcity of water. Lands adversely affected with excess of salts, neutral (NaCl) or alkali ($NaHCO_3$, $Na_2$ $Co_3$) were also called as reh by geologists in mid-nineteenth centure to characterize the appearance of salt efflorescence on the surface of lands. In the chalcolithic period (c.1300 BC) irrigated farming which was developed in hilly uplands shifted to lower river valleys. Floodwaters were stored in reservoirs for irrigation in the valleys and canals were dug. Hence chalcolithic period is also called the era of irrigated farming. Archaelolgists have found a canal constructed dating back to the pre-harappan period (3000 BC) at Kunal (Hisar, Haryana).which was linked to the Saraswathi River about 5000 years ago. During the Vedic period (3700-2000 BC) the peasants dug wells and constructed canals to supply water to the crops. There is reference to irrigation by cannels taken from the rivers there is also reference to soil erosion by rivers. The Aryans being in Northern India had experience on ushara land, 'Alkali soil'. The Chola King Karikala (190 AD) and his successors constructed vennara and Arasil cannals, which take off from Kaveri River by means of channels drawn from dams, called anicuts or dike.

**Canal irrigation in India:** The development of canal irrigation began in the 14$^{th}$ century at the initiative of Sultan Feroz shah tughlak (1351-88), a pioneer in canal irrigation in the medieval times. During hid period five canals were dug among these the most important was the Western Jamuna Canal. The salty patches in the soil. which developed under canal irrigation disappeared when the canal went into disuse after the fall of Mughal Empire in 1817, Blane was appointed by the Government of India to restore the WJC, which took 3 years due to paucity of funds. Alighment of the old Munghal canal consisting of natural channels and depressions was adhered, which resulted in the formation of large swamps and extensive waterlogging. The Eastern Jamuna Canal (EJC) was taking off from the river on its eastern bank near Naushera in Uttar Pradesh, which was designed by Ali Mardan khan in the days *of* Shah Jahan. It was abandoned soon after construction due to the declining power *of* Mughals, but re-opened in January 1830. The Ganga canal belongs to the last years *of* the East India Company's rule. Cautley, in 1839, a military engineer, proposed to adopt a direct line from Hardwar to Roorkee. The canal was opened in April 1854 and irrigated large areas *of* Uttar Pradesh and the Pre-partition Punjab. Other canals constructed for protection against famine, viz., Sirhind Canal (Punjab) 1873-82, Lower Ganga Canal and the Betwa Canal (North-West Provinces), 1881-93. Mutha Canal and Khadakwas1a Dam (Bombay Presidency), 1869-79 and the Nira River Canals (Bombay Presidency) 1877-94.

**Advancement in irrigation potential during 20th century**

When the benefits *of* canal irrigation in British India became apparent, interest arose for such projects in some princely states. The pioneer was the Mysore state that planed a Kannabadi Dam, laternamed the Krishna Raja Sagar Dam (after the ruler *of* Mysore, Krishna Raja Wadeyar II), constructed under confluence *of* three

rivers, viz., the Kaveri, Hemavathi, and the Kakshmanatirtha. Two canals, namely, the north bank high-level canal (Visvesvaraya Canal) and the north bank low-level canal, took off from the reservoir. The Nizamsagar Project was another irrigation project executed by Government *of* Hyderabad (1924-1931). The project comprised *of* a dam across the river Manjira, a tributary *of* Godavari river. The Gang canal (1922-27), which takes off from the Sutlej River at the Ferozpore barrage on its left bank, was to irrigate land in the princely state *of* Bikaner. It was built with the initiative *of* Maharaja Ganga Singh (1880-1943) *of* Bikaner. The Sarda Canal Project in the United Provinces *of* Agra and Oudh was started in 1915 I during the Viceroyalty *of* Lord Hardinge, and was completed in 1926. Government of India through Indian Coucil of Agriculture Research (ICAR) launched the All India Co-ordinated Scheme for studies on soil salinity and water management at different locations in 1968. It set up Central Soil Salinity Research Institute (CSSRI) at Karnal and Water Technology Centre at New Delhi in 1969. A part from these another co-originated scheme on use of saline water in agriculture came in operation in 1972 at 5 centers in the state of Uttar Pradesh, Rajasthan, Karnataka, Andhra Pradesh and Maharashtra.

**Annexure-1:** Biodynamic agriculture developed in 1924 by Rudolf Steiner (1861-1925) an Austrian scientist and philosopher, to a group of farmers near Breslau (which was than in the eastern part of germany) and is now Wroclaw in Poland). He published these concepts in a book titled Spiritual Foundations for the Renewal of Agriculture originally published in observations from farmers that soils were becoming depleted following the introduction of chemical fertilizers at the turn of the century. In addition to degraded soil conditions, farmers noticed deterioration in the health and quality of crops and livestock. Biodynamic agriculture was the first ecological farming system to develop as a grassroots alternative to chemical agriculture. A basic ecological principal of bio-dynamics is to conceive of the farm as an organism a self-contained entity. Emphasis is placed on the integration of crops and livestock. the farmer too is part of the whole. Thinking about the interactions within the farm ecosystem naturally leads to a series of holistic management practices that address the environmental, social and financial aspects of the farm Steiner's use to terms like ethereal forces and astral forces are part and parcel of biodynamic agriculture.

Table 1 provides a brief summery of biological and dynamic farming practices.

| Table 1. Bio-Dynamic Farming Practices. | |
|---|---|
| Biological | Dynamic practices. |
| Green manures | Special compost preparations. |
| Cover cropping | Special foilar sprays |
| Composting | Planting by calender |
| Companion planting | Peppering for pest control |

| | |
|---|---|
| Integration of crops and livestock | Homeopathy |
| Tillage and cultivation | Radionics |

## Chapter 08 SOIL CLASSIFICATION, MAINTENANCE OF SOIL PRODUCTIVITY AND WATER MANAGEMENT

Physically, India may be divided more or less into three main regions v*iz.* (1) the mountainous borders of Himalayas in the north and of the Vindhyas in the south with the linings of Ghats in the south-eastern and south-western coasts and the traverse range or Aravalli hills; (2) the plains or low-lands, a rich Indo--Gangetic alluvium overflown by the rivers-the Ganges, Jamuna and Brahmaputra; and (3) the Deccan plateau or table land. Although primordial mountains remained inaccessible for human settlement, the foothills have been increasingly brought under cultivation and settlement and the upland valleys striking the Himalayas include some or the most fertile of Indian lowland formations. The whole Indo-Gangetic alluvium consists of rich fertile *soil* and has contributed materially to the growth of civilization.

> Agriculturists in ancient India were quite conscious of the nature of soil and its relation to the production of a specific crop of economic importance. The vast knowledge acquired by experience has been handed over from generation to generation. The available information collected from some eminent authors and from translation of old Sanskrit manuscripts is given below:

Rigveda identified productive and non-productive soils.

1) R. Gangopadhyay, in his book on ***"Some Materials for the Study*** *of* ***Agriculture and Agriculturists in Ancient India",*** 1932, has given an account of 'Soil and Classification' as follows: "According to fertility, soil is mainly divided into two classes; *urvara* (fertile) and *anurvara* or *usara* (sterile). *Urvara* mrttika is again sub divided into different kinds according to their peculiar fitness for the cultivation of different kinds of crops; for instance, the soil fit for barley, for sesamum, *urihi* (rice), *mung,* etc. *Anurvara mrttika* (Sterile) is also sub-divided into *usara* (salt ground) and *maru* (desert). The soil watered by river and that watered by rain are respectively called *nmdimrttika* and *deva-mrttika.*

2). Prof. G. P. Majumdar in his excellent translation of '*Upavana Vinoda*' published in 1935 by the Indian Research Institute, Calcutta, has shown that more elaborate attention was paid to the topic of classification of soils with characteristic flora in Charaka. The following excerpt is from the work of Prof. Majumdar. Charaka divides land into three classes, namely, arid (*Jangala),* wet (*Anupa*) and moderate, i.e., (neither too wet, nor too dry) *Sadharana* regions according to the nature of the soil (edaphic conditions) and climatic conditions). The land is again distinguished to be of six kinds each *from* its colour viz., black, pale, dark red, white and yellow and taste viz., sweet, sour, salt, pungent, bitter and

stringent. The land which is vitiated by poison, stones, white-ants and holes (of vermin), or is saline or gravelly or has underground water too deep, is not good for the planting of trees.

i) Jangala Region (barren): The region called Jangala is full of unobstructed open spaces, where a steady and dry wind blows, pervaded with expansive mirages, rivers and rivulets scarce, abounding in artificial wells, also abounding in dry and rough sands and big sandy particles (kankars). This region presents a flat surface, and whose dull monotony is enlivened here and there by scanty growths of thorny shrubs, and tops of a few isolated hills, and in which the waters from springs and wells, accumulated during the rains, become nearly drained and strong gales of warm wind blow (during the greater part of the year).

ii) Anupa Region (literally marshy, or swampy and watery-plants littoral, or inland): "Mostly abounding in rivers and bordered by seas, swept by cold wind, i.e., charged with abundant moisture. Mountains are absent from this region. The land is covered with dense forests. This region contains a large number of pools, and is wooded and undulated with chains of lofty hills traversing its area, and which is impassable owing to its network of rivers and sheets of accumulated rainwater rippling before the currents of the gentle humid air.

iii) Sadharana region (ordinary plants -mesophytes): Charaka says that "the region which is endued with creepers, and plants and trees.

3). Kautilya in his ***'Arthasastra'*** mentioned that lands on the banks of rivers are suitable for growing valliphala (pumpkin, gourd and the like); lands that are frequently over flown by water (parivahanta) for long pepper, rapes (mrdvika) and sugarcane; the vicinity of wells for vegetables and roots, ow grounds (hariniparyantah-moist bed of lakes) for green crops; and marginal furrows between any two rows of crops are suitable for the plantation of fragrant plants, medicinal herbs, cascus roots.

4). The Sage Kashyapa in ***'A Treatise on Agriculture'*** has given a division of the earth, according to its fitness for particular crops into hilly, river and stream irrigated, forest and pasture land etc. The land *(Bhumi*) should be clean, free from pieces of bone and stone, husk and glass, be amended to *kusa kasa* which are wild grasses, and its soil soft, strong, cohesive and moist, slightly reddish and dark in colour. Its surface should be level, without pits, chasms or mounds and the soil should emit the pleasant smell of jasmine, wine, or lotus or blossoms of date-palm or tinisa *(Dalbergia ujjeinensis)*. It may not be surcharged with water or may be watery at all times. It should be conducive to the rapid sprouting of seeds and be easy to plough. It may be covered with the cud of bulls *(Vrsa phena)* and may abound in (beneficent) beasts and insects. It should be compact, solid, heavy in weight fit for the luxuriant growth of herbs, and free from brambles and dry dung, etc. Land should have clear water and fertile soil both at the surface and deeper down. It should be pleasing to the eye, free from white ants and vermin and

depredatory beasts but should harbour (beneficent) beasts and birds. It should not be exposed to storms, whirl-winds and wild fires. It should have an inexhaustible supply of underground water and should be favourable to the plantation of gardens and orchards and to the growth of thick shady trees and all sorts of seeds. It may have slight depressions, be soft to touch and be good for (the grazing of) cows and cattle. The soil should be suitable for digging wells and for the percolation of water. These are some of the good qualities of land in spite of some defects here and there like the patches of waste or desert land. The earth which is of uniform colour and tinge, compact and smooth is considered to be excellent by gods, kings, sages, Brahmanas and Vaisyas and, on account of its good qualities, is conducive to the prosperity and welfare of all. It promotes the health of the families and the growth of wealth, cattle and grain.

The Sage Kashyapa advised that the king should appoint officers to search and acquire the best land who know the way to scrutinize the (quality of the land). They should be equipped with the required eligibility. Either in the morning or in the evening (for the purpose of purifying the atmosphere) the land should then be sprinkled with the fivefold cow-products (milk, curd ghee) (clarified butter), urine, and dung) or may be simply with clean water, by Brahmins proficient in Vedas. This is known as 'Panchakowia'. Kashyapa divided the agricultural land into two categories: **shalibhu** (=land fir for rice cultivation) and **adhakadibhu** (=land suitable for cultivation of pulses and other grains). The wet lands for paddy fields, named variously *Shuli Bhumi, ala Bhumi* and *Sasya Bhumi,* and (2) Dry lands called Adhaka bhumi, Tara bhumi and *Usua bhumi*. Lands have also been classed according to their suitability for particular crops.

**5) Examination and classification of Land:** The classification and examination of lands as suggested by Shri Misra Cakrapani in "Visva-Vallabha" are described below: Land is of three kinds, viz., arid, wet (i.e., marsh) and moderate (i.e. neither too dry nor too wet). and is distinguished by six tastes, which can be known from the colour of the soil. Gray coloured, pale-white, black, white, red and yellow soils are sweet, sour, salt, bitter, pungent and astringent in taste respectively accord-ing to the ancient tradition. Land that is littered with ant-hills, pits and stones is saline and gravelly and has water at great depth. It is poisonous as far as the planting of trees, etc. is concerned. In a region where trees and plants are blighted with frost and in a place littered with stumps, a garden should not be laid. Land in which the water is near the soil and is soft is best suited for planting trees.

**6) Krisi-sukti a comprehensive book on "Agriculture Science" attributed to Kasyapa** classified the land into (1) wet lands for paddy fields, named variously *Shuli Bhumi, ala Bhumi* and *Sasya Bhumi,* and (2) Dry lands called Adhaka bhumi, Tara bhumi and *Usua bhumi*.

7). The **Amarkosha** (c. 400 BC) described 12 types of lands in its chapter on Bhumivargha, depending upon the fertility of the soil, irrigation and physical

characteritistics. These were urvara (fertile), ushara (barren), maru (desert), aparahata (fallow), shadvala (grassy), pankikala (muddy), jalaprayah (watery), kachachaha (land contiguous to water), sharkara (full of pebbles and pieces of limestone), sharakaravati (sandy), nadimarruka (land watered from a river), and devakarruka (rainfed). In the chapter on Vaisyavargaha, soils based on suitability for specific crops are mentioned. For example, Vraiheyam (Vrihi rice and corn), shaleyam (Kalama rice), yavyam (awned barley), yavakyam (awnless barley) tilyam (sesame), mashyam (blackgram).

8) Literature (200 BC to 100 AD) of Tamils in Southern India provides information on soil types (Bedekar, 1993). For example, in Tholkappiyam, written by a poet named Tholkappier (200 BC) for four types of land are mentioned. These are kurinji (hills), mullai (Forest), marutham (cultivable) and neithal (coastal land).

9) Surapala's Vrikshayurveda (c. 1000 AD) (Sadhale, 1996) mentions three types of land – jangala (arid) anupa (marshy), and samanya (ordinary)-further subdivided by colour into black, white, pale dark, red and yellow and by taste into sweet, sour, salty pungent, bitter, and astringent. Samanya land was considered suitable for all kinds of trees.

It is important to note that one of the most sustained land use practices, since the days of Kautilaya, has been the use of river beds for raising cucurbits throughout India.

7. In ancient works of Silpasastra of Visvakarman (architecture) [2] and in Kautilyas Arthasastra [3] as well as in Vasahamihira,s Brahat samhita [4] we come across sections dealing with agriculture, gardening and town-planning. in the Atharva Veda too, there are prayers for the sweet and juicy fruits of trees and creepers [5] Many ancient sages like Kasyapa, Gargya, and Parasara as well as medieval scholars like Cakrapanimisra, Surapala and King Somadeva III of the Chalukyan dynasty, have written on this subject. In the Ratnavali [6] there is the famoua verse, 'uddamokalikam, which speaks of the wondful appearance of abundant flowers on the kings jasmine creeper as a result of the application of a Dohada, fertlilizer, supplied by a hermit There is also the case of the Dohadas coming under what are aclled "Kavisamayas" of poetic conventions. [1] As mentioned above, the subjects of Dohada is often met with in Sanskrit literature. In the Naisadhiyacarita of Sarharsa ($12^{th}$ cenrury A.D) who was well versed in many branches of learning, there is the reference to the fertilizer used for the pomegranate: while explaining the word Dohada-dhupini the commentator Narayana says that Dohada or fertilizer was fumigation. Dohada is that material evolved by competent persons for producing flowers etc., on trees, bushes, creepers and the like out of season" the next two verses of pomegranates the best procedure is to pour on the tree the liquid of mutton and to fumigate it by burning sheep's wool and mutton underneath. If the same tree smeared with a paste made of fish meal, ghee and Triphala as well as with the flesh of goats and sheep, and fumigated with the matter, its fruits will be big as those of the Tala tree.

***8. Soil types of India:*** *The investigations of Voelcker in 1893, and those of Leather in 1898, led to a classification if India soils into four major types and three minor types: (i) the Indo-Gangetic alluvium; (ii) the black cotton or regur soils (iii) the red soils lying on metamorphic rocks; and (iv) the lateritic soils.*

**i) Indo-Gengetic Alluvium:** The Indo-Gangetic alluvium is by far the largest and most important of the soil groups of India. The soils of this group cover about 777,000 square kilometers They are distributed mainly the Punjab, Haryana, Uttar Pradesh, Bihar, Bengal and parts of Assam and Orissa. They produce bumber crops of wheat and rice. Geologically the alluvium is divided into (i) *Khadar*, or new alluvium of sandy composition, generally light in colour, about 10,000 years old, and (ii) *Bhangar,* or the older alluvium. of Pleistocene elate, of more clayey composition, generally of dark colour, and fun of pebbles or *kankar*. The soils differ in consistency from drift sand to loams, and from fine silts to stilts clays. A few pebble beds are also occasionally met with. The presence of impervious clays obstructs the drainage, and also promotes the accumulation of injurious salts of sodium arid magnesium, which make the soils sterile. The formation of hard pans at certain levels in the soil profile as a result of the binding of soil grains by the infiltrating silica or calcareous matter is often observed in these alluvial soils. A majority of the soils are loams or sandy loams, with a soil crust of varying depth. Soluble salts are present in considerable quantities.

> The alluvial soils of Tamil Nadu are transported soils, found mainly in the deltaic areas and on the coastal line, A section of the profile shows alternate layers of sand and silt, The composition of the strata varies with the nature of the silt brought by the rivers which, in turn, varies with the catchment areas and the tracts through which the streams flow.

ii) **Black Cotton Soils:** The typical soil of the Deccan Trap is the *regur* or black cotton soil. It is common in Maharashtra, in the western parts of Madhya Pradesh, Karnataka, and 'some parts of Tamil Nadu, including the districts of Ramnad and Tinnevelly in the extreme south, It is comparable with the chernozems of Russia and with the prairie soil of the cotton-growing tracts of the United States of America, especially the black adobe of California. It is derived from two types of rocks: the Deccan and Rajmahal Trap, and the ferruginous gneisses and schists occurring in Tamil Nadu under semi-arid conditions. The former attains sometimes considerable depths, whereas the latter are generally shallow. The black soil areas have, generally, a high degree of fertility, though some mainly in the uplands are of low producivity. The soils on the slopes and the uplands are somewhat sandy, but those in the broken country between the hills and the: plains are darker, deeper and richer, and arc constantly enriched by deposits washed down from the hills.

iii) **Red Soils:** Red soils extend practically over the whole Archaean basement of

Peninsular India, from Bundelkhand to the extreme south, covering 2,072,000 square kilometres, embracing south Bengal, Orissa, parts of Madhya Pradesh eastern Andhra Pradesh Karnataka, and a major part of Tamil Nadu. These soils also occur in Santhal Parganas in Bihar, and in the Mirzapur, Jhansi and Hamirpur districts of Uttar Pradesh. They were produced as a result to meteoric weathering of ancient crystalline and metamorphic rocks. These soils started developing around the Mesozoic and Tertiary ages. The colour if these soils is generally red, grading sometimes into brown chocolate, yellow; grey and even black. The redness is due more to a general diffusion than to a high proportian of iran content. The soils grade from the poor thin gravelly and light coloured varieties of the uplands to the much more fertile deep dark varieties of the plains and the valleys. They are generally; poor in nitrogen phosphorus and humus. Compared with regur, they are poor in lime, potash and iron oxide, and are also uniformly Low in phosphorus The clay fraction of the soils is rich in kaolinite. More than two-thirds of the cultivated area in Tamil Nadu is covered by red soils they are in-situ formations produced from the rock below under the influence of climatic conditions. The rocks are acidic, consisting of mica or red granites. The soils are shallow and open in texture. They have a low exchange capacity and are deficient in organic matter and plant nutrients.

**iv) Laterites:** Laterite is a soil type peculiar to India and some other tropical countries, characterized by the intermittent occurrence of moist climate. In formation it varies from compact to vesicular rock composed essentially of a mixture of hydrated oxides of aluminium and iron with small quantities of manganse oxides, titania, etc. it is produced by the atmospheric weathering of several types of rocks. Laterites occur in Madhya Pradesh, the coastal region of Orissa, south Maharashtra, Malabar and part of Assam. All lateritic soils are generally very poor in lime and magnesia and deficiant in nitrogen. Occasionally, the $P^2$ $O_5$ content may be high, but there is deficient of $K_2O$. In Tamil Nadu, there are both high-level and low–level laterites which are formed from a variety of rock materials under certain climatic and weather conditions. The laterites at lower elevations grow rice whereas those at higher elevaions grow tea, cinchona rupper and coffee. The soils are rich in nutrients and contain 10 to 20 per cent organic matter.

v) **Forest and Hill Soils:** The soil formation is governed mainly by the character of the deposition of organic matter derived from the forest growth. Broadly, two conditions of soil formation may be distinguished: (i) soils formed under acid condition, with acid humus and low base status, and (ii) soils formed under slightly acid or .neutral condition with high base status, which is favourable to the formation of brown earths. Forest and Hill soils occur in Assam and in Uttar Pradesh, the Sub Himalayan tract comprises three distinct parts viz. *bhabar* area immediately below the hills, *tarai* and the plains. The *tarai* areas are characterized by extreme unhealthiness owing to excessive soil moisture and prolific growth *of* vegetation. The soils in Coorg has deep surface soil of great

fertility, as it receives annually the decomposed products of the virgin forest. The areas towards the west are for the greater part reserved under forests and mountain areas. The land surface is full of pebbles, is easily drained, and has a laterite bed

**vi) Desert Soils:** A large part of the arid region *of* Rajasthan and the Punjab and Haryana, lying between the Satluj and the Aravallis, is affected by desert conditions, which geologically are *of* recent origin. This part is covered under a mantle of blown sand, and is dominated by conditions, which inhibit soil growth. Some of the soils contain a high percentage of soluble salts and varying percentages of calcium carbonate, and possess high pH. They are, however, poor in organic matter. Reclamation is possible only if proper irrigation facilities are made available.

**vii) Saline and Alkaline Soils:** These soils are extensively distributed throughout India in all the climatic zones. These soils occur in Bihar, Uttar Pradesh, the Punjab, Haryana and Rajasthan. The injurious salts are confined to the top layers, being deposited there by the capillary transference of saline solutions from the lower strata. It has been estimated that nearly *850,000* hectares in Uttar Pradesh and over *200,000* hectares in the Punjab and Haryana have been affected by *usar*. Over 10,000 hectares are being affected every year in the Punjab and Haryana. Alkali soils are met with all over Maharashtra.

**MAINTENANCE OF SOIL PRODUCTIVITY**

Manures: Importance of manures in obtaining high crops yields was fully appreciated in ancient India. In Krishi-Parashara, it is stated that crops grown without manure will not give yield and a method of preparing manure from cowdung is described. Kautilya mentioned use of cowdung, animal bones, fishes, and milk as manure. Agnipurana recommends application of the excreta of sheep and goat and pulverized barely and sesame allowed to be soaked in meat and water for seven nights to increase flowering and fruiting of trees. In Varahamihira's Brhat Samhita growing of sesame to flowering stage and then incorporating it as green manure is recommended. The *Abhilasitarthacintamani* mentions a few such fertilisers - 1) the soil underneath a tree struck by lightning is good for warding off trouble for trees from snowfall. 2) Fumigation of trees by burning turmeric, Vidanga, white mustard, flowers of the Arjuna tree, mixed with fish and the flesh Rohita (a kind of deer) will not only help the growth of flowers and fruits but will destroy all worms and insects as well as diseases. Surapala (c. 1000 AD) describes the 'ancient' practice of preparing liquid manure (kunapa) prepared by boiling a mixture of animal excreta, bone marrow, flesh, and dead fish in an iron pot and then adding to it sesame oil cake, honey, soaked black gram, and a little ghee (or clarified butter). No fixed quantities of materials were required to prepare 'kunapa'. This liquid manure was mainly used in raising trees and shrubs. Traditional agriculture practised in the Himalayas regions of the sub continent involves used of green leaf manure as the main fertilizer for the rice crop. Surapala and Sarangadhara recommended the use of kunapa for properly

nourishing trees. The preparation of kunapa is described by Sarangadhara as follows: "One should boil the flesh, fat and marrow of deer, pig, fish, sheep, goat, and rhinoceros in water and when it is properly boiled one should put the mixture in an earthen pot and add into the compound milk, powders of sesame oil cake, masa (black gram) boiled in honey, the decoction of pulses, ghee, and hot water. There is no fixity as to the amount of any of these elements; when the said pot is put in a warm place for about a fortnight, the compound becomes what is called kunapa water which is very nutritious for plants in general". Prior to Sarangadhara, Surapala had referred to kunapa and ingredients included excreta, bone marrow, flesh, brain, and blood of boar mixed with water and stored underground. Surapala also referred to "available" materials and these could be animal fat, marrow, and the flesh of fish, ram, goat, and other homed animals. Other materials were more or less the same as mentioned by Sarangadhara, except that quantities of ghee and honey indicated were small. It should not be difficult to standardize and prepare kunapa water concentrates on mass scale and make these available in jars to users. Here is an opportunity for an enterprise to help farmers, especially the orchardists. Firminger (1864) who was a "Chaplain of the Bengal Establishment" mentions beneficial use of "liquid manure", prepared the way Kunapa was prepared, for vegetable cultivation. He has given no information about who first thought of liquid manure".

**Green leaf manures:** Farmers relied extensively on crop residues legumes and neem for enriching the soil fertility. Ancient Tamil texts, widely quoted the use of *Calotropis giganta*, *Morinda tinctoria*, *Thespesia populnea*, *Jatropha gossypifoila* and Adathoda sp. to be used as green leaf manure. Crop rotation and intercropping were practiced to restore soil fertility. Fauna such as ants, earthworms and frogs were used to improve soil physical properties. Composting practices have also been documented in ancient literature on ideal farming practices. The farmers of Tamil Nadu manure the soil with farmyard manure (FYM), oil cakes, compost and green manures or green leaf manures is an age-old practice.

Recycling of nutrients through pond excavation was achieved through tank silt or pond excavation in the foothill zones. The sediments from ponds coming from open spaces, field, etc., during the monsoon. The sewage slurry and dissolved minerals and nutrients in water coming from animal sheds and household washings are also diverted to the common village pond. All the flocculated clay and organic materials usually settle quickly to give clear water of the pond. Animals used to drink water from this pond. As soon as the ponds dry up in summer season, the farmers dig the pond base by lifting the soil and transport it to the fields. The surface layer of pond base usually removed is about 30 cm depth. This is a rich source of plant nutrients. The application of pond sludge to each field is done once in a span of 10-15 years. Tank silt increases clay content in light textured red soils which helps to increase soil moisture content and finally he crop yield. In Coimbatore district farmers apply tank silt to crops like banana turmeric and jasmine where as in Ramanathapuram farmers apply it to rice @ 25 t/ha. The excavation of pond basin and its application to field was abandoned with the

introduction of chemical fertilizers. Farmers excavate ‘murrum’ a uppermost weathered basalt rock and apply to the fields.

The compost becomes ready to use in five to six months. This partially decomposed farmyard manure after spreading evenly in the field is worked into the soil by ploughing followed by planking.

| Crop<br>Straw | Grain to<br>Straw ratio |
|---|---|
| Rice | 1:1:5 |
| Pearl millet | 1:2:0 |
| Maize | 1:1:5 |
| Cotton | 1:6:0 |
| Wheat | 1:1:5 |
| Barley | 1:1:5 |
| Mustard | 1:2:0 |
| Pulses | 1:1:0 |
| Sugarcane | 1:0:2 |

Penning of sheep, goat, cattle and pig in the fallow fields is common. One or two fields by rotation are kept fallow to receive the animal dung and urine during summer ad well as winter months. Large herds of sheep, goat and cattle are kept in the fallow fields. The farmers used to feel obliged and usually come with a request to cattle herd owners for the night stays at their farm land. The litters of sheep get well mixed with soil during the period of penning. Light cultivation before the onset of monsoon makes it more effective. Sheep feed on the existing farm residue and drops litter in the same field during resting period. The excreta of sheep is acidic in reaction. On each piece of land, penning is continued for 2 to 4 days depending on the size of the flocks to gather or accumulate sufficient manure to improve the fertility status of the soil.

Rishi–krishi method of Vermiculture: The Amrit pani consists of 250 g ghee from cow milk + 500 g honey + 200 litre water + 10 kg cow dung. Firstly, ghee is mixed with cow dung thoroughly followed by honey and then water is added to it. Farmers collect 25 kg soil from the base of banian tree which is sufficient for sprinkling well–prepared Amrit pani on an acre uniformly. Normal earthworm count in an acre gets double (87120) due to enhanced energy and congenial soil environment. If the weight of one worm is 20 g which eats about the same quantity of soil, in 100 days, one worm can excrete 1kg excreta. Then 87 thousand worms will excreta 87 tonnes of excreta rich in mineral nutrients, organic carbon, microbial population, organic acids, growth hormones and growth promoting substances.

Dead animals (pet or domestic) were buried under the fruit trees such as mango tree. The dead animal contains large amount of biomass, mineral matter in the

form of structure and bones specifically nitrogen in protein, phosphorus in bones etc.

Crop rotation helps in efficient use of nutrients. Farmers usually change crop rotation in every three or four years to have a better growth and performance of the cropping system. Stubble mulching is common in the high rainfall areas. Mulching raised the organic matter and nutritional status of soil.

## WATER MANAGEMENT

(Water management-water harvesting-storage-distribution and relevance to modern agriculture)

Rain is essential for cultivation and the latter is essential for life, so one should first acquire carefully the knowledge about rainfall. Over a large part of the country rain has always been unequally and irregularly distributed and that is why Indian cultivators have sought to supplement the rainfall by digging wells and conserve it by tanks and storage reservoirs.

**Ancient Irrigation:** Archaeological investigations in Inamagaon in Mahrastra, India (1300 BC), revealed a large mud embankment on a stone foundation for diverting flood water from the Ghod river through a channel. Rigveda mentions irrigation of crops by river water through channels as well as irrigation from wells. In the Rigveda, the word "well" frequently occurs (videante) and is described as "unfailing and full of water". Water was raised from the well by means of a wheel, a strap and water pails, and also perhaps by buckets tied by rope to one end of a long wooden pole, working about a fulcrum near the other end that carried a heavy weight. The same old crude method is still prevalent in some parts of Northern India. Another method largely employed is to raise water by a small canoe tied by four strings-two at each side and worked between two men standing on a wooden platform projecting over a shallow reservoir. The canoe is swung to and fro, and at each end of the swing, water rises and pours out into the main channel. Macdonell and Keith find clear references to artificial water channels used for irrigation as practised in the times of the Rigveda and Atharvaveda.

## References in epics, arthasastra, law-books and jatakas

Narada enunciates, "No grain is ever produced without water, but too much

water tends to spoil the grain". An inundation is injurious to crops and drainage has to be provided. Definite sources from which water can he had on earth are the canals, wells, lakes, reservoirs, etc,. During the season of clouds rainfall is certain either accidentally or through the will power of the sages. The rain water 'poured down by clouds in rainy season should be stored by the king in ponds, reservoirs, etc., for the benefit of the people, and preserved by him with special care; for agriculture so1ely depends on water. Therefore all the water that can be gathered in the (rainy) season should be well preserved both by the kings as well as other prominent persons-this is the injunction of the great sage Kasyapa. Arthasastra of Kautilyas refers to sluice gates of tanks and mentions that 'persons letting out the water of tanks at any other place other than their sluice gate shall pay a fine of six panas' and persons who obstruct the flow of water from the sluice gate of tanks shall also pay the same fine. It is further satated that ' the water of a lower tank, excavated later on, shall not irrigate the field already irrigated by a higher tank and the natural flow of water from a higher to a lower shall not be stopped, unless the lower tank has ceased to be useful for three consecutive years. Costs were levied on irrigated water regardless of the source. About the same time, 4$^{th}$ century BC, the large Sudarshan lake was constructed in Gujarat and it was subsequently provided with conduits. In western India, the tradition of constructing tanks for irrigation continued throughout the ancient period. Buddhist literature (500-300 BC) provides evidence of building small tanks for irrigation (Randhawawa, 1980).

Extensive tank irrigation systems were developed in Sri Lanka and southern India during the first two centuries of the Christian era. Availability of irrigation made it possible to extend cultivation of rice to large areas, and thus improve food security. Sri Lanka knowledge of tank irrigation technology was most advanced. They could build large tanks and control release of water by 3$^{rd}$ century BC (Brohier, 1934). It is most likely that the contemporary and subsequent kingdoms in southern India got the benefit of Sri Lanka expertise in building tanks. The philosophy about the efficient 12$^{th}$ century Sri Lankan king. He stated, " In such a country, let not even a small quantity of water obtained by rain, go to the sea, without benefiting man". As many as 14 large irrigation tanks existed in the northern half of Sri Lanka in the ancient times.

Topography of the Telangana region of Andhra Pradesh and Karnataka in India is ideally suited for the construction of tanks. A special feature of tanks in Telangana is their construction in series, by bunding the same valley at several points. Surplus water from one tank fed the tank at a lower elevation and so on. In Tamil Nadu, the Chola king Karikala (c. 190 AD) and his successors constructed irrigation tanks off the river Cauvery through canals and several of these exist to this day. For the maintenance of tanks, a committee of villagers called eri-variyam was appointed. The committee ensured repairs and desilting of tanks and distribution of water. During Pallava times (200-900 AD) arrangements were made for their repair and maintenance of building dams, embankments, tanks and aqua ducts in southern India.

Ancient dynasties from Mauryans to Mughals evolved various systems for soil water management such as anicuts, earthern dams field bunds check dams, canals tanks ponds wells and reservoirs. Babur observed two methods of irrigation from wells were with the aid of a wooden Persian Wheel and a leather bucket drawn over a pulley in northern India prior to Arab invasions.

## Locating water table - Keys to the finding of water source

**Chakrapani** in his ***'Visva Vallava'*** has dealt in detail as how one can have an approximate idea regarding water below the surface of different kinds of lands, based on certain characteristics on the land. Generally water is found near or below a marshy place, at sea side, just by its shore, and in the desert, rocky and mountainous country far deep. From a mountain or from the root of a tree the underground artery (sometimes) goes below into a spring. At some places all the arteries are seen to terminate in caves. While digging if stone-like hard earth is reached and when struck it sounds like a thin slab of stone, then there is sure to be plenty of water beneath it. If in a place devoid of any water reservoir, there is found a rank growth of *Vetasa* (rattan), then there would be an artery of water two cubits below the surface flowing towards the west. If rattan plant is seen growing in a place where there is no pool of water, then three cubits towards the west of that plant an artery of water would be found after digging seven cubits deep. If the tree *Ficus oppositefolia* is seen growing in a place devoid of a water reservoir of any sort, then three cubits towards its west there will be found an artery of water two and a half man-lengths below the surface of the earth. (Note: Purusa is the height of a man with his arm raised, which is 120 digits or 5 cubits). Where there stands an *Udumbarika* tree, there three cubits towards its west will be found a dark artery of water two and a half man; lengths below the surface. If there is an ant-hill towards the north of an *Arjuna* tree, then three cubits towards the west of the tree, water is sure to be found at the depth of three and a half man-lengths. If a *Badari* (jujube) tree stands to the west of an ant-hill, then two cubits towards the west springs of water would certainly be found at the depth of three man-lengths. If there be the plant *Bhargi (Clerodendrum siphonantus)*, *Danti (Croton polyandrum) or Malika* (double jasmine), then there is water towards its south at the depth of three man-lengths.

## Locating water in arid areas

Agriculture in India mainly depended on rainfall since ancient times. People knew that much of the rain water percolates through the soil and flows under ground through aquifers. Observations about ground water and its exploration have been made by Saraswata Muni who was well versed with botany and zoology and Manava Muni who was a geologist. According to their observations, the presence of an ant hill or that of a serpent den was regarded as an indication of the underground water. A number of trees like Banyan, Gular, *Palas(Butea*

*monosperma),* Bilwa *(Semicarpus anacardium)* has water at a particular depth in a particular direction. Manava Muni surmises presence of water by colour of the soil or of rocks and stones. He has given a list of the plants or trees which indicates presence of water. Varahamihira was the greatest astronomer of the 6th century A.D. who had made certain observations on water exploration. According to him water in the ground is available in an arid place near Vetasa plant (*Calamus rota/lg*); gular tree *(Ficus glomerata)*, where current of sweet water many be found; in place where bilwa and gular trees are found growing together; if there is an ant-hill to the north of arjuna *(Terminalia arjzma)* tree; if there is a coconut tree with ant hill; if nirgundi tree *(Vitex negzmdo)* is found with an ant hill; if ant hill is inhabited by a serpent and is near to the north side of Mahuwa tree (*Madhuka indica*); near the milky trees having long branches; at spots where trees, shrubs and creepers are fresh and fine and leaves are untorn and near grasses of specific types. Digging of wells was not very common and people depended more on the monsoons and river water. Shallow wells were dug through human labour and water was lifted through indigenous devices which operated on man and animal power. These wells were dug after careful selection of site and after ascertaining availability of ground water through water diviners.

Ancient teachers have enumerated many methods of divining water in arid regions. If there is seen hot vapour (rising from the earth) then there would be found a stream of water at the depth of two man-lengths and underground vegetation. The two-man-deep water would turn pale-white and disappear. There are signs approved by (the astrologer) Sanmuni by which now it is possible to divine whether there is adequate supply of water underground or whether the water is sweet. For the felicity of people living in desert places there generally exists underground a rich stream of water as big as the trunk of an elephant. If to the north of a *Karira* shrub there is an ant-hill then there would be found sweet water towards the south at the depth of ten man-lengths, and at the depth of one man-length there would be yellow frogs. And if on the west of a *Rohita* tree then water would be found at a distance of three cubits and twelve man-lengths below the surface, and towards the west there would be a profuse stream of salt water. If there is an ant-hill of white colour then close to it towards the west there would be a water-vein at the depth of five man-lengths, and towards the west stones and yellow clay at the depth of one man-length. If there is an ant-hill to the east of which stands a *Pilu* tree, then at a distance of one man-length to the south there would be water at the depth of seven man-lengths. At the depth of first man-length there would be found a snake with black and white spots and plenty of salt (water) at the depth of three man-lengths. If an ant-hill stands to the east of *Indradru (Terminalia arjuna)* , then just at one cubit to the west there would be found water at the depth of twenty man-lengths and an iguana only at the depth of one man-length. If there be a group of five ant-hills at one place - the middle one being white in colour - then there would be water under a depth of fifty five man-lengths. If there be *Kusa* grass growing over an ant-hill or there be pale-white *adurva* then twenty one man-lengths below it would be found water.

## Locating water in marshy lands

In a marshy country there are green herbs and the land is wet and full of mosquitoes. There is *Andropogon muricatus*. There is plenty of sweet water underground at the depth of one man-length. Where there are succulent herbs such as *Ipomoea turpethum;* creepers (garuda), *Jyotismati (Cardiospermum halicacabum),* Cyperus, there water is found very near (the surface). Towards the south of a grove of thick trees and creepers there is plenty of water at the depth of four cubits. In a valley the land is low, covered with green turf, sandy, resonant and rich in water.

## Locating water in mountainous country

Sarasvata and Varaha described clear formulae with respect to the mountainous country. Where there is a cluster of the *Bodhi* tree, *Udumbarika, Palasa* and *Nyagrodha,* at one place, water would be found three man-lengths below them even in arid and marshy lands. The place where the trees have glossy and thick foliage and shrubs and creepers have milky juice has sweet water very near (the surface) and is inhabited by sweet-voiced birds. In a place where there grow *Kharjuri, Jambu, Sata-patra, Nipa, Sinduvara, Vata,* N*aktamala, Andumbari, Kakaranva*, and *Vibhitaka,* there water would be found at a depth of three man-lengths.

Water is said to exist underground in a place where flowering trees and plants like J*ati, Kusthaka, Campaka,* etc. and fruit-bearing trees like the pomegranate, lime *(Citrus acida)* and citron are found to grow. Where on a hilly place the *Tala* tree, the coconut, tree, *Kancanara, Vetasa* or any other trees are found to grow, sweet water is found there in plenty. What has been previously described as a *Nirjahara* (water-fall or cascade) is found in a mountainous country issuing from the crevices between the rocks or from the roots of the trees.

In a wet mountainous country a stream with a copious flow of water is generally found to flow from under the vegetation. Sometimes such a stream is also found to exist underground at holy places with shrines. Near the rocks that glisten like a copper vessel facing the east (i.e. sun), or like glass and *Vaidurya* (eat's eye) or are bright like the pearls, or grey like the *Patasa,* or brown in colour, there is plenty of water. Where the dark blue soil or the black soil is found in conjunction with gravel, or where there is white coloured soil and sand or where there is yellowish soil, there exists sweet water. In brown soil the water is acrid in taste and in polish soil (of smooth surface) it is salt.

**Construction of reservoirs**

After the location of underground water, **Chakrapani** describes in his book ***"Visva Vallabha"*** the construction of reservoirs in the following paragraphs: "When water has been located, reservoirs of various shapes and sizes should be constructed outside the villages, their sites and measurements being determined by the availability of space. An artificial reservoir may be of six shapes, *viz.* circular, quadrangular (i.e. square), triangular, polygonal, oblong and semi-circular (half-moon-shaped). Its capacity may be ascertained after it is dug. The best reservoir should measure one thousand poles (or 4000 cubits) in length, medium-sized would be half of it and the smallest one quarter. The size of other reservoirs is determined by the availability of space. A big reservoir, in which there will always remain a large store of water, can be constructed at a lesser cost by constructing a dam between two hills, or in a mountain valley or on a spacious place at the top of a hill. If there be a wide and high table land on all sides with great influx of water and a. narrow outlet for the exit of water, then a big reservoir can be made by constructing a dam there. A wise person should provide a descent of steps from the top of the dam to the bottom of the reservoir and for making the dam strong he should have it plastered with lime cement both on the inner as well as outer face.

A land low from all sides when full of water turns into a pond and becomes a natural reservoir. There can be no prescribed measurements for it...small...pits etc. In the middle of the lakes and on their banks, there are pleasure houses of the kings. For the purpose of pleasure-trip or frolicking in water a boat should be kept there or an approach to the pleasure-house be made by means of a bridge (or causeway). A tank with three peaks (? angles) and one opening is called *Nanda,* that with *Bhadra,* the one with nine peaks and three openings is *Jaya* and that with twelve peaks and four openings is called *Vijaya*

If at the bottom of the well there is found to be sand, a foundation pedestal made of hard wood should be placed below in a manner that it does not block its springs of water.

A *Kunda* (pit) is of four kinds, viz., *Bhadra, Subhadra, Parigha* a:pd Nanda. The first is four-sided, the second is Bhadra, the third Subhadra and in the middle the fourth connected with Peatibhadra. They (i.e. the Kundas) should measure one hundred and eight cubits on each side with four openings, one in each direction, and a half in one corner provided with a quadrangular courtyard and ventilators inside. A very deep natural pool which has come into existence of itself may be of various shapes. Its embankments may be paved as they are with stone and lime mortar.

# Water unit: a thousand poles equals 4000 cubits.

**Changing water quality**

**Chakrapani** in his book ***"Visva Vallabha"*** describes the methods to change water quality. If the powder of *Khadira* is poured into a well whose water is saline or acrid in taste, the water would be turned sweet. The turbid and pungent smelling water of pools etc. would turn sweet and pellucid if the powder as well as the juice of *Kakubha, Musta, Usira,* fruits of *Dhatri* and *Kanaka* and of *Rodhra (Symplocos racemosa)* and Rajasana (?) is poured into them. The juice of *Abhaya (Terminalia chebula)* and the powder of *Pathya Terminalia citrina)* , *Kustha,* Cardamom, *Kugaudhma* (?) and *Kataka* fruit *(Strychnos potatorum)* along with the essence of Khadira and the fruit of wood-apple, if thrown in the turbid water or the salt water of well, they would at once turn the water (clear) and sweet.

**Ancient irrigation systems**

Devices for irrigation water lifting range from age-old indigenous water lifts to highly efficient pumps. Pumps operated by electric motors or engines have come into prominence in all large scale lift irrigation schemes. There are several types of indigenous water lifts are in use in India. They may be manual\y-operated or animal-operated. Based on the optimum range in the height of lift, they may be grouped under devices for low lift, medium lift and high lift.

i) Low Head Water Lifts: The swing basket, *don,* Archemedian screw, and water wheel are suitable when the depth to water surface does not exceed 1.2 m.

ii) Medium Head Water Lifts: Medium head lifts are suitable when the height of lift is within the range of 1.2 to 10m. The Persian wheel, chain pump, leather bucket lift with self emptying bucket, circular two-bucket lift and the counterpoise-bucket lift fall in this category.

iii) High Head Water Lifts: *Rope-and-bucket lift*. The only indigenous water lift suitable for deep wells is the rope-and-bucket lift *(Charasa)* operated by bullocks.

**Rain water harvesting techniques:**

The most common practices followed by the farmers to conserve the soil moisture are summer tillage, field boundary bund with vegetative cover, use of farm yard manure and intercultural operation with hand / bullock drawn equipments.

Farmers have followed the surface water harvesting rainwater harvesting techniques such as local percolation tank, farm pond, Tanka, Nada, Nadi, Talai, Talba, Khadin, Sar, Sagar and Samand. The water-harvesting methods differ from region depending upon rainfall, topography and soil type.

**Tanka** is constructed on farm in courtyard fort, etc, The shape of the Tanka is generally kept circular; however square Tankas are also constructed in buildings, forts and palatial buildings etc, for harvesting roof water, A2 m diameter and 3 m deep Tanka (capacity 10000 liter) is common on farmers. The Tanka is made on sloping land to arrest run off water in the farm however in house the construction is made on an elevated place to avoid entry water into it.

**Talai** is about 2-3 m deep the soil out from the Talai is spread around to make catchments area keeping its slope in mind special attention is paid for selection of locations such that there is adequate flow of rainwater into the Talai. care is also taken so that loose soil does not flow along with water stream into the Talai. In contrast to the Tanka, the Talai is kept open from the top. A pucca masonry ram entrance is also provided on one side of the Talai to facilitate distribution of water using camel, donkey, bullock cart, etc,. The stored water is generally used for animals.

**Nada:** Nada is a common method of conserving rainwater in villages. Low-lying area in between hillocks the catchments area of the Nada is 5 to 10ha. The Nada is constructed on rangeland barren land pasture land and agricultural field. It provides short-term storage of rainwater and mainly used for animals.

**Nadi:** Compared to Nada high embankment is provided around the Nadi. Depth of Nadi is kept up to 6-8 m. Catchments area of 10 to 150 ha is common for a Nadi. However area as high as 200 ha is found in certain specific cases. Nadi is generally constructed on sloppy area so that excess runoff water flows out without causing any damage to the embankment. Adequate cleanliness is maintained in the watershed to maintain purity or stored water. Bath is prohibited inside the Nadi. In the Nadi, water is available for whole of the year as a result it is shelter home for many wild animals and birds.

**Talab**: Talab is relatively shallow and spread over to more area compared to Nadi Runoff from hillocks is channels to a low-lying area in the vicinity and adequately bunded to from a Talab. It is generally constructed on rangeland.

**Khadin:** Khadin is the ancient indigenous rainwater harvesting method mainly

found in jaisalmer district. Accumulation of runoff water in between hillocks is known as khadin khadin means cultivation of crops in about 60-70 ha area. The khandi water is generally used for crop cultivation under preserved moisture conditions and animals consumption.

**Sar, Sagar And Samand:** In certain district of Thar Dessert sar, sagar and samand are used to harvest rainwater for irrigation purposes.

## History of Salinization in India – A lesson for the Future

Thought the dug wells and constructed canals to supply water for crop production (2000-6000 BC) no record of the rise of salinity irrigated tracts is documented with the development of canal irrigation from the era of sultan Feroz Shah Tughlak (1351-88) to the fall of mughal empire (1857) the salty patches in the soil said to have developed due to canal irrigation. disappeared when the canals went into disuse. Irrigation is a mixed blessing water-logging and salinity closely follow. in the past. all such lands that used to be unfit for agriculture were called as ushtra in Sanskrit meaning sterile or barren also called usar. Usar lands were adversely affected with arid climate or scarcity of water. Lands adversely affected with excess of salts, neutral (NaCl) or alkali ($NaHCO_3$, $Na_2$ $Co_3$) were also called as reh by geologists in mid-nineteenth centure to characterize the appearance of salt efflorescence on the surface of lands. In the chalcolithic period (c.1300 BC) irrigated farming which was developed in hilly uplands shifted to lower river valleys. Floodwaters were stored in reservoirs for irrigation in the valleys and canals were dug. Hence chalcolithic period is also called the era of irrigated farming. Archaelolgists have found a canal constructed dating back to the pre-harappan period (3000 BC) at Kunal (Hisar, Haryana).which was linked to the Saraswathi River about 5000 years ago. During the Vedic period (3700-2000 BC) the peasants dug wells and constructed canals to supply water to the crops. There is reference to irrigation by cannels taken from the rivers there is also reference to soil erosion by rivers. The Aryans being in Northern India had experience on ushara land, 'Alkali soil'. The Chola King Karikala (190 AD) and his successors constructed vennara and Arasil cannals, which take off from Kaveri River by means of channels drawn from dams, called anicuts or dike.

**Canal irrigation in India:** The development of canal irrigation began in the $14^{th}$ century at the initiative of Sultan Feroz shah tughlak (1351-88), a pioneer in canal irrigation in the medieval times. During hid period five canals were dug among these the most important was the Western Jamuna Canal. The salty patches in the soil. which developed under canal irrigation disappeared when the canal went into disuse after the fall of Mughal Empire in 1817, Blane was appointed by the Government of India to restore the WJC, which took 3 years due to paucity of funds. Alighment of the old Munghal canal consisting of natural channels and depressions was adhered, which resulted in the formation of large swamps and

extensive waterlogging. The Eastern Jamuna Canal (EJC) was taking off from the river on its eastern bank near Naushera in Uttar Pradesh, which was designed by Ali Mardan khan in the days *of* Shah Jahan. It was abandoned soon after construction due to the declining power *of* Mughals, but re-opened in January 1830. The Ganga canal belongs to the last years *of* the East India Company's rule. Cautley, in 1839, a military engineer, proposed to adopt a direct line from Hardwar to Roorkee. The canal was opened in April 1854 and irrigated large areas *of* Uttar Pradesh and the Pre-partition Punjab. Other canals constructed for protection against famine, viz., Sirhind Canal (Punjab) 1873-82, Lower Ganga Canal and the Betwa Canal (North-West Provinces), 1881-93. Mutha Canal and Khadakwas1a Dam (Bombay Presidency), 1869-79 and the Nira River Canals (Bombay Presidency) 1877-94.

**Advancement in irrigation potential during 20th century**

When the benefits *of* canal irrigation in British India became apparent, interest arose for such projects in some princely states. The pioneer was the Mysore state that planed a Kannabadi Dam, laternamed the Krishna Raja Sagar Dam (after the ruler *of* Mysore, Krishna Raja Wadeyar II), constructed under confluence *of* three rivers, viz., the Kaveri, Hemavathi, and the Kakshmanatirtha. Two canals, namely, the north bank high-level canal (Visvesvaraya Canal) and the north bank low-level canal, took off from the reservoir. The Nizamsagar Project was another irrigation project executed by Government *of* Hyderabad (1924-1931). The project comprised *of* a dam across the river Manjira, a tributary *of* Godavari river. The Gang canal (1922-27), which takes off from the Sutlej River at the Ferozpore barrage on its left bank, was to irrigate land in the princely state *of* Bikaner. It was built with the initiative *of* Maharaja Ganga Singh (1880-1943) *of* Bikaner. The Sarda Canal Project in the United Provinces *of* Agra and Oudh was started in 1915 I during the Viceroyalty *of* Lord Hardinge, and was completed in 1926. Government of India through Indian Coucil of Agriculture Research (ICAR) launched the All India Co-ordinated Scheme for studies on soil salinity and water management at different locations in 1968. It set up Central Soil Salinity Research Institute (CSSRI) at Karnal and Water Technology Centre at New Delhi in 1969. A part from these another co-originated scheme on use of saline water in agriculture came in operation in 1972 at 5 centers in the state of Uttar Pradesh, Rajasthan, Karnataka, Andhra Pradesh and Maharashtra.

**Annexure-1:** Biodynamic agriculture developed in 1924 by Rudolf Steiner (1861-1925) an Austrian scientist and philosopher, to a group of farmers near Breslau (which was than in the eastern part of germany) and is now Wroclaw in Poland). He published these concepts in a book titled Spiritual Foundations for the Renewal of Agriculture originally published in observations from farmers that soils were becoming depleted following the introduction of chemical fertilizers at the turn of the century. In addition to degraded soil conditions, farmers noticed deterioration in the health and quality of crops and livestock. Biodynamic agriculture was the

first ecological farming system to develop as a grassroots alternative to chemical agriculture. A basic ecological principal of bio-dynamics is to conceive of the farm as an organism a self-contained entity. Emphasis is placed on the integration of crops and livestock. the farmer too is part of the whole. Thinking about the interactions within the farm ecosystem naturally leads to a series of holistic management practices that address the environmental, social and financial aspects of the farm Steiner's use to terms like ethereal forces and astral forces are part and parcel of biodynamic agriculture.

Table 1 provides a brief summery of biological and dynamic farming practices.

| Table 1. Bio-Dynamic Farming Practices. | |
|---|---|
| Biological | Dynamic practices. |
| Green manures | Special compost preparations. |
| Cover cropping | Special foilar sprays |
| Composting | Planting by calender |
| Companion planting | Peppering for pest control |
| Integration of crops and livestock | Homeopathy |
| Tillage and cultivation | Radionics |

## Chapter 09. Crops - indigenous and introduced- History of rice, sugarcane and cotton

Indian agriculture is one of the oldest in the world and has millennia with involvement of farmers who have domesticated introduced and genetically enhanced a large number of species to harness maximum productivity Farmers have preserved seeds along with associated knowledge over generations leading to conservation. Archaeological findings have revealed that rice was a domesticated crop grown along the banks of the Ganges in the sixth millennium BC. Later, it extended to ot her areas. Several species of winter cereals viz., barley, oats and wheat and legumes such as Lentil and chickpea domesticated in Southwest Asia, were grown in Northwest India before the sixth millenium BC. Some other millets, such as sorghum, pearl millet and finger millet which were earlier domesticated in Africa, found their way to the Indian subcontinent more than 4000 years ago. In addition, smaller millets such as the species of Panicum, Setaria, Echinochloa, and Paspalumj were domesticated in India since the Neolithic period. Archaeological research also revealed cultivation of several other crops 3000 to 6000 years ago. These include oil seeds such as sesame, linseed, safflower, mustards and castor; legumes such as mung bean, blackgram, horse gram, pigeonpea, field pea, grass pea (khesari) and fenugreek; fibre crop such as cotton (Gossypium spp.) and fruits such as jujube, grape, date, jackfruit, mango, mulberry and black plum. Animals, including livestock, sheep, goats, asses, dogs, pigs and horses were also domesticated.

The primitive communities of the Neoliths period domesticated plants for food, legumes tubers fruits fibres and luxury crops. A classification of the crops cultivated in the early parts of human history has been given in Table 1.

Table 1.Categories of crops cultivated during the prehistoric period.

| Food Crops | Legumes | Roots/Tubers | Fruit | Fibres | Luxury |
|---|---|---|---|---|---|
| Wheat | Peas | Turnips | Nuts | Flax | Cocoa |
| Barley | Beans | Carrots | Apples | Cotton | Tea |
| Rice | Lentils | Garlic | Figs | Hemp | Opium |
| Maize | - | Potatoes | Oranges | - | Tobacco |
| Millets | - | - | Dates | - | - |

**Origin of crop plants:** Russian biogeographer Vavilov's (1949) classification of origin and approximate dates for the most common domestic plants.

| **Plants Species** | **Region of Origin** | **Date in Thousand Years BP** (BP =before present) |
|---|---|---|
| Emmer wheat | Near East (Southwest Asia) | 9-10 |
| Einkorn Wheat | Near East (Southwest Asia) | 9.5-8.5 |
| Barley | Near East (Southwest Asia) | 9.5-8.5 |
| Pea | Near East (Southwest Asia) | 9.5-8.5 |
| Lentil | Near East (Southwest Asia) | 9.5-8.5 |
| Vetch | Near East (Southwest Asia) | 9.5-8.5 |
| Flax | Near East (Southwest Asia) | 9.5-8.5 |
| Naked wheat | Near East (Southwest Asia) | 9.5-8.5 |
| Rice | Southeast Asia | 7-5 |
| Sugarcane | Southeast Asia | 7-5 |
| Sorghum and mulbery | North China | Korea and japan |
| Soyabean | North China | 7-5 |
| Almond, walnut, melon | Central Asia | 6-5 |
| Olive, fig, vine | Mediterranean Europe | 6-5 |
| Sorghum and cotton | Africa | 6-5 |
| Cucubita pepo | Tropical America | 9-8 |

| | | |
|---|---|---|
| Capsicaum, maize (corn) | Tropical America | 8.5-7.5 |
| Common bean, cotton, arrow-root, groundnut, tomato | Tropical America | 7.7 |
| Lima bean | Tropical America | 7.7 |

Domestication of plants and animals or the origin of agriculture is quite recent in the annals of mankind. The more recent investigations show that agriculture began around 10000 years BP (before present) or 8000 BC during the Sumerian times in southwest Asia.

**Indigenous Crops (**Nene, 2002): Archaeological findings have revealed that rice (Oryza sativa L.,) was a domesticated crop grown along the banks of the Ganges in the sixth millennium BC. Later, it extended to ot her areas. Several species of winter cereals (Barley (Hordeum vulgare L.,) oats (Avena sativa L.), and wheat (Triticum aestivum L.,) and legumes (lentil (Lens culinaris Medik) and chickpea (Cicer arietinum L,) domesticated in Southwest Asia, were grown in Northwest India before the sixth millenium BC. Some other millets, such as sorghum (Sorghum bicolour (L.) Moench.) pearl millet (Pennisetum glaucum (L.) R. Br. and finger millet (Eleusine coracana, (L.) Gaertn.) which were earlier domesticated in Africa, found their way to the Indian subcontinent more than 4000 years ago. In addition, smaller millets such as the species of Panicum, Setaria, Echinochloa, and Paspalumj were domesticated in India since the Neolithic period. Archaeological research also revealed cultivation of several other crops 3000 to 6000 years ago. These include oil seeds such as sesame (Sesamum indicum L.,) linseed (Linum usitatissimum L.,) safflower (Carthamus tinctrorius L.) mustards (Brassica spp.), and castor (Ricinus communis L.); legumes such as mung bean (vigna radiata L.) Wilczek). blackgram (Vigna mungo L. Hepper), horse gram (Dolichos biflorus L.) pigeonpea (Cajanus Cajan) (L). Millsp. field pea (Pisum sativum L.) grass pea (Lathyrus sativus L.; khesari) and fenugreek (Trigonella foenumgraecum L.) fibre crop such as cotton (Gossypium spp.) and fruits such as jujube (Ziziphus mauritiana Lam.) grape (Vitis vinifera L.) date (Phoenix sylvestris Roxb.) jackfruit (Artocarpus heterophyllus L.) mango (Mangifera indica L.) mulberry (Morus alba L.) and black plum (Syzigium cuminii L. Skeels). Animals, including livestock, sheep, goats, asses, dogs, pigs and horses were also domesticated (Mehra, 1997). Early indigenous domesticates: Rice was identified from several sites dated earlier than 1500 BC from the Gangetic region. Vavilov (1928) listed 117 economic plants which were domesticated in the Indian center or origin / diversity of crop plants.

**Origin of cultivated plants**

**1. Indian Main Center** includes Assam and Burma:

| | |
|---|---|
| Cereals and Legumes | 1. Rice Oryza sativa |

| | |
|---|---|
| | 2. Chickpea or gram Cicer arietinum |
| | 3. Pigeon pea, Cajanus indicus |
| | 4. Urd bean, Phaseolus mungo |
| | 5. Mung bean Phaseolus aureus |
| | 6. Rice bean Phaseolus calcaratus |
| | 7. Cowpea, Vigna sinensis |
| Vegetables and Tubers | 1. Eggplant Solanum melogena |
| | 2. Cucumber, cucumis sativus |
| | 3. Radish, Raphanus Caudatus |
| | 4. Taro Colocasia antiquorum |
| | 5. Tamarind Tamarindus Indica |
| Fruits | 1. Mango Mangifere indica |
| | 2. Orange Citrus sinensis |
| | 3. Tangerine, Citrus medica |
| | 4. Citron Citrus medica |
| | 5. Tamarind Tamarindus indica |
| Sugar, Oil and Fiber plants | 1.Sugar cane, Saccharum officinarum |
| | 2. Cocoanut palm Cocos nucifera |
| | 3. Sesame Sesamum indicum |
| | 4. Safflower Carthamus tinctorius |
| | 5. Tree cotton Gossypium arboreum |
| | 6. Oriental cotton Gossypium arboreum |
| | 7. Jute, Corchorus capsularis |
| | 8. Crotalaria, Crotalaria juncea |
| | 9. Kenaf, Hibiscus cannabinus |
| Spices, Stimulants, Dyes, and Miscellaneous | 1. Hemp, Cannabis indica |
| | 2. Black pepper piper nigrum |
| | 3. Gum arabic, Acacia arabica |
| | 4. Sandalwood, Santalulm album |
| | 5. Indigo, Indigofera tinctoria |
| | 6. Cinnamon tree, Cinnamomum zeylanticum |
| | 7. Croton, croton tiglium |
| | 8. Bamboo, Bambusa tulda |

**2. Indo-Malayan Center** includes Indo-china and the Indo-Malay Archipelago.

| | |
|---|---|
| Cereals and legumes | 1. Jobs tears Coix lacryma |
| | 2. Velvet beam Mucuna utilis |
| Fruits | 1. Pummelo Citrus grandis |
| | 2. Banana Musa Cavendishii, M. Paradisiaca H. sapientum |
| | 3. Breadfruit Artocarpus communis |
| | 4. Mangosteen, Garainia mangostana |
| Oil, sugar, spice, and | 1. Candlenut Aleurites moluccana |

| | |
|---|---|
| fiber plants | 2. Cocoanut Palm Cocos nucifera |
| | 3. Clove, Caryophyllus aromaticus |
| | 4. Nutmeg, Myistica fragrans |
| | 6. Black pepper, piper nigrum |
| | 7. Manila hemp or abaca musa textilis |

**3. Central Asiatic Center** includes Northwest India (Punjab Northwest Frontier Provinces and Kashmir) and Afghanistan

| | |
|---|---|
| Granis and legumes | 1. Common wheat, Triticum vulgare |
| | 2. clup wheat Tricticum compactum |
| | 3. Shot wheat Triticum sphaerocoecum |
| | 5. Lentil Lens esculenta |
| | 6. Horse bean Vicia faba |
| | 7. Chickpea cicer arietinum |
| | 8. Mung bean, Phaselous aureus |
| | 9. Mustard, Brassica junca |
| | 10. Flax Linum usitatissimum (One of the centers) |
| | 11. Sesame, Sesamum indicum |
| Fiber plants | 1. Hemp, Cannabis indica |
| | 2. Cotton, Gossypium herbaceum |
| Vegetables | 1. Oinon Alium cepa |
| | 2. Garlic, Allium sativum |
| | 3. Spinach Spinacia oleracea |
| | 4. Carrot, Daucus carota |
| Fruits | 1.Pistacia, Pistacia very |
| | 2. Pere Pyrus communits. |
| | 3. Almond Amygdalus communis |
| | 4. Grape, Vitis vinifera |
| | 5. Apple, Malus pumila |

**Introduced or Exotic New Crops:** Portuguese introduced new crops and fruit plants during the sixteenth century and enriched the agriculture of India. They were the greatest benefactors of India. Babar introduced the scented Persian rose. Similarly the botanical garden of Calcutta has performed a very useful function by introducing many important new plants. Following are some of the crops and plants, which were introduced by Portuguese from Brazil, Chille, Peru and Mexico. These crops and trees now form important components of the common cropping systems followed in the country.

**Crops introduced by Britishers**

| | |
|---|---|
| Pseudo cereals | Oats |
| Grain legumes | Pea |
| Fiber crops | Gossypium barbadense (cotton) |
| Vegetables | Leek, Asparagus sp., Beta vulgaris (beet root), Cauliflower), |

| | |
|---|---|
| | Brussels sprout, Knol-khol, Celery, Sweet pepper, Chicory, Squash, Daucas carota (carrot, orange type), Lettuce, Tomato, Sweet pea. |
| Fruits | Bilimbi, Carambola, Papaya, Rose apple, Strawberry, Mangosteen, Helianthus tuberosus (artichoke), Tapioca (cassava), Apple, Apricot, Cherry, Plum), Peach, Pear |
| Medicinal and aromatic plants | Cinchona officinalis (quinine), Origanum vulgare (maijoram), Cinchona officinalis (quinine), Origanum vulgare (maijoram), Papaver somniferum (opium poppy), Pelargonium capitatium (Geranium), Salvia officinalis (sage), Thymus vulgaris (thyme), Vanilla aromatica (vanjlla) |
| Others | Casuarina equisetifolia (Casuarina), Coffee, Eucalyptus globulus (Tasmanian blue gum), Grevillea robusta (silver oak), Hibiscus rosa-sinensis (shoe flower), Lantana odorata (Lantana), Magnolia grandiflora (Bull Bay), Myrtle, Horse bean, Parsnip, Avocado, Pine trees, Poinciana regia (Peacock flower), Mahogany, Cacao (cocoa) |

## Crops introduced from West and Central Asia by Mughals or Arabs

Onion, Garlic, Turnip), Cabbage, Coriander, Sweet muskmelon, Carrot, (black & red type), Date palm, Pea, Clove), Grape.

**Crops introduced by Spaniards:** Phaseolus vulgaris (French bean)

**Crops introduced from China:** Soyabean, Loquat, Walnut, Litchi,

**Crops introduced from Latin America:** Rubber, Pineapple

**Crops introduced from Southeast Asia and Pacific islands:** Sugar-palm, Breadfruit, Citrus decumanus (pomelo), Citrus paradisi (grapefruit), Durio zibethinus (durian) and Metroxylon sagus (sago)

**Some recent introductions:**

Mentha arvensis (spearmint, USA) Acacia senegal (Australia),
Acacia mangium (Australia) and Actinidia chinensis (Kiwifruit, New Zealand)
Crops introduced by Portuguese: **Groundnut, Tobacco, Potato and Agave.**

**Tobacco** was introduced during the reign of Emperor Akbar. It seems that they first introduced it into Goa and than into Bijabur. The potato (Solanum tubersum), a native of highlands of Chile and Peru, was introduced into India by the Portuguese In the seventeenth century. The first mention of potato in India occurs

in Terry`s account of a banquet given by Asaf Khan to Sir Thomas Roe in A.D 1615 at Ajmer. Portuguese introduced agave (*Agave Americana*) or the century-plant, which has now become naturalized throughout India. Its panicles of white flowers are highly ornamental, and its sword-like leaves protect our gradients.

**History of Rice:** Rice was grown in China nearly 5000 years ago. Remains of rice were found in the Yung Shao excavations in China, dating as far back as 2600 BC. According to one writer, Julien, it was reserved for the Emperor of China to sow seed of rice at a particular ceremony (established about 2800 BC) in the beginning of the cultivation season, and the sowing of the less important kinds of grain was relegated to the princes of his family. Archaeological excavation dated to 2300 BC at Lothal in Gujarat, a southward extension of the Harappa and Mohenja-Daro culture indicated the rice cultivation. Do Condolle, affirms that rice had been a valued crop in India since Vedic times, though its cultivation in that sub continent might not be of the same antiquity as that of China. The archaeological rice sample from India was from carbonized grains excavated from Hastinapur, north to Delhi and from Atrajnjikera in Uttarpradesh had revealed that rice was cultivated from 1500 to 700 BC. One of the Indian names of rice dhanya, for instance, means the supporter and nursery of mankind. Dhanya means 'sustainer of the human race' which indicates its age-old importance. Various ceremonies in India include the use of dhanya and the kernel tandula since it is regarded as an emblem of wealth, fortune, and prosperity. Rice is a symbol of fertility and as such as originally used in China to pelt newly wed couples in order to bring them good luck and assure them of many children. The Sanskirit word Urihi which most writers accept as the most direct name for the grain in that language finds mention in Atharvaveda (1100 BC). It may be interesting to note that the name of rice kernel is 'arisi' in Tamil language and the Arabian name for it is alruzz, in the Spanish it is called arroz. What says that the Arabic word al-ruzz is not derived from the Tamil word (from which some people argue that the word rice is derived) but from the Greek word Aruza the name for rice. The famous Ayurvedic Doctor Susuta (1000 BC) mentions in his "materia medica" different groups of rice based on duration, water requirements and nutritional values, recommended for particular ailments. The names of some of the ancient kings of India were derived from or associated with the word rice, thus about the sixth century BC, the King of Nepal, father of Gautama Buddha, was known as Suddhodana, which means ' pure rice'. The Sanskirit word for wild rice 'neevara' is also used in Telegu language for the wild rice, which invades the fields and waterways. Rice spread eastward form India to China and thence to Japan and westward into Iran, Iraq, Turkestan and Egypt. According to Green historians, Alexander the Great (about 300 BC.) carried rice from India Europe and it went from thence to Egypt and other countries in Africa. Large scale cultivation in Europe did not however begin till the close of the seventh century AD. because of the unsuitability of natural conditions available there. From India rice went to Persia, Arabia and Turkestan where its cultivation is still primitive, as they do not posses the right conditions for its culture.

**History of wheat cultivation:** Although wheat was introduced long before the

Christian era, it attained its importance only after it. It was the chief food of the 'mlechcha' (non-believes in God), "the barbarians", perhaps the Greeks and the people living outside India, and received the name 'mlechcha-Bhojana' (food for the non-believers). It was for a long time known as 'Yavana'a kind of barley. A Greek writer has also mentioned about wheat. Parasara, in Krishi-samgraha, speaks of wheat being a winter crop.

History of sugarcane cultivation: Sugarcane was cultivated in India since pre-historic times and was an important crop there by the end of the fourth century B.C. The RigVedic Aryans had the cane, and possibly the family name Ikshaku, had connection with large plantation. Apparently the cane was mostly chewed only and sometimes pressed and the juice used as drink. The idea of drying up the juice over fire came later, and the earliest known product was 'gula', or 'guda', a ball. In Bengal it is known as 'bheri' or 'bheli', from its form resembling a kettle-drum. There was no attempt at crystallization. In course of time the next stage came, when crystals were allowed to form, culminating in the production of 'sitopala', white crystals like rock crystals. A thoroughly scientific classification of the products of manufacture will be found in our medical works. It is also interesting to note that while only two varieties were known to Char aka, the number had in-creased to twelve by the time 8usruta came. Among the latter's twelve there was one called 'tapasa', evidently the wild ancestor of the modern forms. It is a remarkable fact that there is still a variety of cane known as 'Uri akh' in the north-west of Bengal which flowers. freely, and the cultivators use the seed for propagation, the adjective, 'uri' meaning wild, as in 'Uridhan'. One of the twelve varieties of Susruta was 'paundraka', or 'paundra', the same as 'paunda' and 'punri.' of our cultivators, undoubtedly the best of the indigenous canes. The commentators of Amarakosha tell us that the variety is so named because it grew in the country called Punara, or Northern Bengal. It seems the country derived its name from this fact just as the name Gauda from 'guda'. The people who cultivated the cane were known as Paundras. During the invasion of India (327 BC) Alexander’s army found the local people obtaining ‘honey’ from reeds without the aid of bees. The methods of growing cane and making sugar diffused east to Indochina and west to Arabian countries and Europe. Kautilya noticed that the cultivation of sugarcane involves trouble and expense. The difficulty was overcome by co-operation. The cultivators formed a 'grantha' or 'knot' or club among themselves both for the purpose of cultivation and manufacture of sugar. Co-operation was resorted to whenever the individual peasants were unable to meet the wants separately. It is known as 'ganta' in Bengali, and is not at all a new idea recently introduced. The share-produce system of cultivation so common in our country is a form of co-operation. The name sugar is derived from the Sanskrit word ‘Sarkara’, meaning gravel or sand. The earliest crude sugar made from the juice of the sugarcane was like sand. The original name was changed during its journey, to ‘Sukkar’ in Arabic, ‘Sakharon’ in Green, Sucre in French and finally to sugar in English. The next major event in the history of sugarcane was the importation of thick stemmed varieties of *Saccharum officinarum* from Thhiti to Jamaica in 1791 by Captain Bligh.

History of Cotton cultivation: Gossypium herbaceum var. africanum may be regarded as a wild ancestor of the domesticated plants. The development of cotton textiles appears to have taken place, not in Africa, but in the Indus valley in what is now Pakistan. Trade routes were open between Africa and India at that time, and linted cotton may well have been introduced to India as a curiosity, used first as a trimming or for embroidery on linen and woollen fabrics. The earliest known cotton fabrics in the Old World belong to the Indus civilization, indicating that the development of cotton as major new raw material took place in Sind. Excavations in Mohenja-Daro, Sind, Pakistan (Indus Valley) by Gulati and Turner (1928) revealed that occurrence of cotton in the form of strings and fragment of cloth covering the household articles, which archaeologists date to about 3000 BC. The fragments discovered at Mohenja-Daro were evidently made by competent craftsmen, and not by people experimenting clumsily with a new art, or with an unfamiliar raw material. In all hair characteristics that could be measured, the Mohenja-Daro cotton was within the range of Indian cotton of the present day so it is certain that the major changes involved in the evolution of lint were complete at that time. The existence of cotton threads has also been mentioned in the Rig Veda-the oldest scripture of the Hindus, written about 1500 BC and repeated references of cotton utilization have been recorded in the 'The sacred institute of Manu' and 'Asvalayana' (800 BC). From India, cotton was introduced eastward to China and Westward to Egypt around A.D 600 but it was probably not cultivated there as a field crop for textile purposes until the thirteenth or fourteenth century. Arab traders introduced cotton cultivation to the rest of African continent. It was brought to southern Europe (Sicily and Spain) by the Arab conquerors in the ninth and tenth centuries A.D. The Greek and Roman civilizations depended largely on flax wool and silk. The inventions of the automatic power loom by Edmund Cartwright in 1785 in England and the cotton given by Eli Whitney in 1793 in America revolutionized the cotton industry. Throughout the nineteenth century, cotton production expanded steadily and now it is cultivated in all tropical, subtropical and warm temperature parts of the world. Wool, silk and flax were used for spinning and weaving long before cotton became important. Purseglove (1960, 1963) suggested that *Gossypium herbaceum* could have reached South America in Tertiary times via the Antarctic, retreating northward as glaciation advanced. Fryxell (1965) showed that cotton seeds can survive floating in sea water for at least a year with undiminished viability and can thus be distributed by ocean currents. Purseglove (1968) agree that the most likely explanations were that cottonseeds floated across the Atlantic from Africa to South America.

## Chapter 10. Cultivation of Field Crops in Ancient India

The most probably earlier cultivation of crops was started on the foothills of upland areas of easily worked soil and not in the valleys because development of agriculture in the valley implies water control which need more skill and relatively more advance stage of technological development. This hypothesis about the beginning of agriculture is the forested foothills was put forward by Sauer - the American biographer.

Sauer (1952), in his hypothesis about the origin and development of agriculture, propounded that:

i. Agriculture did not originate in communities desperately in short supply of food, but among communities where there was sufficiency of food resulting into relative freedom from want and needed.

ii. The hearths of domestication are to be sought in regions of marked diversity of Plants and animals.

iii. The primitive agriculture did not orgin in the large river valleys, subject to the lengthy foods and requiring protective dams, drainage or irrigation, but in moist hill lands.

iv. The agriculture began in forested lands, which had soft soil easy to dig.

v. The pioneers of agriculture had previously required special skills but the hunters would be least inclined towards the domestication of plants.

vi. The founders of agriculture were sedentary folks, because growing of crops requires constant attention and supervision and unless guarded properly, the crop will be lost.

Raising of crops was an important vocation even in the pre-Vedic period and it put an end to nomadic life. Animal husbandry was dominant and crop raising was combined with livestock and trees. The economy of the country, according to Patanjali, depended upon agriculture and cattle breeding. Farmers of the Vedic period possessed a fair knowledge about soil fertility, selection of seeds, seasons of sowing and harvesting and other practices including manuring of fields. In ‘Arthashastra’ there is mention about the suitability of different lands for cultivation of crops. Farmers of the Vedic period knew the methods of improving soil fertility through rotation of crops. They planted deep rooting plants which served as natural aerators. Sweet potato was used to loosen the soil for the next crop. The swelling roots of the crop acted like mild explosives. As an incentive to the farmer, sweet potato was included in the diet specified for fasts which indirectly

helped in creating consumer demand for the crop. Most common rotations were of three years which included deep rooted, shallow rooted and legume plants. These were wheat-chick pea; sugarcane-green manure crop; wheat-fallow; pigeon pea, sorghum, etc. Mixed farming which included a combination of crops and livestock components was already in practice. Mixed cropping was the accepted system for raising crops. Legumes such as chick pea and other pulses were often grown in combination with wheat in order to augment the nitrogen availability for wheat. Some of the important crop mixtures were sorghum + pigeon pea + cow-pea; black gram or green gram (Mung bean) +s sorghum or bajra; wheat + chick pea; and wheat + linseed. In general, monocropping was not the accepted practice.

**Seasons:** Six seasons mentioned in Rigveda are viz., Grishma (May-June), Varsha (July-August), Hemant (September-October), Sharad (November-December), Shishir (January-February) and Vasanta (March- April).

Seasons in Temperate climate

| Winter | Spring | Summer | Autumn |
|---|---|---|---|
| January | April | July | October |
| February | May | August | November |
| March | June | September | December |

**Planting time and selection of land for different crops** (Kasyapa): The planting should be commenced with the beginning of the rainy season in several countries. Kashyapa has mentioned taking a crop even in summer if water was available. He divided arable lands into two major catergories; viz., lands suitable for growing rice (paddy) and lands suitable for other crops. Basically lowlying lands, which could be irrigated easily, were meant for rice, whereas the uplands where water supply was limited were meant for the crops such as pulses. Rice fields were to be of higher fertility than fields under other crops and were to be bunded to retain water but the bunds had to gave openings to allow excess water to flow elsewhere. Rice soils were to be clayey and rice fields close to each other and to the threshing ground. Rice fields were always to have standing water. Kashyapa stated that fields for pulses, etc., were to be highlands and were considered of second quality. These crops needed less water.

**Land preparation**: In Rigveda, farmers are stated to have resorted to repeated ploughings of land before sowing seeds. Clearly the purpose of such ploughings must have been to remove weeds, loosen the soil and pulverize it to the extent required. Excavations made at Kalibangan, Rajasthan (India) revealed a ploughed field (2450-2300 BC) that showed a grid of furrows, with North South furrows 1.9 m apart and East-West furrows 30 cm apart. This pattern probably indicates the practice of mixed cropping. Practice of incorporating sesame as green manure before land preparation has already been mentioned in Varha Mihira's Brhat Samhita. There is a reference to heavy and light ploughs in Vedic literature. These were probably used for deep or shallow ploughing as required. Sage Parasara had

stated that Anila i.e., Swati, Uttarashadha, Uttarabhardrapada, Uttarpahalguni, Rohini, Mrigashirsha (Mriga), Mula, Punarvasu, Pushya, Shravana and Hasta are good stars for ploughing. Plowing on Monday, Wednesday, Thursday and Friday results in good growth of crops. The second, third, fifth, seventh, tenth, eleventh, and thirteenth, day of the month are good for ploughing. Ploughing should be commenced on auspicious lagnas, such as Taurus (April 21), Pisces (February 20), Virgo (August 22), Gemini (May 21), Sagittarius (November 23) and Scorpio (October 23). Lagna is the moment of the Sun's entrance into the respective regions. Furrows should be single or in groups of three to five. Single furrows lead to success, in threes to wealth, and those in five yield plenty of harvest. One plough gold in Hamanta (December-January), silver and copper in Vasanta (April – May) only crops in summer (June-July), but in rainy season (August-September) one can plough only poverty.

**Soil as a basic resource for successful crop production (Kasyappa):** Kashyapa divided the agricultural land into two categories: shalibhu (=land fir for rice cultivation) and adhakadibhu (=land suitable for cultivation of pulses and other grains). A good quality land yields good results to everyone, confers good health on the entire family, and causes growth of money, cattle and grain. Thus the importance of a good soil can never be overemphasized. Kashyapa states that it is the responsibility of the king to appoint knowledgeable persons, regardless of their caste affiliation, to scrutinize the suitability of land for growing crops. Kashyapa points out that a good soil should be devoid of bones and stones., should be a plastic clay with reddish and black hue, full of essence (potency), and glossy with water, should not be too deep or shallow, should be conducive to speedy seedlings emergence, should be easily absorb moisture and should be inhabited with beneficial living creatures (earthworms?). and should have a substantial mass. Kashyapa states that the soil may posses Brahaminic qualities, qualities of Kshatriyas, as also those of Vaisyas and Sudra. Using traits normally associated with these castes, one could conjecture that a soil should be fertile and give stable yields; a soil should give yields by controlling enemies such as pests, a soil should give sometimes, bumper yields, and a soil should give good yield when looked after with close attention respectively.

**The plough and other implements:** Parasara provides information on construction details of the plough–a version called the desi plough ' wooden plough' as well as reference to a few other implements such as an abadha (disc plough) phalika (leaf shaped iron piece to replace the normal iron blade for deep ploughing), Viddhaka (spike tooth harrow with 21 spikes), and madika (wooden plant for levelling the field were provided. The use of a disc 54 angulas in diameter (approx. 1 m) in place of plough share for using on hard virgin soil is recommended.

The dates for ploughing operation are suggested on 20, February; 21, April; 21, May; 22, August; 23, October and 23, November. A calender for ploughing for taking the crops was only mentioned in Krishi –Parashara.

| Starting of ploughing | Crops |
|---|---|
| 20, February | Sugarcane, black gram |
| 21, April | Rice (to be transplanted later) |
| 21, May | Rice (to be directly seeded) and other warm season crops such as cotton and seasme |
| 23, October | Late sown wheat and barley plus mustard |
| 23, November | Field vacated by rice for planting sugarcane and fodder crops. |

Kashyapa has specially indicated that use of strong wood for various purposes (e.g. making a tying post) such as tinduka (Diospyros melanoxylon), tinisha (Ougeinia oojeinensis) or a sarjaka (Vateria indica). Manure should be available and used for increasing the 'potency' of the land. Besides plow, spades, lancets, small horns, (for breaking soils crust) knife, sickles, ropes, etc., were mentioned. Ploughing was to begin with the visibility of rain-bearing clouds and plots were to be filled with water for puddling to prepare for planting paddy. Kashyapa refers to worship of plough as well as bullocks.

**Farm implements:** Ancient literature of the subcontinent did not miss out on farm implements. Vedas describe a simple bullock drawn wooden plough, both light and heavy with an iron bar attached as a plough share to open the soil. Krishi Parashara (c. 400 BC0 (Sadhale, 1999) gives details of the design of the plough with Sanskrit names for different parts. This basic design has hardly undergone any change over centuries. Even today the resource poor farmers use a similar bullock drawn plough. A bamboo stick of a specific size was used to measure land. Vedic literature and Krishi Parashara also mention disc plough seed drill, blade harrow (Bakhar), wooden spike, root horrow, plankers, axe, hoe, sickle, supa for winnowing, and a vessel to measure grain (udara). Pairs of bullocks used for ploughing in ancient days varied from one to eight. Plough was considered as the most sacred and essential implement in agricultural operations and was known by different names. The more commonly known desi plough was a multipurpose implement.

**Seed collection and preservation** (Sage Parasara)**:** All sorts of seeds should be procured in Magha (February) or Phalguna (March) and should then be dried well in the sun without putting those directly on the ground.' To procure healthy seeds of panicles are located in the field, cut from the standing crop, and collected in a pouch.A mixture of different kinds of seeds causes great loss. Uniform seeds produce excellent results. *The origin of plentiful yield is the seed.*

**Kashyapa:** A good quality of seed is stated to be the first step towards the success in farming. Seeds of several trees specified for plantation are also to be procured and preserved. Seeds of wheat, pulses, fruits, vegetables and condiments such as turmeric, cumin, black pepper, etc., also need to be preserved for cultivation in the proper season. Kashyppa describes the procedure of preserving the seeds and

advises farmers to dry the seeds in the sun, store them in different kinds of vessels, and protect them from stormy rains and moisture as well as from rats, cats, and rabbits.

**Crop diversity:** India had a large and wide diversity in cereals, millets, pulses, oil seeds, fibres, vegetables and fruits. The species and varietal diversity provided wide choices for selection according to soil type, climate and management practice. A variety of rice which was ready for harvest in sixty days was available in ancient India. Magadha grew another variety with large grains of extra ordinary fragrance which was called rice of grandes. Manasollasa referred to eight varieties of rice distinguished by their colour, odor, size and period of growth. India had five wild species of rice from which there had been a regular trend of evolution from perennial to annual habit, from cross pollination to self-pollination and from lesser to greater fecundity. Wheat recovered from Mohenjodaro belonged to *Triticum vulgare, T. compactum* and *T. sphaerococum. T. sphaerococum* is a wheat of great antiquity (2300 B.C) and was widely grown in north India. It has high resistance to drought. Barley was cultivated throughout the Harappans period. Aryans were accustomed to barley diet. They adopted wheat and barley in the Indus valley culture and generated new variability required for intensive cultivation. Millets such as sorghum, bajra and ragi were also important. They were primarily grown for grain but the straw was also regarded valuable as a cattle feed. About 25 species of sorghum were known to have been available. The use of ragi *(Eleusine coracana)* straw as a cattle feed was noticed in *1800* B.C. Pulses figured predominantly in crop rotations and crop mixtures in the early period. Being legumes they maintained and improved fertility of the soil. Lentil, black gram, green gram and Lathyrus (Khesri) are pulses of antiquity and were noticed in Narmada basin during 1657-1443 B.C India is the original home of green gram. A wild variety of *Vigna sublobata* was found in Tarai forests. It was immune to yellow mosaic virus and was used in plant breeding. Black gram was widely accepted as a nutritious pulse crop in the ancient Indian culture since the Vedic period. It was used in socio religious ceremonies and even today its importance has not waned. Similarly lentil also enriched the traditional diet. In oil seeds, sesamum was the most important crop grown by Harappans in the Indus valley. The *Brassica* group covering brown mustard, yellow mustard and thoria is collectively known as Indian rape. The other important oil seeds comprised linseed and castor. Cotton cultivation was known to Harappans. Wild and weedy types of cotton have been recorded from Gujarat, Kathiawar and Deccan. They are perennial and known as tree cotton. Harappans also knew date palm, pomegranate, lemon, coconut and melon. Babar (before $16^{th}$ century) mentioned in his memoirs the plants he saw in India. They were mango, plantain, tamarind, mahuwa, Jamun, chironji, khirni, karonda, ber, aonla and orange. It is obvious that the earlier people possessed a good knowledge of crops. The strategy for the selection of crops and the adoption of different cropping and farming systems was decided on the basis of resources available with the individual and his immediate and long term needs. Through a continuous process of selection and elimination, promising plants or varieties were identified and their multiplication brought

about by adopting diligent methods of seed collection, preservation and exchange within the social groups.

**Choice of crops and varieties:** Kashyapa listed rice and other cereals as the first, pulses and other grains as the second vegetables (including fruits) the third, and creepers and flowers etc., the fourth. Kashyapa considered three main varieties of rice, Shali, Kalama, and Shastika. Shali rice is said to have twenty six varieties depending on the quality of land in different regions. Kalama is slightly thick white, and with a surplus sap. Shastika is tasteless. Vrihi is considered to be oldest name for rice. Shukla vrihi (white rice) mentioned in Krishna Yajurveda (300 BC). In the same Veda Krishnanam vrihini (black rice), asunam vrihinam (fast growing, 60 day rice), mahavrihinam (large seeded rice) and naivaram (wild rice) have been mentioned. Atharvaveda, naivaram became nivara and in addition to black rice, red rice, and the 60-day rice were mentioned. A new name for rice appeared in the Atharvaveda; i.e., tandula (for dehusked rice). The word vrihi for rice was used in Upanishads. Shali was used for those rices, which were planted at the beginning of the rainy season and harvested in winter; these were probably the 6 month varieties. Vrihi, Shali, Nivara, Shastika as well as a new word Kalama appeared in Susruta Samhita (400 BC) and Amarkosha of Amarsinha (200 AD).

**Rice varieties-other aspects**: Some of the other highlights under the topic collection and preservation of seed are (i) it is the king's government in today's context (responsibility to ensure seed supply, ii (seed must be properly dried in sun, (iii) giving a gift of seed is a superior act, (iv) different varieties of rice mature at different times taking 3 to 8 months, (v) farmers should respect traditional knowledge of the region and use it. (vi) seeds of all kinds of other crops should be likewise collected, dried, and stored in pots, heaps, of husk or bowls and (vii) seed must be proected from rabbits, rats, and cats, and moisture. Taking care of good seeds religiously is conducive to the benefit of farmers (as has been) said by great sages.

**Basmati Rice:** The word 'basmati' has its origin in the Sanskrit words 'vaas' means fragrance and 'matup' means possessing Thus vaasmati should mean something possessing fragrance in northern India, 'va' is often pronounced as 'ba' and thus the word 'basmati' should have been used for a kind or rice having fragrance of scent.
**Golden rice:** Kashyapa had claimed that Peetvarna vrihi (yellow rice) improved digestion or a sambaka variety called Hema (golden rice).

**Sequence of cropping:** In the Yajurveda, distinct references to the rotation of crops are found. Crops were grown in the same field by rotation and the system of fallowing was also known (Rigveda). The Taittiriya Samhita distinctly mentions that in' the *course* of a year, two crops were harvested from the same field. It also mentions different seasons for ripening of different crops and the proper times for harvesting them. In a descriptive passage of the Ramayana sali, godhuma and yava are seen waiting for harvest with the advent of winter. But wheat and barley are winter or *rabi* crops sown in October and gathered at the end of May. Kautilya

gives directions for seasonable cultivation and harvesting. The Arthasastra evinces not only thorough acquaintance with these two harvests but even with a third. A king is instructed to march against his enemy in Margasirsa (January) in order to destroy his rainy crops and autumnal handfuls, in Caitra (March) to destroy autumnal crops and vernal handfuls, and in Jyesthamula (June) to kill vernal crops and rainy season handfuls. Thus there were three crops-one sown in rainy season and garnered before Magha, another sown fn autumn and garnered before Caitra and a third sown in spring and stored by Jyaistha (cf. Barley "ripened in summer being sown in winter, rice ripened in autumn being sown in the rains, while beans and sesamum ripened ,in winter and the cool season". Arthasastra catalogues the crops of different seasons. Paddy, kodruva, sesamum, panic, daraka and varaka are sown in the first season (purvavapah), mudga, masa and saivya are sown in the second season (madhyavapah), kusumbha, lentil, kuluttha, barley, wheat, kalaya, linsed and mustard are sown in the last season. The Artha sastra .agree with *kharif* and *rabi*- crops respectively. The Milinda speaks as well of a third monsoon - (pavllssako) besides the regular rains of the later Summer and early winter. The three monsoons of course did not uniformly visit every part of the country each year; and whether a locality grew one or two or three crops depended on-rainfall, climatic conditions and character of the soil. In many places the food crops as well as edible fruits and vegetables grew spontaneously without tillage. To the Greek observers these phenomena seemed strange. The description of the forest scenery in the Epics (Ramayana; Mahabharata) and the Jatakas frequently go at length over the crops and fruits growing in wild areas without human labour. In Arthasastra, it is stated that raising of a second crop by, the cultivators was sometimes made compulsory as a last resource for taxation. After a careful observation of the meteorological charts, it suggests the quantity of rain required by .a specific crop and the cultivator is instructed for the particular crop along the rain forests.

**Crop rotation in Rigveda:** Continuous cropping was a practice, but pulses (legumes) and other crops were also sown. "The cultivators harvesting the crops in general, separately and in due order" has been interpreted to be giving an idea of crop-sequence or crop-rotation and line-sowing and avoiding overlapping during harvest.

**Seed and sowing:** Ancient scholars showed awareness of the importance of good seed; i.e selection of the apparently healthy seed from a ripening crop, preserving it safely in storage, with or without treatments and sowing the good seed again with or without some treatment. About 2000 years ago, Parashara recommended (i) proper drying of seed (ii) freedom from the seeds of weeds (iii) visual seed uniformity (iv) storing seeds in strong bags, and (v) storing seed where white ants would not have access and at a location where seed would not come in contact with substrates that would allow moulds to grow such as cowshed wastes, damp spots, or left over foods. Sage Parasara had stated that Uttrashadha, Uttarashadha, Uttarabhardrapada, Uttarpahalguni, Mula, Jeyshtha, Anuratha, Magha, Rohini, Mrigashirsha (Mriga), Rohini, Hasta, and Revathi are the good nakshatras for sowing. Two days should be avoided for sowing, transplanting;

Tuesday, which portends threat from rats and Saturday, which foretells threat from locusts and insects. Sowing should not be done on ' empty' days (such as the fourth, ninth, and the fourteenth day of the lunar fortnight of a month) especially if the moon is weak. Seeds of grains should be planted at a distance of hand (approximately 1½ ft =45 cm) when the sun is in Cancer. In Leo the distance should be half of it. In Virgo it should be four fingers, (3-4 inches =7.6 –10.2 cm). Butter milk makes the seeds sprout earlier than the normal time. Salt would kill the embryo. Kautilya in Artha Sastra indicated that decision to sow seeds of specific crops should be taken on the basis of known rainfall patterns. He recommended that rice be sown first and mungbean and black gram later. He also suggested some seed treatments. (e.g., cowdung, honey and ghee) to ensure good germination. Manu mentioned that a professional farmer (the Vysya) must be able to determine the quality of seed. The most significant recommendation by Manu was severe punishment to a trader selling spurious seed. Kashyapa's The procedure of sowing involves ploughing, levelling, furrowing, or digging pits. The procedure is said to depend on the characteristics of land, availability of water, sunshine, and also on additional wisdom. Varahamihira recommended pelleting of seed with flours of rice, blackgram and sesame and fumigating them with turmeric powder to ensure good germination. Surapala listed several botanicals such as seed treatment materials for shrubs and trees. Even today cowdung, suggested by Kautilya in the 4$^{th}$ century BC, is used for treating cotton and some other seeds by a large number of farmers. Sowing of seed was considered a very important event. Prayers and rituals were associated with the sowing operation. Primitive bamboo drills were used for sowing seed. Adjusting the inter-plant and inter-row spacing was done on the basis of sowing time; late sowing meant more seeds per unit urea. A wooden plank was run over sown fields to ensure uniform seed germination. The art of sowing rice in small areas; i.e. in nurseries and transplanting of the seedlings is not a recent practice. It was first perfected in the deltas of Godavari and Krishna rivers in 100 AD.

The general practice of sowing seeds, according to Varahamihira, involved soaking them in milk for ten days, taking out daily with hand, smearing with ghee, rolling many times in cowdung and fumigating with the flesh of deer or hog. Then the seeds were sown in a soil which was already treated with sesamum crushed together with flesh and hog's marrow. They grew and bloomed when sprinkled with milk and water. Another method was to soak the seeds hundred times in a paste of Ankola *(Alangium salvifolium* Wang) fruiter in its oil or in a paste or oil of Slesmataka *(Cordiarothii* Roem and Schult) fruit and sow in a soil mixed with hail. The seeds would sprout instantly and bear fruits. Hard seeds like tamarind sprouted when sprinkled with a mixture of the flour of rice, black gram and sesamum and wheat particles together with stale meat, and fumigated with turmeric powder, repeatedly. For Slesmataka the shell of the seeds was removed, then soaked in water, mixed with the paste of *Alangium* fruits and dried in the shade seven times, mixed with buffalo dung and stored in the dry dung. The seeds were then sown in a soil soaked with rain water. The bearing was good.

Seeds were treated in a special manner to get special results. Cotton seed

was treated with red lac juice in a special manner to get red tinged cotton. It was also treated with cow dung paste to facilitate sowing and control of seed borne diseases. The seedlings for transplanting at a distant place were smeared from root up to the stem with a mixture of ghee, Usira or Khas *(Vetiveria zizanioides),* sesamum, honey, Vidanga *(Emblica ribes),* milk and cow-dung.

Sali paddy was grown by transplanting (Kalidas in Raghuvamsha). Incidentally, the technique of transplanting rice was widely practice in Krishna-Godavari deltas in 100 AD. It was the most important agricultural operation during the Sangam age (AD 300 - 600). Varahamihira has recorded two methods of grafting. They are (i) inserting the cutting of a plant into the root of another, cut off from its trunk, and (2) inserting the cutting of a tree into the stem of another. The junction of the two in both the cases was covered with a coating of mud and cow dung. Grafting was advocated for jackfruit, ashoka, plantain, rose apple, lemon, pomegranate, grape, jasmine, etc. Further, he recommended February-March for grafting those plants which have not developed branching; December - January for those which have developed branching and August - September for those which have developed large branches. The grafted trees were to be watered both in the morning and evening every day in summer, on alternate days in the cold season and whenever the soil becomes dry in the rainy season.

**Kashyapa's view on rice cultivation:** Rice is divided by experts into three main varieties based on their taste and colour; shali, kalama, and shastika. The golden rice sambaka vrihi (rice) var hema and peetavarna vrihi (yellow rice), which removes indigestion. Kalama of red colour, kalama of thick form, kalama of long form, vrihi (rice) of sambaka variety called hema (golden). Kala vrihi (sweet and nourishing rice), sit vrihi (white rice) and peetavarna vrihi (yellow rice), which removes indigestion. Kashyapa's procedure of rice cultivation starts with plowing, maintaining standing water, planting of seedlings, weeding, water management, crop protection, harvesting at the proper time, pounding on the threshing floor, cleaning and storing in the house. *Kashyapa for the first time has recommended transplanting of rice in ancient literature*.

**Weeds and weeding:** The role of weeds in reducing crop yields was well understood by our ancestors Parashara pointed out the need to weed rice fields; as many as four weedings were suggested. Weeding as an essential practice in raising crops is stated in the Sangam literature. Parashara recommends collection of crop seeds free of weed seeds.

**Nutrient management:** Kashyapa emphasized that the Brahmins proficient in Vedas should sprinkle the fivefold cow-products (milk, curd, ghee [clarified butter], urine, and dung) or may be simply sprinkle with clean water over the land (for the purpose of purifying the atmosphere) either in the morning or in the evening. This is known as 'Panchakowia'

**Water management:**

**Sage Parasara**: Construction of bunds to retain water in plots is recommended to rice. Bunding has not been recommended in low-level fields since there would be adequate moisture. Direct seeding of rice has been recommended for low-lying areas. Avoid flooding of rice once the panicles have come out, however the soil must remain moist.

**Kashyapa was supportive of irrigated crop production:** Kashyapa focused his attention on irrigated agriculture. Construction of wells and device for lifting water had been described. Kashyapa has given details about where how water reservoirs should be constructed. He stressed construction of a reservoir near farmers' fields, ensuring source of water for the reservoir, making strong causeways and thus taking steps to avoid flooding of inhabited areas, and regularly inspecting and repairing the reservoirs, especially during the rainy season. The last one is good reminder to present day, lazy, and indifferent staff of the government irrigation departments. Each farmer should have access to two reservoirs. Kashyapa's recommendations on buildings and maintenance of reservoirs are technically sound. Kashyapa recommended planting of trees around water reservoirs obviously to protect and beautify them. He suggested picnic spots around reservoirs, a feature that is considered 'modern' in the 21$^{st}$ century. Construction of canals has been indicated in verses 111 through 143 of section I. Kashyapa has mentioned four sources of canal. i. river, ii. tank which could have been filled by a river, iii. large lake, and iv. canals collecting water from mountain cascades. Kashyapa has stressed provision of a proper gradient for the canals and a network of these canals surrounding villages. He emphasized selection of soil with right structure and profile for making canals and avoiding saline soils. Protection of the canal system, like the protection of reservoirs was also stressed. Kashyapa recommended construction of wells, especially in areas where canal water was not available. Best time for digging wells was the post rainy season. He suggested study of indicators for the presence of sub soil water such as existence of trees and course, water divining. He stressed laying strong foundation with bricks and building walls with bricks and mortar. Even provision of steps to enter a well was recommended. Kasyapa has mentioned the use of ghatiyantra (the so-called Persian wheel) with the help of bullocks, elephants, and humans. Harvesting of rain was stressed. A verse that says everything about water for farming is 'It may be a canal, a well, a pool, or a lake, but find they must and acquire a guaranteed source of water."

**New crops and other plants:** Portugese introduced new crops and fruit plants during the sixteenth century and enriched the agriculture of India. They were the greatest benefactors of India. Babar introduced the scented Persian rose. Similarly the botanical garden of Calcutta has performed a very useful function by introducing many important new plants. Following are some of the crops and plants which were introduced by Portuguese from Brazil, Chile, Peru and Mexico. These crops and trees now form important components of the common cropping systems followed in the country.

**Crops**

1. Groundnut (Peanut) - main source of edible oil in India. A native of Brazil.
2. Tobacco - introduced by Portugese during the reign of Emperor Akbar.
3. Potato - widely accepted and grown in India as a favourite vegetable. It is a native of Chille and Peru
4. Amaranth - the colourful crop is grown along the whole length of Himalayas. It is a native of Brazil.
5. Chillies - the ornament of Indian garden and soul of pickles. It is a native of Brazil and Peru.
6. Agave - a century plant and has become acclimatized throughout India.
7. Allamanda *(Allamanda cathartica* L. Mant) - a climber with beautiful flowers. It is a native of Brazil and South America.

**Fruits**

1. Cashewnut - widely grown in India and a native of Brazil.
2. Guava - common fruit crop of India. It grows wild in Brazil.
3. Custard apple - widely grown as a forest crop. Introduced by Portugese.
4. Sapota - a gift from Portugese. Delicious fruit and native of Mexico.
5. Pineapple - extensively grown in eastern parts ofIndia. It is indigenous to Brazil.Indian people evinced keen interest in the introduced crops and gave a fair trial under close observation. This resulted in the spread of the selected crops throughout India.

**Growth promoters:** In respect of diseases, Varahamihira says the tree catches disease from cold weather, strong winds and hot sun. In such cases a paste made of vidanga, ghee and silt must be applied to the affected parts. Water and milk should be sprinkled on such trees. When there is a premature fruit drop, the tree should be watered with milk that has been cooled after being boiled with horse gram, black gram, green gram, sesamum and barley. After this treatment, the trees will produce abundant flowers and fruits. A mixture of powdered dung of goats and sheep, sesamum powder, wheat articles, beef and water, kept for seven nights should be sprinkled for increasing flowers and fruits of trees, creepers and shrubs. In the Sangam age, the dung of cow and sheep and green leaves were used to increase the yield of crops. Krishi Parashara has prescribed the method of preparing manure from cattle dung and dry leaves. Sesamum, cowdung, barley powder, fish and water when mixed in fixed proportions formed an effective manure. According to Varahamihira, sesamum is sown and ploughed back when it blooms in order to mix it with the soil. Cowdung, dung of buffaloes, goats and sheep, clarified butter, sesamum, honey, horsegram, blackgram, green gram, barley, roots of certain plants, ashes, stale meat, beef and marrow of hog were used as manure. The Indus valley produced surplus food. All important cities had large storage facilities for stocking grains. The rulers at that time had the wisdom of maintaining buffer stocks. One of the granaries stored enough barley to provide wages for *400* days. Another granary had the capacity to pay in kind for 10,930 man days. Trade was by barter and payment to labourer was in kind. The artisans, carpenters and others received their wages in kind from the farmers.

Agriculture without supervision was considered fruitless. The owner of the

field was to look after the field himself. If he failed to supervise the agricultural operations, the belief was that the Goddess of prosperity would desert him and in her place adversity would enter his field. According to Arthashastra, if any farmer was found negligent in his duties of carrying on the agricultural operations in time, the King had the right to snatch away the land from him and hand it over to another man of the village. The foremost duty of the King was to protect agriculture and render assistance to the farmers. These directions show that the concept of management was known and practised by everybody including the King.

**Harvesting and measuring yields** (Sage Parasara)**:** Aardra, Kritika, Chitra, Pushya, Hasta, Swati, Uttarashadha, Uttarabhadrapada, Uttaraphalguni, Mula, and Shravana are the nakshatras recommended for the token harvest. Harvest should not be done on ' empty' days. The fourth, ninth, and the fourteenth days of the lunar fortnight are Rikta or empty days. Grains should be measured from left to right and not the other way. Adhaka is a wooden vessel used to measure gains roughly equivalent to 7 lb and 12 oz (about 3.5 kg) It is equal to one fourth drona. Measuring the grains from the right leads to expenditure whereas from the left leads to happiness and enhancement of yield.

**Measurement of crop produce** (Kashyapa): He should also make arrangements of prastha, kunja, drona, and small nadika for (proper) measurement of grains of cereals and adhaka (pigeonpea) etc., and other commodities. The first three are the measures of capacity, prastha = ¼ adhaka; drona = 4 adhakas, kunja – should have been kunchi = 1/32 adhaka, where one adhaka=256 fistfuls=32 kunchis, i.e., 32 handfuls, nadika is a measure of length = 2 hastas, where one hasta is the distance between the elbow and the tip of the middle finger and is approximately equal to 18 inches. Pala ( a weight of gold = 4 karshas = 64 mashas = 640 grain of masha (blackgram).

**Storage of grains** (Sage Parasara)**:** The auspicious Meena (Pisces) lagna (February) is the best for storing grains. Hasta, Sharavana, Dhanishtha, Shatabhishita, Pushya, Bharani, Uttarashadha, Uttarabharapada, Uttaraphalguni, Mula, and Magha are the auspicious nakshatras for storing grains. Monday, Thursday, Friday, and Saturday should of course be avoided.

**Farming Systems:** The importance attached to food quantity in Anna Sukta shows that arable farming was given equal importance as stock farming. The praise of land, bullocks, seeds and peasants in various hymns clearly indicates' importance attached to arable farming, crop husba ndry with different types of field grasses for food and fodder being considered for the dual purpose of man and animal. The traditional land use and occupational structures in Indian agriculture have invariably been site-specific based on available resources and sound ecology. In India foe example people of Rajasthan developed nomadic and animals care based occupation because the land fragile and could not be used intensively. The people of Mizoram and Nagaland developed shifting cultivation as their system of survival

because they had to live on slopes and this was the best way to sustain their soil fertility and productivity and conserve and use the bio-resources in sustainable manner. This highly organized agro-ecosystem called Jhum is based on empirical knowledge accumulated over centuries. It functions in harmony with environment and provides enough time for recovered of forest and soil fertility that is lost during cropping phase. It involves slashing of vegetation burning it before the on set of monsoon raising mixture of crops on temporarily enriched soil for a year or two leaving it fallow for a few needs fresh system like Zabo system a combination of forestry soil and water conservation, Alder system for soil health and Panikheti system of wet rice cultivation with judicious use of water have been developed. Shifting agriculture practised in India has mixed cropping as a standard feature. It was once conceded primitive by scientists, however now it is being suggested as a means to increase world food production. During the cropping phase the farmers raise 8-35 crops species on a small plot of 2 to 2.5 ha with simultaneous sowing and sequential harvesting the crop mixture provides crop cover against loss of nutrients, optimisms resources facilitates recycling of biomass and nutrients and improves soil characteristics.

Zabo farming system is practiced in Nagaland. 'Zabo' means impounding of water. The system is a combination of agriculture, forestry, livestock, fishery and soil and water conservation. The Zabo system comprises protected forest land on the top of the hill, well planned rainwater harvesting tank on the top of the hill and indigenous methods of nutrient management in hill region, cattle yard and terraced rice fields towards foothills. The Soils of the area are salty clay loam in texture with grayish brown colors and there are no means of irrigation. Animal manure is the major source of crop nutrition. The silt deposited in the tanks is dug out during off-season and added to the fields. This silt is very rich in nutrients as it contains lot of forest litter. Farmers also add leaves and succulent branches to the fields and leave for decomposition. This helps in building up soil fertility and maintenance of soil health. This indigenous farming system is good example of integrated use of land, water and nutrient. Shifting cultivation, which otherwise causes soil and nutrients loss, the Zabo method of cultivation is ecofriendly, takes care of natural resources and soil erosion is negligible.

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Farms yield gold if properly managed but lead to poverty if neglected. Only the capable (people are) to undertake farming for the welfare of people. An incapable farmer lands himself in poverty. An agriculturalist who looks after the welfare of his cattle, visits his farms, daily has the knowledge of the seasons, is careful about the seeds, and is industrious is rewarded with the harvest of all kinds and never perishes. farms should be never left to the care of anyone other than oneself. Kashyapa has recommended *cooperative farming* too for the first time. He also advises the farmers to take up second cultivation every year. This is said to be particularly beneficial on a fertile land with sufficient water supply throughout the year.

## Chapter 10. Cultivation of Field Crops in Ancient India

The most probably earlier cultivation of crops was started on the foothills of upland areas of easily worked soil and not in the valleys because development of agriculture in the valley implies water control which need more skill and relatively more advance stage of technological development. This hypothesis about the beginning of agriculture is the forested foothills was put forward by Sauer - the American biographer.

Sauer (1952), in his hypothesis about the origin and development of agriculture, propounded that:

vii. Agriculture did not originate in communities desperately in short supply of food, but among communities where there was sufficiency of food resulting into relative freedom from want and needed.

viii. The hearths of domestication are to be sought in regions of marked diversity of Plants and animals.

ix. The primitive agriculture did not orgin in the large river valleys, subject to the lengthy foods and requiring protective dams, drainage or irrigation, but in moist hill lands.

x. The agriculture began in forested lands, which had soft soil easy to dig.

xi. The pioneers of agriculture had previously required special skills but the hunters would be least inclined towards the domestication of plants.

xii. The founders of agriculture were sedentary folks, because growing of crops requires constant attention and supervision and unless guarded properly, the crop will be lost.

Raising of crops was an important vocation even in the pre-Vedic period and it put an end to nomadic life. Animal husbandry was dominant and crop raising was combined with livestock and trees. The economy of the country, according to Patanjali, depended upon agriculture and cattle breeding. Farmers of the Vedic period possessed a fair knowledge about soil fertility, selection of seeds, seasons of sowing and harvesting and other practices including manuring of fields. In ‘Arthashastra’ there is mention about the suitability of different lands for cultivation of crops. Farmers of the Vedic period knew the methods of improving soil fertility through rotation of crops. They planted deep rooting plants which served as natural aerators. Sweet potato was used to loosen the soil for the next crop. The swelling roots of the crop acted like mild explosives. As an incentive to the farmer, sweet potato was included in the diet specified for fasts which indirectly

helped in creating consumer demand for the crop. Most common rotations were of three years which included deep rooted, shallow rooted and legume plants. These were wheat-chick pea; sugarcane-green manure crop; wheat-fallow; pigeon pea, sorghum, etc. Mixed farming which included a combination of crops and livestock components was already in practice. Mixed cropping was the accepted system for raising crops. Legumes such as chick pea and other pulses were often grown in combination with wheat in order to augment the nitrogen availability for wheat. Some of the important crop mixtures were sorghum + pigeon pea + cow-pea; black gram or green gram (Mung bean) +s sorghum or bajra; wheat + chick pea; and wheat + linseed. In general, monocropping was not the accepted practice.

**Seasons:** Six seasons mentioned in Rigveda are viz., Grishma (May-June), Varsha (July-August), Hemant (September-October), Sharad (November-December), Shishir (January-February) and Vasanta (March- April).

Seasons in Temperate climate

| Winter | Spring | Summer | Autumn |
|---|---|---|---|
| January | April | July | October |
| February | May | August | November |
| March | June | September | December |

**Planting time and selection of land for different crops** (Kasyapa): The planting should be commenced with the beginning of the rainy season in several countries. Kashyapa has mentioned taking a crop even in summer if water was available. He divided arable lands into two major catergories; viz., lands suitable for growing rice (paddy) and lands suitable for other crops. Basically lowlying lands, which could be irrigated easily, were meant for rice, whereas the uplands where water supply was limited were meant for the crops such as pulses. Rice fields were to be of higher fertility than fields under other crops and were to be bunded to retain water but the bunds had to gave openings to allow excess water to flow elsewhere. Rice soils were to be clayey and rice fields close to each other and to the threshing ground. Rice fields were always to have standing water. Kashyapa stated that fields for pulses, etc., were to be highlands and were considered of second quality. These crops needed less water.

**Land preparation**: In Rigveda, farmers are stated to have resorted to repeated ploughings of land before sowing seeds. Clearly the purpose of such ploughings must have been to remove weeds, loosen the soil and pulverize it to the extent required. Excavations made at Kalibangan, Rajasthan (India) revealed a ploughed field (2450-2300 BC) that showed a grid of furrows, with North South furrows 1.9 m apart and East-West furrows 30 cm apart. This pattern probably indicates the practice of mixed cropping. Practice of incorporating sesame as green manure before land preparation has already been mentioned in Varha Mihira's Brhat Samhita. There is a reference to heavy and light ploughs in Vedic literature. These were probably used for deep or shallow ploughing as required. Sage Parasara had

stated that Anila i.e., Swati, Uttarashadha, Uttarabhardrapada, Uttarpahalguni, Rohini, Mrigashirsha (Mriga), Mula, Punarvasu, Pushya, Shravana and Hasta are good stars for ploughing. Plowing on Monday, Wednesday, Thursday and Friday results in good growth of crops. The second, third, fifth, seventh, tenth, eleventh, and thirteenth, day of the month are good for ploughing. Ploughing should be commenced on auspicious lagnas, such as Taurus (April 21), Pisces (February 20), Virgo (August 22), Gemini (May 21), Sagittarius (November 23) and Scorpio (October 23). Lagna is the moment of the Sun's entrance into the respective regions. Furrows should be single or in groups of three to five. Single furrows lead to success, in threes to wealth, and those in five yield plenty of harvest. One plough gold in Hamanta (December-January), silver and copper in Vasanta (April – May) only crops in summer (June-July), but in rainy season (August-September) one can plough only poverty.

**Soil as a basic resource for successful crop production (Kasyappa):** Kashyapa divided the agricultural land into two categories: shalibhu (=land fir for rice cultivation) and adhakadibhu (=land suitable for cultivation of pulses and other grains). A good quality land yields good results to everyone, confers good health on the entire family, and causes growth of money, cattle and grain. Thus the importance of a good soil can never be overemphasized. Kashyapa states that it is the responsibility of the king to appoint knowledgeable persons, regardless of their caste affiliation, to scrutinize the suitability of land for growing crops. Kashyapa points out that a good soil should be devoid of bones and stones., should be a plastic clay with reddish and black hue, full of essence (potency), and glossy with water, should not be too deep or shallow, should be conducive to speedy seedlings emergence, should be easily absorb moisture and should be inhabited with beneficial living creatures (earthworms?). and should have a substantial mass. Kashyapa states that the soil may posses Brahaminic qualities, qualities of Kshatriyas, as also those of Vaisyas and Sudra. Using traits normally associated with these castes, one could conjecture that a soil should be fertile and give stable yields; a soil should give yields by controlling enemies such as pests, a soil should give sometimes, bumper yields, and a soil should give good yield when looked after with close attention respectively.

**The plough and other implements:** Parasara provides information on construction details of the plough–a version called the desi plough ' wooden plough' as well as reference to a few other implements such as an abadha (disc plough) phalika (leaf shaped iron piece to replace the normal iron blade for deep ploughing), Viddhaka (spike tooth harrow with 21 spikes), and madika (wooden plant for levelling the field were provided. The use of a disc 54 angulas in diameter (approx. 1 m) in place of plough share for using on hard virgin soil is recommended.

The dates for ploughing operation are suggested on 20, February; 21, April; 21, May; 22, August; 23, October and 23, November. A calender for ploughing for taking the crops was only mentioned in Krishi –Parashara.

| Starting of ploughing | Crops |
|---|---|
| 20, February | Sugarcane, black gram |
| 21, April | Rice (to be transplanted later) |
| 21, May | Rice (to be directly seeded) and other warm season crops such as cotton and seasme |
| 23, October | Late sown wheat and barley plus mustard |
| 23, November | Field vacated by rice for planting sugarcane and fodder crops. |

Kashyapa has specially indicated that use of strong wood for various purposes (e.g. making a tying post) such as tinduka (Diospyros melanoxylon), tinisha (Ougeinia oojeinensis) or a sarjaka (Vateria indica). Manure should be available and used for increasing the 'potency' of the land. Besides plow, spades, lancets, small horns, (for breaking soils crust) knife, sickles, ropes, etc., were mentioned. Ploughing was to begin with the visibility of rain-bearing clouds and plots were to be filled with water for puddling to prepare for planting paddy. Kashyapa refers to worship of plough as well as bullocks.

**Farm implements:** Ancient literature of the subcontinent did not miss out on farm implements. Vedas describe a simple bullock drawn wooden plough, both light and heavy with an iron bar attached as a plough share to open the soil. Krishi Parashara (c. 400 BC0 (Sadhale, 1999) gives details of the design of the plough with Sanskrit names for different parts. This basic design has hardly undergone any change over centuries. Even today the resource poor farmers use a similar bullock drawn plough. A bamboo stick of a specific size was used to measure land. Vedic literature and Krishi Parashara also mention disc plough seed drill, blade harrow (Bakhar), wooden spike, root horrow, plankers, axe, hoe, sickle, supa for winnowing, and a vessel to measure grain (udara). Pairs of bullocks used for ploughing in ancient days varied from one to eight. Plough was considered as the most sacred and essential implement in agricultural operations and was known by different names. The more commonly known desi plough was a multipurpose implement.

**Seed collection and preservation** (Sage Parasara)**:** All sorts of seeds should be procured in Magha (February) or Phalguna (March) and should then be dried well in the sun without putting those directly on the ground.' To procure healthy seeds of panicles are located in the field, cut from the standing crop, and collected in a pouch.A mixture of different kinds of seeds causes great loss. Uniform seeds produce excellent results. *The origin of plentiful yield is the seed.*

**Kashyapa:** A good quality of seed is stated to be the first step towards the success in farming. Seeds of several trees specified for plantation are also to be procured and preserved. Seeds of wheat, pulses, fruits, vegetables and condiments such as turmeric, cumin, black pepper, etc., also need to be preserved for cultivation in the proper season. Kashyppa describes the procedure of preserving the seeds and

advises farmers to dry the seeds in the sun, store them in different kinds of vessels, and protect them from stormy rains and moisture as well as from rats, cats, and rabbits.

**Crop diversity:** India had a large and wide diversity in cereals, millets, pulses, oil seeds, fibres, vegetables and fruits. The species and varietal diversity provided wide choices for selection according to soil type, climate and management practice. A variety of rice which was ready for harvest in sixty days was available in ancient India. Magadha grew another variety with large grains of extra ordinary fragrance which was called rice of grandes. Manasollasa referred to eight varieties of rice distinguished by their colour, odor, size and period of growth. India had five wild species of rice from which there had been a regular trend of evolution from perennial to annual habit, from cross pollination to self-pollination and from lesser to greater fecundity. Wheat recovered from Mohenjodaro belonged to *Triticum vulgare, T. compactum* and *T. sphaerococum. T. sphaerococum* is a wheat of great antiquity (2300 B.C) and was widely grown in north India. It has high resistance to drought. Barley was cultivated throughout the Harappans period. Aryans were accustomed to barley diet. They adopted wheat and barley in the Indus valley culture and generated new variability required for intensive cultivation. Millets such as sorghum, bajra and ragi were also important. They were primarily grown for grain but the straw was also regarded valuable as a cattle feed. About 25 species of sorghum were known to have been available. The use of ragi *(Eleusine coracana)* straw as a cattle feed was noticed in *1800* B.C. Pulses figured predominantly in crop rotations and crop mixtures in the early period. Being legumes they maintained and improved fertility of the soil. Lentil, black gram, green gram and Lathyrus (Khesri) are pulses of antiquity and were noticed in Narmada basin during 1657-1443 B.C India is the original home of green gram. A wild variety of *Vigna sublobata* was found in Tarai forests. It was immune to yellow mosaic virus and was used in plant breeding. Black gram was widely accepted as a nutritious pulse crop in the ancient Indian culture since the Vedic period. It was used in socio religious ceremonies and even today its importance has not waned. Similarly lentil also enriched the traditional diet. In oil seeds, sesamum was the most important crop grown by Harappans in the Indus valley. The *Brassica* group covering brown mustard, yellow mustard and thoria is collectively known as Indian rape. The other important oil seeds comprised linseed and castor. Cotton cultivation was known to Harappans. Wild and weedy types of cotton have been recorded from Gujarat, Kathiawar and Deccan. They are perennial and known as tree cotton. Harappans also knew date palm, pomegranate, lemon, coconut and melon. Babar (before $16^{th}$ century) mentioned in his memoirs the plants he saw in India. They were mango, plantain, tamarind, mahuwa, Jamun, chironji, khirni, karonda, ber, aonla and orange. It is obvious that the earlier people possessed a good knowledge of crops. The strategy for the selection of crops and the adoption of different cropping and farming systems was decided on the basis of resources available with the individual and his immediate and long term needs. Through a continuous process of selection and elimination, promising plants or varieties were identified and their multiplication brought

about by adopting diligent methods of seed collection, preservation and exchange within the social groups.

**Choice of crops and varieties:** Kashyapa listed rice and other cereals as the first, pulses and other grains as the second vegetables (including fruits) the third, and creepers and flowers etc., the fourth. Kashyapa considered three main varieties of rice, Shali, Kalama, and Shastika. Shali rice is said to have twenty six varieties depending on the quality of land in different regions. Kalama is slightly thick white, and with a surplus sap. Shastika is tasteless. Vrihi is considered to be oldest name for rice. Shukla vrihi (white rice) mentioned in Krishna Yajurveda (300 BC). In the same Veda Krishnanam vrihini (black rice), asunam vrihinam (fast growing, 60 day rice), mahavrihinam (large seeded rice) and naivaram (wild rice) have been mentioned. Atharvaveda, naivaram became nivara and in addition to black rice, red rice, and the 60-day rice were mentioned. A new name for rice appeared in the Atharvaveda; i.e., tandula (for dehusked rice). The word vrihi for rice was used in Upanishads. Shali was used for those rices, which were planted at the beginning of the rainy season and harvested in winter; these were probably the 6 month varieties. Vrihi, Shali, Nivara, Shastika as well as a new word Kalama appeared in Susruta Samhita (400 BC) and Amarkosha of Amarsinha (200 AD).

**Rice varieties-other aspects**: Some of the other highlights under the topic collection and preservation of seed are (i) it is the king's government in today's context (responsibility to ensure seed supply, ii (seed must be properly dried in sun, (iii) giving a gift of seed is a superior act, (iv) different varieties of rice mature at different times taking 3 to 8 months, (v) farmers should respect traditional knowledge of the region and use it. (vi) seeds of all kinds of other crops should be likewise collected, dried, and stored in pots, heaps, of husk or bowls and (vii) seed must be proected from rabbits, rats, and cats, and moisture. Taking care of good seeds religiously is conducive to the benefit of farmers (as has been) said by great sages.

**Basmati Rice:** The word 'basmati' has its origin in the Sanskrit words 'vaas' means fragrance and 'matup' means possessing Thus vaasmati should mean something possessing fragrance in northern India, 'va' is often pronounced as 'ba' and thus the word 'basmati' should have been used for a kind or rice having fragrance of scent.
**Golden rice:** Kashyapa had claimed that Peetvarna vrihi (yellow rice) improved digestion or a sambaka variety called Hema (golden rice).

**Sequence of cropping:** In the Yajurveda, distinct references to the rotation of crops are found. Crops were grown in the same field by rotation and the system of fallowing was also known (Rigveda). The Taittiriya Samhita distinctly mentions that in' the *course* of a year, two crops were harvested from the same field. It also mentions different seasons for ripening of different crops and the proper times for harvesting them. In a descriptive passage of the Ramayana sali, godhuma and yava are seen waiting for harvest with the advent of winter. But wheat and barley are winter or *rabi* crops sown in October and gathered at the end of May. Kautilya

gives directions for seasonable cultivation and harvesting. The Arthasastra evinces not only thorough acquaintance with these two harvests but even with a third. A king is instructed to march against his enemy in Margasirsa (January) in order to destroy his rainy crops and autumnal handfuls, in Caitra (March) to destroy autumnal crops and vernal handfuls, and in Jyesthamula (June) to kill vernal crops and rainy season handfuls. Thus there were three crops-one sown in rainy season and garnered before Magha, another sown fn autumn and garnered before Caitra and a third sown in spring and stored by Jyaistha (cf. Barley "ripened in summer being sown in winter, rice ripened in autumn being sown in the rains, while beans and sesamum ripened ,in winter and the cool season". Arthasastra catalogues the crops of different seasons. Paddy, kodruva, sesamum, panic, daraka and varaka are sown in the first season (purvavapah), mudga, masa and saivya are sown in the second season (madhyavapah), kusumbha, lentil, kuluttha, barley, wheat, kalaya, linsed and mustard are sown in the last season. The Artha sastra .agree with *kharif* and *rabi*- crops respectively. The Milinda speaks as well of a third monsoon - (pavllssako) besides the regular rains of the later Summer and early winter. The three monsoons of course did not uniformly visit every part of the country each year; and whether a locality grew one or two or three crops depended on-rainfall, climatic conditions and character of the soil. In many places the food crops as well as edible fruits and vegetables grew spontaneously without tillage. To the Greek observers these phenomena seemed strange. The description of the forest scenery in the Epics (Ramayana; Mahabharata) and the Jatakas frequently go at length over the crops and fruits growing in wild areas without human labour. In Arthasastra, it is stated that raising of a second crop by, the cultivators was sometimes made compulsory as a last resource for taxation. After a careful observation of the meteorological charts, it suggests the quantity of rain required by .a specific crop and the cultivator is instructed for the particular crop along the rain forests.

**Crop rotation in Rigveda:** Continuous cropping was a practice, but pulses (legumes) and other crops were also sown. "The cultivators harvesting the crops in general, separately and in due order" has been interpreted to be giving an idea of crop-sequence or crop-rotation and line-sowing and avoiding overlapping during harvest.

**Seed and sowing:** Ancient scholars showed awareness of the importance of good seed; i.e selection of the apparently healthy seed from a ripening crop, preserving it safely in storage, with or without treatments and sowing the good seed again with or without some treatment. About 2000 years ago, Parashara recommended (i) proper drying of seed (ii) freedom from the seeds of weeds (iii) visual seed uniformity (iv) storing seeds in strong bags, and (v) storing seed where white ants would not have access and at a location where seed would not come in contact with substrates that would allow moulds to grow such as cowshed wastes, damp spots, or left over foods. Sage Parasara had stated that Uttrashadha, Uttarashadha, Uttarabhardrapada, Uttarpahalguni, Mula, Jeyshtha, Anuratha, Magha, Rohini, Mrigashirsha (Mriga), Rohini, Hasta, and Revathi are the good nakshatras for sowing. Two days should be avoided for sowing, transplanting;

Tuesday, which portends threat from rats and Saturday, which foretells threat from locusts and insects. Sowing should not be done on ' empty' days (such as the fourth, ninth, and the fourteenth day of the lunar fortnight of a month) especially if the moon is weak. Seeds of grains should be planted at a distance of hand (approximately 1½ ft =45 cm) when the sun is in Cancer. In Leo the distance should be half of it. In Virgo it should be four fingers, (3-4 inches =7.6 –10.2 cm). Butter milk makes the seeds sprout earlier than the normal time. Salt would kill the embryo. Kautilya in Artha Sastra indicated that decision to sow seeds of specific crops should be taken on the basis of known rainfall patterns. He recommended that rice be sown first and mungbean and black gram later. He also suggested some seed treatments. (e.g., cowdung, honey and ghee) to ensure good germination. Manu mentioned that a professional farmer (the Vysya) must be able to determine the quality of seed. The most significant recommendation by Manu was severe punishment to a trader selling spurious seed. Kashyapa's The procedure of sowing involves ploughing, levelling, furrowing, or digging pits. The procedure is said to depend on the characteristics of land, availability of water, sunshine, and also on additional wisdom. Varahamihira recommended pelleting of seed with flours of rice, blackgram and sesame and fumigating them with turmeric powder to ensure good germination. Surapala listed several botanicals such as seed treatment materials for shrubs and trees. Even today cowdung, suggested by Kautilya in the 4$^{th}$ century BC, is used for treating cotton and some other seeds by a large number of farmers. Sowing of seed was considered a very important event. Prayers and rituals were associated with the sowing operation. Primitive bamboo drills were used for sowing seed. Adjusting the inter-plant and inter-row spacing was done on the basis of sowing time; late sowing meant more seeds per unit urea. A wooden plank was run over sown fields to ensure uniform seed germination. The art of sowing rice in small areas; i.e. in nurseries and transplanting of the seedlings is not a recent practice. It was first perfected in the deltas of Godavari and Krishna rivers in 100 AD.

The general practice of sowing seeds, according to Varahamihira, involved soaking them in milk for ten days, taking out daily with hand, smearing with ghee, rolling many times in cowdung and fumigating with the flesh of deer or hog. Then the seeds were sown in a soil which was already treated with sesamum crushed together with flesh and hog's marrow. They grew and bloomed when sprinkled with milk and water. Another method was to soak the seeds hundred times in a paste of Ankola *(Alangium salvifolium* Wang) fruiter in its oil or in a paste or oil of Slesmataka *(Cordiarothii* Roem and Schult) fruit and sow in a soil mixed with hail. The seeds would sprout instantly and bear fruits. Hard seeds like tamarind sprouted when sprinkled with a mixture of the flour of rice, black gram and sesamum and wheat particles together with stale meat, and fumigated with turmeric powder, repeatedly. For Slesmataka the shell of the seeds was removed, then soaked in water, mixed with the paste of *Alangium* fruits and dried in the shade seven times, mixed with buffalo dung and stored in the dry dung. The seeds were then sown in a soil soaked with rain water. The bearing was good.

Seeds were treated in a special manner to get special results. Cotton seed

was treated with red lac juice in a special manner to get red tinged cotton. It was also treated with cow dung paste to facilitate sowing and control of seed borne diseases. The seedlings for transplanting at a distant place were smeared from root up to the stem with a mixture of ghee, Usira or Khas *(Vetiveria zizanioides),* sesamum, honey, Vidanga *(Emblica ribes),* milk and cow-dung.

Sali paddy was grown by transplanting (Kalidas in Raghuvamsha). Incidentally, the technique of transplanting rice was widely practice in Krishna-Godavari deltas in 100 AD. It was the most important agricultural operation during the Sangam age (AD 300 - 600). Varahamihira has recorded two methods of grafting. They are (i) inserting the cutting of a plant into the root of another, cut off from its trunk, and (2) inserting the cutting of a tree into the stem of another. The junction of the two in both the cases was covered with a coating of mud and cow dung. Grafting was advocated for jackfruit, ashoka, plantain, rose apple, lemon, pomegranate, grape, jasmine, etc. Further, he recommended February-March for grafting those plants which have not developed branching; December - January for those which have developed branching and August - September for those which have developed large branches. The grafted trees were to be watered both in the morning and evening every day in summer, on alternate days in the cold season and whenever the soil becomes dry in the rainy season.

**Kashyapa's view on rice cultivation:** Rice is divided by experts into three main varieties based on their taste and colour; shali, kalama, and shastika. The golden rice sambaka vrihi (rice) var hema and peetavarna vrihi (yellow rice), which removes indigestion. Kalama of red colour, kalama of thick form, kalama of long form, vrihi (rice) of sambaka variety called hema (golden). Kala vrihi (sweet and nourishing rice), sit vrihi (white rice) and peetavarna vrihi (yellow rice), which removes indigestion. Kashyapa's procedure of rice cultivation starts with plowing, maintaining standing water, planting of seedlings, weeding, water management, crop protection, harvesting at the proper time, pounding on the threshing floor, cleaning and storing in the house. *Kashyapa for the first time has recommended transplanting of rice in ancient literature*.

**Weeds and weeding:** The role of weeds in reducing crop yields was well understood by our ancestors Parashara pointed out the need to weed rice fields; as many as four weedings were suggested. Weeding as an essential practice in raising crops is stated in the Sangam literature. Parashara recommends collection of crop seeds free of weed seeds.

**Nutrient management:** Kashyapa emphasized that the Brahmins proficient in Vedas should sprinkle the fivefold cow-products (milk, curd, ghee [clarified butter], urine, and dung) or may be simply sprinkle with clean water over the land (for the purpose of purifying the atmosphere) either in the morning or in the evening. This is known as 'Panchakowia'

**Water management:**

**Sage Parasara**: Construction of bunds to retain water in plots is recommended to rice. Bunding has not been recommended in low-level fields since there would be adequate moisture. Direct seeding of rice has been recommended for low-lying areas. Avoid flooding of rice once the panicles have come out, however the soil must remain moist.

**Kashyapa was supportive of irrigated crop production:** Kashyapa focused his attention on irrigated agriculture. Construction of wells and device for lifting water had been described. Kashyapa has given details about where how water reservoirs should be constructed. He stressed construction of a reservoir near farmers' fields, ensuring source of water for the reservoir, making strong causeways and thus taking steps to avoid flooding of inhabited areas, and regularly inspecting and repairing the reservoirs, especially during the rainy season. The last one is good reminder to present day, lazy, and indifferent staff of the government irrigation departments. Each farmer should have access to two reservoirs. Kashyapa's recommendations on buildings and maintenance of reservoirs are technically sound. Kashyapa recommended planting of trees around water reservoirs obviously to protect and beautify them. He suggested picnic spots around reservoirs, a feature that is considered 'modern' in the 21$^{st}$ century. Construction of canals has been indicated in verses 111 through 143 of section I. Kashyapa has mentioned four sources of canal. i. river, ii. tank which could have been filled by a river, iii. large lake, and iv. canals collecting water from mountain cascades. Kashyapa has stressed provision of a proper gradient for the canals and a network of these canals surrounding villages. He emphasized selection of soil with right structure and profile for making canals and avoiding saline soils. Protection of the canal system, like the protection of reservoirs was also stressed. Kashyapa recommended construction of wells, especially in areas where canal water was not available. Best time for digging wells was the post rainy season. He suggested study of indicators for the presence of sub soil water such as existence of trees and course, water divining. He stressed laying strong foundation with bricks and building walls with bricks and mortar. Even provision of steps to enter a well was recommended. Kasyapa has mentioned the use of ghatiyantra (the so-called Persian wheel) with the help of bullocks, elephants, and humans. Harvesting of rain was stressed. A verse that says everything about water for farming is 'It may be a canal, a well, a pool, or a lake, but find they must and acquire a guaranteed source of water."

**New crops and other plants:** Portugese introduced new crops and fruit plants during the sixteenth century and enriched the agriculture of India. They were the greatest benefactors of India. Babar introduced the scented Persian rose. Similarly the botanical garden of Calcutta has performed a very useful function by introducing many important new plants. Following are some of the crops and plants which were introduced by Portuguese from Brazil, Chile, Peru and Mexico. These crops and trees now form important components of the common cropping systems followed in the country.

**Crops**

8. Groundnut (Peanut) - main source of edible oil in India. A native of Brazil.
9. Tobacco - introduced by Portugese during the reign of Emperor Akbar.
10. Potato - widely accepted and grown in India as a favourite vegetable. It is a native of Chille and Peru
11. Amaranth - the colourful crop is grown along the whole length of Himalayas. It is a native of Brazil.
12. Chillies - the ornament of Indian garden and soul of pickles. It is a native of Brazil and Peru.
13. Agave - a century plant and has become acclimatized throughout India.
14. Allamanda *(Allamanda cathartica* L. Mant) - a climber with beautiful flowers. It is a native of Brazil and South America.

**Fruits**

6. Cashewnut - widely grown in India and a native of Brazil.
7. Guava - common fruit crop of India. It grows wild in Brazil.
8. Custard apple - widely grown as a forest crop. Introduced by Portugese.
9. Sapota - a gift from Portugese. Delicious fruit and native of Mexico.
10. Pineapple - extensively grown in eastern parts ofIndia. It is indigenous to Brazil.Indian people evinced keen interest in the introduced crops and gave a fair trial under close observation. This resulted in the spread of the selected crops throughout India.

**Growth promoters:** In respect of diseases, Varahamihira says the tree catches disease from cold weather, strong winds and hot sun. In such cases a paste made of vidanga, ghee and silt must be applied to the affected parts. Water and milk should be sprinkled on such trees. When there is a premature fruit drop, the tree should be watered with milk that has been cooled after being boiled with horse gram, black gram, green gram, sesamum and barley. After this treatment, the trees will produce abundant flowers and fruits. A mixture of powdered dung of goats and sheep, sesamum powder, wheat articles, beef and water, kept for seven nights should be sprinkled for increasing flowers and fruits of trees, creepers and shrubs. In the Sangam age, the dung of cow and sheep and green leaves were used to increase the yield of crops. Krishi Parashara has prescribed the method of preparing manure from cattle dung and dry leaves. Sesamum, cowdung, barley powder, fish and water when mixed in fixed proportions formed an effective manure. According to Varahamihira, sesamum is sown and ploughed back when it blooms in order to mix it with the soil. Cowdung, dung of buffaloes, goats and sheep, clarified butter, sesamum, honey, horsegram, blackgram, green gram, barley, roots of certain plants, ashes, stale meat, beef and marrow of hog were used as manure. The Indus valley produced surplus food. All important cities had large storage facilities for stocking grains. The rulers at that time had the wisdom of maintaining buffer stocks. One of the granaries stored enough barley to provide wages for *400* days. Another granary had the capacity to pay in kind for 10,930 man days. Trade was by barter and payment to labourer was in kind. The artisans, carpenters and others received their wages in kind from the farmers.

Agriculture without supervision was considered fruitless. The owner of the

field was to look after the field himself. If he failed to supervise the agricultural operations, the belief was that the Goddess of prosperity would desert him and in her place adversity would enter his field. According to Arthashastra, if any farmer was found negligent in his duties of carrying on the agricultural operations in time, the King had the right to snatch away the land from him and hand it over to another man of the village. The foremost duty of the King was to protect agriculture and render assistance to the farmers. These directions show that the concept of management was known and practised by everybody including the King.

**Harvesting and measuring yields** (Sage Parasara)**:** Aardra, Kritika, Chitra, Pushya, Hasta, Swati, Uttarashadha, Uttarabhadrapada, Uttaraphalguni, Mula, and Shravana are the nakshatras recommended for the token harvest. Harvest should not be done on ' empty' days. The fourth, ninth, and the fourteenth days of the lunar fortnight are Rikta or empty days. Grains should be measured from left to right and not the other way. Adhaka is a wooden vessel used to measure gains roughly equivalent to 7 lb and 12 oz (about 3.5 kg) It is equal to one fourth drona. Measuring the grains from the right leads to expenditure whereas from the left leads to happiness and enhancement of yield.

**Measurement of crop produce** (Kashyapa): He should also make arrangements of prastha, kunja, drona, and small nadika for (proper) measurement of grains of cereals and adhaka (pigeonpea) etc., and other commodities. The first three are the measures of capacity, prastha = ¼ adhaka; drona = 4 adhakas, kunja – should have been kunchi = 1/32 adhaka, where one adhaka=256 fistfuls=32 kunchis, i.e., 32 handfuls, nadika is a measure of length = 2 hastas, where one hasta is the distance between the elbow and the tip of the middle finger and is approximately equal to 18 inches. Pala ( a weight of gold = 4 karshas = 64 mashas = 640 grain of masha (blackgram).

**Storage of grains** (Sage Parasara)**:** The auspicious Meena (Pisces) lagna (February) is the best for storing grains. Hasta, Sharavana, Dhanishtha, Shatabhishita, Pushya, Bharani, Uttarashadha, Uttarabharapada, Uttaraphalguni, Mula, and Magha are the auspicious nakshatras for storing grains. Monday, Thursday, Friday, and Saturday should of course be avoided.

**Farming Systems:** The importance attached to food quantity in Anna Sukta shows that arable farming was given equal importance as stock farming. The praise of land, bullocks, seeds and peasants in various hymns clearly indicates' importance attached to arable farming, crop husbandry with different types of field grasses for food and fodder being considered for the dual purpose of man and animal. The traditional land use and occupational structures in Indian agriculture have invariably been site-specific based on available resources and sound ecology. In India foe example people of Rajasthan developed nomadic and animals care based occupation because the land fragile and could not be used intensively. The people of Mizoram and Nagaland developed shifting cultivation as their system of survival

because they had to live on slopes and this was the best way to sustain their soil fertility and productivity and conserve and use the bio-resources in sustainable manner. This highly organized agro-ecosystem called Jhum is based on empirical knowledge accumulated over centuries. It functions in harmony with environment and provides enough time for recovered of forest and soil fertility that is lost during cropping phase. It involves slashing of vegetation burning it before the on set of monsoon raising mixture of crops on temporarily enriched soil for a year or two leaving it fallow for a few needs fresh system like Zabo system a combination of forestry soil and water conservation, Alder system for soil health and Panikheti system of wet rice cultivation with judicious use of water have been developed. Shifting agriculture practised in India has mixed cropping as a standard feature. It was once conceded primitive by scientists, however now it is being suggested as a means to increase world food production. During the cropping phase the farmers raise 8-35 crops species on a small plot of 2 to 2.5 ha with simultaneous sowing and sequential harvesting the crop mixture provides crop cover against loss of nutrients, optimisms resources facilitates recycling of biomass and nutrients and improves soil characteristics.

Zabo farming system is practiced in Nagaland. 'Zabo' means impounding of water. The system is a combination of agriculture, forestry, livestock, fishery and soil and water conservation. The Zabo system comprises protected forest land on the top of the hill, well planned rainwater harvesting tank on the top of the hill and indigenous methods of nutrient management in hill region, cattle yard and terraced rice fields towards foothills. The Soils of the area are salty clay loam in texture with grayish brown colors and there are no means of irrigation. Animal manure is the major source of crop nutrition. The silt deposited in the tanks is dug out during off-season and added to the fields. This silt is very rich in nutrients as it contains lot of forest litter. Farmers also add leaves and succulent branches to the fields and leave for decomposition. This helps in building up soil fertility and maintenance of soil health. This indigenous farming system is good example of integrated use of land, water and nutrient. Shifting cultivation, which otherwise causes soil and nutrients loss, the Zabo method of cultivation is ecofriendly, takes care of natural resources and soil erosion is negligible.

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Farms yield gold if properly managed but lead to poverty if neglected. Only the capable (people are) to undertake farming for the welfare of people. An incapable farmer lands himself in poverty. An agriculturalist who looks after the welfare of his cattle, visits his farms, daily has the knowledge of the seasons, is careful about the seeds, and is industrious is rewarded with the harvest of all kinds and never perishes. farms should be never left to the care of anyone other than oneself. Kashyapa has recommended *cooperative farming* too for the first time. He also advises the farmers to take up second cultivation every year. This is said to be particularly beneficial on a fertile land with sufficient water supply throughout the year.

## Chapter 11 Plant protection-Indigenous Technological Know-How - Harvesting-Threshing and Storage

### *Introduction*

Plant protection began when man attempted to understand ailments affecting crops. Crop plants are affected through 'abiotic' and 'biotic' disorders. Insects came on the agriculture scene more than 250 million years ago well before the human beings who appeared only about one million years age. The association of man with insects was well known to Indians who knew production of silk and lac in the days before 3870 BC. The documents available on man's efforts to protect crops are found in the Rigveda (c. 3700 BC), Krishi-Parashara (c. 100 BC), Sangam literature of Tamil (200 BC-100 AD), Agni-Purana (c. 400 AD) Varaha Mihiria's Brhat-Samhita (c. 500 AD) Kashyapiyakrishisukti (c. 800-900 AD) Suprapala's Vrikshayurveda (c. 1000 BC) Someshwera Deva's Manasollasa (c. 1100 AD), Sarangadhara's Upavanavinoda (c. 1300 AD), Tuzuk-e-Jahangiri (c.1600 AD) Dara, Shikoh's Nuskha Dar Fanni – Falahat (c. 1650 AD) Jati Jaichand's diary (1689-1714 AD) an anonymous Rajasthani manuscript (1877 AD) and Watt's Dictionary of Economic Products of India (1889-1893 AD). Since the agriculture has a very long history of more than 10000 years its gradual development can be discussed briefly in the following periods for greater clarity: (i) The Ancient Period 10,000 BC to beginning of anno Domini (AD): (ii) The Medieval period beginning of AD to 18$^{th}$ Century AD and (iii) The Modern period –19$^{th}$ Century AD to date.

### *The Ancient Period*

One of the major events in human history is the transition from hunting gathering to agriculture. Susruta Samhita (400 BC) emphasized the importance of protecting seeds from white ants and Kautilya (321-296 BC) was the first to suggest use of seed dressers for producing healthy plant stands. There is reference to algae and mushrooms in Rigavda only as saprohytes. In the Buddhist document Kallavagga (C. 100 BC) "mildew of paddy" and blight of sugarcane" is mentioned. In Krishi-Parashara (Sadhale, 1999) we find that the plant protection in ancient days was not covered in depth, except for prayers to God Indra and other supernaturals. However there were several reference to the crop losses caused by insect pests. For example in the verse 126 it is stated "Commencing plowing on the 14$^{th}$ day of the month in any agriculture season was not shown as auspicious and met with serverl loss throught insect pests". Also emphasized were the auspicious "lagnas" for initiating agriculture in a particular season such as Turus (21$^{st}$ April) based on the movement of the sun's entrence into the respective zodiac signs.

### *Use of organic materials*

The oldest documents on the use of organic materials to control crop disorders is probably the Kautilya's Arthasastra (c.300 BC) (Shamasastry, 1961), cut ends of sugarcane setts meant for planting were plastered with a mixture of honey ghee, the fat of hogs and cow dung. Varahamihira (Bhat,1981) suggested use of milk

ghee and cow dung for dressing seeds and smoking them by burning animals flesh or turmeric before sowing. He also suggested sprinkling seeds with a mixture of flowers of cereals legumes and sesame as well as stable minced meat. Literature in agriculture during with knowledge on seeds storage crop protection and use of botanical pesticides Neem leaves were commonly used to contain the storage insects and seed infection during storage. There is also a mention about the use of seed treatment with coal ash before storage to prevent insect damage during storage. Pigeonpea seeds were before storage Sun draying of seeds to reduce moisture content before storage was a common practice during Anicent Period for the management of insect pests (Jeyarajan, 1999).

### *The Medieval Period*

The earliest specific reference to insects pests is found in Krishi-Parashara. Rice pest the gandhi bug (Leptocorisa varicornis F.) has been mentioned. Another word, pandarundi (White eashead) possibly implied rice stem borer (Trporyza incetulas walker) (Sadhale, 1999). Jahangir the Mughal Emperor in India (1605-1627) in his memories described a disorder of marigold that could be ascribed today to species of Alternaria botrytis, or Sclerotinia The occurrence of melon fruit fly Dacus sp. during 1620 AD and the non-availability of control measures during that time were discussed (Nene, 1998). Jati Jaichand's diary (1658-1714) mentions possibly botrytis gray mold of chickpea and ear blight (Curvularia penniseti) of pearl millet (Javalia et al., 2001).

### *Practices using inorganic and organic materials*

It was Someshwara Deva (c. 1126 AD), a Chaluyka king. who suggested treatment of seed with ash, besides other materials to ensure good germination (Shamasastry, 1926) Use of ash however was suggested as far back as 120 BC by Varro a Roman encylopedist (Orlob, 1973), and was known to Tamils (Jeyarajan 1999). Dara Shikoh (Razia Akbar, 2000) mentioned the use of common salt solution for soaking fig cuttings prior to planting. Apparently salt was used to disinfect cuttings. Unfortunately concentration of salt solution was not mentioned.

Nuskha Dar Fanni-Falahat (Razia Akbar, 2000) has many recommendations to project plant species from insects, fruit-drop fruit cracking heat, and cold These are:

Use of dung garlic, and pine oil should protect the cuttings from damage by some insects and pathogens Burning of garlic was recommended for "expelling caterpillars" by the Roman author Palladius (orlob, 1973).

Resin application to roots has been recommended for preventing cracking of pomegranate is found in ancient literature.

Application of excreta of sheep, pig and donkey and human urine can at best keep the apple tree well nourished which in turn perhaps keeps insect and diseases damage animals.

A practice that is still followed to project melons from excessive heat or cold has been mentioned. Covering melon fruits earthen pots is a that small farmers can followed today.

Fumigation

Diseases of cucurbits were controlled thought smoking by burning the bones of cow and dog mixed the excreta of cat. (Sadhale, 1996)

For the control of insect pests several ancient recommendations available are as follows: (Saxena and Choudhary 1996).

Table 1. Some important products used in pest management during Ancient and Medieval periods in India.

| | | |
|---|---|---|
| Root of vasika (Justicia adhaatoda) | Varahamihira (505-587 AD) | Soothing effect, insectidal antifungal antibacterial anthelminitic. |
| Branches and leaves of atimuktaka (Hiptage banghalensis) | Varahamihira (505-587 AD) | Leaf juice insecticidal: bark contains glucoside (hiptagin and tannis |
| Mustard (Sinabis alba=Brassica alba) | Surpala (1000 AD) | Insect antixenosis and antibiosis: acaricidal: namaticidal antifungal |
| Bidanga (vidanga Embelia ribes) | Surpala (1000 AD) Someshwara Deva (1126 AD) | Anthelmintic: antibacterial: |
| Ash | Someshwara Deva (1126 AD) | Dessicated insects 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 app.) | 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 and moth-proofing of |

| | | |
|---|---|---|
| | | cloth anthelmintic; antibacterial |
| Cotton (Gossypium spp) sent oil | | |

Insects infesting trees could be removed by smoking a mixture of white mustard, black pepper, asafoetida, vidanga 9embelia ribes), vaca (Zingiber zerumber0, and water mixed with beef horn of buffalo flesh of pigeonpea and the powder of bhillata (Semecarpus anacardium)

Sprinkling water mixed oil cake could control insects infesting creepers.

Dusting cow dung ash and brick-dust could destroy leaf-eating insects.

Trees were watered with cold water for  days to remove insects from the roots and branches.

A would caused by insects was healed if sprinkled with milk after being anointer with mixture of vidanga sesame cow's urine ghee (clarified butter), and mustard.

Table 2. Informatrion contained in Surapala's Vrikshayurveda, related to kinds of internal disorders observed in trees caises and symptoms attributes and remedies suggested'

| Causa give | Symptoms | Caused elaborted | Possible causes |
|---|---|---|---|
| Vata | Truk slender and crooket, kots on truk or leaves; hard fruits (less juice and sweet) gradual defoliation flower and fruits | Arid land on account of excessive supply of dry and pungent substances | Underground mechanical barrier: leaf galing insects root infecting fungi or nematodes viruses saline/alkaline soils |
| Pitta | Leaf yellowing. premature drop decay of flowers and fruits | Occurencen at the end of summer if trees are excessively watered with bitter, sour salty and srorg subtances. | Viral disease salinity in irrigation water. predisposal to blossom blight and fruit decays due to fungal /bacterial infections |
| Kafa | Fruit bearing delayed and fruits are tasteless and ripen prematurely oozing without wounds | Appears in water and spring if trees are excessively watered and spring if trees are excessively | Fungal gummosis/rot: nutrient deficiencies or toxicities: excessive |

| | | | |
|---|---|---|---|
| | | watered with sweet, oily sour or cold substances. | watering. |

1. Reproduced from Sadhale (1996)
2. Author's interpretation of causes in the context of present-day knowledge

Honey mustard and licorice too possess antimicrobial properties Cow dung which is unusually mixed with urine. has antiseptic properties. In addition cow dung can promote biological control. Milk could act as good sticker and may also promote biotical control of pathgens.

In the 17th century document document of Dara shikoh (Raizia Akbar, 2000) use of cow dung for smearing the cuttings. of fig before planting is mentioned Garlic finds a mention especially for insects control (Razia Akbar, 2000) In a 19th century document from Rajasthan (Javlia 1999), some interesting practices mentioned are: (1) use of foliar and soil applications of oil (sesame?) to trees from frost and termites: (2) Sprinkling of curd (91) mixed with asadoetida (112 g) on trees to prevent powdery mildew; and (3) use of asafoetida Exbelia ribes mixed with curd every 10 days to protect canker (or anthracnose of orange).

Use of cow dung for dressings seeds pasting cut ends of vegetatively propagating units such as sugatcane 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 cow dung in various ways but the agriculture scientists have ignored use for purpose other than use as manure.

**The Modern Period**

G. Watt whose six volumes of "A dictionary of economic products of India" (published from 1889-1893) which include description of disorders of crops covering a period since 1820s. Watt (1889-1893) mentions several fungal disease such as (i) ergost of barley oats, pearl millet and horse gram (?), (ii) smut and rust (puccinia sp) of wheat (iii) leaf rot of coconut (pellicularia koleroga), (iv) rust of barberry (v) rust (Melampsora lini) of linseed (vi) rust of barbeery (v) rust (Melampsora lini) of linseed (vi) rust (white rust?) of mustard (vii) late blight of potato (viii) powdery and downy mildews of grape vine (ix) root blight of tea (x) bunt of wheat, (xi) smut and rusts of barely and maize, (xii) false smut of paddy, (xiii) blight of cotton (xiv) Cercospora leafspot of cotton in Madras (Chennai) (xv) powdery mildew (?) of indigo (xvi) rust and smut of pearl millt in western united provinces (Uttar pradesh) (xvii) mildew (Cercospora sp?) of black gram (xviii) fingoid disease (tuto angare nona chittigabari gandi) of betelvine in Bengal (xix) whip smut of sugarcane and (xx) rust and smut of sorghum.

Dipping seed in salt solution was a practice in 19th century (Gupta and Raje, 1896) ozanne was the first to use copper sulsafe to control sorghum smut by dipping in solution (85g copper sulface in 1150 ml weater) the use of Bordeux mixture (copper sulface and lime) developed in France in 1882 was first documented in India by Butler in 1906 Sulfur was also used in 1906-1907 in India (Bhagwagar and Patel, 1999)

**Pesticides**

Mustard paste or suspension is is known to posses antifungal, acaricidal, nematicidal, and insecticidal properties. The sprouting mustard seeds around the packed betel leaves would release a volatile antifungal gas.

## Increased use of animal wastes for manure

Kunapa, the liquid manure, is better for plants than the composts from plant residues. There is always a danger of passing on dormant pathogens to fields with plant-based composts. There should be no such danger with application of kunapa water. Also the animal wastes are likely to provide microflora that might give better biocontrol of plant pests and disease than plant-based composts, and also attract predators of plant pests. From the volumes of the dictionary of the economic products of India by Watt (1889-1893), the available information on the practices followed in the 19th century India are (i) application of cattle manure to pigeon pea to reduce frost damage; (ii) application of Calotropis gigantean for two years (seasons) to reclaim soils with salts efflorescing; (iii) sanitation, Le., removal of all dead organic matter from the betel leaf sheds to prevent spread of diseases; and (iv) reduction in betel vine disease (gandi = collar rot) by soil application of onion juice mixed with cow dung.

**Relevance to Present day Sustainable Agriculture**

The present day concept of integrated pest management (IPM) is mainly oriented towards the eco-friendly approaches considering the human and animals health and other profits. The use of botanicals and other safer chemicals In fact this is not now and there was ample evidence that our ancestors had knowledge and experience and lived under healthier environments that the present situation Thuogh Indian agriculture in the modern age is making large strides of progress it is necessary to consider the treasure of ancient knowledge particularly the development and use of safer pesticides for the development of mankind.

## Harvesting, Threshing and Storage

In Riveda harvesting of barely with sickles in mentioned. Harvesting was done both by cutting down the crop at ground level and by cutting off the earheads. Threshing was done on the threshing floor and winnowing with a supa. Cleaned grain was stored in storage bins and a trash burned. In Krishi-Parashara, making of a lelvelled threshing pit and installation of a threshing pillar called medhi are mentioned. The wood for the pillar was obtained from a tree that produces milky sap, obviously to get wood that is not too hard lest the grain in broken. The pillar was treated with neem (Azardiachta indica A. Juss) leaves and mustard.

Parashara mentions adhaka, a wooden vessel with a capacity of about 3.5 kg (paddy rice). The grain was stored at a place safe from termites, rats, and other pests.

Kautilya's Arthasastra states, "Grain and other crops shall be collected as often as they are harvested crops. when reaped, shall be heaped in high piles or in the form of turrets. The crops piles shall not be kept close. The threshing floors of different fields shall be in close proximity. Workmen in the fields shall always have water the stalks by beating them on the ground or by making the bullocks tread on them. Cleared paddy was collected , measured and stored in proper places. Sickles and swords were used for harvesting millet heads. For threshing buffaloes were made to tread or men used to thresh the ears with their feed. Black gram was threshed with sicks. Women considerably contributed to threshing and cleaning. A common vessel for measuring grain was referred to as ambanam.

***Post harvest storage pest management***

A majority of farmers were found to do threshing of maize and paddy manually. To prevent food grains from insect infestation, use of neem leaves, ash, salt, camphor, etc. either singly or in combination was common. For storage of seed, use of kerosene+ ash,  and onion was popular. Some of the respondents were mixing neem paste, kerosene, or sheep or goat faeces with mud for use as plaster of thr storage structure. Use of indigenous practices for controlling the rats like live-traps keeping dogs and cats, filling the burrows with ash, pieces of glass, bunch of hair and then plastering them was common in the trival as well as non-tribal areas. Indigenous practices used by the respondent in storage of produce are i) Cow dung cake + neem leaves, ii) Neem + mud (for plastering), iii) Mud + kerosene (for plastering), iv) Mud + faeces of goat / sheep (for plastering), v) Neem + ash, vi) Ash + mercury + Ash, vii) Husk, viii) Ash + salt (rice), ix) Neem + ash + campher, x) Neem + husk, xi) onion for seed, etc.

## Chapter 12 Gardening in Ancient and Medivel period- Abori -horticulture-orchards

Gardens were an indispensable feature in house and town planning in ancient times. Excavations at Harappa have indicated that people were familiar with date palm, pomegranate, lemon, melon, and possibly coconut. Rigveda mentions several trees such as pippala (*Ficus religiosa* L.), Khadir (*Acacia catechu* wild), Shisham (*Dalberiga sisoo* Roxb.), Shimbalam (*Bombax malabraicum* DC) and palasa (*Butea frondosa* Roxb.).

The Aryans of Vedic times were quite understandably lovers of nature. The name they gave to flowers, sumansa, "that which pleases the mind", reveals their aesthetic sensibilities. It is these sensibilities which were reflected in their gardens and a very refined art of gardening.

In Artha Sastra, more than 30 tree species are mentioned as those found in forests and edible fruit trees are mentioned without qualification. Emperor Ashoka (274-237 BC) encouraged arbori-horticulture. Commonly grown fruit trees were plantain, mango, jackfruit and grapes. The Sangam literature refers to jackfruit, coconut, date palm, areacanut, plantain, and tamarind. Agrnipurna mentions many trees; it has a separate chapter on horticulture which formed the base of treatises that followed.

Varahimihira wrote a chapter on “treatment of trees’ in his Brhat –Samhita. One of the highlights of Varahimihira writing is specific reference on grafting to be done on trees such as jack fruit, plantain, jambu (Black plum) Kapittaha (Limnoia acidissima L.) lemon and pomegranate. A method of grafting described was what is known tody as the ‘wedge grafting”.

Gardens continued to be an equally important part of the urban landscape in subsequent periods. In Vatsayana's *Kamasutra* (300-400 AD), "*vrakshayur veda*" is mentioned as one of 64 kalas or arts recognised in ancient India. It included the construction and maintenance of gardens and parks for health, recreation and enjoyment. In Jain canonical texts too, among the important parts of a city mentioned are pleasure gardens (*arama*), gardens (*ujjana*) and tanks (*vapi*). Gardens continued to be viewed as a source of joy and happiness throughout the ancient period. As the very first verse of the ancient text *Vrkshayurveda* puts it: "He is indeed a monarch if his house has extensive gardens, spacious gardens containing large pools of water with lovely lotus blossoms over which humming bees fly . . . That may be regarded as the consummation of all happiness . . . (giving) intense pleasure to the mind."

The ancient texts have their share of information on the subject. The pleasure grounds surrounding Indraprastha are described in the *Mahabharata*. The Buddhist text Lalitavistara mentions 500 gardens around Kapilavastu, which were laid out for Prince Siddhartha. The divine Nandanakanan is the god of gardening in Indra's

paradise. The ancient Indian kings built pleasure gardens of immense beauty for themselves. Megasthenes admiring the palace of Chandragupta wrote, "in the Indian royal palace . . . in the parks tame peacocks are kept and pheasants which are domesticated, there are shady groves and pasture grounds planted with trees, . . . while some trees are native to the soil, others are brought from other parts and with their beauty enhance the charm of the landscape."

The early Buddhist period saw the transition from royal to public gardens at many places. The *Venuvana* and *Ambavana* in the vicinity of Rajagaha, the *Mahavana* near Vaishali, the *Nigrodharama* near Kapilavastu and the *Jetavana*in the outskirts of Sravasti were all royal gardens of early Buddhist times which later were opened to public and converted into permanent retreats for the monks of different orders. Subsequently many monastries had their own gardens attached to monastic complexes.

Horticulture was well developed in the ancient times referred to in the Jaina canonical literature. Various types of gardens are mentioned in the canons. Examples are Ujjana (garden), Nijjana (the kings private garden), Arama (garden with canopies as resting places), Sahasramravana (mango grove with a thousand mango trees), Agrodyana (home garden in front of the buildings), Ashokavana (garden with ashoka trees), Gunashila Udyana (ornamental garden) and Jeernodyana. These gardens had trees, bushes, shrubs and creepers of various kinds some flowering and others fruit types. Aramas canopies covered with dense creepers that protected the gardens from sun rays and provided cool comfort to the dwellers therein.

This is how the Chinese pilgrim Hsieun Tsang who arrived at the monastic University of Nalanda in 630 A.D. saw it: "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."

As regards gardens attached to a private dwelling, obviously of the rich and opulent, we have a description in Vatasayan's *Kamasutra*. It states: "attached to every house there should be a *vrksavatika* or *puspavatika,* a garden where flowering plants and fruit trees can grow, as well as vegetables. A well or tank, large or small, should be excavated in the middle." The garden was to be in charge of the mistress of the house and she was to procure seeds of common kitchen vegetables and medicinal herbs every day. The garden was also to be designed with bowers and vine groves with raised platforms for rest and recreation. A swing was to be fitted on a spot well guarded from the sun by a canopy of foliage. She was to ensure that it was laid out with beds of plants that yield an abundance of flowers, with an emphasis on those with sweet perfume, like the *mallika* and the *navamalika*, as well as those "that delight the eye like the japa with its crimson glory or the *kurantaka* with its unfading yellow splendour. There should also be rows of shrubs yielding fragrant leaves or roots, like *balaka* and *usirs*".

As in all hot climates an expanse of water was an almost essential feature of the ancient garden. Gardens consist of the artificial lakes and pools as well as the steps leading down to them for bathing. Kalidasa mentions a palace garden called *samudragrha* which was a summer house built in a cool place surrounded on all four sides by fountains. A further refinement, for cooling the air in the hot season, was the water machine, *variyantra* which, from Kalidasa's description seems to have been a sort of revolving spray, rather like the one used to water lawns. The garden's irrigation was taken care of by means of narrow drains (*kulya*) full of running water with water fountains as their source. Water wheels incessantly threw jets of water to flood the flower beds and the circular ditch (*alavala*) at the base of the trees.

As noted earlier, along with the private gardens of the rich there were in due course public gardens (*nagarupvana*) as well. When situated outside the town they were termed *bahirupvana*. These were the favourite resorts of the townspeople for *udyanyatras* or picnics. The *Kamasutra* mentions how a party of well dressed *nagarakas* would go out of the town to these gardens early in the morning mounted on horses accompanied by *ganikas* and followed by servants to spend the day.

With gardens and parks emerging as an important backdrop to the social life in ancient India, horticulture (*udyanavyapara*) developed as a discipline and scientific knowledge was applied to the art of arbori-horticulture. In the post Vedic literature there is evidence to show that botany developed as an independent science known as *Vrkshayurveda* on which were based the science of medicine (as embodied in the Caraka and *Susruta samhitas*), the science of agriculture (as embodied in the *Krsi Prasara*) and the science of horticulture (as illustrated in the *Upavanavinoda*). While there are no treatises so far discovered on the subject of ancient horticulture as such, there is a small chapter, the *Upavanavinoda* as a branch of *Vrksayurveda*, in *Sarngadhara*'s encyclopaedic work, the *Sarangadhara Paddhati* of the 13th Century, which is a compilation of relevant material from earlier classical sources.

The chapter "*Upavanvinoda*" among other things discusses the selection of soil for planting of trees, the classification of plants, the sowing of seeds and methods of their propagation, the process of planting, the rules of protection of plants, construction of garden house, details of nutrient solutions, treatment of plants in disease, botanical marvels and experimental results. Texts such as *Garuda Purana* also dealt with the laying out of pleasure gardens and pavilions along with notes on construction of religious, military and residential buildings.

**Management in gardens:** Management and maintenance practices for parks and gardens too came to be formulated. In Kautilya's time there was a separate department entrusted with the care of gardens and forests. The cultivation of parks for public health and recreation was one of the duties of the forest officers. The *aramas* or gardens were kept in order by a number of junior officers known as *aramikas*. They were under a superintendent *aramaprekshaka* who supervised their

work. There were settlements of park keepers known as *aramika gama*. Special classes of skilled artisans were patronised by the State. Vatsayana's *Kamasutra* mentions well trained experts, the *aramadhipatis* and a special class of skilled artists, gardeners and weavers, *malakars* and *malinis*. Gardens at times contained not only flowering plants but also fruit trees which used to bring considerable income to the exchequer. Gardening in ancient India through design forms and mechanisms and by combining scientific and artistic principles thus ensured an integration of nature with everyday life in urban areas.

**Abori–horticulture, Orchards, History and Diversity of Fruit Crops in India**

**Tree culture** (Vrksayurveda): The water reservoirs which have no shade on their banks are not pleasing. Hence gardens should be laid in the precincts of reservoirs of water. Soft soil is good for all kinds of trees. First, one should sow sesamum in that soil and when they grow and put forth flowers, they should be uprooted. This is the first process in preparing the land. The astrologers have declared the constellations such as Dhruva, Mrdu, Mula, Visakha, Brhaspati, Sravana, Asvini and Hasta to be auspicious for the planting of trees. The soap-nut tree, Asoka, Pumnaga, Sirisa, Pdyangu, are the auspicious trees and should be planted first in the gardens or the houses. The bread-fruit tree, Asoka, the plantain, the' rose-apple, Lakuca, the pomegranate, the vine, Pativata, the citron and Atimuktaka-these are the trees that grow from scion plastered with mud. They should be carefully planted by taking their stem or by digging them up from the roots. Plants that have not put forth branches should be transplanted in the winter; those that have put forth branches, in the beginning of winter (i.e. the dewy season); and those that have developed trunks, at the advent of the rainy season according to their respective quarters. Transplanting of the trees is done after plastering them root and branch with ghee, usira, sesamum, honey, vidanga, milk and cow dung. The rose-apple, Vetasa, Vanira, Kadamba, Udumbara) Atjuna, the citron, the vine, Lakuca, the pomegranate, Vanjula, Natka-rnala, Tilakll, Panasa, Timira and Amrataka are the sixteen trees that grow in the wet or marshy soil. A pit one cubit wide and twice as much deep should be dug and filled with water. When it becomes dry it should be heated with fire and then plastered with honey and ghee mixed with ashes. It should then be filled with ground Masas, sesamum and barley mixed with soil. Then pouring the broth of the flesh of fish over the filling, it should be beaten down till it becomes hard and compact. If the seed is sown into it four fingers deep and is nurtured with fish-broth and gravy, it grows into a surprising creeper with glistening leaves and soon spreads over the entire bower. Seeds that are soaked in milk for ten days, kept in two hast as of ghee, fumigated with the fumes of the flesh of a hog and deer, and mixed with the fats of fish and hog, grow bearing flowers simultaneously, when sown in a prepared and cleaned soil and nourished with water mixed with milk. Cessation of bearing fruit (i.e. sterility) is cured by Kulattha, Masa, Mudga, sesamum and barley. Along with this, nurturing with boiled and cooled down milk is conducive to the increase of fruit and flower. Two adhakas of the dung of sheep and goats, one adhaka of sesamum, one prastha of meal, a *drona* of water and beef equal in weight-all these (mixed together and) kept for a week (lit. 7 nights)

should be administered as nurture to trees, creepers, thickets and plants for making them bear flower and fruit for all times. Diseases like the searing of leaves, all rest of the growth of leaves, drying up of the branches and excessive exudation of the sap afflict the trees owing to exposure to cold wind and the sun. Their remedy, according to scientific works, lies first in. clearing them (of the diseased part) and then plastering them with the paste of Vidanga and ghee and nurturing them with water mixed with milk.

Buddhism adopted the cult of tree worship from the older religions which prevailed in the country (Sixth century B.C). Gautam Buddha was born under 'ASHOKA' *(Saraca indica),* attained enlightenment under 'PIPAL' *(Ficus religiosa),* preached his new gospel in mango *(Mangifera indica)* groves and under the shady 'Banyan' *(Ficus benghalensis)* and died in the 'SAL' *(Shorea robusta)* grove. Most important trees of ecological value were identified with the name of saints who were revered and worshipped in the society during that period.

| Name | Botanical Name | Name of saint |
|---|---|---|
| Pipal | Ficus religiosa | Sakya muni |
| Banyan | Ficus benghalensis | Kashyapa |
| Gular | Ficus glomerata | Kanaka muni |
| Siris | Albizzia lebbeck | Krakuchhanda |
| Sal | Shorea robusta | Vishwa bahu |
| Ashoka | Saraca indica | Vipaswi |

Buddha attained perfect wisdom under the PIP AL tree; hence it is called the "tree of knowledge". People during the period of Buddha were involved in tree planting and in every village '*Banyan*' and '*Pipal*' trees were planted. Never before or after has religion been so much associated with the tree culture and tree planting. During 237B.C emperor Ashoka actively promoted tree planting on large scale. For the first time in the Indian history, a monarch has encouraged tree culture and adopted it as a state policy. He encouraged planting of trees in the gardens, along road and in the form of avenues. Mughal emperor Jahangir (1616-1674) was the greatest builder of gardens in India. The famous gardens of Kashmir, Shalimar, Anantnag and Verinage owe their existence to him. In ancient India messages were given through religion to establish sound traditions based on the realisation that partnership between the women and nature ensured sustenance. Women were therefore actively associated with tree culture and in many places trees like Pipal, Banyan, Gular, Siris, Sal, Ashoka, Aonla, Neem and Shami *(Prosopis cineraria)* were worshipped. The leaves of Mango and Neem were

considered auspicious and leaves and flowers of Tulsi *(Ocimum sanctum)* and Marygold were used for worship. Tulsi' was the symbol of cosmos. All these traditions are practised in India even today. The ancient Indian civilization was primarily dependent upon and intimately related with forests and flora in Sanskrit scriptures (like Vrikshayurveda, Upavana vinoda, Brhat Samhita, etc) the science of plant life has been described and three indigenous fruits viz., mango banana and jackfruit are extensively mentioned.

Archaeobotanical endience record wild date, jambos, banana, jujube, apricot, apricot, breadfruit, etc,. There is a rich heritage of mango varieties in India. Mango fruit had attracted the fancy of Moghul rulers especially there are choice varieties like Alphonso, Dashehari, Mulgoa, etc,. In citrus natural interspecific and intervarietal hybrids occur extensively in rootstock material which have been found to carry tolerance to viruses and root diseases. Indigenous citrus germplasm provide a good source of parents for rootstock breeding programs. In temperate fruit wild species of Prunus, Pyrus and Malus have been recorded in Himalayas and these carry resistance to root rot and collar and cold hardiness.

A Sanskrit treatise “Sarangathara Padhati” an anthology compiled by Sarangadhara –a courtier of king Hammira, contains Padhati” an anthology compiled” treating arbori-horticulture (translated by Majumder 1935) In Brhat Samhita (ca 500 A.D) there are reference on the methods of propagation like cuttings grafting and about plants suitable for different methods of propagating Propagation of jackfruit, jamun and fact Sadhale (1996) draws a close parallel and resemblance among “Vrikshayuveda” of Surapala (ca 1000 AD) “Upavana Vinoda” of Sarangadhara and Varaha Mihira’s “Brhatsamhita” in respect of science of plant life. The Brahma Vaivata Purana (around 800 AD) lists some good fruits which include indigenous ones like mango (amra), banana (kadali) jackfruit (panasa), bael (sriphala) and introduced but ancient ones like pomegrante (dadima) date (khajura) and grape (draksa) (sensarma 1989) (Table 1) Four fruits, viz., mango, banana, bael and jackfruit are considered as ancient and sacred fruits extensively used in pujas religious festivals and ceremonial occasions.

Table 1. Fruits mentioned in the Puranas.

| | | |
|---|---|---|
| Dadima (Pomegranate) | (E) | Vayu, Mastsya, Brahmavaivarta Brahma, Kurma |
| Khajura (Wild Date) | (E) | Vayu, Mastsya, Brahmavaivarta Brahma, Kurma |
| Jambu (Jamun) | (I) | Vayu, Kurma |
| Amra (Mango) | (I) | Vayu, Brahmavaivarta, Brahma, Agni, Mastsya, Kurma |
| Panasa (Jack fruit) | (I) | Brahmavaivarta, Vayu, Brahma, Mastsya, Kurma |
| Kadali (Banana) | (I) | Vayu, Mastsya, Brahmaviarta, Brahma, Agni |
| Narikela (Coconut) | (I) | Brahmavaivarta, Agni, Brahma |

| | | |
|---|---|---|
| Sriphala (Vilva/Bael) | (I) | Brahmavaivarta, Vamana, Kurma |
| I=indigenous E=exotic Source: Sensarma, 1989 | | |

The Indian sub-continent is a center of domestication and diversity of wide array of plant materials and Vavilov (1949) designated this center as Tropical south asian Center. Zevan and de wet (1982) assigned this as "Hindustani Center" as an important region of diversity of crop plants. The Moghuls Spanards, Potuguese and the British introduced new fruit crops such as apple pear peach spricot grape almond date palm cashew nut litchiu strawberry, blueberry and pineapple.

Fruits plants introductions into India occurred during the ancient times through traders, invaders, travellers etc., Thus grape is reported to have been introduced in tropical India during 620 BC (Olma, 1976) and subsequently by invaders from AFghanistan and Persia in 1300 AD. Pomegranate, sapota and loquat reached India so early that their exact period of introduction is difficult to trace. Hiuen Tsiang, the Chinese pilgrim, mentioned the presence of pomegranate in 629 AD stated that loquat was not present. He also saw grapes, pear, peach, plum, apricot and Diospyros sp. Custard apple was perhaps introduced into India even before Portuguese brought the other species of Annona. Pineapple reached India as early as 1548. Both pineapple and custard apple are recorded in Ain-i-Akbari. Fruits like guava and papaya introduced in the sixteenth century and litchi in seventeenth century naturalized so much that these appear to be native in India. Most of the present day commercial cultivars of these fruits are selections from the variability generated by the introduced types.

After 1870, European and American settlers and Missionaries carried out intdouctions of pome, stone and nut fruits. During this period, Captain Lee in Kullu valley, Coutts in Shimla and Stokes in Kotgarh made valuable introductions in Himachal Pradesh (Singh 1669). A Frenchman, Pychard introduced many varieties in Kashmir between 1910 and 1920. Consequently, several varieties of different temperate fruits namely apple, pear, peach, plum, apricot, walnut and almound fully adapted and established in India temperate regions. The prominent cultivars among these were red Delicious, Golden Delicious. Cox's Orange Pippin, Red Gold, Richared, STarkings Delicious, Granny Smith and Yellow Newton of apple besides Ambri introduced from Central Asia. William's Bartlett, Conferrence, Winter Nelis, Keiffer, Fertility and Beurre Hardy of pear; Stark Lambert, Biggarreau Noir Gross, Redford Prolific and Early rivers. Crawford's Early and C.O Smith of Peach, Santa Rosa, Beauty, Green Gage, Mariposa, Maynard and Grand Duke of Plum; New CAstle, Royal Moorpark, St. Ambroise and Turkey of Apricot and Thin Shelled. Not Pareil and California Paper Shelled of almond.

## Important finds of fruits from archarological sites

Fruits: wild date tamarind, Indian jujube, Indian jambos vine apricot Indian cherry emblica myrobalan wild banana wild canarium wild breadful Indian almond (Kajale, 1991, 1996).

**Mango** – a pre eminent tropical fruit – has been described as the "choicest fruit of hindustan" by Moghuls History records the fact that mangoes have been cultivated in India nearly 4 to 5 thousand years ago. It has been closely associated with indian way of life since time immemorial and has a universal appeal to all sections of the society Hindus consider mango tree as the symbol of "Prajapati Lord of Creation. Mango tree is believed to be useful in scaring away evil spirits (Malla, 2000), The nutritive value of mango has been mentioned in Kurma Purana.

Brahadaranyaka Upanished (1000 BC) and a little later Shatapatha Brahmana mention the mango tree.

Lord Buddha (563-483 BC) was accustomed to resting under the shade of mango tree. In Jataka literature of Buddhists reference to mango has been noted Similarly in Jain literature written after Lord Mahaveera (540-468 BC) mango trees are called Sahasramravana".

Mango fruit has attracted Babar the founder of Moghul Empire in Indian. He dot established "Lakh Bagh" near Darbhanga in Bihar and descriotion of mango in "Ain-i-Akbari" is very detailed His don Jahangir, a Naturalist was an admirer of mango fruits. Mango orcharding became a preogative of Nawabs during Moghul period especially in Uttar Pradesh and Bengal and grafting was permitted only in royal gardens.

Europeans especially Portuguese French and British traders and travelers took a fancy for mango fruits Early foreign travelers Hieuntsang (632-645 AD) Ibn Hankul (902-968 AD) Ibn Batuta (1325-1349 AD) anf Ludo bici Verthena (1503-1508 AD) all prasied the mango fruites as they made mention of it their travelogues. Grafting method of vegetative propagation become a comman practice by then, mango varieties Alfonso pairi safeda Fuzlee Langra Mulgoa Banganpalli etc., have become popular.

Mango originated in northeastern India along with the adjoining region of Myanmar.

**Date (Phoenix sp.)**

A mention has been made of wild date in Ramayana as growing in panchaavati and it is also seen in the potters of Mohenjadaro.

**Fig (Ficus sp).**

Bruhadaranyaka Upanishad has recorded this tree, indicating its antiquity. Besides it has been recorded in Ramayana and Mahabharata.

## The History of Gardening: A Timeline From Ancient Times to 1600

**35,000 BCE** (BCE = Before the Common Era or Christian-Roman Era)

Homo Sapiens at the end of the period had knowledge of many plants dervied from food gathering techniques. Different kids of fruits, nuts, and roots were only gathered, not cultivated.

**4000 BCE -**Indus Valley agriculture is very extensive: wheat, peas, sesame seed, barley, dates, and mangoes.

**3500 BCE-** Cotton growing and cotton textiles quite advanced in India, and remained so until the 13th century

**3000 BCE- Farming in Ancient India:** Most of the crop gown in the ancient times in the Indus Valley is likened to monsoon type crops such as cotton, sugarcane, rice wheat, barley, sesame, bananas, apples and dates.

**200 BCE-** King Dutthagamini in India has a large artwork of the Sacred Fig Tree (Buddha's tree) made of precious materials and placed in the Great Gold Dust Dagoba park and gardens. Cultivation and trade of coconuts between East Africa and India.

**460 AD**- Egg plants were cultivated in China and India.

Portuguese introduced the grafting technique into Indian horticulture about A.D 1550.

Pineapple (*Ananas comosus*) is indigenous to Brazil. The Portuguese introduced it into India in the middle of the sixteen century. In A.D 1578, Acosta mentioned that this fruit was grown profusely in western India.

Cashewnut (Anacardium occidentable) is a native of Brazil. Its red fruit the so-called apple, is acrid and to it is appended the nut like a bud. It is certainly a Portuguese introduction into India. Its earliest mention is by Acosta (A.D 1578), who found it in gardens in the city of Santa Cruz in the kingdom of Cochin.

Chillies (*Capsicum annum*) is a native of Brazil and Peru which has been introduced in the sixteen century as the ornament of Indian garden and soul of pickles.

Portuguese introduced the *Allamanda cathartica* is a climber with beautiful yellow flowers. It was introduced into India from Brazli.

Amaranth (Amaranthus caudatus) was introduced by the Portuguese into Malabar from Brazil.

Guava is also a Portuguese introduction into India, possibly from Brazil.

Sharifa (*Annona squamosa*) or custard- apple was introduced by the Portuguese into India in the sixteenth century, It grows wild in the Deccan Plateau, custard-apple is the bullock`s-heart (*Annona cherimola*), a delicious fruit which grows in Karnataka and Bengal.

Chiku (*Manilkara kauki*; Syn. *Archras zapota*) is a native of Mexio and its cultivation is spreading in India. Chiku is also a gift of the Portuguese to India.

To India, Brazil gave two most beautiful ornamental plants, viz. Jacaranda mimosifolia, with violet-blue flowers, and solanum macranthum, the brinjal-tree with purple and white flowers.

Portuguese introduced Amaranth (Amaranthus caudatus) into Malabar from Brazil.

## Chapter 13. Vegetable farming-Floriculture-Perfumes

### Vegetable farming

*Kashyapa's Krishi-Sukta (800-900 AD) listed rice and other cereals as the first, pulses and other grains as the second, vegetables (including fruits) the third, and creepers and flowers etc., the fourth. Seeds of wheat, pulses, fruits, vegetables and condiments such as turmeric, cumin, black pepper, etc., also need to be preserved for cultivation in the proper season. Kashyapa has advised four types of cultivation viz., i) rice, ii) pulses, iii) vegetables and creepers and flowers. The farmers should cultivate delicious vegetables like Jatika, Rasijatika, Valkika, Vana-vallika, Patolika, egg-plants, Savaka, pumpkin-gourd, Kalata, Kustumburu, Sur ana, Sakuta, and turmeric and ginger-both cultivated and wild-as well as various other luscious plants for the sake of cooking. In the writer's opinion these are the principal vegetables. In some countries the varieties of vegetables are different depending on their species, shape, taste and colour. The cultivators should grow vine, Indian spikenard, cardamom, etc. in their respective regions of cultivation. A wiseman should grow indigenous vegetables on low as well as high land according to the season and country after learning the method of cultivation. Of the cultivable commodities the varieties of paddy occupy the first place, the pulses the second, and the vegetables the third. In the fourth place come ghee, milk, curds, etc. These four kinds of products comprise the entire food-stuff. This stuff promotes the happiness of all the gods and is the means of sustenance of the whole human-kind. This gives nourishment, health and long-life and was created by Brahma at the beginning of creation all over the earth.*

In the spring, the summer and at some places in the dewy season the cultivation of vegetables is sure to bring rich reward. The seeds of the egg-plant, *Valli, Jatika,* pepper, *Savaka* etc. dried in the sun should be sown in ploughed field for the sake of sprouting. The seeds of the egg-plant, etc. dried in the sun, should be sown in the soil dressed with cow-dung, etc. for sprouting. They should be regularly watered and then covered with the straw-shed. In three days the sprouts appear in the depressions where the seeds were sown. After twenty days when the sprouts have taken firm roots, the wise cultivator should transplant them in a properly ploughed field. Watering the roots at that very time promotes the life of the plants.

The cultivation of vegetables is good in low land in the summer and not in the rainy season. It is successful in other seasons also. In the same manner the bulbs of *Sakuta, Surana* and turmeric should also be implanted in hollow depressions or in a bed of hot soil and they will thrive. In this way, the cultivation of creeping plants is manifold. Pumpkin-gourds, wild pumpkins, cardamom, spikenard and *agavalli* (Piper Betel) may also be grown on high land. Of *patolika,* egg-plant, *Saka* (leafy vegetables), and *Savaka,* the unripe young fruit is tasteful and is therefore highly commended. He should cultivate, nourish and protect the various *sakas* (pot herbs), which are fit for eating, sucking and chewing.

The cultivators should after making depressions etc. in their various fields, cultivate seasonably in spring, summer, rains, autumn, dewy season and winter pot-herbs and other vegetables whose leaves, rind, flowers or bulbous roots are (edible and) delicious, nourishing and health-giving, and reap the rich fruit of their labours. They should grow, seasonably and according to usage, instructions of former sages and the nature of the soil, cardamom, cloves, ginger, arecanut, betel plant, sugarcane, plantain trees and other life-promoting and beneficial herbs like the long-pepper in their field-beds or on high land (i.e. wet or dry land) as the case may be. The Brahmanas, Ksatriyas, Vaisyas, Sudras, men of mixed castes, hunters and soldiers *(vim)* should all grow to their best efforts coriander, *surana, valli,* pumpkin-gourd, and *Patolika,* in their own land of whatever sort it may be. Experienced cultivators carry out all the processes needed for the infixing of the seeds, weeding of the ill-growth and protection of the plants till the time of inflorescence, under their own supervision according to the traditional usage. Of these vegetables, leaves, flowers, fruit, unripe fruit or bulbous roots are taken for use either at the beginning of efflorescence, or in the middle or end of it, as the case may be.

The king should also introduce balances with a beam and scales made of bronze or brass for the weighing of vegetables. Whatever help in the cultivation of food grains and vegetables, etc. and in the procurement of oils, cloth, etc. is recommended by former sages in their treatises that the king should render for the happiness of his' subjects in every village and every house as well as for his own welfare. He should promote agriculture by regulating cultivation, sowing, etc. according to time and season, and cold and hot places.

Betel stimulates love, reveals-physical charm, enhances personal magnetism (i.e makes one attractive), gives good smell to the mouth, strengthens the body, and dispels diseases arising from the vitiation of phlegm. It also bestows many other advantages. Betel leaves. used with a moderate dose of lime imparts red-colour (or love); an extra quantity of betel-nut spoils colour (or passion); excessive lime produces bad smell in the mouth; while an extra quantity of betel-leaf, pleasant smell. At night it is beneficial to have an over-dose of betel-leaf white by day, of areca-nut To change this order is a mere farce of betel-chewing. When betel-leaf is made fragrant by means of kakkola (*Luffa echinata*), areca-nut the fruit of Levali (*Cicca acida*) and Jatiphala (*Myristica fragrams*), it makes one happy with the joy of amorous odour.

**Quest for spices** (A.D 1498-1580): Europeans had to pay extortionate prices for species, particularly pepper, which not only made their food tasty, but was also used as a preservative for meat. Pepper was also used in wine and pastry.

**Floriculture in Ancient India**

The divine character of the trees has been depicted in a number of seals sealings potteries potsherds and some rock paintings as archeological evidence of

the Mohenjodaro and Harappa period (3500-1750 BC). A few trees such as pipal or asvatta (*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. There are vivid descriptions of trees in the Rigveda (3700-2000 BC). Methods of plant multiplication by seed and vegetative means were prevalent and find mention in the Vedas, Arthasasthra and Brhat Samhita. Plants were also featured in personal adornment and beautification of the home. Girls wore flower to Champaka (Michelia champaca) and jasmine in their hair and those of Siris (Albizzia labbek) in their ears. They made garlands of many kinds of flowers and painted their foreheads and cheeks with sandal paste obtained from Santalam album. Poet Kalidasa has made frequent references to these in his writings. In his Ritusamhara, Kalidasa gave charming descriptions of indigenous beautiful trees of India with flowers in different months.

According to Vatsyana all big houses and palaces of kings had to pleasure garden –vrksavatika and pushpavatika. Among the trees, one of the most beautiful was the red flowered Saraca indica popularly known as asoka. It was said that Sita was confined by Ravana in a grove of asoka trees. Another favourite tree of those days was Kadama (Anthocephalus cadamba) and its flower appear in golden balls. It was closely associated with the life of Lord Sri Krishna.

Of the climbers, Madhavilata (*Hiptage madhablata*) received frequent mention in Kalidasa's play (5$^{th}$ 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.

After rise of the Mauryas in the 4$^{th}$ to 3 $^{th}$ century BC there has been vast secular literature and texts both vedic and post-vedic like vedas Brahamanas, Aranyakas Upanishads sutras smritis Mahakavyas puranas Buddhists texts (Jataka) and jain literature (Sutras) the sagas of the Upanishads have described the Cosmic Tree rooted in the Brahman the ultimate whose branches are space wind, and earth the cosmic tree is the world mother the goddess of nature which have been a part of flock cult in Hindu muthology. kalpavarska is mentioned in Ramayana. Mahabharata, Jatakas Divyavadana and the jain sutras. In Brahamancial religion, vata (*Ficus benghalensis*) was identified with identified with shiva asvatha (*Ficus religiosa*) with Vishnu) lotus with Surya (Sun) and nine leaves of nine trees (navatatrika) with nine different aspects of Durga. The art of gardening and kinds

of gardens were described by Sarangdhara (1300 AD) and Vatsyayana (300-400 AD) respectively. Vatsyayana (AD 300-400) has also rendered interesting accounts of four kinds of gardens namely pramadodyam udyan vrishavatika and nandanvana. The science of plant life. (Vrikshayurveda) on arbori-horticulture and usefulness of trees and gardens were well-known in ancient India. In the Ramayana mention is made of Ashokavana or Panchavati, in which sita was held captive Ashoka tress (*Saraca asoca*) were prodominant in this garden. In the Panchavati, five trees were planted. asvattha (*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. The association of Lord Krishna with the Kadamba tree (*Anthocephalus indicus*) is well known.

During the Buddhist period gardens were laid out around the monasteries and stupas and there were beautiful gardens in Nalanada the Taxila. It is said that Lord Buddha was born under the people tree in a garden Thebodhi tree under which the Buddhist. The planting of roadside avenue trees (margeshuvriksha) was an important contribution of the king Asoka (233 BC). He was the first king in Indian History who encouraged Arboriculture and adopted it as a state policy. Mathura sculptures of Kashan period depicted Kadamaba tree (Anthocephalus cadamba), Champaka (Michelia champaca), Mesua ferra and lxora abrorea.

The Hindus were so fond of ornamental plants that some of them were actualy worhsipped. Besides asoka (Saraca indica), Padma (Nelumbo nucifera) and tulsi (Ocimum Sanctum),t he pipal (Ficus Religiosa) and banyan were given a very high place. The tree and Buddha Gaya under which Lord Gautama Buddha attained enlightenment, was a pipal, its branches were taken far and wide and planted to be given rise to new trees. The life of Lord Buddha (56 B.C.) was intimately associated with numerous trees. The art of gardening was spread to neighbouring east from India with preaching of Lord Buddha. The trees which were associated with Lord Buddha are Sal (Shorea robusta), asoka (Saraca indica) and plaksha (Butea monosperma).

Concept of identifying trees with goes and goddesses and threats and punishments against the destruction of usefull trees helped to save the trees and flora which is a remarkable contribution of our ancient people In Ramayana stated “I hava not cut down any fig tree in the month of Vaisakha why then does the calamity befall me”. Felling of trees as an offence has been mentioned in several old texts like Kautilya’s Arthasastra, Agni purana, Varsha Purana Mastsya Purana and Buddhist and jain literature. During the Mughal period ($16^{th}$ and $17^{th}$ centuries AD) and the British period ($18^{th}$ and $19^{th}$ 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 Moughals in India during 16th and 17th centuries. Babur mentioned in the Baburinama some indigeneous ornamental trees like hibiscus (Hibiscus rosa sinensis), oleander (Nerium indicum), Keora (Pandanus odoratissimum) and white jasmine. He is credited with the introduction of scented Persian rose in India. Babur (1483-1530), the Mughal emperor had established gardens in Persia and 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. The most important Mughal gardens are the Taj Mahal Garden Agra (1654 AD); Shalimar and Nishat Gardens, Srinagar, Pinjore Gardens, Pinjore and the Garden at Hamayun's tomb, Delhi the rose was introduced into out 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. Apart from planting garden. Jahangir popularised char-chenars i.e. planting four chenars at the corners of a square, so that there may always be shade at the centre. The most important plants the famous Shalimar Bagh in Srinagar were the majestic China tree (*Platans orientails*), the chypress (*Cupresus sempervirens*) and the weeping willow (*Salix babylonica*) and flowers like rose narcissus daffodil, iris, lilies tulip and carnation. The Arabs terraced the slops with vineyards. The Arabs specialized in the culture of data-palm. According to Swindle, the data-palm produces more well-mineralized, highly flavored and nutritious human food per acre than any other temperate zone crop. While it has its feet in running water, its head is in the fires of heaven. Information on agriculture and horticulture especially gardening of Arabs could be obtained from the book 'Abu Zakariya' written by Yahya bin Muhammad. Abu Zakriya says that all garden doorways should be farmed by clipped evergreens, that cypresses should be used to line paths and grouped to mark the junctions of paths. He objected to the mixing of evergreen with deciduous trees. Plants named in his text include lemon and orange trees, Pines and most of our common deciduous trees, cypresses, oleander, myrtle and rose as the only flowering shrubs, violets, lavender, balm, mint, thyme, marjoram, iris, mallow, box and bay laurel. He lays much stress on aromatics, as, indeed, did all the Islamic gardeners. His climbing plants are vines, jasmines and ivy. The mahua (*Madhuca indica*) tree bears fruit twice a year and from its kernels they make oil, which they use for lamps.

Betel vines: Ibn Battuta also saw betel vines in Kerala. He states, Betel-trees are grown like vines on cane trellises or else trained up coco-palms. They have no fruit and are grown only for their leaves. The Indians have a high opinion of betel, and if a man visits a friend and the latter gives him five leaves of it, you would think he had given him the would, especially if he is a prince or notable, A gift of betel is a far greater honour than a gift of gold and silver.

## *European period*

Missionary priests, Englishmen, Portuguese, amateur and professional gardeners from Europe, Asia and Africa, introduced a large number of plants into Indian gardens. Portuguese introduced Agave americana and Allamanda cathartica. Which have now been naturalised throughout India. Several botanical gardens were established during 18$^{th}$ and 19$^{th}$ centuries in various parts of India, where indigenous and exotic plants were introduced and maintained. Roxburgh, the father of Indian Botany, was the first Botanist to adopt the Linnaean system of binomial nomenclature in relation to the plants of India. His pioneering work, Flora Indica, Plantae Coromendelianae and his portfolio of paintings of 2,382 plants mainly the work of Indian artists formed the basis of Hooker's 'Flora of British India'.

Portuguese control the spice trade in the Indian Ocean during1497 AD. The term 'herbal' was put in use in 1516 as per the Oxford English Dictionary. Robert Fortune (1852) sent tea plants from China to Indian Himalayas. Cinchona trees (for quinine) sent from Kew NBG to India in 1861. 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 entitled "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 18$^{th}$ and 19$^{th}$ 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. Among the noteworthy introductions of that period are the mahogany (*Swietenia mahogany*) from Jamaica in 1795 and the Giant Amazon lily, Victoria regia. onto Sipbur gardens. Joseph Hooker brings 6,5000 species of plants from India to Kew NBG in 1851. *Grevillea robusta* and and *Araucaria excelsa* in 1857 and *Amherstia nobilis* in 1859 were introduced in the Lalbagh Botanical Garden, Bangalore. In the Government Botanic Garden, Saharanpur, *Canna glauca*, *Jatrophia multifida* and few other plants were introduced in 1817. *Bougainvillea spectabilis* was introduced by the Agni-Horticultural Society, Calcutta in 1858 from South Africa. The Lalbagh Botanical

Garden, Bangalore introduced flower seeds from the Royal Botanical Garden Kew (England) in 1864.

**PERFUMES**

India has a perfumery tradition that dates back to over 5,000 years to Indus Valley civilization. In the excavations of Harappa and Mohanjodaro, a 'water distillation still' and 'receiver' have been recorded whose shape resemble to the 'deg' and 'bhabka' currently used by 'attars's (traditional perfumers) of Kannauj in India.

There was competition in the preparation of aromatic essence. 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- Akbar! (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. All these things show that the level of scientific and industrial enterprise was pretty high in ancient India. In fact civilization grows if people' desire increases for a happier livings, which in turn finds new avenues of getting luxury goods.

**Hair colouration:** Cook the grains of Kodrava (*Paspalum scrobiculatum*) in sour gruel or vinegar in an iron dust and make a fine paste. After washing the hair with sour gruel (or vinegar) apply this paste to the head. Then, covering the head with green (juicy) leaves, remine for six hours. Thereafter remove the paste from the head and apply a paste of myrobalan (*Emblica officinalis*). Cover it again with green leaves and retain it for another six hours. On being washed, the hair will become black.

**Royal head-bath:** A scented water fix for the washing of kings' head is prepared with equal quantities of woody cassia, costus (*Saussurea lappa*), Renuka (*Piper aurantiacum*), Nalika (*Hibiscus cannabinus*), Sprkka (*Bryonopsis laciniosa*) Rasa or Bola (*Commiphora myrrha*), Tagara (*Valeriana wallichii*), Valaka (*Aprorosa lindieyana*), Nagake-sara (Mesua ferrea) and Patra (*Laurus cassia*).

Betel stimulates love, gives good smell to the mouth, improves digestion and dispels diseases arising from vitiation of phlegm. Betel leaves used with moderate dose of lime imparts red colour ( or love); extra quantity of betelnut spoils colour or passion; excessive lime produces bad smell in the mouth; while an extra quantity of betel-leaf produce pleasant smell.At night, it is beneficial ti have an over dose of betel leaf, while by day, of arecanut. To change this order is a mere farce of betel chewing.

**Perfume from roses-a discovery:** Here is an account in Jahangir's own words about the famous rose scent, **itr.i.Jahangiri:** "This itr (i.e., Jahangiri itr- so called otto of roses) is a discovery which was made during my reign through the efforts of the mother of Nur-Jahan Begam. When she was making rose water a scum formed on the surface of the dishes into which hot rose water was poured from the jugs. The scum was collected. It is of such strength in perfume that if one drop be rubbed on the palm of the hand it scents a whole assembly and it appears as if many red rosebuds had bloomed at once. There is no scent of equal excellence to it. It restores hearts that have gone and brings back withered souls. In reward for that invention I presented a string of pearls to the inventrees. Salima Sulthan Begam (may the lights of God be on her tomb) was present, and she gave this oil the name of "'its – i – Jahangiri".

# Chapter 14. Medicinal plants and their relevance 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.

**The Siddha System of Medicine:** The Siddha system of medicine owes its origin to the Dravidian culture which is of the Pre-vedic period. An examination of the ancient literature would reveal that the vedic Aryans owed allegiance to the cult of Shiva and the worship of the phallus (linga) which was later on absorbed by, and incorporated into the Vedic culture. The Shiv Cult is associated with its medical counterpart, the Siddha system of medicine, which is mainly therapeutic. Mercury, sulphur, iron, copper, gold, bituman, white, yellow and red arsenic and other materials as well as vegatable poisons are extensively used in the pharmacopocia of the Siddha tradition. The Siddha system of medicine is prevalent in the Sourthen States of India, Sri Lanka, Malaysia, and Singapore, where the Dravidian civilization was document. In the North of India, the Siddhar-Kalpa system (Siddha means one who has attained immortality and Kalpa means panacea) is known as Tantric Science. Siddha Science considers nature and man as essentially one. One who knows the anatomy of nature and its five elements knows well the anatomy of men. Nature is the foremost physician. The Tamils who are inhabiting the Southern peninsula of the sub-continent of India have an impressive and venerable past, as ancient as that of perhaps the Egyptians. They undertook a systematic study of nature and its elements and from what they were able to grasp, they had developed a highly systematised medicine which is now known as Siddha system. It is well founded on the basic principles of nature and its elements offer a careful and thorough study of the human system.

**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 ot be known as Siddhars system of Medicine. This system can be traced to the prevedic period. Siddhar, a Tamil word that is derived from its root 'chit' means perfection in life or heavenly bliss. It generally refers to eight kinds of supernatural powers attainable to man. Siddhars are the persons who had attained such miraculous powers attainable to man. The persons who had attained such miraculous powers in life are known as Siddhars. They are men born with great talents who lived thousands of years ago in Tamil country, who by their devotion and search for truth, achieved perfection in their life time.

**Ancient Siddha Medical Works:** The earliest mention the use of medicinal plants is to be found in Thirumular Thirumantiram-Ennayiram, Tholkappiam and the ancient Tamil works of Sangarm Literature which are believed to have been written thousands of years before the Christian era. There are now more than 500 works in Tamil dealing with various subjects such as science of life, nature of universe, astronomical data, cosmic dance, atomic theory, space travel, alchemy, 'Kaya Kalpa' medicine, etc.

**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. Perhaps they were aware of the germicidal action and the medicinal properties of the Margosa, Tirumular, the great siddha is said to have been in deep penance for several thousands of years before the Christian Era in eternal bliss under a sacred pipal tree.

**Basis of the Siddha System :** According to Siddha medical science the universe consists of 5 elements. Earth, Water, Fire, Air and Ether which correspond to the five senses of the human body. Man consumes water and food, breathes the air and then maintains the heat in the body. He is alive because of the life force given by ether. The earth is the first element which gives fine shape to the body, including bones, tissues, muscles, skin, hair etc. Water is the second element representing blood, secretions of the glands, vital fluid etc. Fire the third element that gives emotion, vigour and vitality to the body. It also helps digestion, circulation and stimulation besides respiration and the nervous system. Above all other is the characteristic of man's mental and spiritual faculties. A suitable

proportion of these five elements in combination with each other produces a healthy person. These elements are divided into two halves, namely physical and subtle. And this subtle part is futher sub-divided into two equal parts of which one is retained as such and the other part is again subdivided into four equal parts. This is what is known in Siddha system of Medicine as the theory of Panchikarnam (Fivefold combination). It is fact the functioning of the five elements in the human body. The ideal of the unification of energy and matter and the synthesis of the various phenomena of sound, light, heat, etc. which modern science has been endeavouring to establish were achieved by the ancient Siddhas, when modern equipements was not available for research. Siddhas also held that he who knows the secret doctrine of the five elements, could change a baser metal into gold. And Siddhas alchemy is based on this theory.

**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.

**Culture and History of Siddha Medicine:** The original Home allotted to mankind by the Creator was in the temparate and fertile region of the East and pointedly in India. It is from here that the human race began its culture and career. India may, therefore, be safely stated as that the first country from which human culture and civilization originated and spread. According to Indian history prior to Aryans migration, the Dravidian was the first inhabitant of India of whom the Tamilians were the most prominent. The Tamilians were not only the earliest civilized but also those who may more considerable progress in civilization than any other early people. The languages of India were divided into two great classes, the northern with Sanskrit as the pre-pondering element and the southern with Dravidian language as independent bases. The science of medicine is of fundamental importance to man's well being be and his survival and so it must have originated with man and developed as civilization. It is, therefore rather pointless to try to determine the exact point of time to which the beginning of these systems could be traced. They are eternal, they began with man and may end with him. The Siddha was flouriest in south and Ayurveda prevalent in the north. Instead of giving the name of any of individual as the founder of these systems our ancestors attributed their origin to the creator. According to the tradition it was Shiva who unfolded the knowledge of Siddha system of medicine to his concert Parvati who handed it down to Nandi Deva and he the Siddhars. The Siddhars were great scientists in ancient times.

According to tradition, the origin of Siddha system of medicine is attributed to the great Siddha Ayastiyar. Some of his works are still standard books of medicine and surgery in daily use among the Siddha Medical practitioners.The science of medicine is of fundamental importance to man's well being and his survival, and so it must have originated with man and developed as civilization advanced. It is therefore rather pointless to try to determine the exact

point of time when any system of medicine was evolved and codified. A system of medicine is not a discovery but a gradual evolution during successive periods of history. It owes its progress to great men, who have not only enriched the science, but also society and civilization as a whole.

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.

The Tamils have a distinct civilization, which is not disputed by historians. The recorded history of the Tamils is thousands of years old. Apart from the literature of the first, the middle and the last Sangam periods which bears ample testimony to the extent of Tamil civilization and its eminence, mention is made even in contemporary Sanskrit literature about Cholas, Pandiyas and Cheras and their kingdoms. A civilized society must naturally have had a system of medicine which catered to the health needs of its people. This was the Siddha system. The term 'Siddhi' means 'achievement' and the Siddhars were men who achieved certain results in medicine, as well as in yoga or tapas. The results in medicine were achieved by the Siddhars through their mental powers, they bequeathed to their 'Chilas' or pupils, who preserved and propagated the science. Eighteen siddhars seem to have existed. They should have lived at different periods and bequeathed their experiences in medicine and yoga to posterity. The names of these eighteen Siddhas differ from one source to another. It is not necessary to dogmatise which of these enumerations is correct. Some of the Siddhas, for example, Kapila and Kakabujanda have written treatises both in Tamil and in Sanskrit. It is possible that the originals were written in Tamil and that they were translated into Sanskrit later. The following is the list of eighteen Siddhas according to one recension: 1. Nandi 2. Agasthiyar 3. Thirumular 4. Punnakkeesar 5. Pulasthiyar 6. Poonaikannar 7. Idaikadar 8. Bogar 9. Pulikai Isar 10. Karuvurar 11. Konkanavar 12. Kalangi 13. Sattainathar 14. Azhuganni 15. Agappai 16. Pambatti 17. Theraiyar and 18. Kudhambai. The names like Bogar, Idaikadar and Theraiyar are of recent origin and these Siddhars lived probably in the middle ages. There are also authors of Siddha treatises like Sattaimuni, Yugimuni, Macha Muni, Kakabusundar etc., whose works are available in parts at the present day and are being used.

**Important Tamil Books in Siddha medicine:** Siddha Vaidya Thirattu, Therayar Maha Karisal, Brahma Muni Karukkadia 300, Bhogar700, Pulippani500, Agasthiyar

Paripuranam 400, Therayar Yamagam, Agasthiyar Chenduram300, Agasthiyar500, Athmarakshmrutham, Agasthi Pin80, Agasthiyar Rathna, hurukkam, Therayar Karisal300 , Veeramamuni Nasa Kandam, Agasthiyar600, Agasthiyar Kanma Soothiram, 18 Siddhar's Chillari Kovai, Yogi Vatha Kaviyam, Therayar Tharu, Agasthiyar Vaidya Kaviyam1500, Bala Vagadam, Chimittu Rathna (Rathna) Churukkam, Nagamuni200, Agasthiyar Chillari Kovai , Chikicha Rathna Deepam, Agasthiyar Nayana Vidhi , Yugi Karisal 151, Agasthiyar Vallathi 600, Therayar Thaila Varkam, Siddha Formulary of India (Part I).

The Rigveda (5000 years B.C.) mentioned 67 medicinal plants, Yajurveda 81 and Atharvaveda (4500-25000 B.C), 290 species. Later the Charak Samhita (700 B.C.) and Sushrut Samhita (200 years B.C) have described properties and uses of 1100 and 1270 plants respectively, in compounding of drugs and these are still used in classical formulations in the Ayurvedic system of medicine.

**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.

**Distribution of Medicinal plants in Tamil Nadu**

Analysis of habits of medicinal plants indicates that they are distributed across various habitats. One third are trees and an equal portion shrub and the remaining one-third herbs, grasses and climbers. A very small proportion of the medicinal plants are lower plants like lichens, ferns algae, etc. Majority of the medicinal plant are higher flowering plants.

The State of Tamil Nadu is endowed with a very rich flora. Due to the various physiographic features and physiognomic factors, different types of vegetation exist in the state: 1. Coastal vegetation, 2. Island vegetation and 3. Vegetation of hills and mountains comprising of:

1) Dry deciduous forests
2) Moist deciduous forests
3) Semi-evergreen forests
4) Wet evergreen forests
5) Sholas (Southern montane wet temperate forests)

The altitude varies from sea level to 2637 m including the well known mountain ranges - the Nilgiri, the Anamalais and the Cardamom hills which harbours different types of ecological niches, ecosystem and innumerable medicinal plants. A few ethnic tribes like the Irular, Kaanikkara, Karumpar, Palliyan, Paniyar, Sholagar, Thodar and others dwell in these ecosystems and still depend on naturally occurring or cultivated from the state. Out of this, it is found that 1474 are medicinal plants. A total number are found to be used in Siddha system of medicine which is commonly practiced throughout the state.

Tampcol has two medicinal farms, one in Chennai city at Arumbakkam and at Valavandinadu, Kolli hills, Namakkal district. In Chennai farm six varieties of medicinal plants are cultivated in five acres to meet the fresh herb requirements for the production of herbal hair tonic, other medicated oils and also supplied to pharmacy at Arignar Anna Govt. Hospital for Indian medicine and Homoeopathy, Chennai.

Another 150 varieties of medicinal plants are maintained in the parts as reference material. The farm is also visited by the students of all systems of Indian Medicine. Leading practitioners of Indian Medicine also make use of this farm as their reference for medicinal plants. This farm is very popular and has contributed for herbal awareness in Chennai City. The farm participates in the exhibitions conducted by Educational Institutions,Trade fairs and seminars/conferences in the city. The public are also encouraged to buy the medicinal plants at low prices to enhance the importance and awareness of herbal medicines.

The Kolli Hills medicinal farm is situated in Valavandinadu at the altitude of 3600 ft. The land is undulating with rocky slopes. Out of 105 acres year-marked, the corporation has developed 55 acres and cultivating a dozen species of medicinal plants on large scale and another 50 varieties which includes trees, climbers, perennials are cultivated on bunds, hedges, fence line etc. as per suitability of the

species. Further, the farm has a large nursery in which seedlings/saplings/cuttings/graftings are raised for own cultivation and to supply to the government institutions concerned and also to progressive farmers in the state and out side.

**RAW DRUGS TRADING:**

The corporation is handling 400 varieties of raw drugs of plant, metal / mineral, animal and marine origin for the production of its own products and to supply to four government pharmacies of ISM in the state and also for the outside sales. The corporation is well worsed in the All India raw drug trade and can source raw drugs for domestic and overseas markets.

**TAMPCOL PRODUCTS:**

Tamil Nadu Medicinal Plant Farms and Herbal Medicine Corporation Ltd (TAMPCOL) was established in 1983 by the Government of Tamil Nadu at Chennai. The corporation has been manufacturing 50 medicines of Siddha, Ayurveda and Unani systems and supplying to all the ISM wings in PHC's / Dispensaries / Hospitals and Taluk / District hospitals in the state of Tamil Nadu apart from supplying to TNEB dispensaries and CGHS dispensaries in Chennai city. The products are also sold in the open market through dealers and Tampcol's outlets in Chennai and Palayamkottai. The particulars of medicinal plants cultivated in Tamil Nadu are presented in Tables 1-3.

Table 1. Medicinal plants under cultivation in Tamil Nadu

| Sl.No. | Botanical Name | Tamil Name | Trade Name |
|---|---|---|---|
| 1. | Piper longum | Thippili | Long pepper |
| 2. | Alpinia speciosa | Sittrathai | Galangal |
| 3. | Centella asiatica | Vallarai | Gotucola |
| 4. | Bacoppa monnieri | Neer birammi | Birammi |
| 5. | Phyllanthus amarus | Keelanelli | Phyllanthus |
| 6. | Eclipta alba | Vellai karisalai | Brhingraj |
| 7. | Phyla nodiflora | Poduthalai | - |
| 8. | Wedelia calandulaecae | Manjal karisalai | - |
| 9. | Ocimum sanctum | Thulasi | Thulasi |
| 10. | Ocimum kilimanjariacum | Karunthulasi | Krishna Thulasi |
| 11. | Ruta graveolens | Aruvatha | Burke- Sadaf |
| 12. | Desmodium gangeticum | Orilai | Desmodium |

| | | | |
|---|---|---|---|
| 13 | Uraria picta | Moovilai | Uraria |
| 14. | Pogostemman patchouli | Patchilai | Pogostemman |
| 15. | Acorus calamus | Vasambu | Sweet flag |
| 16. | Adathoda zeylanica | Adathoda | Adathoda |
| 17. | Vettiveria zyzynoides | Vettiver | Vettiver |
| 18. | Gymnema sylvestre | Siru kurunjan | - |
| 19. | Decalepis hamiltonii | Malai nannari | Decalepis |
| 20. | Melina arborea | Perungkumil | Kumbi |
| 21. | Embilica officinalis | Nellikkai | Amla |
| 22. | Aegle marmelos | Vilvam | Bel |
| 23. | Saraca asoka | Asokam | Asok |
| 24. | Terminalia arjuna | Marutham | Arjuna |
| 25. | Syzigiyam Jambolanum | Naval | Jambolanum |
| 26. | Croton tiglium | Nervalam | Jamal got |
| 27. | Michalia Champaka | Senbagam | Champak |
| 28. | Syzigium aromaticum | Elavangam | Cloves |
| 29. | Piper nigrum | Milagu | Black pepper |
| 30. | Cinnamum tamala | Elavanga pattai | Cinnamum |
| 31. | Myristica fragrance | Jathikkai | Nutmeg |
| 32. | Steriospermum suaveolens | Pathiri | Pata |
| 33. | Cichorium intybus | Kasini | Kasini |
| 34. | Andrographis paniculata | Nilavembu | Kalameg |
| 35. | Tinospora cardifolia | Seenthil | Guduchi |
| 36. | Asparagus recimosus | Thanneervittan kilangu | Asparagus |
| 37. | Psoralea corilifolia | Karbogalarisi | Babchi |

**Table 2. Agrotech of Medicinal plants**

| S.No. | Botanical Name | Trade Name | Type & Duration of Crop |
|---|---|---|---|
| 1. | Centella asiatica | Vallarai | Perennial Crop - 3 Months |
| 2. | Eclipta alba | Vellai karisalai | Seasonal Crop - 3 Months |
| 3. | Wedelia calandulaceae | Manjal karisalai | Perennial Crop - 3 Months |

| | | | |
|---|---|---|---|
| 4. | Ruta graveolense | Aruvatha | Annual Crop - 1 Year |
| 5. | Alpinia speciosa | Sittrathai | Annual Crop - 1 Year |
| 6. | Andrographis paniculata | Nilavembu | Seasonal Crop - 6 Months |
| 7. | Phyllanthus amarus | Keelanelli | Seasonal Crop - 3 Months |
| 8. | Moranta arundunaecae | Arrow root | Seasonal Crop - 1 Year |
| 9. | Cichorium intybus | Kasini | Seasonal Crop - 5 to 6 Months |
| 10. | Solanum nigrum | Manathakkalai | Seasonal Crop - 5 to 6 Months |
| 11. | Psorelia corilifolia | Karbogalarisi | Seasonal Corp - 5 to 6 Months |
| 12. | Adathoda zeylanica | Adathoda | Perennial Crop - 3 Months |
| 13. | Ocimum sanctum | Thulasi | Seasonal Crop - 6 Months |
| 14. | Gymnima sylvastre | Sirukurinjan | Perennial Crop - 1 Year |
| 15. | Bacoppa monnieri | Neer Birammi | Perennial Crop - 3 Months |

**Table 3. Plants cultivated and exported from Tamil Nadu**

| S.No. | Botanical Name | Trade Name | Area of Cultivation |
|---|---|---|---|
| 1. | Gymnima sylvestre | Gymima | Dinducal, Kolli Hills, Tuticorin. |
| 2. | Centella asiatica | Gotucola | Salem, Erode, Hosur. |
| 3. | Cichorium intibus | Kasini | Ooty, Hosur, Kolli Hills |
| 4. | Eclipta alba | Bhringraj | Trichy, Salem, Madurai |
| 5. | Coleus forskholi | Forskholi root | Thiruvannamalai, Salem, Madurai. |
| 6. | Gloriosa superba | Gloriosa | Salem, Krishnagiri, Moolanoor, Ottanchathiram, Sivakasi. |
| 7. | Cassia angusitefolia | Senna | Tirunelveli, Tuticorin, Virudhunagar. |
| 8. | Indigofera tinctoria | Indigo | Viluppuram, Tindivanam, Vandavasi, Thiruvannamalai, Thiruvallur. |
| 9. | Ocimum sanctum | Thulasi | Salem, Hosur |
| 10. | Ruta graveolense | Burk-e-sathaf | Hosur, Ooty, Kolli Hills. |
| 11. | Decalepis | Decalipis | Kolli Hills. |

| | | | |
|---|---|---|---|
| | hamiltonii | | |
| 12. | Phyllanthus amarus | Phyllanthus | Thiruvallur, Salem, Hosur, Madurai. |

**Medical Education in Ancient India:** Medicinal knowledge gained over trial and error over the thousands of years in India and neighbouring regions 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. Knowledge arranged systematically with logic becomes science. During the due course of time, Ayurveda became the science of life. 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. Taxila situated about 20 miles west of Rawalpindi (now in Pakistan) was the most important seat of learning in ancient India dating from the sixth century B.C. It attracted students from all corners of India, viz., from Rajagriha, Mithila, Kashi, Ujjain, Kuru, Koshala, etc. Its fame had spread far and wide in foreign countries; students from there were said to come here to learn. Nalanda was another center of learning which flourished from the fifth to twelfth century A.D. The plant wealth of forest was utilized through 'Ayurveda' for the welfare of human beings. The most important trees extensively used in medicinal preparations were Neem *(Azadirachta indica),* Aonla *(Phyllanthus officinalis),* Harra *(Terlllinalia chebula),* Behda *(Termlinalia bellirica),* and Bael *(Aegle marmelos).* 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.

**Siddha Education:** There are two Government Siddha medical colleges with a total admission capacity of 150 students at the Under Graduate level. One at Palayamkottai with admission capacity of 100 and the other at Chennai with an admission capacity of 50. In addition to the above another 3 private Siddha medical colleges are also there in Tamilnadu with an admission capacity of 30 students each. Admissions are purely on the basis of Common Entrance Test conducted by the Govt. of Tamil Nadu after 10+2. These colleges are affiliated to Dr. MGR Medical university, Chennai. Both the Government colleges are having the facilities for post-graduate education with total admission capacity of 80 (Palayamkottai : 60 and Chennai :20).

The Government has constituted the Tamil Nadu Medicinal Plants Board to address the issues connected with conservation and sustainable use of Medicinal Plants, cultivation of Medicinal Plants and export of such products. An international organization, called ICMAP (International Council for Medicinal and Aromatic Plants) was initiated and located in Paris, France. The Government of Tamil Nadu

has established the National Institute of Siddha at Tambaram, Chennai. This institute has teaching facility in 6 Siddha subjects as mentioned below:

- *Siddha Maruthuvam - Pothu (General Medicine)*
- *Gunapadam (Pharmacology)*
- *Sirappu Maruthuvam (Special Medicine)*
- *Pillaippini Maruthvam (Paediatrics)*
- *Noi nadal (Pathology)*
- *Nanju nool (Toxicology)*

The Central council of Indian Medicine regulates the education of Siddha system in the country. Within the council, there is a separate education committee for this system. The education committee is charged to deal with all matters pertaining to Siddha education including the development of a detailed curriculum and syllabus both at uncer-graduate levels.

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

**Domestication of animals for settled life:** The raising of animals is as old as civilization itself, for, our common domestic animals were domesticated before the beginning of written history. Paleolithic man hunted animals for food and raiment; his successor, the Neolithic man, tamed and confined them. It was in the Neolithic or New Stone age that men first practised agriculture, which included the raising of domestic animals. Carbon-14 testing of animal and plant remains showed the domestication of sheep at 9000 BC in northern Iraq; cattle in the 6th millennium BC in northeastern Iran; goats at 8000 BC in central Iran; pigs at 8000 BC in Thailand or asses, at 7000 BC in Jarmo, Iraq; and horses at 4350 BC in Ukraine. The domestication of sheep and goat took place in the pre-agricultural phase when nomadic man with the help of dog brought them under his control. Small ruminants like sheep and goat constituted the important dietary source of the early man. This was probably the first step towards secured food production in his adventurous life. The early man had the wisdom to distinguish between sheep and goat and their varying ecological requirements. The sheep is essentially a grass eater preferring protection of open woods. The goat is a browser preferring foliage of shrubs and trees and is content with sparse forest. To the early man, sheep and goat provided milk, meat and clothing. Sheep scored over the goat in respect of wool and quality of meat while goat provided more milk.

Animals like horses, elephants, camels, sheep, goats, bullocks, cows and buffaloes played vital role in the development of human civilization *from* early time. The large ruminants like cows and buffaloes were wild animals of the forest and they used to invade the fields of river valley civilization as crop robbers. The early men judged the utility of these animals for power (energy), food (milk and meat), manure (dung and urine) and hide (shoes and shields). These crop robbers were, therefore, captured and domesticated to meet the day-to-day needs of life.

**Life span of animals**

The life span of some animals mentioned by Shalihotra is given below:

| | |
|---|---|
| Elephant: | 120 years |
| Horses: | 32 years |
| Cows: | 24 years |
| Asses and camels: | 25 years |
| Dogs: | 16 years |
| Jackals: | 25 years |
| Bees: | 14 days |

**Livestock in agriculture:** "When *Prajapati* created cattle, he made them over to

the *Vaisya;* and if a *Vaisya* is willing to keep them, it must not be kept by any other caste." *(Manu Samhita*). Vaisyas were primarily agriculturists, formed a wealthy and respectable section of the community and produced fine breeds of cattle. Agriculture, cattle-rearing, trade and commerce constituted the four fold *vartha* or pursuits suitable for making fortune. Cattle-rearing has been noted in the Epics as important and universal an occupation as farming in *Ramayana* and *Mahabharata*. The famous cow "Kamdhenu" (meaning producing according to desire) of Bashistha existed in Mahabharata. In the Mahabharata is given that lion, tiger, boar, buffalo, elephant, bear, and ape are the seven wild animals (aranyah); and cow, goat, sheep, horse, mule and ass are seen domestic animals. Of the former group, boar, buffalo and elephant are reared. The kings themselves, the Ksatriyas, owned and reared the cattle and cattle-wealth was the mainstay of their house-hold finances. The outstanding examples are the emperor of Kosala (Ramayana) or of the prince of Kasi (Jataka). The kings maintained buffaloes, camels, asses, mules, swine and dogs for a variety of purpose *(Arthasastra*) besides horses, elephants, cows, sheep, and goats. In the *Dhumakari Jatakti*, the high bred Brahmin is a goat keeper. The *setthis* or merchants mentioned in *Jataka* were also keeper of cattle. The art of weaving gradually developed and is considered as a further adaptation of basket making from bamboo, which was a natural resource of the forest. The fibre used was the wool of sheep, which was woven into carpets and fabrics for garments. The Rigveda mentions about the fine quality of wool of sheep and the domestication of the animal by the 'Gandhars' in the northeast of India.

The Vedic Aryans were primarily pastorals and grazed their cattle in the forests. The Kings were required to make ample provision for pastures by setting apart suitable land at the time of forming villages. The Arthashastra mentions about the breeding policy for animals. It has also defined the duties of graziers. The graziers were asked to attach bells to the necks of their cattle so as to scare away snakes and tigers. The sound of the bell helped the graziers in locating the whereabouts of the herd. Cow was the principal wealth and symbol of Aryans and most of the wars were fought for acquiring cows. The cows were milked three times a day and castration of bull was practised.

Zebu bull was the symbol of Gupta dynasty (240 B.C.). The coins during the Gupta period bore the image of ‘Nandi bull’ which is a humped Zebu. Improvement of Zebu cattle was the most important step taken by man in the development of agriculture. The preference of Zebu for dry land and its aversion for water indicate its origin in the dry mountainous environment. Similarly buffalo played an important role in the economy of ancient India. In the Mauryan age the buffalo became a recognised dairy animal. The female buffalo gave plenty of milk and male was ideal for transport and for ploughing in the muddy rice-fields. One of the centres of domestication of buffalo in India was the Indus valley. In India, buffalo is valued on account of its higher milk yield and higher fat content in milk which is suitable for the preparation of Ghee (butter-oil). Ghee is one of the important components of diet and widely used in religious functions also. During the Mughal rule, large parts of the country were pastoral and rearing of sheep was

a flourishing occupation of many people. Emperor Akbar (1555-1605) promoted the wool industry particularly related to the manufacture of 'Shawls' and carpets. Shawls made from 'TUS' were famous for lightness, warmth and softness.

**Breeding of cattle:** In the Agnipurana we find the king enjoined to preserve the breed of cattle in the country. There were certain restrictions on castrating bulls. Emperor Asoka issued an order that a bull, a goat or a ram must not be castrated on the 8th, 10th, 15th and 13th day of each fortnight, neither on the *Punarvasu* day, on a festival day and in every fourth month of the year. A herd of 100 head of asses and mares shall contain five stallions, that of goats and sheep ten rams, and those of cows, buffaloes and camels shall contain four breeding males each.

**Sacredness of animals:** The cow is the foremost of all quadrupeds as surely as the Brahmana is among the four castes. The deification of bull is considered as the animal of Siva. The Siva with his bull is represented in the coins of the Kusanas and Scytho-Sassanian kings and in a coin of Sasanka, king of Gauda. But it is for the first time and as late as in a coin of the Huna Mihiragula that a bull-emblem of Siva is seen with the legend. 'jayatu vrsah' on the reverse. Touching a cow with feet is sin (Ramayana and Mahabharata) is to be read with the crimes indicated for cruelty to cows. Cows have been mentioned as a symbolical representation *of* the Earth rays *of* sun or the Goddess *of* speech. In the *Matsya Purana,* the earth is represented as taking the form *of* a cow. At the root of the (cow's) horn sits Brahma, in its middle sits *Kesava* (Lord Visnu) and at the end sits Siva-thus, the triad of gods resides there permanently. At the tip of the (cow's) horn are all the holy places as well as personages and all the gods reside in her body. Thus cow is the very embodiment of all the gods. At the top of her forehead resides the goddess (Parvati), in her nostrils the god *Kartikeya,* and in her ears the two Naga (serpent) chief *Kambala* ,and *Asvatara.* In the eye of that divine *Surabhi* (cow) and the sun and the moon, in the teeth the eight *Vasus* and in her tongue sits the god *Varuna.* The Sarasvati resides in her lowing, Yama and Yaksa (Kubera) on her temples, the *risis* (sages) in her pores and the water of the Ganges in her urine. The Yamuna along with other goddesses, resides in her dung. Twenty eight crores of gods dwell in down.

**Dairying in Ancient India:** In the Indian mythology, the cow has been termed as the "mother" and the whole body of the cow has been described as the permanent abode of various Gods and Goddess. Cow is the mother of Rudras, daughter of Vasus, sister of Aditi's sons, and is "Ambrosia" in the form of ghee. Lord Krishna used to call his cows by name (a method of identification of animals). In Garg Samhita (Golok Khand) three titles, which used to be conferred upon persons possessing cowherds namely, i) Brakh Bhanu- the person who reared 10 lakh (one million) cows, ii) Nand-the person who reared 9 lakh cows and iii) Upnand – the person who reared 5 lakh cows.

Regarding the milk processing and its conversion into different products, sufficient evidence is available in the Mahabharata regarding items such as curd, butter and ghee, and these were prepared in every household. The traditional technology of milk heating (simmering), i.e., slows heating for a longer time on the fire of dried cow dung cakes is prevalent even today. The Westerners could know the importance of heating milk much later and the process of pasteurization came into being only after 1862 AD. During the rainy season, autumn, and the dewy season they should milk the cattle both the times (morning and evening); and during the winter, spring and summer, only once (i.e. in the morning). He who milks the cattle a second time during these seasons shall be punished by having his thumb cut off. If he allows the milking-time to lapse, he shall forfeit his remuneration for that time. A 'drona' of a cow's milk will yield one 'prastha' of ghee; the same quantity of buffalo's milk will yield 'one-fifth more; and that goats and sheep will yield two-fifths more.

**Rearing and care of cows is given in Brhat Parasara Samhita:** The householder should milk the cows in the morning as well as in the evening. They do not, as a rule, make increase in their yield of milk if the milking man is changed. The cow is the very congregation of all the gods, for in her head sits the god Brahma, on her shoulders Siva, on her back Vishnu, tin her feet the Vedas and whatever other gods are left, they occupy every hair on her body. The Lord Hari (Vishnu) is pleased with devotional attentions paid to her. A cow should not be milked without her calf, nor when she is pregnant. One who milks her prior to ten days after her delivery, goes to hell.

**Therapeutic aspects in Dairy:** Human milk has been considered as remedy for '7-fold doshas'. The milk of black complexioned women is considered for the treatment of eye diseases whereas the milk of fair complexioned women is used for the treatment of 3 doshas. The cow milk in general is strength giving. Milk of white cows cures "Vaat" (rheumatic and cardiac complaints) and the milk of black cows cure kafa (lung infections). The milk of black teats possess highest medicinal value which no other kind of milk approach. Like this, there are many mentions of medicinal value of cow milk on Rigveda and Atharvaveda.

In ancient medical treatise Charak Samhita, ten characteristic of cow milk, i.e., tasty, cooling, soft, oily, thick, mild, viscious, bulky, and resistant to external effects and has pleasant flavour have been described. Not only this, the morning cow milk (pratardoha) midday cow milk (saganv) and evening cow milk (samandoha) possess different characteristics and properties. This type of analysis has been mentioned in an old treatise 'Bhava Prakash' as under: Before-noon milk is appetizing, digestive and improving semen quality, at-noon milk gives strength and destroys cough and liver ailments and increases hunger. In childhood it stimulates growth and in old in old age prevents wasting, and increasing sperms by daily consumption in night the milk cures many diseases. Hence milk can be consumed at any time.

In 'Susruta Samhita' the properties of cow milk and dahi (curd) have been described as flavored, tasty, digestive, strength giving, restorative, pure and pleasant, and anti-rheumatic. Given with equal proportion of honey, butter, peepal, dry ginger, black pepper, Vacha and rock salt (sendha namak) together and mixed them with same quantity of cow curd, removes the ill effects of snake poison. The malai (thin accumulate on milk surface after heating) of milk has been known to possess immense capability of completely eradicating of ailments associated with the imbalances of Vaat (rheumatic) and pitta (liver disorder) in addition to providing vigour and strength. Ancient literature states that there is a nerve in the spine of a cow termed as suryaketu which when exposed to sun synthesizes gold, imparting anti-poisonous properties to the milk. This is cow ghee is supreme in characteristics. It cures all the three doshas (imbalance of humours) and inactivates toxins and improves eyesight.

**Animal management:** During post-Vedic era medicines occupied an honorable position and Samhitas by Charaka and shusruta were followed from about 700 BC. At that time there was development of materia medica. The only source of use of indigenous drugs in veterinary medicine is Agni Purana, which reveals the real picture of practice of veterinary medicines during the Gupta dynasty (300-500 DA). The ancient system of Indian medicine is termed Ayruveda (Gavyayurveda fir cattle, Hastyayurveda for elephants, and Ashvayurveda for equines. Shalihotra lectured on the subject of horse and its treatment, the "Ashvayurveda"or"Turangama shatra". Garuda Purana also describes the treatment of horses. King Nala had a surname 'Ashvavit, i.e., versed in the science of horses. Nakula and Sahadeva, the twin sons of Madri, were taught by Drona the art of training, management and treatment of horses and cattle respectively. In the Mahabharata, Virata Parva, third chapter, when the Pandavas entered into services of Kind Virata, Nakula declared himself well versed in the science of management and treatment of horses, and Sahadeva referred to his scientific knowledge about the cows. To Nakula is ascribed the work called Ashvachikitsa or "Treatment of diseases of the horse" which is still in existence. This book is also called "Shalihotra". In the Mahabrarata, Virata Parva (Chapter III). Sahadeva, the fifth Pandava, has described himself as well versed in the science of management and treatment of cows. He also mentions that he knows such type of cows and bulls whose urine when smelled by a barren woman, the conception occurs (Mahabrarata, Virat III.12). Perhaps the cow urine contains some type of hormone, which needs to be investigated. Nakula Samhita is considered the first treatise dealing with treatment of animals with herbal preparations and was compiled during the Mahabharata period. During the early medieval period drugs of vegetables and animals origin and minerals have been used for treatments. Jayadeva also wrote on the treatment of horses and he is quoted by Jayadatta. Shalihotra, father of veterinary science in India, flourished in Shalatur, a town near Kandhar or old Gandhara. According to an incomplete manuscript of Shalihotra (India Office Library, London), he is described as the father of Susruta. Hastyayurveda or Gahayurveda is also an important branch of veterinary medicine. The source of the science is Palakapya's Hastyayurveda which is now available (Published in Anandashran Sanskrit Series, Poona, 1894). Susruta Samhita. Thus it may be assumed that this work also belongs to 1000 BC.

Kautilya, the prime minister of Chandragupta Maurya (325-260 BC) in his Artha-sastra refers to the duties of military surgeons to treat and protect the infantry horses and elephants from diseases, epidemics, and food problems. The camel and the dog are conspicuous in royal stables and kennels (the mention of dogs in royal house-hold is frequent in the Ramayana). The ducks are not seen in domestic animals. Cow, buffalo, goat and sheep were reared for dairy as well as for meat supply 'and skin. Swine and fowl were meant entirely for consumption. The ox alone drew the plough. The bull, mule, ass and camel were used for draught (on rare occasions also horse and elephant (Arthasastra). The dog assisted herdsmen to reconnoitre grazing forests (Arthasastra) or guarded royal apartments or served as hunting accomplices to the king or nomadic huntsmen *(*Dasabrahmana Jataka). The horse and elephant were employed according to their varied nature for draught riding and war. Animals used for draught purposes were generally cas-trated and sometimes their horns were cut off (Mahabharat). The beasts, wild and domestic yielded a large variety of animal produce, viz., skin, claw, horn, hoof, plume, tusk, wool, etc.

Every villager also used to keep a few animals for draught purposes or for doing or to meet the supply to his own household. The village maintained common on pay or on a share of produce, shepherds, who were entrusted with the work of taking the animals to the pasture ground in the morning and bring them back in the evening *(Anguttaranikaya*; *Rigveda*). The Arthasastra rule requires of Herdsmen is the knowledge to treat cow diseases and ford them safely. The Arthasastra wants the best herd to be entrusted for a fixed wage for otherwise they may be spoiled by over milking. Herds of the next grade are surrendered for a fixed amount of dairy produce, viz., 8 varakas of ghee per year, which the owner will receive. Black, red or black and red bulls are, commended for yoking to the plough. Therefore at the commencement of tilling the land one should take care to select bulls of this kind and smear the sides of the mouths with butter or ghee.

**Animal feed:** The breeds were fed on barley and corn, and in the Agnipurana, a calf marvellously thriving on a food consisting of masa *(Phaseolus radiatus),* sesame, wheat, clarified butter, the cream of milk and salt. For bulls which are provided with nosestrings and equal horses in speed and in carrying loads, half a *bhara* of meadow grass, twice the above quantity of ordinary grass, one *tula* (100 palas) of oil cakes, 10 *adhakas* of bran, 5 *palas* of salt, one kudumba of oil for rubbing over the nose, one *prastha* of drink, one *tula* of pulp of fruits, one *adhaka,* of curd, one *drona* of barley or cooked *masa,* one drona of milk or half an *adhaka* of *sura* (liquor), one prastha of oil or ghee (clarified butter), 10 *palas* of sugar, and one *pala* of the fruit of *srngavera* which may be substituted for milk, The same commodities less by one quarter each will form the diet for mules, cows and asses and twice the quality for buffaloes and camels. All cattle should be fed with fodder and water to their satisfaction. For draught oxen and cows yielding milk, the feed shall be provided in proportion to the duration of time the oxen are put to work and the quantity of milk, which the cows yield.

**Protection of cattle:** Cattles must be protected from brutes and thieves. Instances of taking flesh except on ceremonial functions are available in ancient literature. Taking of animal food is strictly forbidden in ancient laws under the threat of expiable sin and eternal perdition unless taken in conformity with the law, i.e. Vedic rites and sacrifices. Fines are enjoined for neglecting nasal perforation in proper time for stringing draught beasts to the yoke. Milking of cattle is allowed twice a day during the rains and the autumns, but in the dry winter and summer seasons only once on pain of the cowherd losing his thumb. Once in six months sheep and other animals shall be shorn of their wool. Stud bulls, bulls let out in the name of village deity (gramadevavrsah) and cows within ten days of calving are exempt from penalisation for trespass. Ropes and whips only are to be used in case of stray cattle and any injury to them incurs the penalty for assault. Livestock is protected along with other properties of a householder by laws of torts. "For causing pain with sticks, etc., to minor quadrupeds, one or two *panas* shall be levied; and for causing bleeding to the same, the fine shall be doubled. In the case of large quadrupeds not only double the above fines, but also an adequate compensation shall be levied. A person who himself kills or steals the cattle *or* instigates another to do so, should be punished with death.

**Indigenous knowledge for management of Livestock Diseases:** In ancient India people had sufficient knowledge of the diseases of farm animals and the methods of curing them. Vishnudharmottara Mahapurana (500-700 AD.) contains informations on the medical practices of treating the diseased animals.

Dipping the food of animals in its urine for the control of food 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.

**Mastitis:** Mastitis is caused by injury of the udder and by subsequent invasion by pathogens. The udder is inflamed and becomes hard. Sometimes a tumor is formed in the teats and during milking the animal feels severe pain and does not allow milking. For curing this disease the livestock owners follow mainly three practices. They either apply a mixture of ghee, sugar, and curd on the inflamed portion or sometimes milk froth around the teat. Both these practices according to scientists are effective as the ingredients used act as soothing agents and soothe the hard teat with cracks. Another practice is to give hot bath to the affected animal. This helps in reducing inflammation, pain, and swelling, and also increases blood circulation.

**Foot-and-mouth disease.** Foot-and-mouth is an acute infectious disease caused by

a virus and occurs in animals at any time round the year. The common symptoms of this disease are high fever, sluggishness, smacking of the lips, abrupt reduction of milk yield, and abortions. For treating this disease the livestock owners follow many practices. They wash the affected portion with fitkari (alum). Alum acts as an antiseptic; it checks secondary infection by inhibiting pathogens. It is an astringent and also helpful in coagulation of blood. Sometimes the foot of animal is dipped in its urine as the latter has germicidal property. Also, application of ground custard apple leaves or sprinkling camphor powder on affected area is practiced. Both act as a fly-repellent, and are anti-inflammatory and give soothing effect. Sometimes the livestock owners warm garlic pieces in hot mustard oil and after the oil cools, apply it on the affected area. Scientists opined that due to pungent smell it acts as a fly-repellent. It also acts as an antiseptic and disinfectant. Another practice is to wash the affected area with hot water, as it has cauterization property, which is helpful in checking bleeding.

**Tail neurosis.** Tail neurosis is treated by dipping the tail of the animal in hot mustard oil or by applying powdered camphor on the affected area. Both these practices are scientifically correct as camphor acts as a fly-repellent whereas hot mustard oil is antiseptic, fly-repellent, irritant, and also helpful in fast healing.

**Pneumonia.** The traditional treatment followed by villagers for curing pneumonia is to drench local liquor 3-4 times a day and apply mustard oil on the chest of the affected animal. The disease symptoms are shivering and rise in body temperature. Both these practices provide warmth to the body and are helpful in eliminating cold from the body. Also, the animal is made to inhale turpentine or eucalyptus oil. Inhalation of the oil is effective in easing respiration.

**Anoestrus.** Anoestrus is a reproductive disorder where the animal does not have regular heat cycle, Le., either it does not come in heat or remains continuously in heat thus prolonging calving interval. It may be due to hormonal imbalance or improper feeding or persistent corpus luteum or presence of cyst in ovary thus hindering proper ovulation and heat cycle. For curing this disease, livestock owners follow mainly two practices, which are scientifically correct, i.e., the animal is fed with a mixture of methi (Trigonellafoenum-graceum), gur Gaggery), and bajra (pearl millet). These substances act as stimulants and help in stimulating estrogen hormone. Also, sprouted whole wheat is fed for 10-15 days continuously. The sprouts are rich in vitamins and minerals and thus help in increasing fertility.

**Retained placenta.** The indigenous practice followed by villagers is to drop the placenta by hand with the help of experienced people. According to scientists if the placenta does not fall within 48 hours it must be dropped by hand. Another practice is to feed the animal its own milk. Animal milk is rich in calcium, vitamins etc. It helps in maintaining uterine tone, which is helpful in retention of placenta. Some villagers use ten mango (Mangifera indica), leaves, two pieces each of jaiphal (Myristica fragrans) and kaiphal (Myrica magi). All these materials are ground and made into paste and then heated gently. The nearby area of vagina

and thigh of the affected animal is then massaged with the warm paste. The placenta is expelled from the uterus within one hour of application. According to scientists, mango leaves have laxative and anti-hemorrhagic properties. Both the properties are essential for the removal of placenta. Kaiphal acts as antiseptic and farmers use it for the removal of placenta where presence of infective organisms is always expected. Jaiphal works as febrifuge and narcotic.

**Diarrhea.** Frequent expulsion of profuse loose watery bowel content is termed as diarrhea. This condition always involves abnormality in stomach and intestine. Farmers reported that they feed the mixture of mustard oil, water, and edible soda. Scientists considered the practice correct as sodium bicarbonate balances pH of the body and water helps to cpeck the fluid loss.

**Indigestion.** The traditional treatment followed by villagers for curing this disease is to feed the mixture of dhania (Coriandrum sativum) andjeera (Cuminum cyminum). These are carminatives and help in easy digestion of food. Also, the animal is fed with overnight soaked mixture of yellow mustard oil cake, jaggery, and salt after thorough cooking. Scientists reported that yellow mustard oil cake is rich in calcium and phosphorus, which helps in secreting digestive juices and increasing enzymatic activity. Salt improves the secretion of digestive juices and jaggery provides energy. Black salt, jeera, adrak (ginger; Zingiber officinale) and garlic paste is given to the animal. These substances increase the appetite by increasing motility of intestine and help in rapid digestion. Black salt is a mild laxative.

**Tympany.** The traditional practice followed by farmers for treating tympany is to feed turmeric powder in curd; ajwain (Trachyspemum ammi), and salt in water; mixture of ajwain, heeng (asafoetida), garlic salt, methi, and turmeric; and garlic and ginger paste with common salt and mustard oil. Scientists opined that all these substances are carminative and antiflatulent, help in improving appetite, and do not cause constipation. Another practice followed is to make the animal to run fast as it helps in expulsion of gases.

**Hemorrhagic septicemia.** Hemorrhagic septicemia is an infectious disease, usually acute in nature caused by bacteria (Pasteurella multocaeda) and affects mostly cattle and buffaloes. The informants mentioned that they give hot ash massage to the affected animal. The scientists reported that this practice is helpful in reducing inflammation and swelling. Sometimes a sharp cut on a swollen portion is also given, which decreases blood supply, reduces swelling, and facilitates respiration.

The livestock owners practice different techniques, which have been inherited over generations, and developed by indigenous trial and error methods. Most of the livestock owners in rural areas had a tendency to treat their livestock through traditional knowledge of medicinal properties of herbal products available locally.

Table 1. Indigenous animals management practices (pregnancy and delivery) followed in parts of Rajasthan and their scientific validity.

| Area / Sub Area | Indigenous practice. |
|---|---|
| Heat identification in animals | Through mucous discharge from vagina from bellowing eating less food frequent urination mounting on another cow, raising its tail swelling inlets etc. |
| Breeding | Prefer first or second day of head for getting animal crossed. |
| | Get the animals crossed with available (desi) bull of the village. |
| Way of recognizing that animals has conceived | By observing sings of animals i.e does not come in next heat dull temperature stops jumping kicks by legs milk production decreases etc., |
| Care of pregnant animals | Allow pregnant animals to go out for grazing. |
| | Dry the animals 2-3 months before parturition. |

| Area / Sub Area | Indigenous practice. |
|---|---|
| Feeding during pregnancy | Concentrate is fed to pregnant animals which includes several grasses. barley water moong and moth Chui guar churi wheat and methi dalia. |
| Area/Sup Area | Indigenous practice. |
| Symptoms before actual parturition | Pelvic hip bones look depressed skin near the tail regions looks relaxed enlarged teats full with milk uneasiness and frequent sitting and standing. |
| Facilitating delivery | Give mixture of jaggery ajwain methi dried and crushed ginger and waste of oilseeds. |
| Care during parturition | Clean the place of calving. |
| | Give comfort to pregnant animals by spreading something underneath i.e., dry grasses jut bags etc., |
| | House pregnant animals in separate place or room |
| Expulsion of placenta | Give “hot” food as jaggery sugarcane leaves bamboo leaves rice bran animal’s own milk etc. |
| Postnatal care | Mixture of dried and crushed ginger ajwain cumin seeds jaggery and oil is prepared and given up to 15 days. |
| | Mixture of green gram dhal and turmeric in water is given. |

**Use of animals flesh as human food:** The usefulness of cattle in India for power, food and manure was fully realised with the development of agriculture. The earlier practice of animal sacrifice was given up under the influence of Buddhism and bullocks became the companion of man in the conquest of virgin lands. Indian farmers regard cattle as members of their own social group and treat them with reverence on different occasions during the year. The virtues of ahimsa and abstention from meat-diet are followed by exceptions made in favour of sacrifice

and hunting for the royal race in the Mababharata. Buddha himself allows fish and flesh to his disciples. Strabo's remark on Megasthenes authority that the Brahmanas "eat flesh but not that of animals employed in labour", whatever truth it may contain, reflects at any rate a sound economic sense which in some quarter regulated animal diet. Animals are to be slaughtered for flesh only in the abattoir (parisunam) on pain of fine. The varieties of' animal flesh were also disposed of from separate stalls in the market place and different sets of stockists and butchers throve on them; e.g., the cattle-butcher, sheep-butcher, pig-sticker, fowler, deer-stalker, etc. In its rules on cow slaughter, the Arthasastra wants the immunity of only calves, milch cows and stud bulls. In the Satapatha Brahmana, Yajnavalkya is fond of tender beef. According to Panini 'goghna' means a 'guest' because a cow is killed for him. Apastamba permits the slaughter of a cow at the reception of a guest, at the worship of the *manes* and at nuptial celebrations (Grhyasutra; Manu). In Bhavabhuti's Uttararamacarita a heifer is stated to be slain by Valmiki in honour of Vasistha's visit to his *asrama*. According to the Dasabrahmana Jataka, Slaughter of ox for flesh was very common and there were special slaughter-houses for beef. Even cows did not necessarily find exemption. In a Vinaya list of unpalatable and inedible food to which the people fell only in famine, occur, elephant, horse, dog and snake. Fowl, swine and cow never come in the list of animals and birds forbidden even for the Brahmana's table. Beef and ham are classed among non-edibles. High-crested cocks born of Vrtra's blood (sikhandah) occur as non-eatable to the twice-born and the initiated. in the Mahabharata. Cocks and pigs occur in an exhaustive list of animals prohibited for the Snataka Brahmana in Gaut. XXIII. 5 and Manu. In the Ramayana cow-killing and milking a cow just delivered are sins.

**Use of cowdung as plant food** If one wishes the prosperity of his cattle, one should not even by mistake allow the cowdung to be removed on Sundays, Tuesdays and Saturdays. Barring the above three days one may give away the cow-dung to anybody. The removal of cowdung on Tuesdays and Saturdays is detrimental to cattle. A successful cultivator should worship the heap of cowdung in the month of *Magha,* 'and on an auspicious day he should turn up the manure with spades. Reducing the manure which is drying in the heat of the sun, into, the powder the should deposit it in pits, in each. field in the, month of *Phalguna*. Then at the time of sowing, he should dress the field with m,anure, For, without manuring the crop neither thrives nor yields fruit.

## Chapter 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. In modern practice such land is neither ploughed nor manured, nor does it require additional water. Lambrick remarks that 'the whole operation involves an absolute minimum of skill, labour and aid of implements. Other crops, including cotton and sesamum, would be sown as autumnal *(kharif)* that means they would be sown at the beginning of the inundation and harvested' at its close, in autumn. For this fields surrounded by earth embankments would be required, most probably along the banks of natural flood channels. Although this method is more precarious than the former, both exploit the natural fertility of the alluvium, and the annual inundation. Both systems are still in use. According to my experience of cultivation in the riverain areas of the Punjab, when the land has appropriate moisture, land is ploughed, seed is sown and the soil is smoothened with a plank. The practice followed by the Harappans could not have been different. For the proper sowing of crops, soil has to be stirred and seed has to be covered.

Alexander and his successors and Megasthenes set the stage in the history of Greek presence in India and the ‘Indica of Megasthenes’ analyzes the Greek account of India. Seleucus was the ambassador to Chandragupta Maurya. The book covers the history of the Greek kingdoms in Bactria and northern India and the development of the Indian Ocean trade. Sandwiched between these two historical sections lies the core of the book: two massively detailed chapters surveying Greek knowledge of India. The first deals with the physical geography of India, its hydrology and meteorology, and the second with the natural history of the subcontinent including its biology and geology and their military, commercial, and even medical implications. Megasthenes states that Maurya officers were concerned with the measurement and supervision of alluvial deposit for revenue purpose.

The Greek writers highly praised the fertility of Indian soil and' favourable climate condition and inner-system while describing the principal agricultural products of the land. Since there is double rainfall in the course of each year, one in the winter season, when the sowing of wheat takes place as in other countries, and the second at the time of the summer solstice which is the proper season for sowing rice and 'bosporum', as well as sesamum and millets-the inhabitants of India almost always gather in two harvests annually (Diodorus, II. 36).

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."

What the Arab gardeners regarded as correct rules for Planting, and some off the garden plants which they favored, says Hyams, can be gathered from an authoritative twelfth-century work on agriculture and horticulture written by Yahya bin Muhammad (Abu Zakariya).' Abu Zakriya says that all garden doorways should be farmed by clipped evergreens, that cypresses should be used to line paths and grouped to mark the junctions of paths. He object to the mixing of evergreen with deciduous trees. He loss of water through evaporation. Plants named in his text include lemon and orange trees, Pines and most of our common deciduous trees, cypresses, oleander, myrtle and rose as the only flowering shrubs, violets, lavender, balm, mint, thyme, marjoram, iris, mallow, box and bay laurel. He lays much stress on aromatics, as, indeed, did all the Islamic gardeners. His climbing plants are vines, jasmines and ivy.'

**Babur-NAMA** –An Autobiography and a Book on Natural History: Babur-nama reflects the character and interests of the author, zehir-ud-din Muhammad Babur. Babur, the founder of the Mughal dynasty in India, is regarded as one of the most romantic and interesting personally ties of Asian history.

**Alberuni** (Abu Raihan Muhammed bin Ahmed), a Central Asian scholar, with keen perception, came to northern India early in the eleventh century, and made a remarkable observation on the structure and formation of the Indo-Gangetic alluvium. "If you have seen the soil of India with your own eyes and meditate on its nature," wrote Alberuni, 'if you consider the rounded stones found in the earth, however deeply you dig, stones that are of smaller size at greater distance from the mountains, and where the streams flow more slowly, stones that appear pulverized in the shape of sand where the streams begin to stagnate near their mouths and near the sea, if you consider all this, you could scarcely help thinking that India has once been a sea which by degrees has been filled up by the alluvium of the streams.'

**Protection of cultivators:** Sher Shah had genuine concern for the peasantry and safety of their crops. Abbas Khan states, One of the regulations Sher shah made was this: That his victorious standards should cause no injury to the cultivations of the 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. I have heard from Khan-i` Azam Muzaffar Khan, who said he often accompanied Sher Shah, that he used to look out right and left,

and (which God forbid) if he saw any man injuring a field, he would cut his ears with his neck, would have him to be paraded through the camp. And if farm the narrowness of the road any cultivations was unavoidably destroyed and give compensation in money to the cultivations. If he enters an enemy's country, he did not enslave or plunder the peasantry of that country nor destroy their cultivation. `For, said he, the cultivators are blameless, they submit to those in power; and if I oppress them they will abandon their villages, and the country will be ruined and deserted, and it will be a long time before it again becomes prosperous.

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. **Peter Mundy** tells us that the peasants near Agra were treated 'as Turks treat Christians', 'taking from them all they can get by their labour, leaving them nothing but their bad, mud-walled, ill-thatched houses and a few cattle to till the ground, besides other miseries.'

> **Pelsaert,** who was in Agra during the rule of Jahangir, observed: 'The land would give a plentiful, or even an extraordinary, yield if the peasants were not so cruelly and pitilessly oppressed; for villages which, owing to some small shortage of produce, are unable to pay the full amount of the revenue-farm, are made prize, so to speak, by their masters or governors, and wives and children sold on the pretext of a charge of rebellion. Some peasants abscond to escape their tyranny, and take refuge with rajas who are in rebellion, and consequently the fields lie empty and unsown, and grow into wildernesses. Such oppression is exceedingly prevalent in this country.' Bernier, commenting on the state of the northern part of the country, its agriculture and peasantry, states: 'Of the vast tracts of country constituting the empire of Hindustan, many are little more than sand, or barren mountains, badly cultivated, and thinly peopled; and even a considerable portion of the good land remains untilled from want of labourers, many ofwhom perish in consequence of the bad treatment they experience from the Governors. These poor people, when incapable of discharging the demands of their rapacious lords, are not only often deprived of the means of subsistence, but are bereft of their children, who are carried away as slaves. Thus it happens that many of the peasantry, driven to despair by so execrable a tyranny, abandon the country and seek a more tolerable mode of existence, either in the towns or camps, as bearers of burdens, carriers of water, or servants to horsemen. Sometimes, they' fly to the territories of a Raja, because there they find less oppression, and are allowed a greater degree of comfort.

In Vijayanagar, **Abdul Razzak** (A.D.1336 – 1646) saw that palm leaves were used for writing and paper was not known. He observes, 'the inhabitants of cambay alone use paper. All other Indians write on the leaves of trees. Abdul Razzak

observed that chewing of pan (betel leaf) was a common practice at Vijiayanagar, and he attributes virility of the king to its stimulating properties.

**Quest For Spices** (1498-1580 A.D): The Europeans had to pay extortionate prices for species, particularly pepper, which not only made their food tasty, but was also used as a preservative for meat. Pepper was also used in wine and pastry.

**Domingo Paes**, a Portuguese merchant, who visited Vijiyanagar in A.D.1520. Domingo Paes presented a pair of spectacles to Vyasaraya, guru of Krishna-devaraya. Krishna Deva of Vijayanagar constructs the great dam and channel at Korragal, also the Basavanna channel.

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

**Stevens** is famous as the first Englishman known to have set foot on Indian soil. Born in Wiltshire and educated in Winchester, he made his way to Rome and there entered the Jesuit order. Being desirous of serving in India, he obtained a passage at Lisbon in the spring of 1579 and reached Goa in October of that year. He was the first European to make a scientific study of Konkani, and he wrote two religious works, one of which was a long epic in Marathi. Describing a visit to Malabar he mentions a number of crops including pepper and coconut. "Here grows the pepper; and it springs up by a tree or a pole, and is like our ivy berry, but something longer, and at the first the bunches are green, and as they wax ripe they Cut them off and dry them. The leaf is much lesser than the ivy leaf and thin to zero. All the inhabitants here have very little houses covered with the leaves of the coco-trees. All the pepper of Calicut and coarse cinnamon grows here in this country. The best cinnamon comes from Ceylon, and is pilled from the young trees. Here are very many palm or coco-trees, which is their chief food; for it is their meat and drink, and yields many other necessary things.

**Jeane-Baptiste Tavernier**, a French jeweller and merchant, visited India six times, between the years 1638 and 1688. He corroborates the account given by Bernier. He states: 'The peasants have for their sole garment a scrap of cloth to cover those parts which natural modesty requires should be concealed; and that they are reduced to great poverty, because if the Governors become aware that they possess any property they seize it straightaway by right or by force. You may see in India whole provinces like deserts from whence the peasants have fled on account of the oppression of the Governors.' The flight of peasants from the land intensified during the reign of Aurangzeb. With the decrease in the number of peasants, the income of the assignees, the *jagirdars,* was reduced. The *jagirdars,* to make good their loss, put increased pressure on the working peasants. Moreover, the practice developed of selling governments of provinces for immense

sums in hard cash. Hence, it naturally became the principal object of the individual thus appointed Governor, to obtain repayment of the purchase-money, which he had borrowed at a ruinous rate of interest. This in turn resulted in more repression on the cultivators.

**Betel vines:** Ibn Battuta also saw betel vines in Kerala. He states, Betel-trees are grown like vines on cane trellises or else trained up coco-palms. They have no fruit and are grown only for their leaves. The Indians have a high opinion of betel, and if a man visits a friend and the latter gives him five leaves of it, you would think he had given him the would, especially if he is a prince or notable, A gift of betel is a far greater honour than a gift of gold and silver.

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**. After describing the indigenous flowering trees and shrubs, Abu-I-Fazl mentions the names of those introduced from foreign countries. Abu-l-Fazl mentions that Akbar imported gardeners' from Iran and Turan. ABU-L-FAZL provides a detailed account offruits grown in India during the reign of Akbar in the *Ain-i-Akbari*. 'His Majesty looks upon fruits as one of the greatest gifts of the Creator, and pays much attention to them,' states Abu-I-Fazl. 'The horticulturists of Iran and Turan have, therefore, settled here, and the cultivation of trees is in a flourishing state.' 'Melons and grapes have become very plentiful and excellent; and water-melons, peaches, almonds, pistachios, pomegranates, etc., are everywhere to be found. Abu-I-Fazl mentions the names of eighteen vegetables and the seasons in which they were grown. Food and fodder for royal horses was standardized. Abu-I-Fazl states, 'In winter, they give boiled peas or vetch; in summer, grain.

'The betel leaf is, properly speaking, a vegetable, but connoisseurs call it an excellent fruit,' states **Abu-l-Fazl.** 'The eating of the leaf renders the breath agreeable, and repasts odorous. It strengthens the gums, and makes the hungry satisfied, and -the satisfied hungry. I shall describe some of the various kinds. 1. The leaf called *Bilahri* is white and shining, and does not make the tongue harsh and hard. It tastes best of all kinds. After it has been taken away from the creeper it turns white, with some care, after a month, or even after twenty days when greater efforts are made. 2. The *Kaker* leaf is white with spots, and full, and has hard veins. When much of it is eaten, the tongue gets hard. 3. The *Jaiswar* leaf does not get white, and is profitably sold mixed with other kinds. 4. The *Kapuri* leaf is yellowish, hard, and full of veins, but has a good taste and smell. 5. The *Kapurkant* leaf is yellowish-green, and pungent like pepper; it smells like camphor. You could not eat more than ten leaves. It is to be had at Banaras; but even there it does not thrive in every soil. 6. The *Bangla* leaf is broad, full, hard,

plushy, hot, and pungent. There are several kinds of leaves known under different names: 1. The *Karhan* leaf, which they separate for seedlings and call *Peri*. The new leaf is called *Gadauta*. 2. The *Nauti* leaf. 3. The *Bahuti* leaf. 4. The *Chhiw* leaf. 5. The *Adhinida* leaf. 6. The *Agahniya* or *Lewar* leaf. With the exception of the *Gadauta* (i.e., new leaf), the leaves are taken away from the creeper when a month old. The last kind of leaf is eaten by some others keep it for seeding: they consider it very excellent, but connoisseurs prefer the *Peri*. 'A bundle of 11,000 leaves was formerly called *Lahasa,* which name is now given to a bundle of 14,000. Bundles of 200 are called *Dholi;* a *Lahasa* is made up of *Dholis*. In winter they turn and arrange the leaves after four or five days; in summer every day. People also put some betel nut and *kath* on one leaf, and some lime paste on another, and roll them up; this is called a *hira*. Some put camphor and musk into it, and tie both leaves with a silk thread. Others put single leaves on plates, and use them thus. They are also prepared as a dish.

The *Ain-i-Akbari* tells us that fish formed an important part of the people's food in Bengal and Orissa, and also in Sind. Travellers record that its use was common in the south of India, and that it was sometimes dried and salted for provisioning ships. Fish-oil was prepared in Sind, the use of fish manure was established in Gujarat when Thevenot visited Surat in 1666, and, speaking generally, it may be reasonably assumed that the fisheries were conducted very much on the familiar lines.

**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. Geese and ducks are cheap. There are also goats and sheep in abundance and pigs are obtained at so low a price that the Portuguese settled in the country live almost entirely upon pork.

**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.

## Chapter 17. OUR JOURNEY IN AGRICULTURE AND VISION FOR THE FUTURE

Indian history can be broadly divided into five phases based on archeological findings:

1. Period of Saraswati (Harappan) civilization - 6500 B.C - 1000 B.C or also called 'Vedic period' in history of India.

2. Golden period of Indian History - 500 B.C - 800 A.D

3. Muslim influence in India - 1000 A.D - 1700 A.D

4. British period in India - 1700 A.D - 1947 A.D

5. Modern India - 1947 - till date

The famine from 1876-78 led to institution of Famine Commission of 1880. George Nathaniel Curzon succeeded Lord Mayo as Viceroy of India. 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. These Colleges were purely teaching institutions affiliated to traditional universities and contributed little to research.

Agriculture Colleges were started at Poona (Pune) and Kanpur. Teaching was the main mandate. The Civil Veterinary Department was established in 1889, the main attention was on horse and male breeding. Systematic investigation on animal breeding began in 1890 with the Imperial Bacteriologist at the College of Science, Poona, Which was shifted to

Mukteswer where the Imperial Bacteriologist Laboratory was established in1895. This institution has been pioneer in the field of Veterinary research in the Country. Veterinary Colleges were started at Bombay, Lahore (now in Pakistan), Calcutta and Madras. 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 become the matters of great concern to Government of India. To meet the food shortage the Grow More Food campaign was started in 1943.

On the recommendation of the Royal Commission on Agriculture in India (1927-1928), the Indian Lac Cess committee, through it had its origin in Lindsay-Harlow Committee (1921) got its statutory enactment in 1931 and the Indian Central Jute Committee (ICJC) on the line of cotton committee was set up in 1936. To undertake improvement and development of sugarcane, Jiggery (gur), Sugar and other bi-products the Indian Central Sugarcane Committee (ICSC) was constituted in 1944. The Development Council for sugar industries was formed in 1951. The ICSC was entrusted with responsibility of Research on Sugarcane. The development of Gur was entrusted to the All India Village Industries and Khadi Commission. 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.

Agricultural development has to be guided not only by compulsion of improving food and nutritional security but also by the concern for environmental protection, sustainability, profitability and even export. Crop productivity has to be improved in comparison with other countries. Further following the WTO agreement and liberalization process, the consequent liberalization process, the consequent globalization of markets would call for competitiveness and efficacy of agricultural production. The process of agricultural development could be accelerated and sustained only through investments on research and education.

**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.

The Indian Council of Agricultural Research is an autonomous apex body responsible for the: organization and management of research and education in all disciplines of agricultural sciences. It has been reorganized twice. In 1963 an expert committee (M.W.Parker Committee), was appointed by the Government of India to inquire into the present set up and to suggest suitable changes in the ICAR. The Committee submitted its report in 1964. As per recommendations of the committee the ICAR become an autonomous body; its rules and by-laws were revised. A scientist heads as Director General (DG). To assist the DG, four posts of Deputy Director General (DDG)-Crop Science, Soils, Agronomy, Irrigation and Agricultural Engineering, Animal Sciences and Agricultural Education–were created. The Institute of Horticultural Research (Hessarghata), and Central Soil Salinity Research Institute (Karnal) were started. By this time there were 33 Research Institutes (25 in agriculture, 7 in Veterinary and animal husbandry and fishers and one in statistics) under the ICAR. In 1965, the ICAR became the nodal agency for coordinating agricultural research in the country. It gained administrative control over the various institutes and commodity research institutes. Late Dr B.P.Pal took over as the first scientist as Vice President of ICAR. Dr. Pal instituted the All-India Coordinated Research Projects on various crops to integrate different disciplines and different institutions and Universities for an effective national grid of coordinated experiments. He has been internationally acclaimed for this contribution In 1973, the AgrIcultural Research Service (ARS) was started by Dr M.S. Swaminathan, the first Director-General and Secretary of the Government of India and Dr Pal's, successor; to enable scientist's to move to other institutes within the system or sister organizations viz., the CSIR, BARC, etc. ICAR started the National Agricultural Research Project (Phase I) in 1983-94. NARP Phase II was wound up in 1992. Intensive Agricultural Area Programme (IAAP) was initiated in 1964. From 1966-67, High Yielding Variety Programme (HYVP) in crops like rice, wheat, maize, jowar, bajra, was started. The Krishi Vigyan Kendras (KVKs ) and Trainers 'Training Centres (TTCs) were established on the recommendations of the Education Commission (1964-66).The Lab to Land Programme was launched by the ICAR in 1979 to extend and promote adoption of new technology amoung the small and marginal farmers and agricultural laborers to test the relevance of Technology under their socio-economic conditions.

**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. However, only the IARI has been given the status of a deemed university by virtue of which it awards its own post-graduate degrees in the field of agriculture. NDRI and IVRI are

performing this function through affiliation with other universities. 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

## *Timeline of Agricultural activities in India since Independence*

| Year | Events |
|---|---|
| 1947Sep, | Central Tobacco Research Institute established at Rajahmundry, (AndhraPradesh) |
| | Central Marine Fishers Research Institute established at Cochin (Shifted to Mandapam in 1949) |
| | Central Island Fishers Station (now an Institute)established at Barrack pore(West Bengal). |

| Year | Events |
|---|---|
| 1949 | Turlock Singh invents the concept of standard acre. |
| | Central Potato Research Institute established at Patina.(It Was transferred to Simla in 1956.) |
| | The University Education Commission under the Chairmanship of Dr.S.Radhakrishanan, recommends the creation of rural universities. |
| 1950 | Indian Agricultural Research Institute started in Delhi. Intensive Cultivation Scheme in 19 Villages at the initiative of K.M. Munshi. |
| | Garden Colony Scheme Launched in Punjab. |
| 1951 | Fertilizer factory set up at Sindri (Bihar) |
| | The Japanese mint, source of menthol, introduced into India by Sir R.N. Chopra. |
| | A factory established at Calcutta to manufacture BHC., |
| | Indian Institute of Sugarcane Research started at Lucknow. |
| 1953 | Jute Agriculture Research Institute started at Barrackpur, West Bengal. |
| 1955 | National Dairy Research Institute started at Karnel. |
| | Fertilizer Association of India organized. |
| | Lower Bhavani Project completed in Madras (Tamil Nadu). |
| 1956 | All-India Soil Survey Scheme started in the IARI. |
| | Central Potato Research Institute started at Simla. |
| 1957 | Central Institute of Fishers Technology started at Cochin. |
| 1958 | All-India Soil and land Use Survey Organization started. |
| 1959 | Institute of Agriculture Research Statistics., which made a modes beginning in 1933 as a Statistics, Wing of the ICAR, comes into being.(It was strengthened and renamed Indian Agricultural Statistics Research Institute in 1978). |
| | Central arid zone research institute established at jodhpur (Rasjasthan) |
| 1960 | International Rice Research Institute established at Los Babies, Philippians. Over the years this institute actively collaborated with rice research in India. |
| | Govind Ballabh Pant University of Agriculture and Technology set up at Pantnagar, Uttar Pradesh. |
| 1961 | Fertilizer Corporation of India set up at New Delhi. |
| | Intensive Agricultural District Programme (IADP) stated in seven districts. Package of agricultural practices prepared for wheat and rice cultivation in the States. |
| | Dwarflines of wheat incorporating Norin Genes released by N.E. Borlaug at CIMMYT, Mexico. These varieties later had a major impact on India's Green Revolution. |
| 1962 | Central Sheep and Wool Research Institute started at |

| | |
|---|---|
| | Avikanagar, Rajasthan. |
| | Punjab Agricultural University set up at Ludhiana, Punjab (inaugurated on 8 July 1963. |
| | Orissa University set up at Technology set up at Bhubaneshwar,Orissa. |
| **Year** | **Events** |
| | Indian Grassland and Fodder Research Institute established at Jhansi, Uttar Pradesh. |
| 1963 | N.E. Borlaug visits India, On return to Mexico he sends 100kg seed of each of the dwarf and semi-dwarf wheat varieties and 613 primary selections in advanced generation to the IARI. The IARI arranged multi-location testing programme at Delhi, Ludhiana , Pusa, Kanpur, Pantnagar, Bhowali and Willington. Out of these, 'Kalyan Sona' was independently selected at Delhi and Ludhiana, and 'Sonalika' at Delhi. |
| | Central Tuber Crops Research Institute started at Trivandrum, Kerala . |
| | The National Seeds Corporation set up. |
| 1964 | Intensive Agricultural Areas Programme (IAAP) started in 114 blocks, with M.S. Randhawa as Director-General. |
| | C.Subramaniam appointed Minister for Food and Agriculture and Community Projects Government of India. |
| 1964 | India faces food crisis due to prolonged drought. |
| 1965 | About 250 tonnes of wheat seed imported from Mexcio. |
| | B.P. Pal appointed Vice-President of the ICAR. He was the first agricultural scientist to hold this post. |
| | Andhra Pradesh Agricultural University set up at Hyderabad, Andhra Pradesh. |
| | University of Agricultural Sciences set up at Bangalore , Karnataka. |
| | National Dairy Development Board formed at Anand, Gujarat. |
| | Agricultural Prices Commission established. |
| | Warehousing Corporation set up. |
| 1966 | The Report of the Education Commission (Headed by Dr.D.S. Kothari) recommends the setting up of at least one agricultural university in each State. |
| | Agro-industries Corporations set up in Bihar, Punjab and TamilNadu |
| | Start 0f the Green Revolution. |
| | Rojo 69' and 'Sonora 64' imported from Mexico. |
| | Naively Fertilizer Plant commissioned. |
| 1967 | Indian Institute of Horticultural Research started at Bangalore, Karnataka. |

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| | International Rice Research Institute, Philippines, enters into an agreement with the ICAR and the USAID to participate in the development of rice research in India. This led to development of many high-yielding varieties of rice. |
| | All-India co-ordinated Research Project on Soybean started by the ICAR. |
| | C.T. Patel develops hybrid cotton, 'H 4'. Which gave a yield of 6,918 kg per hectare. |
| 1969 | Wealth tax imposed on agricultural land. |
| | Assam Agricultural University set up at Jorhat, Assam. |
| | Central soil Salinity Research Institute started at Karnal, Haryana. |
| **Year** | **Events** |
| 1970 | Central Plantain Crops Research Institute started at Kasaragod, Kerala. |
| | Haryana Agricultural University set up at Hisser, on account of bifurcation of the Punjab Agricultural University. |
| | Indian Dairy Corporation started with V. Kurien as Chairman. |
| | Operation Flood started by the National Dairy Development Board. |
| 1971 | Directorate of Agricultural Aviation started by the Government of India. |
| | Tamil Nadu Agricultural University set up at Coimbatore. |
| | Rajendra Agricultural University set up at Patna, Bihar. |
| 1972 | Ceiling on Land-holdings fixed at 4-7 hectares of double-cropped Land per family. |
| | International crops Research Institute for Semi-arid Tropics established at Hyderabad , Andra Pradesh, with R.W. Cummings as its first Director. |
| | Kerala Agricultural University set up at Mannuthy, Kerala. |
| 1974 | Central Soil and Water Conservation Research and Training Institute started at Dehradum. |
| 1976 | Central Institute of Agricultural Engineering started at Bhopal. |
| | Central Institute for Cotton Research started at Nagpur. |
| | National Bureau of Plant Genetic Resources set up at New Delhi. |
| | National Bureau of Soil Survey and Land- Use Planning started functioning independently at New Delhi; shifted to Nagpur in 1978. |
| | Integrated Rural Development programme started. |
| 1977 | Prakash Singh Badal appointed Minister, Food and Agriculture, Government of India. |

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| | Surjit Singh Barnala appointed Minister, Food and Agriculture,as a Parkash Singjh Badal becomes Chief Minister of Punjab. |
| | Production of Potatoes in India rises to 7,287 thousand tones. |
| 1978 | Central Agricultural Research Institute for Andaman and Nicobar Group of Islands started at Port Blair. |
| 1979 | Brahm Parkash Choudhary appointed Minister, Food and Agriculture, Government of India. |
| | Central Avian Research Institute comes into being at Izatnagar, Uttar Pradesh. |
| 1980 | Ramagundam Fertilizer project completed to manufacture ammonia and urea. |
| | Wealth tax on agricultural lands- an iniquitous, Vexatious and anti-improvement measure- abolished. |

14 Feb, 1556. Akbar introduces the *Fasli* or "harvest" year-a solar year for revenue and other civil purposes, instead of the usual Muhammadan lunar year, but dating from the Hijri year 963. It corresponds with the Hindu solar years of the Saka reckoning, but beginning with Aswin.

14 Feb, 1594- Publication of Garcia da Orta's *Coloquivs,* a description of Indian medicinal plants

## VISION FOR AGRICULTURE IN 2020 AD

Every country needs a vision statement, which stirs the imagination and motivates all segments of society to a greater effort. It is an essential step in building a political consensus on a broad national development strategy, which encompasses, inter-alia, the roles and responsibilities of different agents in the economy, such as Central, State and local government, the private corporate sector, the small and tiny sector, people's organisation etc. It must identify potential risks and bottlenecks and their possible solutions in order to mobilise efforts in a focussed manner. It is clear, therefore, that to meet these objectives, a vision statement has to operate at several levels of generality and specificity. A vision is a picture of what is possible or what is desired in a longer-term future. It could be of one individual in origin or it could be a collective in its conception.

President APJ Abdul Kalam's address to the joint session of Parliament in 2003: The people to strive towards the goal of transforming India into a Developed Nation by 2020. This vision captures our people's heightened self-confidence, rooted in India's impressive achievements in many fields. It also reflects the increased expectations of our people at the beginning of the new century, that India no longer be categorized as a developing, much less, a poor country. Nearly

260 million people, who are below the poverty line, want to join the mainstream of development. Our people are impatient to achieve 100 percent literacy, health for all, shelter for all, prosperity through knowledge-driven productivity, and a better quality of life—all of these enriched with our value system. Hence, it is time India launched a new vision, which I would call "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)". More than two-thirds of India's population lives in rural areas. We need to give a new thrust to their all-round development through a mega mission for their empowerment. The richness and diversity of India's bio-resources are a major gift of nature to us. 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. An ambitious afforestation programme with people's participation that establishes Joint Forest Management Committees in all the 1.73 lakh villages located on the fringes of the forest areas has been launched. The scope of the National River Conservation Plan has been considerably broadened to include works in 155 towns along polluted stretches of 29 rivers spread over 17 States. India successfully hosted the Eighth Conference of Parties to the United Nations Framework Convention on Climate Change in New Delhi last year. The successful adoption of the Delhi Declaration helped to raise awareness of developing country concerns in climate change. India welcomes the adoption of the Plan of Action at the World Summit on Sustainable Development, which was held in Johannesburg last year. India's first meteorological satellite was successfully launched. The forthcoming launches of satellites in the INSAT-3 series will add further capacity to the INSAT system, which is already one of the largest domestic communication satellite systems in Asia. An exclusive satellite for education, EDUSAT, is also under development. ISRO has taken up the task of tele-medicine connectivity to provide medical services to remote areas. The Indian Remote Sensing Satellites continue to provide valuable data for our resources survey and management. Ground water prospect maps for six States were released recently to help locate sites for drilling borewells.

The Nation has been searching for a lasting solution to the recurring problem of droughts and floods, which have been taking a huge human and economic toll. Networking of our river systems to transfer water from the surplus basins to the areas of deficit has engaged people's attention for many decades. The Government has set up a Task Force to prepare a practical blueprint for this project, without compromising environmental safety and the interest of displaced people. This initiative will bring significant benefits in drinking water, irrigation, power generation, inland navigation, and tourism. I must emphasize that this mega project does not negate the need for promoting small and micro programmes for water conservation at local levels. The two are mutually complementary. The National Water Resources Council has adopted a new National Water Policy emphasizing integrated water resources development and management for optimal and sustainable utilization of available surface and ground water. The Centre has launched a Fast Track Programme for the completion of those major and medium

irrigation schemes that can be completed in one year. Subsequent to the approval by the Narmada Control Authority, the dam height was raised, and this has mitigated the problem of drinking water and irrigation in arid areas of Saurashtra and North Gujarat. The policy of procurement at the Minimum Support Price, while ensuring remunerative prices for wheat and rice farmers in surplus States, has resulted in huge stocks of rice and wheat with the public agencies. As a response to this, the Government has been encouraging exports of food grains. The wide-ranging recommendations on long-term food management made by the High Level Committee are being examined. There is an urgent need to review the current policies, which have impeded crop diversification and led to unsustainable food subsidies, and to ensure crop neutral support to our farmers without excessive procurement. Fertilizers are a critical component in our scheme of food security. The new pricing policy for urea to be implemented from April 2003 aims at greater transparency, efficiency, and fiscal discipline. While the Government is committed to deregulate the marketing and distribution of fertilizers, it would ensure that major fertilizers are available in the country both in adequate quantity and quality at affordable prices to farmers in all the States. The sugar industry has lately faced serious difficulties, constraining the capacity of sugar factories to make timely payment to sugarcane farmers. Several steps have been initiated to protect the interests of sugarcane growers, while ensuring viability of sugar mills. Sustained efforts are being made to promote horticulture as a major area of diversification in agriculture. The cold storage scheme is working well and has created an additional capacity of 28 lakh tonnes. A new scheme of construction, renovation, and expansion of rural godowns called Grameen Bhandaran Yojana has been launched. This scheme will help prevent distress sales by small and marginal farmers. A new National Policy on Cooperatives has been announced. A National Seeds Policy has been finalized. Under the scheme of Agriclinics and Agribusiness Centres, launched last year, unemployed agriculture graduates provide extension services to the farmers on payment. Recognizing the need for value-addition in agricultural and horticultural produce, the Government has given high priority to the development of food processing industries. A Group of Ministers has been constituted to propose a single modern integrated food law and related regulations, to replace the existing myriad laws, which have affected the growth of this sector.

**Agricultural Education in India**

Greater coverage and better quality education at all levels from basic literacy to hi-tech science and technology is the essential prerequisite for raising agricultural productivity. The Education Division is headed by the Deputy Director General (Education). Five Assistant Directors General (ADGs)- ADG (HRD-I), ADG (HRD-II), ADG (Education Planning and Development), ADG (Accreditation), ADG (Home Science), and Deputy Secretary (Education), assist the DDG (Edn). Each is supported by a Section Officer (SO) and other staff. The Examination Cell established to conduct All India Entrance Examination is functioning under a

revolving fund scheme from the current financial year, and is headed by ADG (HRD-I). The Education Division provides administrative support to the National Academy of Agricultural Research Management (NAARM).

**Thrust Areas**

- Accreditation for quality assurance.
- Global competitiveness in HRD.
- Distance education for reaching the unreached.
- Fellowship as a tool for HRD, National integration and reducing inbreeding.
- Women technological empowerment.
- Faculty competence improvement.
- Networking for access to information

"A developed country is one which is able to utilize its core strength to the best possible extent. If a country is not able to use its core strengths or is underutilizing its core strengths it remains underdeveloped". Utilization of core strengths is finally the utilization of strengths of its people. Empowering each Indian with right skills and knowledge (to enable him/her to add value addition) is crucial for national development. If people are poor, it is because they have not been empowered with right skills, which can provide value addition in the competitive world of market economics.

We cannot afford to ignore the rights of our children to live prosperously in a world which is going to pay only those who have the right skills. Education and skill imparting is not a slot machine – it requires gestation periods for a person who enters it to come out with reasonable skills and knowledge base. So we need to bold in our approach to expand skill and knowledge delivery systems to our people on a massive scale to enable them to be productive in a competitive globalised world. That will in turn and would also spread entrepreneurship thus creating a virtuous cycle of economic acceleration and knowledge-skill base growth.

## *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.

The Department of Biotechnology (DBT) has unveiled a document "Biotechnology - A Vision". The document outlines time-bound mission oriented inter-agency, inter-disciplinary projects to achieve the objectives. The mission would be a well-directed effort for the generation of products, processes and technologies to provide food, environment, health and nutritional security. India and Switzerland have taken up a wheat research programme to develop high-yielding improved

varieties, resistant to fungal diseases. The DBT and the Indian Council of Agricultural Research (ICAR) are working towards a Swiss proposal for joint research on Golden Rice i.e. a pro-vitamin-A rich rice variety. Collaborative arrangements have also been entered into with the National Institute of Mental Health, USA and the Brain Research Centre, Riken, Japan, for research in neuro-sciences. There is a major mission for technology for bamboo products recently approved. This will greatly facilitate rural poor to earn through selling bamboo with value addition.

**National Textile Policy:** *Deciding* to redefine the goals and objectives, focus on thrust areas and sharpen strategy in tune with the times, the National Textile Policy – 2000 is enunciated as follows: The Indian Textile Industry shall be the policy to produce cloth of good quality at acceptable prices to meet the growing needs of the people; increasingly contribute to the provision of sustainable employment and the economic growth of the nation; and compete with confidence for an increasing share of the global market. The strategic thrust areas will be on technological upgradation, enhancement of productivity, quality consciousness, strengthening of the raw material base, product diversification, increase in exports and innovative marketing strategies, financing arrangements, maximising employment opportunities and integrated human resource development. The important endeavour will be to achieve increase in cotton productivity by at least 50 % and upgrade its quality to international standards, through effective implementation of the Technology Mission on Cotton; launch the Technology Mission on Jute to increase productivity and diversify the use of this environment-friendly fibre; strengthen and encourage the handloom industry to produce value added items and assist the industry to forge joint ventures to secure global markets; facilitate the growth and strengthen HRD Institutions including NIFT (National Institute of Fashion Technology)on innovative lines; review and revitalise the working of the TRAs (Textile Research Associations) to focus research on industry needs. The textile sector is grappling with the challenges of a globalized market and problems created by slow modernization. Nine Apparel Parks have been sanctioned for setting up garment units with state-of-the-art machinery. Several new schemes have been approved to improve facilities in major textile centres in the country. At the same time, the problems of the traditional handloom and handicraft sectors, which provide livelihood to vast numbers of our weavers and artisans, are also being comprehensively addressed through a special package of measures.

**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.