Study Guide

for

Course Code: AGR 301, Course Title: Basic Agriculture

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AGRICULTURE

Definition: Agriculture is a Latin word. Agri means farming/raising crop and colere means cultivation.

"Agriculture is an art of science as well as a business of raising crop and rearing of animals to meet the basic necessities of man kind through exploiting natural resources (soil, water, climate) to provide food , fiber and shelter.''

History of Agriculture

Agriculture involving domestication of plants and animals was developed at least 10,000 years ago, although even earlier people began altering plant and animal communities for their own benefit through other means such as fire-stick farming. Agriculture has undergone significant developments since the time of the earliest cultivation. The Fertile Crescent of Western Asia, Egypt and India were sites of the earliest planned sowing and harvesting of plants that had previously been gathered in the wild. Independent development of agriculture occurred in northern and southern China, Africa's Sahel, New Guinea, parts of India and several regions of the Americas. Agricultural practices such as irrigation, crop rotation, fertilizers, and pesticides were developed long ago but have made great strides in the past two centuries. The Haber-Bosch method for synthesizing ammonium nitrate represented a major breakthrough and allowed crop yields to overcome previous constraints.

In the past century, agriculture in the developed nations, and to a lesser extent in the developing world, has been characterized by enhanced productivity, the replacement of human labor by synthetic fertilizers and pesticides, selective breeding, and mechanization. The recent history of agriculture has been closely tied with a range of political issues including water pollution, biofuels, genetically modified organisms, tariffs, and farm subsidies. In recent years, there has been a backlash against the external environmental effects of mechanized agriculture, and increasing support for the organic movement and sustainable agriculture.

Origins

Scholars have developed a number of hypotheses to explain the historical origins of agriculture. The transition from hunter-gatherer to agricultural societies, based on evidence from south west Asia and China, indicates an antecedent period of intensification and increasing sedentism known as the Natufian in south West Asia and the Early Chinese Neolithic in China. Current models indicate that a range of food resources was being used more intensively. Wild stands that had been harvested previously started to be planted.

Evidence is also now emerging that the crops grown initially were wild and not domesticated. Crops such as emmer and einkorn wheat do not appear to have become domesticated until well into the Neolithic and 'ancient cultivated rice' (Oryza sativa) took 3000 years to become domesticated.
Localized climate change is the favored explanation for the origins of agriculture in the Levant. The fact that farming was 'invented' at least three times elsewhere, suggests that social reasons may have been instrumental. When major climate change took place after the last ice age (c. 11,000 BC), much of the earth became subject to long dry seasons.[citation needed] These conditions favored annual plants which die off in the long dry season, leaving a dormant seed or tuber. These plants tended to put more energy into producing seeds than into woody growth. An abundance of readily storable wild grains and pulses enabled hunter-gatherers in some areas to form the first settled villages at this time.

The Oasis hypothesis was proposed by Raphael Pumpelly in 1908, and popularized by Vere Gordon Childe who summarized the hypothesis in his book Man Makes Himself This hypothesis maintains that as the climate got drier, communities contracted to oases where they were forced into close association with animals which were then domesticated together with planting of seeds. The hypothesis has little contemporary support [citation needed], as the climate data for the time does not support the hypothesis.

The Hilly Flanks hypothesis, proposed by Robert Braidwood in 1948, suggests that agriculture began in the hilly flanks of the Taurus and Zagros Mountains, and that it developed from intensive focused grain gathering in the region.

The Feasting model by Brian Hayden suggests that agriculture was driven by ostentatious displays of power, such as throwing feasts to exert dominance. This required assembling large quantities of food which drove agricultural technology.

The Demographic theories were proposed by Carl Sauer and adapted by Lewis Binford and Kent Flannery. They describe an increasingly sedentary population, expanding up to the carrying capacity of the local environment, and requiring more food than can be gathered. Various social and economic factors help drive the need for food.

The evolutionary/intentionality hypothesis, advanced by scholars including David Rindos, is the idea that agriculture is a co-evolutionary adaptation of plants and humans. Starting with domestication by protection of wild plants, followed specialization of location and then domestication.

The Levantine Primacy Model was developed in the 1980s by Ofer Bar-Yosef and his collaborators. This provides a cultural ecology explanation, based on the idea that some areas were better favored with domesticable plants and animals than others.

The domestication hypothesis put forth by Daniel Quinn and others states that first humans stayed in particular areas, giving up their nomadic ways, then developed agriculture and animal domestication.

Another hypothesis is that humans were prevented from staying in one place for much of their history, due to the risk of attacks from other tribes.

The Innovation and Specialization Model was put forward recently by Rupert Gerritsen, in Australia and the Origins of Agriculture (2008). This hypothesis considers the question in terms of economic development and treats agriculture as a form of specialization arising from two factors, higher population densities and innovation in areas of higher net natural productivity, and long-term advantageous information acquisition at nodal points in communication in long range scale-free networks.

Importance of Agriculture

The agriculture sector is not only important at national level but also at international level. About fifty years back, the agriculture sector was neglected both in the developed and underdeveloped countries of the world. It was regarded as residual reservoir particularly of labor for employment in industries. In 1960's the importance of agriculture was realized and adequate attention was given to this sector. The importance of balanced growth of agriculture and industrial sectors was stressed by the development economists. In 1970's and since the beginning of 1980's, agriculture in the process of development, has gained increased significance.

Importance of Agriculture in Economic Development:

Pakistan is basically a farming community. About 70% of its population is living in rural areas and nearly 50% of them engaged in farming, livestock and agro-based industries. However, Agriculture sector plays a vital role in the economic development of a country. It is confirmed and supported by the following facts.

1. **Determination of GDP growth rate:** The GDP growth rate in Pakistan is mainly dependent upon the growth rate in agriculture sector. For example, the GDP growth rate increased from 4.5% in 1993-94 to 5.2% in 1995-96 mainly due to increase in the production of cotton, rice and wheat in the year 1995-96. It came down to 3.1% in 1996-7 due to fail in the production of cotton, wheat and sugarcane.
2. **Agricultural Development essential to curtail inflation:** If the rate of growth in agriculture sector is low, it brings shortage of food, vegetable, and other essential raw materials in the country. The prices of the essential goods go up. The slow rate or fall in the production of agriculture sector generates inflationary pressure and creates bottlenecks in the economic development of the country.
3. **Major component of GDP:** Agriculture sector is the single largest component of GDP in Pakistan. Its contribution is 25% to Pakistan's GDP. The progress of agriculture sector provides a sound base for economic development and is considered one of the preconditions for take off or self sustained growth.

4. **Providing labor force to industry**: In most of the developing countries (including Pakistan) agriculture is the main source of providing manpower of various sectors of economy. In Pakistan, 50% of labor force is employed in agriculture sector. With the improved growth in the agriculture sector due to mechanization, the surplus labor force can be easily absorbed in the small and large scale industries. The provision of new employment both in the agriculture industrial and other sectors can increase the income of the workers and help them to get out of low income equilibrium.
5. **Foreign exchange earner:** The agriculture sector is the main source of foreign exchange earnings in Pakistan. The export of cotton, cotton based products, rice etc fetch about 65% of our total export earnings. This helps in the import of capital machinery, equipment, technical know how etc which essential inputs for development are. The availability for foreign exchange not only helps in the industrialization programme but also improves the balance of payments.
6. **Meets food requirements:** Pakistan's population is growing at an alarming rate of 2.77% annually. The agriculture sector is successfully meeting the food requirements of over 13 crore persons in Pakistan. Had there been no green revolution in agriculture sector during sixties and seventies, we would have spent the major portion of foreign exchange earned on the food import. The economic development would have also been retarded due to low capital formation.
7. **Support of industries:** The improved growth in the agriculture sector provides raw material to manufacturing industries. The production of cotton, jute, sugarcane, fruits etc enable the cotton, jute, sugarcane fruit processing and other agro based industries to get material from within the country and expand production. The industries not only meet the domestic requirements of cloth, sugar, jute bags etc but also earn foreign exchange by exporting them.
8. **Expanded industrial market:** The expanding and progressive sector brings prosperity to the agriculturists. The increase in the income of formers is spent on the purchase of industrial output such as clothes, motorcycles, cars, fans etc. The improvement in the agriculture sector thus provides on outlet for the products of the expanding industries.
9. **Marketable surplus:** When the agriculture sector is expanded on scientific lines, it yields handsome marketable surplus. The surplus which may be cotton, jute, wheat, sugar, silk, fish, timber etc can help to pay the import of industrial raw materials, capital equipments and technology. This helps in bringing about rapid economic development.

IMPORTANCE OF AGRICULTURE FOR PAKISTAN

Agriculture is very important for Pakistan. It helps the country in the development of economy. Every country has a vast land, which is used for agriculture. Pakistan is also an agricultural country. Its total area is 7, 96,096 square kilometers. 70% of our total population is living in the villages. The major source of their living is agriculture. Agriculture employed 66% of the total workforce in 1950-51 but by 1999-2000. This figure dropped to 47.3%. This shows that people are now not interested in farming. They are doing jobs in industry and other fields.

They are leaving farming and migrated to cities. Because cities have more chances of jobs. There are more factories and more development project offices. So, people move from villages and settle in the cities. Another reason in the villages is that, people are using tractor and machinery, so they need less people.

In Pakistan, the best area for agriculture is Punjab. Its soil is very fertile and its irrigation system is very fine. Its total is equal to quarter of the total area for Pakistan. But it has 57% of the total cultivated land. In Pakistan, we have two main crops, which are Kharif crops and Rabi crops. Kharif crops grow in Summer while Rabi crops grow in Winter.

The most important food crops in Pakistan are as following:

1. Wheat: - Wheat is a major need of our country. It is grown on a large area. This crop is sown in October and November and harvested in April and May.

2. Rice: - Pakistan produces over 4.3 million tons of rice.

3. Maize: - Maize is a Kharif crop that grows in warm places.

4. Millet: - These crops can grow even in poor soils.

5. Pulses: - Pulses are good source of protein.

The most important cash crop in Pakistan is following:-

1. Cotton: - Cotton is our leading exports. Pakistan produces 9.8 billions bales of cotton a year.

2. Tobacco: - Tobacco is also an important cash crop. The best tobacco growing areas are in Mardan and Peshawar.

3. Lives Stock: - Most of the milk comes from the buffaloes. Cow produces almost a million tons of milk a year.

Branches of Agriculture
Following types of agriculture which are as follow:

1. **Agronomy:** Branch of Agriculture which deals with the principle and practices of crop production & soil management.
2. Soil sciences
3. Horticulture

    a. olericulture
    b. floriculture
    c. land scaping
4. Entomology
5. Plant breeding and genetics
6. Plant pathology
7. Agri-economics
8. Food science and technology
9. Agriculture extension
10. Forestry
11. Fish culture

Salient Features of Pakistan Agriculture

Pakistan's principal natural resources are arable land and water. About 25% of Pakistan's accounts for about 21.2% of GDP and employs about 43% of the labor force. In Pakistan, the most agricultural province is Punjab where wheat and cotton are the most grown. Some people also have mango orchards but due to some problems like weather, they're not found in a big range.

1. **Crops:** The most important crops are wheat, sugarcane, cotton, and rice, which together account for more than 75% of the value of total crop output.
   Pakistan's largest food crop is wheat. In 2005, Pakistan produced 21,591,400 metric tons of wheat, more than all of Africa (20,304,585 metric tons) and nearly as much as all of South America (24,557,784 metric tons), according to the FAO. The country is expected to harvest 25 to 23 million tons of wheat in 2012. Pakistan has also cut the use of dangerous pesticides dramatically. Pakistan is a net food exporter, except in occasional years when its harvest is adversely affected by droughts. Pakistan exports rice, cotton, fish, fruits (especially Oranges and Mangoes), and vegetables and imports vegetable oil, wheat, pulses and consumer foods. The country is Asia's largest camel market, second-largest apricot and ghee market and third-largest cotton, onion and milk market. The economic importance of agriculture has declined since independence, when its share of GDP was around 53%. Following the poor harvest of 1993, the government introduced agriculture assistance policies, including increased support prices for many agricultural commodities and expanded availability of agricultural credit. From 1993 to 1997, real growth in the agricultural sector averaged 5.7% but has since declined to about 4%. Agricultural reforms, including increased wheat and oilseed production, play a central role in the government's economic reform package.
   Outdated irrigation practices have lead to inefficient water usage in Pakistan. 25 per cent of the water withdrawn for use in the agricultural sector is lost through leakages and line losses in the canals. Only a limited amount of the remaining water is actually absorbed and used by the crops due to poor soil texture and unleveled fields.

Much of the Pakistan's agriculture output is utilized by the country's growing processed-food industry. The value of processed retail food sales has grown 12 percent annually during the Nineties and was estimated at over $1 billion in 2000, although supermarkets accounted for just over 10% of the outlets.

The Federal Bureau of Statistics provisionally valued major crop yields at Rs.504,868 million in 2005 thus registering over 55% growth since 2000[9] while minor crop yields were valued at Rs.184,707 million in 2005 thus registering over 41% growth since 2000. The exports related to the agriculture sector in 2009–10 are Rs 288.18 billion including food grains, vegetables, fruits, tobacco, fisheries products, spices and livestock.

2. **Livestock:** According to the Economic Survey of Pakistan, the livestock sector contributes about half of the value added in the agriculture sector, amounting to nearly 11 per cent of Pakistan's GDP, which is more than the crop sector. The leading daily newspaper Jang reports that the national herd consists of 24.2 million cattle, 26.3 million buffaloes, 24.9 million sheep, 56.7 million goats and 0.8 million camels. In addition to these there is a vibrant poultry sector in the country with more than 530 million birds produced annually. These animals produce 29.472 million tons of milk (making Pakistan the 4th largest producer of milk in the world), 1.115 million tons of beef, 0.740 million tons of mutton, 0.416 million tons of poultry meat, 8.528 billion eggs, 40.2 thousand tons of wool, 21.5 thousand tons of hair and 51.2 million skins and hides.
   The Food and Agriculture Organization reported in June 2006 that in Pakistan, government initiatives are being undertaken to modernize milk collection and to improve milk and milk product storage capacity.
   The Federal Bureau of Statistics provisionally valued this sector at Rs.758,470 million in 2005 thus registering over 70% growth since 2000.
3. **Fishery:** Fishery and fishing industry plays an important role in the national economy of Pakistan. With a coastline of about 1046 km, Pakistan has enough fishery resources that remain to be fully developed. It is also a major source of export earnings.
4. **Forestry:** About only 4% of land in Pakistan is covered with forest. The forest of Pakistan are a main source of food, lumber, paper, fuel, wood, latex, medicine as well as used for purposes of wildlife conservation and ecotourism.

Chapter 2 - AGRONOMY
DEFINATION:

"Branch of agriculture which deals with the principles and practices of crop production and soil management"

OR

"Agronomy is an art, science of raising field crops managing soil resources to meet the fundamental necessities of life."

OR

"Agronomy is a science and technology of producing and utilizing plants for food, fiber fuel by soil conservation."

TYPES OF CROPS:

* Arable/Agronomic crops
* Horticulture crops
* Forests

Arable/Agronomic crops:

These crops included wheat, maize, cotton, rice etc.

Horticulture crops:

These crops included fruits and vegetables.

Forests:

These crops included trees and plants.

WEEDS:

"Any plant out of its proper place is known as weed."

OR

"Any unwanted plant is known as weed".

PRINCIPELS OF CROP PRODUCTION:

The principles of crop production is as follow:

(for wheat)

*Improve cultural practices
*Good seed of approved and new varieties.
*Correct manuring at right time.
*Irrigation application at right/proper time.
*Adequate plant protection measures.
Ist timing of irrigation:

After 15 to 20 days.

2nd timing of irrigation:
After 20 to 25 days.

STAGES OF PLANT:
There are two types of plant stages.

*Vegetative growth
*Reproductive growth

Vegetative growth:
In this growth plant complete hight, size out elongate it stem number of leaves in vegetative growth.
Reproductive growth:
In this type of growth grain, fruit produce in reproductive growth.

TYPES OF PLANTS:
There are two types of plants.

*Determinate plants
*Indeterminate plants

Determinate plants:

The type of plant in which first the vegetative growth is completed then reproductive growth is started is called determinate plants.
E.g. Wheat

Indeterminate plants:
The type of plants in which the plants carry vegetative reproductive growth of the same time is called the indeterminate plants.

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Climate

Definition:

Climate in a narrow sense is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years.

The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind.

Climate in a wider sense is the state, including a statistical description, of the climate system

The difference between climate and weather is usefully summarized by the popular phrase

"Climate is what you expect, weather is what you get.

Over historical time spans there are a number of nearly constant variables that determine climate, including latitude, altitude, proportion of land to water, and proximity to oceans and mountains. These change only over periods of millions of years due to processes such as plate tectonics.

Other climate determinants are more dynamic: the thermohaline circulation of the ocean leads to a 5 °C (9 °F) warming of the northern Atlantic Ocean compared to other ocean basins Other ocean currents redistribute heat between land and water on a more regional scale. The density and type of vegetation coverage affects solar heat absorption water retention, and rainfall on a regional level. Alterations in the quantity of atmospheric greenhouse gases determines the amount of solar energy retained by the planet, leading to global warming or global cooling. The variables which determine climate are numerous and the interactions complex, but there is general agreement that the broad outlines are understood, at least insofar as the determinants of historical climate change are concerned

Climate of Pakistan

Climate is an average or general conditions of temperature, humidity, atmospheric pressure, rainfall of a place. The climate of Pakistan, on the whole is dry and extreme. It means that the summers are extremely hot and winters are extremely cold and there is a little rainfall during the year.
Pakistan lies in the moderate zone. The climate is usually arid, characterized by hallucinating summers and cool or cold chills, and broad variations among-sty extremes of temperature at arranged locations. There is little rain. These generality's should not, though, obscure the separate differences offered among particular sites.
For example, the coastal area lengthwise the Arabian Inundation is typically warm, while the arctic snow-covered edges of the Karakoram Variety and of other bushels of the far north are so cold date round that they are just accessible by world class climbers for a few weeks in May and June of apiece year.

Pakistan has are four seasons:
1- A cool, dehydrated winter from December from February.
2- A Hallucinating, dry coil from Demo through May.
3- The summer raining season, or southwest downpour period, from June from September.
4-The losing ground monsoon epoch of October and November.
The start and length of these periods vary rather according to location.

The climate in the assets city of Islamabad varies from standard daily low of 2° C in January to standard daily high of 40° C in June. Semi of the yearly rainfall happens in July and Imposing, averaging about 255 millimeters in apiece of those two months. The balance of the date has notably less rainwater, amounting to about fifty millimeters per month. Hailstorms are ordinary in the spring.

Pakistan's main city, Karachi, which is as well the bucolic's industrial middle, is further humid than Islamabad however gets less rain. Just July and Imposing average further than twenty five millimeters of rainwater in the Karachi area; the residual months are fantastically dry. The temperature is as well more identical in Karachi than in Islamabad, ranging from an standard daily low of 13° C during chill evenings to an standard daily high of 34° C on summer days. Though the summer temperatures do not find as high as those in Punjab, the high dampness causes the nation immense deal of discomfort.

Most areas in Punjab experience quite cool chills, often accompanied by rainwater. Woolen wraps are damaged by women and men for heat because few domiciles are angry. By mid February the temperature starts to rise; springtime weather persists until mid April, when the summer warmth sets in. The start of the southwest downpour is due to attain Punjab by May, however since the ancient 1970's the weather prototype has been uneven. The coil monsoon has also skipped over the area or has caused it to rainwater so hard that avalanches have effected. June and July are unjustly hot. Though official guess rarely arrange the temperature mentioned 46° C, bulletin sources maintain that it attains 51° C and often carry news about people who have yielded to the warmth. Heat records were busted in Multan in June 1993, whenever the mercury was accounted to have risen to 54° C. In Imposing the cruel heat is punctuated by the raining season, referred to as "BARSAAT", which realizes relief in its awakening. The hardest allotment of the summer is afterward over; however cooler weather does not come waiting late October.

Land of Pakistan

Pakistan is a land of many splendors. The Scenery changes northward from coastal beaches, lagoons and mangrove swamps to sandy deserts, desolate plateaus, fertile plains, dissected uplands and high mountains with beautiful valleys, snow-covered peaks and eternal glaciers.
This variety of landscape divided Pakistan into six major regions-
The Northern High Mountainous Region, the Western Low Mountainous Region, the Postwar Uplands, the Baluchistan Plateau, the Punjab Plain and the Sindh Plain.

The Himalayas

Stretching in the north from east to west are a series of high mountain ranges which separate Pakistan from China, Russia and Afghanistan. They include the Himalayas, the Karakoram and the Hindukush mountains. The Himalayas spread in the north-east and the Karakoram rises on the north-west of the Himalayas and extends eastward up to Gilgit. The Hindukush mountains lie in the north west of the Karakoram but extend eastward into Afghanistan. With the assemblage of 33 giant peaks over 7,315m, the region is the climbers' paradise. Many summits are even higher than 26,000 ft. (7,925m) and the highest K-2 (Mt. Goawin Ausün) at 28,250ft. (8,610m) is exceeded only by Mt. Everest. Inhospitable and technically more difficult to climb than even Mt. Everest, they have taken the biggest toll of human lives in the annals of mountaineering. The very passes are rarely lower than the summit of Mt. Blonc and several are over 18,000 ft. (5,485m). The Karakoram Highway that passes through the mountains is the highest trade route in the world.
Besides, the region abounds in the vast glaciers, large lakes and green valleys which have combined at places to produce holiday resorts such as Gilgit, Hunza and Yasin in the west and the valleys of , Dir, Chitral, Kaghan and Swat drained by the rivers Chitral, Panjkora, Kunhar and Swat respectively in the east. Dotted profusely with scenic spots having numerous streams and rivulets, thick forests of pine and junipers and vast variety of fauna and flora, the Chitral, Kaghan and Swat valleys have particularly earned the reputation of being the most enchanting tourist resorts of Pakistan.
South of the high mountains, the ranges lose their heights gradually and settle down finally in the Margalla hills (2,000-3,000 ft.) in the vicinity of Islamabad, the capital of Pakistan, and swat and Chitral hills north of river Kabul.

The Western Low Mountains Region

These mountains spread from the Swat and Chitral hills in a north-south direction, and cover a large portion of N.W.F.P. North of the river Kabul their altitude ranges from 5,000 ft. to 6,000 ft. in Mohmand and Malakand hills. The aspect of these hills is exceedingly dreary and the eye is everywhere met by the dry rivers between long rows of rocky hills and crags, scantly clothes with coarse grass, scrub wood and dwarf palm.

South of the river Kabul spreads the Koh-e-Sofed Range with a general height of 10,000 ft., its highest peak Sakaram being 15,620 ft. South of the Koh-e-Sofed are the Kohat and the Waziristan hills (5,000 ft.) which are traversed by the Kurram and Tochi rivers, and are bounded on south by Gomal river. The whole area is a tangle of arid hills composed of limestone and sandstone.

South of the Gomal River, the Sulaiman Mountains run for a distance of about 300 miles in a north-south direction, Takhte Sulaiman (11,295 ft.) being its highest peak. At the southern end lie the low Marri and Bugti hills.

South of the Suliaman Mountains is the Kirthar Range which forms a boundary between Sind plains with Quetta in Baluchistan Plateau. It consists of a series of ascending ridges running generally north and south with broad flat valleys in between. The highest peak named Kute ji Kabar (dog's grave) is 6,878 ft. above sea-level.

The Western Mountains have a number of passes which are of special geographical and historical interest. For centuries they have been watching numerous kings, generals and preachers passing through them, and the events that followed brought about momentous changes in the annals of mankind. Khyber Pass, the largest and the most renowned of these is 35 miles long and connects Kabul in Afghanistan with the fertile vale of Peshawar in N.W.F.P. the Tochi Pass connects Ghazni in Afghanistan with Bannu in Pakistan and the Gomal Pass provides a route from Afghanistan to Dera Ismail Khan which overlooks at the Punjab plains. The Bolan Pass connects the Sind plains with Quetta in Baluchistan and onward through Chaman with Afghanistan.

Enclosed by the branches of western mountains are a number of fertile plains which have been formed by rivers rising from these mountains and falling into Indus.

The Balochistan Plateau

The Balochistan Plateau extends westward, averaging more than 1,000 feet in elevation, with many ridges running across it from northeast to southwest. It is separated from the Indus Plain by the Sulaiman and Kirthar ranges. It has a remarkable indigenous method of irrigation called the karez, which consists of underground channels and galleries that collect subsoil water at the foot of hills and carry it to the fields and villages. The water is drawn from the channels through shafts that are sunk into the fields at suitable intervals. Because the channels are underground, the loss of water by evaporation is minimized. The technology for the construction of the karez probably came from western China, brought into Balochistan by the Buddhist monks who traveled back and forth over the Karakoram Range. The plateau is an extremely arid country and is the most sparsely populated region in Pakistan. Pastoral activity supplements a primitive form of agriculture. True pastoral nomadism survives in the northwest. Goats and fat-tailed sheep account for the majority of the stock, and much of the local traffic consists of camels and donkeys, although trucks and buses are in use on the new roads.

The Desert Areas

The desert areas include the steppes of the Sindh Sagar Doab (at its centre is the Thal, which has true desert conditions) and Cholistan in the Bahawalpur region (Punjab), which is known as the Nara or Registan in the Khairpur region (Sindh) and as the Thar Desert in the Thar Parkar region of southeastern Sindh. All these areas are extensions of the Thar Desert of western India.

Water resources of Pakistan

Indus valley, cradle of ancient civilization: The Indus valley has been the cradle of ancient civilization like those of the delta area of the Nile and the valleys of the Tigris and Euphrates. These three areas were the contemporary regions in which great civilizations flourished, about four to five thousand years ago. However, recent archaeological findings reveal that the Indus valley civilizations probably antedated that of the Tigris and the Euphrates. Excavations in the Indus valley have revealed that the dwellers of Moenjo-Daro, Kot Diji, and Harapa had established powerful empires. A stroll through the ruins of Moenjo-Daro and Harapa reveals that the houses in these cities were provided with all types of amenities. There were comfortable bedrooms, guestrooms, dinning rooms, porter's lodges, lavatories, handsome courtyards, drainage, fresh water wells, and tanks. The dwellings of Moenjo-Daro period are found so well finished and highly polished that these even match with that of today's then of prehistoric.

It is believed that the ancient people of the valley of Indus were outstanding in the field of agriculture and industry as compared to the civilization of contemporary period in Egypt and Mesopotamia. The textile crafts made from cotton are living examples of their expertise. Such was the glory of the ancient people of Indus valley; perhaps they were the first sedentary farmers of the world. The richness and wealth of the Indus valley was the greed of the foreigners. The valley of Indus has always been the cherished goal of the invaders and conquerors that followed one after another from the northwestern passes through the mountain ranges. The Aryans, the Iranians, the Graeco-Bactrians, the Parthenians, the Kushans, the white Huns, Muslims emperors, and Britishers plundered the rich valley of the Indus from time to time and ruled over the valley and northern India. Entire history of Indus valley reveals that one invader or another has treaded the present Pakistan. The Muslims of the sub-continent first tried to shake off a century old rule of British in 1857 and finally succeeded to drive them away in 1947, and the great valley Indus became part of Pakistan. Pakistan lies between latitudes 24 degree and 37 degree North and longitudes 61 degree to 76 degree East. Its surroundings include Iran on the west, Afghanistan on the northwest, Gilgit Agency, Azad Kashmir and disputed territory of Jammu and Kashmir lie on the northeast, India on the east and the Arabian Sea exists on its south.

Catchments of Indus river system: The Indus basin is a part of the catchments of the Indus river system that includes the northwest mountains, the Katchi plain, desert areas of Sindh, Bahawalpur, and the Rann of Kachh. The Indus and its major tributaries flow in longitudinal valleys in structural troughs paralleled to the mountain and invariably take an acute bend descending to the alluvial plains by cutting through mountains. These plains are stretched over a distance of 1528 Kilometers (950 miles) to the tidal delta near the Arabian Sea. The total catchment area of Indus River system spreads over 944,573 square kilometers (364,700 square miles). Of which 553,416 square kilometers (213,674 square miles) exist in Pakistan with a varying width of over 320 kilometers (nearly 200 miles) in the Punjab to about 80 kilometers (50 miles) in the narrow neck between the Thar Desert and the Khirthar mountains. The flat plain of Indus basin is made up of highly fertile alluvium deposited by the river Indus and its tributaries. Agriculture is concentrated essentially to this plain, where it has been developed by harnessing principal surface water resources available. Since, evaporation is high with meager and unreliable rainfall over Indus plains, hence, agriculture is wholly dependent on irrigation supplies. The river Indus and its tributaries are like a funnel, they rise in the northern mountain areas, receive water from various resources (snow, glacier melt, and rainfall), converge into a single stream at Panjnad (Mithankot), cover about 1005 Kilometers (625 miles) through the Sindh province, and finally discharge into Arabian sea.

Historical perspective: The Almighty Allah has gifted Pakistan with abundant water resources with water flowing down the Himalayas and Karrakurram heights from the world's largest glaciers, a free and unique bounty of nature for this land of alluvial plains. As a result of this natural resource, today we have the world's marvellous and the largest contiguous irrigation system that currently irrigates over 16 million hectares of land, out of 34 million hectares of cultivable lands available. This land lies within the plains formed by river Indus and its tributaries. Britishers started the barrage irrigation system during 1930s. However, before that the residents of Punjab, Sindh, and Frontier had constructed a number of inundation canals to irrigate their lands. In the Punjab, 38 such canals had been taken out of Sutlej, Indus, and Chenab rivers to irrigate areas around Bari Doab, Multan, Muzaffargarh, and Dera Ghazi Khan. In Sindh, water level of the Indus during summer had always been higher than the surrounding lands, thus, 16 inundation canals in this area had conveniently carried out the irrigation water during past century. However, British Army Engineers undertook construction and improvement of several irrigation canals in the sub-continent. Subsequently, construction works on Bari Doab Canal; Sidhnai Canal, Lower Sohag, Ramnagar Canal, Lower Jhelum Canal, Kabul Canal, and Lower Sawat were completed by the end of l9th century. However, at the time of independence country had 29 canals to provide regulated supply to an area of about 11 million hectares, beside an area of about 3.2 million hectares irrigated through inundation canals leading from Indus and its tributaries. These main inundation canals included Upper Sutlej, Lower Sutlej, Shahpur, and Chenab in Punjab; whereas, Rohri, Fuleli, Pinyari, and Kalri in Sindh. However, after the construction of barrages these canals are no more inundation canals but get regulated water supply and some of them have become perennial while few are nonperennial.

We have entered into 21st century with world's largest and unified irrigation system that consists of three major reservoirs (Chashma, Mangla, and Tarbela); 19 barrages (Ferozepur, Sulemanki, Islam, Balloki, Marala, Trimmu, Panjnad, Kalabagh, Sukkur, Kotri, Taunsa, Guddu, Chashma, Mailsi, Balloki, Sidhnai, Rasul, Qadirabad, and Marala); 12 link canals; 45 irrigation canals; and over 107,000 water courses and millions of farm channels & field ditches. The total length of main canal system is estimated about 585000 Kilometer (36932 miles) and that of watercourses & field channels exceeds 1.62 million Kilometers (over 1.02 million miles).

Surface water resources: Irrigated agriculture was, still is, and will remain in future the backbone of Pakistan's economy. Nature has blessed Pakistan with abundant surface and subsurface water resources. These resources had been exploited and utilized for agricultural, domestic, and industrial purposes in the past and will continue to be explored in future. The river Indus and its tributaries provide the surface water. At the time of independence, we had about 67 MAF water available for diversion, this amount increased to about 85 MAF by the year 1960. At this juncture, the right of three eastern rivers (Beas, Sutlej, and Ravi) was given to India under Irrigation Water Treaty 1960, during this period, Indus Basin Project (IBP) was implemented with international assistance of the Wold Bank. IBP enabled Pakistan to acquire significant capability of river flow regulation through integrated system. By the dint of river regulation-cum-storage facilities of IBP and other irrigation developments on the river Indus, canal diversions progressively increased and peaked to about 108 MAF. The recent statistical data shows that the River Indus and its tributaries provide about 147 MAF during flood season. Out of which nearly 106 MAF is diverted into canals and is available for agriculture, while, about 32 MAF outflows into sea, whereas, over 8.6 MAF is considered as evaporation and seepage losses in the river system. It is worth mention here that during last 3-5 years hardly 2-5 MAF water has flown into sea, whereas, at least 12 MAF must be left to sea in order to control intrusion of brackish water.

Ground water resources: The Indus plains constitute about 34 million hectares (over 85 million acres) of cultivable land, which is under-lain predominantly by sand alluvium to a considerable depth. Annual recharge to ground water system of this Indus plain is estimated around 55 MAF, out of which about 48 MAF is within the commands of Indus basin irrigation system (IBIS). Presently, 39 MAF is being extracted annually. Ground water is also found in some rain-fed (Barani) lands, and inter-mountain valleys at depths varying from 100 to 200 ft. During 1950s, large area in the Indus basin became waterlogged and soil salinity increased adversely affecting the agricultural productivity. It was the time when government got involved and took initiatives in the ground water development. The efforts began to control the twin menaces of waterlogging and salinity by the way of providing drainage facilities. Government embarked on a series of SCARPs in the late 1950s aimed at lowering the ground water table by providing "vertical drainage" through large capacity deep tube wells. Because of better economic returns, priority was given to locating SCARPs in the areas with ground water quality suitable for supplemental irrigation, making the drainage a by product in effect. During past four decades, about 15000 SCARP tube wells have been installed by the Government in 57 projects covering a gross area of about 7.7 million hectares affected land for putting it back into production. Almost 75% of all SCARP tube wells were installed in the Punjab. About 81% of total tube wells installed in Punjab province are located in fresh ground water areas, whereas, remaining 19% tube wells have been installed in saline ground water areas. The tube wells installed in the fresh ground water areas have been pumping water directly into watercourses; thus, they are being used for irrigation in addition to canal water. However, the tube wells installed in the areas with saline ground water, discharge saline water directly into drains, from where it is being disposed of.

Soon after the initiation of the SCARP program: Large-scale development of ground water was started by the private tube wells. According to latest reports issued by the Government of Pakistan, the number of private tube wells has increased from 27000 to over

400000 during period between 1964 and 1995. All of the 400000 private tube wells have been installed in fresh ground water zones and are being used for irrigation purposes. About 80 per cent of these tube wells are located in Punjab and supply around 40 per cent of total irrigation in the province.

Future of water resources and needs: One of the key issues to Pakistan is the growing population pressure, which is responsible for driving its water resource development. It has the world's fastest growing population that has surpassed the 140 million mark by now and is still increasing at an alarming rate of around 2.8%, which needs to be checked, whereas the growth rate in agriculture sector remains somehow lower than the demand due to limiting irrigation water. To keep up the pace of agricultural growth comparable to population growth, we must bring additional lands under cultivation. In order to achieve the required growth targets in agriculture, we will need estimated amounts of about 149 MAF by 2000, 215 MAF by year 2013 and about 277 MAF by year 2025. This scenario warns that Pakistan has already slid from water affluent country to a water scare country and already a shortage of over 40 MAF persists and it will increase to a projected water shortage of over 108 MAF, and 151 MAF by years 2013 and 2025, respectively. Since no additional water is available, it is better to improve the existing water system and land capabilities; otherwise, Pakistan will be facing acute shortages of food, fiber, and edible oils in near future. It is time to recognize our responsibilities and start taking steps in right direction. We must keep eye on the issues such as, inadequate management and inefficient operation of irrigation systems, poor water application & unequal water distribution, depletion of ground water resources, reduction in storage capacities of existing system, and wastage of summer river surpluses and slow agricultural growth.

Development potential and future strategies

Improve surface storage capacity: Future development of the country depends on water resources expansion and management. It has been recognized that more than 83 MAF water can be generated through various resources (See Table). These potential resources include; surface water 33 MAF, ground water 9 MAF, watercourse improvement 15 MAF, minor canals 5 MAF, and distributaries 21 MAF. According to a report of working group on water resources for the 7th five year plan (1987), no new storage have been created after the completion of Tarbela due to rising controversies over the construction of such reservoirs. Thus, it has become necessary to focus on small size irrigation schemes (storage on rivers). There is a need to construct small dams on rivers Indus, Jhelum, Chenab, and their small tributaries. The potential sites for these small reservoirs/dams need to be surveyed. However, some of these sites are located at "Sehwan-Manchar Lake, Chotiari depression, Hamal Lake, Skardu, Bunji, Kohala, Kunhar, Rohtas, Neelam Valley, Ambahar, Dhok Pathan, Dhok Abakki, and Thal Reservoir" those may be explored/utilized. The level of Mangla dam can also be raised to increase its storage capacity. Another option is to manage the existing irrigation system in a better way and undertake new schemes wherever possible.

Conjunctive use of ground water: Conjunctive use refers to the co-ordinate, combined, creative exploitation, and judicious use of ground water for sustained development. It deals with neither over extraction nor under extraction of the source. This option has technically and economically been considered as the most viable strategy in the past studies. But, the tragedy of this source is that the government has no effective control over the excessive pumping of ground water in some areas, hence, it has started to diminish in those areas. The ground water table has already started declining in 14 out of 45 canal commands. Due to over-exploitation of this resource, the sustainability of irrigated agriculture is facing a new threat in some of the canal commands in Punjab. This situation needs to be checked and addressed urgently. However, Indus Basin Irrigation System (IBIS) has a potential of around 48 MAF water within its commands and nearly 39 MAF of ground water is being extracted annually. This leaves with 9 MAF of water still available at this source. This amount could be extracted and utilized for irrigation purpose.

Increase the efficiency of existing system: The unchecked growth of population has increased pressure on land and water resources throughout the world; thus, it has become imperative to conserve our water supplies. New sources of supply are becoming scare and are unlikely to be constructed in the near future due to geopolitical reasons, naturally, the emphasis must be given on methods that can salvage the supplies already being lost within the irrigation system in the form of seepage. Several reports have shown that about 25 to 30% of the water is being lost in the conveyance system of the different countries of the world. A considerable amount of water is lost during its conveyance due to seepage in lengthy canals; lining of the system channels could reduce these losses. As reported by WAPDA, more than 5 MAF of irrigation water could be saved by lining the minor canals only, and additional amount of about 3.6 MAF could be saved by water course improvement (see, GOP, Sixth five year plan, 1983-88), this makes a total saving of over 8.6 MAF. However, due to financial constrains, it is not possible to line entire canal system thus, the portions with high potential of seepage and those located in the areas with high salt content could be lined, by doing so, not only huge quantities of irrigation water could be saved but also the risk of water logging and salinity could be reduced. This would result in saving of huge investments that otherwise are required for drainage projects. Also, the existing system requires development of new irrigation projects on non-perennial basis. It has been stemmed out in the Water Apportionment Accord (WAA) of 1991, that remodelling / construction of non-perennial canals should be taken, this would not only provide additional water for agriculture but also save a bulk amount (derived during monsoon) from flowing into sea. In this regard construction of Thar Canal in Sindh (non-perennial canal) should be undertaken to carry the additional water during monsoon season.

Water distribution: The proper management, efficient application, and uniform distribution of available water at farm-gate have remained major problems since the existence of the irrigation network. Increasing water demand, deferred maintenance, siltation of channel prism, excessive water by tampered outlets and illegal water extraction & theft all lead towards inequity in the system. It has even become increasingly significant over last two decades. There is inequity in distribution at all levels in the system. Inequity in water distribution between head and tail is of the order of between 20 to 50 %. The water is distributed amongst the farmers "as per turn system" on a watercourse and each farmer receives his share on the basis of the area owned by him. Each farmer is allotted a specified time period, in proportion to his land holdings. In other words, this system disregards the crop consumptive use, frequency, and timely application of irrigation water. The tail enders however, receive 10 to 12 % less share of water, because the allowance is based on the theoretical losses, whereas, the actual or operational losses are high due to silt deposits at the heads, grass growing on banks and in the beds, trees taking their toll of water, rodents, snakes and other insects having their abodes in the banks, variety of irregular cuts (nuccas) with borrow bits full of water, overtopping on banks, and seepage through bed. The present situation is that the head reaches are waterlogged and the tail enders do not have enough water to meet their minimum requirement which results in low crop yields. For maximizing crop production, this constraint in the system would have to be removed. Government should take measures to bring flexibility in the existing system to meet the crop water requirements. Similarly, outlets on a minor or distributary receive different amounts of water. Illegal pumping from canals and excessive losses add to the inequity in distribution. Also, due to poor operation and maintenance of irrigation systems, the water distribution is not equitable and reliable. This has shaken the confidence of tail users and has discouraged them to use nonwater inputs for increasing crop yields.

Due to shortage of water, the tail enders have been forced to use poor quality water without proper mixing, which has given birth to salinity in such areas. This problem could be overcome by lining the whole watercourse, again the investment becomes a constraint, it is not possible to line the whole or optimum length of the watercourses. The logical reaches need priority lining are the head sections where silt deposits and raises the bed level which reduces the flow of water, the sandy areas where the percolation losses are too high. The watercourse improvement, proper maintenance, and equal distribution would result in saving of more than 15 MAF of water.

Adoption of water conservation techniques: Water conservation can play an important role in sustaining agricultural development. This requires substantial improvements in water use efficiency, choice of suitable cropping pattern, growing water-efficient crops, and introducing modern irrigation application techniques (trickle. sprinkler etc.). It has been observed that once water reaches at the farm gate, then, it becomes the responsibility of farmer to use it. Farmers in Pakistan generally practice basin, border or furrow methods of irrigation but the application efficiency of these methods is very low and the water applied this way is not distributed uniformly on their fields. It is quite common to find a combination of over and under irrigation within a single field. Over and under irrigation conditions results in poor crop germination that causes yield reductions.

Recommendations: The unchecked growth of population has increased pressure on land and water resources throughout the world; thus, it has become imperative to conserve our water supplies. New sources are becoming scare and are unlikely to be constructed in the near future (except small dams) due to geo-political reasons, naturally, the emphasis must be given on methods that can salvage the supplies already being lost within the irrigation system in the form of seepage.

The second largest contribution to the total water availability comes from the ground water resources. This source has been exploited and very well utilized by the public SCARP and private tube wells. It can still provide over 9 MAF of water. This source could be exploited and judiciously used for irrigation purposes. However, in some areas groundwater is rapidly depleting due to excessive pumpage, government should take control in such areas to save them from depleting.

Water conservation programmes, such as, lining of minor canals. distributaries, and water courses should be accelerated, this would not only save the huge quantities of water, but would also help reduce problems of water logging and salinity in the country. Conjunctive use of water based on scientific lines should be encouraged. Efforts should be made to convert the present rotation-based-irrigation system to demand oriented system. Besides that, the modern irrigation application techniques (trickle, sprinkler etc.), that have potential to improve water distribution and water use efficiencies, should be introduced in the areas with water scarcity. Particularly, in Sindh province, for the development of Kohistan areas of Dadu and Karachi districts, such techniques would be beneficial, thus, may be initiated.

Since, improper management, poor operation and maintenance of irrigation systems, inefficient application, and inequitable distribution of available water at farm gate have remained major problems since the existence of the irrigation network. Increasing water demand, deferred maintenance, siltation of channel prism, excessive water by tampered outlets, and illegal water extraction all lead towards inequity in the system. Similarly, outlets on a minor or distributary receive different amounts of water. Thus, it is need of time that government should take appropriate measures to ensure equitable distribution, to stop illegal extraction, and to improve system efficiency. One way to over come these problems is to empower water users so that they can play effective role in managing the proper water supplies in their distributaries, minors, and watercourses. The past experiences show that irrigation department has failed to stop illegal theft and extraction thus irrigation distribution system needs to be privatized through water users associations. Also, irrigation water is supplied at negligible cost to irrigators that is why they do not treat water as a precious resource; therefore, there is a need to increase the water prices to make irrigators realize the importance of this asset.

Inspite of continuous efforts, the desired national targets have not been achieved. Low crop yields, decreasing fertility of lands, onslaught of water logging & salinity problems coupled with environmental degradation, improper water management, and miserable economic conditions of the farmers are the indicators that we have to work harder and go a long way to make improvements in agriculture sector through development and transfer of modern technologies of agricultural lands. However, to enhance optimum crop production per unit volume of water consumed, high yielding varieties should be introduced and better agronomic inputs (fertilizers and pesticides) should be applied on scientific basis. It is also recommended that the crops should be irrigated as per their requirements. The existing crop water requirements can theoretically be met by converting the existing irrigation system to crop consumptive use based system. This will allow water to be delivered at time of requirement and the amounts nearly matched to crop needs.

Farmer's organizations, water user associations, and private sector be involved in construction, operation, and maintenance of irrigation system. Such associations are conceived as a mechanism for creating a co-operative framework for improvement of watercourses.

Table. Scenario of water resources of the country

Surface water resources	**Annual water flow MAF**
Water available at canal head (1947)	67

Water available at canal head (1960)	85
Rim station flow (1997)	147
Water diverted to canals (1997)	106
Water flow to the sea (1997)	32
Losses in the river system	8.6
Ground water resources	MAF
Recharge to groundwater	55
Recharge to groundwater within canal command	48
Groundwater pumping	39

Water required in future			
Year	**Water required**	**Water available Surface + Ground**	**Shortage**
.	**MAF**	**MAF**	**MAF**
2000	149	109	40
2013	215	107	108
2025	277	126	151

Potential for water development per annum	
Water source	**MAF**
Surface water reservoir (Kalabagh, Basha, and Dassu)	17
Surface water reservoir (12 small dams sites proposed)	16
Water lost in canals and distributaries	21
Water lost in minors	5
Water lost in water courses	15
Groundwater	9
Sub-total	83

Agro-Ecological Regions of Pakistan

Basically,Pakistan has been divided into ten agro-ecological zones based on physiography, climate, land use and water availability.

Indus Delta

This zone extends from little south of Hyderabad to Arabian sea including Badin and Thatta.The mean monthly summer rainfall is 75 mm and winter rainfall less than 5 mm.

Southern Irrigated Plain

This represents lower indus plain in Sindh extending from Jacobabad to Dadu.The mean monthly summer rainfall is 18 mm in the north and 45 to 55 mm in the south.

Sandy Desert (a)

This zone includes vast sandy area of Thar-Cholistan.The maximum rainfall is 300 mm.

Sandy Desert (b)

This zone includes areas of Thal-Mianwali.The rainfall is between 300 and 350 mm.

Northern Irrigated Plain (a)

The area between two major rivers (doabs) of the Punjab (Jhelum and Sutlej) come under this zone.The mean annual rainfall is 300 to 500 mm in the east and 200 to 300 mm in the southwest.

Northern Irrigated Plain (b)

This zones includes alluvial valleys of Peshawar and Mardan. The mean monthly rainfall is 20 to 30 mm.

Barani Lands

It covers the salt range of Pothowar plateau and the himalyan piedmont plains, such as those of Attock, Rawalpindi, Bannu and Karak.In the North the mean monthly rainfall is 200 mm in summer and 35 to 50 mm in winter.The mean monthly rainfall is 85 mm in summer and 30 to 45 mm in winter.

Wet Mountains

This region contains high mountains as found in upper Hazara and Swat. The mean monthly rainfall is 235 mm in summer and 116 mm in winter.

Northern dry mountains

It includes Gilgit,Baltistan,Chitral and Dir valleys.The mean monthly rainfall is 25 to 75 mm in winter and 10 to 20 mm in summer.

Western dry mountains

This mountainous track extends from Bannu (NWFP) To Zhob, Pashin, Quetta and Kalat in Balochistan.Tribal area of Khurram and Waziristan area also fall in this zone.The mean monthly rainfall is 95 mm in summer and 63 to 95 mm in winter.

Dry Western Plateau

It extends from Chagai to the coastal area of Mekran.The mean monthly rainfall is 37 mm.

Sulaiman Piedmont

It extends from D.I Khan in NWFP to Dera Ghazi Khan in Punjab and Dera Bugti, Kachhi and Nasirabad in Balochistan.The mean monthly rainfall is less than 15 mm

Farming system

A farming system is an established way to operate a piece of land to raise crops, livestock or both and includes everything done on farm and outside the farm related to farm operations."

INTRODUCTION

A farming system is an established way to operate a piece of land to raise crops, livestock or both and includes everything done on farm and outside the farm related to farm operations.

CLASSIFICATION CRITERIA

The classification of farming systems is based on **2 main principles**;

(1) Available natural resources - includes land, water resources, climate, grazing areas etc.

(2) Dominant pattern of farm and household activities - such as crops, aquaculture, livestock, forestry, processing and off-farm activities etc.

There are many ways to categorize farming systems;

a) extensive and intensive farming systems

b) subsistence and commercial farming systems

c) dry and irrigated farming systems

d) individual and multiple farming systems

e) arable farming, livestock rearing and mixed farming

FACTORS INFLUENCING

THE CHOICE OF FARMING SYSTEMS IN PAKISTAN

1) SOIL - factors of soil including, texture, depth, slope, erosion, pH, fertility, mineral nutrients, alkalinity, salinity, acidity, drainage etc.

2) CLIMATE - temperature, precipitation, irrigation, solar radiations and photoperiod, humidity, winds, storms, air pollutants etc.

3) RESOURCES - factors like capital, labor, seed, fertilizers, inseticides, farm machinery, technology, storage facilities etc.

4) CAPABILITIES OF PLANTS AND ANIMALS - the genetic potentials and production of the selected animals and plants in relation to the selected place for setting up the farm

5) ECOLOGY - crops, pests, trees, animals, weeds, and diseases etc of the selected location for setting up the farm.

6) SOCIAL, POLITICAL AND ECONOMIC FACTORS - markets, agro-based industry in vicinity, consumer choice, demand, farm inputs and output prices, transportation, etc.

KINDS OF FARMING SYSTEMS

There are many different types of farming systems in the world based upon the above described classification criteria. A few important kinds are briefed here;

i) ARABLE FARMING

Farming system which includes production of only crops in the field and the related farm operation of cultural practices, harvesting, storage, transportation and marketing. It includes many different types of cropping systems.

ii) LIVESTOCK FARMING (PASTORAL FARMING SYSTEM)

The rearing of animals at farm for production of meat, milk and eggs and related farm operation of management like purchase of farm inputs, vaccination schemes and transport of the products to the market.

iii) POULTRY FARMING

The raising of chicken for meat and egg production in farms and associated management operations.

iv) INTENSIVE FARMING

In this system multiple cropping system and raising of more livestock is carried out at the same time in one calender year in order to get maximum output from the land and labour resources. There is efficient utilization of solar energy and available resources at the farm to get the maximum yield.

v) EXTENSIVE FARMING

In this system extensive land is used for the farming, with minimum expenditure of on attention to efficient use of the other resources. Yields per unit area of land are usually low. The purpose of such farming system is to get the maximum output from the scarce resource e.g., water, labour, fertilizer.

vi) DIVERSIFIED FARMING

In this system a wide spectrum of crops are cultivated and many different types of animals are raised.

vii) SUBSISTENCE FARMING

The farming system the basic objective is to fulfil the requirements of food, clothing and shelter of the farming family. It is common in developing countries due to small land holdings of the farmers.

viii) COMMERCIAL FARMING

The farming system in which objective is commercial scale production of farm products including crop and livestock products (milk, meat, eggs).

ix) TRUCK FARMING

The objective of such farming system is to produce one or two main types of crops or livestock to transport the products to the nearby markets or agro-based industry. The products are produced in bulk and marketed.

x) DRY / RAINFED FARMING

Farming system in which crop cultivation and rearing of livestock is carried out in areas with low rainfall and no irrigation facilities. The yields are largely affected by water availability. The objective of such system is to conserve moisture and get maximum possible income and output from the available rainfall or water.

xi) URBAN BASED FARMING SYSTEM

In large towns and cities, intensive production of perishable high value commodities such as fresh vegetables is being carried out. This is a commercial system with high levels of inputs (fertilizers, pesticides etc.) and links to the both rural and urban areas.

xii) ARID FARMING SYSTEM

This system depends on irrigation water for raising of crops and rearing of animals in the farm. This system in Pakistan is dependant upon the large and diverse canal system of Indus rivers and its tributires which irrigate vastness of plains of Punjab, Khyber Pakhtunkhwa, Sindh and small area of Balochistan.

xiii) OTHER FARMING SYSTEMS IN PAKISTAN

There are numerous other examples of farming systems like;

a) Agri-pastoral farming system (crops + livestock farming)

b) Fruit Farming (orchards)

c) Mountain Farming (contour plantations)

d) Grassland Farming (fodder production for livestock farming)

e) Fish Farming (raising of fish and associated farm enterprises) etc.

TILLAGE

DEFINATION:

"Tillage is defined as, the mechanical manipulation of the soil aimed at improving its physical condition or **tilth."**

Tillage can also be described as the practice of modifying the state of soil in order to provide conditions favorable to crop growth.

Tillage can also be defined as, the physical manipulation of soil, and it is intended to destroy weeds, incorporate crop residues and amendments into soil, increase infiltration and reduce evaporation, prepare seedbed and break hard layers to facilitate root penetration.

In general, tillage is a group of field operations carried out in the process of field crop production, the main purpose of which is to increase crop yield and to prevent yield or economic losses by reducing the costs of production. Tillage practices differ from one area to another depending upon soil type, cropping pattern, soil moisture (rainfed), and climatic factor.

AIMS OF TILLAGE:

1. Production of a suitable tilth, or soil structure.
2. Control of weeds
3. Control of soil moisture
4. Incorporation of organic matter (manures and fertilizers), and agrochemicals for weed and pest control.

Objectives of tillage:

There are several major objectives of tillage.

1. Improve soil tilth and prepare a seedbed.
2. Manipulate plant residues and farm wastes.
3. Manage water and air in the soil.
4. Control weeds and soil borne insect pests and diseases.
5. Establish a surface layer which prevents wind and soil erosion.

These are discussed below:

PREPARATION OF SEEDBED:

The desirable characteristics of a seed bed are:

1. Weed-free soil, which prevents the loss of precious water and plant nutrients to weeds.

2. Granular soil structure, which allows close contact of the seed and the plant roots with soil particles. It also facilitates penetration of air and water. Different soil types require different management to produce a seedbed of desirable tilth.
3. Soil free of compacted layers, which reduce air and water penetration and inhibit root development.
4. Generally level soil surface which facilitates planting seeds at a uniform depth and is especially important for proper water management in irrigated areas.

There are many methods of seedbed preparation. As the number of acres farmed by one person and the cropping intensity increase, there is an increasing demand for more efficient tillage management.

MANIPULATION OF PLANT RESIDUES AND FARM WASTES:

In some areas virtually all of the plant residues such as straw, stubble, fodder, and even roots are utilized for animal feed and fuel. However, with some crops there is a good deal of crop residue left in the field which, if buried in the soil, can increase its organic matter content.
Incorporation of organic matter into the soil results in:
(a) Increased soil infertility.
(b) Increased water penetration and water-holding capacity.
(c) Enhanced soil microbial activities.
However, the problem of how and when to handle crop residues must be addressed.

Decaying organic matter ties up the soil nitrogen supply for sometime, so a small quantity of chemical nitrogen fertilizer should be added to the soil. The presence of straw or crop residue causes mechanical problems in the irrigated areas, especially in cereal farming, as the straw and stubble clog the tillage implements and seedling drills. In rainfed areas, however, leaving some straw in the field as straw mulch is desirable for conserving soil moisture and preventing wind and water erosion.

MANAGING WATER IN THE SOIL:

Tillage practices vary widely depending on the soil type, climatic regions, and crops. In irrigated areas tillage operations are mainly directed at destroying weeds, stubble, and systems of previous crops and improving the physical condition of the soil for proper seedbed preparation. Tillage plays an important role in irrigated areas. Field must be level and smooth with proper slope and drainage. Sometimes beds are prepared for growing various crops; this allows for both irrigation and drainage.

In areas of low rainfall, and where crops are produced under rainfed conditions, the main need is to conserve soil moisture and reduce evaporation and soil erosion. In semiarid areas of Pakistan, water management is critical. Limited moisture for crop growth is often the major limiting factor for crop yields. Successful tillage systems and practices have recently been developed specifically for proper moisture conservation in the rainfed areas and a large array of tillage implements has been tested.

Farmer of the barani areas normally do 8-10 shallow ploughings with a cultivator for moisture conservation of rainwater. But instead of rain moisture conservation, these excessive shallow ploughings cause compaction, and a hardpan is developed, they not only restrict water infiltration deep into the soil profile, but also restrict the penetrating roots searching for moisture and nutrients. Thus crop growth and development are affected. One deep ploughing with a mouldboard plough before the onset of the summer monsoon rains as primary tillage, and two ploughings with a cultivator along with planking just before the end of monsoon rains are the best tillage systems for better moisture conservation. This system is also effective for termite and weed control for the coming rabi season crops such as wheat, barley, lentil, and chickpea. Since dryland farming often involves large areas of open land, this is the area where large machines are most efficiently used.

CONTROLLING WEEDS:

For many centuries, little was done to control or eliminate weeds. A lot of backbreaking manual labor was developed to weed control but with little success. Nowdays, with the use of mechanical tillage practices, weeds can be controlled effectively and economically. However, chemical weed control through various herbicides is also being practiced successfully.

PREVENTING WIND AND WATER EROSION:

Since the semiarid lands are rainfed areas and are often subject to wind and water erosion, an acceptable and appropriate tillage system must provide for soil erosion prevention and control. For example, one mouldboard ploughing with planking followed by two ploughings with a cultivator and planking will create rough soil surfaces containing clods from .5-5 cm which will help control both wind and water erosion. The excessive ploughings done by barani farmers will destroy the soil structure resulting in soil and water erosion.

EFFECT OF TILLAGE ON SOIL CONDITIONS:

Some of the main effects of tillage are discussed in the following paragraphs :

EFFECT ON SOIL MOISTURE:

Tillage practices and systems have been developed to facilitate water penetration into the soil and increase the amount of water retained for crop use later. The higher moisture content with the mouldboard plough indicates that better water infiltration deeper into the soil profile resulted from loosening of the compact layer. This tillage method is preferable to continous shallow ploughing with a cultivator.

It is unfortunate that many farmers either do not understand the concept of moisture conservation and tillage and its importance, or they do not have the equipment required to do the job properly. Excessive shallow tillage operations result in increased soil compaction which restrict root growth, impedes air exchange, and also create problems in soil drainage.

The soil contains not more but less water, and its physical structure is broken down. This prevents water infiltration and encourages soil erosion.

SOIL WATER RETENTION:

The pore size distribution resulting from loosening the soil effects its ability to retain moisture against applied suction as well as its water transmission characteristics. Tillage also affects soil water retention by changing surface tension, infiltration and redistribution, and evaporation of water from soil. However, the direction, duration, and the magnitude of effect depends upon pre-tillage operations and climatic conditions.

The rough soil surface and depressions caused by tillage decrease runoff. Retention of rainwater in surface depressions increases the time available for water to percolate into the soil and, thus, water intake into the soil. This results in storing part of the rainwater in the soil profile. The nature and magnitude of soil surface roughness differs with soil type, implement used, the number of ploughing passes, and the moisture status at which the tillage operations are performed. The effectiveness of the rough surface also depends on the intensity and the amount of precipitation and the stability of soil aggregates. Soil with less stable aggregates on the surface is readily dispersed by high intensity rains, which reduces infiltration and increase runoff and potential soil loss.

INFILTRATION:

Apart from prolonged retention in depressions, tillage also enhances infiltrations of water if large voids are produced in a soil layer that is impeding infiltration, and if these voids are maintained for sufficient time. Tillage must penetrate the limiting layer completely, otherwise only surface storage is increased. Hendreson (1979) stated that the major factor determining the effect of tillage in infiltration was the structural stability of soil. In structurally unstable soils, the surface layer that slakes repeatedly under wetting and drying becomes relatively impervious, limiting infiltration.

EFFECT ON SOIL STRUCTURE:

Tillage directly affects the roughness and bulk density of the soil. These factors in turn directly affect water infiltration, crusting, and compaction, which in turn affect seedling emergence, root development, and nutrient uptake. The immediate effect of tillage is to loosen the soil and decrease its bulk density. Different tillage practices produce different bulk densities, and alteration in the bulk density of soil changes its porosity, inter-particle contact, and volume of water content. Changes in bulk density changes the fraction of all three soil components, (mineral matter, organic matter, and water)

EFFECT ON SOIL TEMPERATURE:

Research has shown that different tillage practices result in differences in soil temperature. For example, straw or stubble mulch usually decreases soil temperature. This may be advantage in the fall season, allowing earlier seeding and promoting profuse tillering of wheat and barley. In the spring, however, it may be disadvantage when seeding would be delayed or when the growth of fall-seeded crops would be retarded.

EFFECT ON EVAPORATION:

Evaporation from the soil is a major pathway of water loss created by tillage. Surface roughness caused by loosening of the upper soil layer by tillage increases the area of soil exposed to the atmosphere and allows greater penetration of wind. This results in increased evaporation from tilled compared with untilled soil. Soil mulch and straw mulch tillage systems reduce these evaporation looses, which is extremely important in rainfed agriculture.

EFFECT ON SOIL NUTRIENT UPTAKE:

Nitrogen (N) is probably the nutrient most affected by tillage, although both phosphorus (P) and potassium (K) are also influenced. Incorporation of organic matter and changes in the amount and location of soil water are the factors that cause most of the fluctuation in nutrient levels. The tillage effect can either be positive or negative for a given time and set of agro-climate conditions. Warm moist soil has greater microorganism activity, which result in greater mineralization on N, and in turn result in its higher uptake by plants (Standford et al.1973).

TILLAGE IMPLEMENTS

A variety of tillage implements are used to weaken soil strength, reduce compaction, and allow the free movement of air and water in order to promote plant growth. A wide array of different tillage implements are used in the country for primary tillage and seedbed preparation and for crops. These tillage implements range from the light animal-drawn desi plough to heavy implement drawn by high -powered tractors. Different tillage implements have been designed and are used for various operations depending on the kind of soil types of cropping, and agro-climatic conditions. These include the mouldboard plough, disc plough ,disc harrow, chisel, subsoiler, practices. The farmer has to consider both energy requirement and tilth conditions all the tillage implements are of great importance when considering their effects on crops production.

SEED

A **seed** is a small embryonic plant enclosed in a covering called the seed coat, usually with some stored food. It is the product of the ripened ovule of gymnosperm and angiosperm plants which occurs after fertilization and some growth within the mother plant. The formation of the seed completes the process of reproduction in seed plants (started with the development of flowers and pollination), with the embryo developed from the zygote and the seed coat from the integuments of the ovule. All seeds are different size, shape and color.

Seeds have been an important development in the reproduction and spread of flowering plants, relative to more primitive plants such as mosses, ferns and liverworts, which do not have seeds and use other means to propagate themselves. This can be seen by the success of seed plants (both gymnosperms and angiosperms) in dominating biological niches on land, from forests to grasslands both in hot and cold climates.

The term "seed" also has a general meaning that antedates the above—anything that can be sown, e.g. "seed" potatoes, "seeds" of cornor sunflower "seeds". In the case of sunflower and corn "seeds", what is sown is the seed enclosed in a shell or husk, whereas the potato is a tuber.

A typical seed includes three basic parts: (1) an embryo, (2) a supply of nutrients for the embryo, and (3) a seed coat.

The embryo is an immature plant from which a new plant will grow under proper conditions. The embryo has one cotyledon or seed leaf in monocotyledons, two cotyledons in almost all dicotyledons and two or more in gymnosperms. The radicle is the embryonic root. The plumule is the embryonic shoot. The embryonic stem above the point of attachment of the cotyledon(s) is the epicotyl. The embryonic stem below the point of attachment is the hypocotyl.

Within the seed, there usually is a store of nutrients for the seedling that will grow from the embryo. The form of the stored nutrition varies depending on the kind of plant. In angiosperms, the stored food begins as a tissue called the endosperm, which is derived from the parent plant via double fertilization. The usually triploid endosperm is rich in oil or starch, and protein. In gymnosperms, such as conifers, the food storage tissue (also called endosperm) is part of the female gametophyte, a haploid tissue. In some species, the embryo is embedded in the endosperm or female gametophyte, which the seedling will use upon germination. In others, the endosperm is absorbed by the embryo as the latter grows within the developing seed, and the cotyledons of the embryo become filled with this stored food. At maturity, seeds of these species have no endosperm and are termed exalbuminous seeds. Some exalbuminous seeds are bean, pea, oak, walnut, squash, sunflower, and radish. Seeds with an endosperm at maturity are termed albuminous seeds. Most monocots (e.g. grasses and palms) and many dicots (e.g. Brazil nut and castor bean) have albuminous seeds. All gymnosperm seeds are albuminous.

The seed coat (the testa) develops from the tissue, the integument, originally surrounding the ovule. The seed coat in the mature seed can be a paper-thin layer (e.g. peanut) or something more substantial (e.g. thick and hard in honey locust and coconut, or fleshy as in the sarcotesta of pomegranate). The seed coat helps protect the embryo from mechanical injury and from drying out.

In addition to the three basic seed parts, some seeds have an appendage on the seed coat such an aril (as in yew and nutmeg) or an elaiosome (as in Corydalis) or hairs (as in cotton). A scar also may remain on the seed coat, called the hilum, where the seed was attached to the ovary wall by the funiculus.

Kinds of seeds

Many structures commonly referred to as "seeds" are actually dry fruits. Sunflower seeds are sold commercially while still enclosed within the hard wall of the fruit, which must be split open to reach the seed. Different groups of plants have other modifications, the so-called stone fruits (such as the peach) have a hardened fruit layer (the endocarp) fused to and surrounding the actual seed. Nuts are the one-seeded, hard-shelled fruit of some plants with an indehiscent seed, such as an acorn or hazelnut.

Seed production

Immature elm seeds

Seeds are produced in several related groups of plants, and their manner of production distinguishes the angiosperms ("enclosed seeds") from the gymnosperms ("naked seeds"). Angiosperm seeds are produced in a hard or fleshy structure called a fruit that encloses the seeds, hence the name. (Some fruits have layers of both hard and fleshy material). In gymnosperms, no special structure develops to enclose the seeds, which begin their development "naked" on the bracts of cones. However, the seeds do become covered by the cone scales as they develop in some species of conifer.

Seed production in natural plant populations vary widely from year-to-year in response to weather variables, insects and diseases, and internal cycles within the plants themselves. Over a 20-year period, for example, forests composed of loblolly pine and shortleaf pine produced from 0 to nearly 5 million sound pine seeds per hectare. Over this period, there were six bumper, five poor, and nine good seed crops, when evaluated in regard to producing adequate seedlings for natural forest reproduction.

1) Endosperm; 2) Zygote; 3) Embryo; 4) Suspensor; 5) Cotyledons; 6) Shoot Apical Meristem; 7) Root Apical Meristem; 8) Radicle; 9) Hypocotyl; 10) Epicotyl; 11) Seed Coat

The inside of a Ginkgo seed, showing a well-developed embryo, nutritive tissue (megagametophyte), and a bit of the surrounding seed coat

Diagram of the internal structure of a dicot seed and embryo: (a) seed coat, (b) endosperm, (c) cotyledon, (d) hypocotyl

The seed, which is an embryo with two points of growth (one of which forms the stem, the other the roots) is enclosed in a seed coat with some food reserves.

Angiosperm seeds consist of three genetically distinct constituents: (1) the embryo formed from the zygote, (2) the endosperm, which is normally triploid, (3) the seed coat from tissue derived from the maternal tissue of the ovule. In angiosperms, the process of seed development begins with double fertilization and involves the fusion of the egg and sperm nuclei into a zygote. The second part of this process is the fusion of the polar nuclei with a second sperm cell nucleus, thus forming a primary endosperm. Right after fertilization, the zygote is mostly inactive, but the primary endosperm divides rapidly to form the endosperm tissue. This tissue becomes the food the young plant will consume until the roots have developed after germination. The seed coat forms from the two integuments or outer layers of cells of the ovule, which derive from tissue from the mother plant, the inner integument forms the tegmen and the outer forms the testa. When the seed coat forms from only one layer, it is also called the testa, though not all such testae are homologous from one species to the next.

In gymnosperms, the two sperm cells transferred from the pollen do not develop seed by double fertilization, but one sperm nucleus unites with the egg nucleus and the other sperm is not used. Sometimes each sperm fertilizes an egg cell and one zygote is then aborted or absorbed during early development. The seed is composed of the embryo (the result of fertilization) and tissue from the mother plant, which also form a cone around the seed in coniferous plants such as pine and spruce.

The ovules after fertilization develop into the seeds; the main parts of the ovule are the funicle; which attaches the ovule to the placenta, the nucellus; the main region of the ovule where the megagametophyte develops, the micropyle; a small pore or opening in the ovule where the pollen tube usually enters during the process of fertilization, and the chalaza; the base of the ovule opposite the micropyle, where integument and nucellus are joined together.

The shape of the ovules as they develop often affects the final shape of the seeds. Plants generally produce ovules of four shapes: the most common shape is called anatropous, with a curved shape. Orthotropous ovules are straight with all the parts of the ovule lined up in a long row producing an uncurved seed. Campylotropous ovules have a curved megagametophyte often giving the seed a tight "C" shape. The last ovule shape is called amphitropous, where the ovule is partly inverted and turned back 90 degrees on its stalk (the funiculus).

In the majority of flowering plants, the zygote's first division is transversely oriented in regards to the long axis, and this establishes the polarity of the embryo. The upper or chalazal pole becomes the main area of growth of the embryo, while the lower or micropylar pole produces the stalk-like suspensor that attaches to the micropyle. The suspensor absorbs and manufacturers nutrients from the endosperm that are used during the embryo's growth.

The embryo is composed of different parts; the epicotyl will grow into the shoot, the radicle grows into the primary root, the hypocotyl connects the epicotyle and the radicle, the cotyledons form the seed leaves. Monocotyledonous plants have other structures; instead of the hypocotyle-epicotyle, it has a coleoptile that forms the first leaf and connects to the coleorhiza that connects to the primary root and adventitious roots form from the sides. The seeds of corn are constructed with these structures; pericarp, scutellum (single large cotyledon) that absorbs nutrients from the endosperm, endosperm, plumule, radicle, coleoptile and coleorhiza—these last two structures are sheath-like and enclose the plumule and radicle, acting as a protective covering. The testae or seed coats of both monocots and dicots are often marked with patterns and textured markings, or have wings or tufts of hair.

Seed size and seed set.

A collection of various vegetable and herb seeds

Seeds are very diverse in size. The dust-like orchid seeds are the smallest, with about one million seeds per gram; they are often embryonic seeds with immature embryos and no significant energy reserves. Orchids and a few other groups of plants are mycoheterotrophs which depend on mycorrhizal fungi for nutrition during germination and the early growth of the seedling. Some terrestrial orchid seedlings, in fact, spend the first few years of their lives deriving energy from the fungi and do not produce green leaves. At over 20 kg, the largest seed is the coco de mer. Plants that produce smaller seeds can generate many more seeds per flower, while plants with larger seeds invest more resources into those seeds and normally produce fewer seeds. Small seeds are quicker to ripen and can be dispersed sooner, so fall blooming plants often have small seeds. Many annual plants produce great quantities of smaller seeds; this helps to ensure at least a few will end in a favorable place for growth. Herbaceous perennials and woody plants often have larger seeds; they can produce seeds over many years, and larger seeds have more energy reserves for germination and seedling growth and produce larger, more established seedlings after germination.

Seed functions

Seeds serve several functions for the plants that produce them. Key among these functions are nourishment of the embryo, dispersal to a new location, and dormancy during unfavorable conditions. Seeds fundamentally are means of reproduction, and most seeds are the product of sexual reproduction which produces a remixing of genetic material and phenotype variability on which natural selection acts.

Embryo nourishment

Seeds protect and nourish the embryo or young plant. They usually give a seedling a faster start than a sporeling from a spore, because of the larger food reserves in the seed and the multicellularity of the enclosed embryo.

Seed dispersal

Unlike animals, plants are limited in their ability to seek out favorable conditions for life and growth. As a result, plants have evolved many ways to disperse their offspring by dispersing their seeds (see also vegetative reproduction). A seed must somehow "arrive" at a location and be there at a time favorable for germination and growth. When the fruits open and release their seeds in a regular way, it is called dehiscent, which is often distinctive for related groups of plants; these fruits include capsules, follicles, legumes, silicles and siliques. When fruits do not open and release their seeds in a regular fashion, they are called indehiscent, which include the fruits achenes, caryopsis, nuts, samaras, and utricles.

Seed dispersal is seen most obviously in fruits; however, many seeds aid in their own dispersal. Some kinds of seeds are dispersed while still inside a fruit or cone, which later opens or disintegrates to release the seeds. Other seeds are expelled or released from the fruit prior to dispersal. For example, milkweeds produce a fruit type, known as a follicle, that splits open along one side to release the seeds. Iris capsules split into three "valves" to release their seeds.

By wind (anemochory)

Dandelion seeds are contained within achenes, which can be carried long distances by the wind.

The seed pod of milkweed (Asclepias syriaca)

Some seeds (e.g., pine) have a wing that aids in wind dispersal.

The dustlike seeds of orchids are carried efficiently by the wind.

Some seeds, (e.g. milkweed, poplar) have hairs that aid in wind dispersal.
Other seeds are enclosed in fruit structures that aid wind dispersal in similar ways:
Dandelion achenes have hairs.
Maple samaras have two wings.

By water (hydrochory)

Some plants, such as Mucuna and Dioclea, produce buoyant seeds termed sea-beans or drift seeds because they float in rivers to the oceans and wash up on beaches.

By animals (zoochory)

Seeds (burrs) with barbs or hooks (e.g. acaena, burdock, dock) which attach to animal fur or feathers, and then drop off later.

Seeds with a fleshy covering (e.g. apple, cherry, juniper) are eaten by animals (birds, mammals, reptiles, fish) which then disperse these seeds in their droppings.

Seeds (nuts) are attractive long-term storable food resources for animals (e.g. acorns, hazelnut, walnut); the seeds are stored some distance from the parent plant, and some escape being eaten if the animal forgets them.

Myrmecochory is the dispersal of seeds by ants. Foraging ants disperse seeds which have appendages called elaiosomes (e.g. bloodroot, trilliums, Acacias, and many species of Proteaceae). Elaiosomes are soft, fleshy structures that contain nutrients for animals that eat them. The ants carry such seeds back to their nest, where the elaiosomes are eaten. The remainder of the seed, which is hard and inedible to the ants, then germinates either within the nest or at a removal site where the seed has been discarded by the ants.This dispersal relationship is an example of mutualism, since the plants depend upon the ants to disperse seeds, while the ants depend upon the plants seeds for food. As a result, a drop in numbers of one partner can reduce success of the other. In South Africa, the Argentine ant (Linepithema humile) has invaded and displaced native species of ants. Unlike the native ant species, Argentine ants do not collect the seeds of Mimetes cucullatus or eat the elaiosomes. In areas where these ants have invaded, the numbers of Mimetes seedlings have dropped.

Seed dormancy

Seed dormancy has two main functions: the first is synchronizing germination with the optimal conditions for survival of the resulting seedling; the second is spreading germination of a batch of seeds over time so a catastrophe after germination (e.g. late frosts, drought, herbivory) does not result in the death of all offspring of a plant (bet-hedging). Seed dormancy is defined as a seed failing to germinate under environmental conditions optimal for germination, normally when the environment is at a suitable temperature with proper soil moisture. This true dormancy or innate dormancy is therefore caused by conditions within the seed that prevent germination. Thus dormancy is a state of the seed, not of the environment. Induced dormancy, enforced dormancy or seed quiescence occurs when a seed fails to germinate because the external environmental conditions are inappropriate for germination, mostly in response to conditions being too dark or light, too cold or hot, or too dry.

Seed dormancy is not the same as seed persistence in the soil or on the plant, though even in scientific publications dormancy and persistence are often confused or used as synonyms.

Often, seed dormancy is divided into four major categories: exogenous; endogenous; combinational; and secondary. A more recent system distinguishes five classes: morphological, physiological, morphophysiological, physical and combinational dormancy.
Exogenous dormancy is caused by conditions outside the embryo, including:
Physical dormancy or hard seed coats occurs when seeds are impermeable to water. At dormancy break, a specialized structure, the 'water gap', is disrupted in response to environmental cues, especially temperature, so water can enter the seed and germination can occur. Plant families where physical dormancy occurs include Anacardiaceae, Cannaceae, Convulvulaceae, Fabaceae and Malvaceae.
Chemical dormancy considers species that lack physiological dormancy, but where a chemical prevents germination. This chemical can be leached out of the seed by rainwater or snow melt or be deactivated somehow. Leaching of chemical inhibitors from the seed by rain water is often cited as an important cause of dormancy release in seeds of desert plants, but little evidence exists to support this claim.
Endogenous dormancy is caused by conditions within the embryo itself, including:
In morphological dormancy, germination is prevented due to morphological characteristics of the embryo. In some species, the embryo is just a mass of cells when seeds are dispersed; it is not differentiated. Before germination can take place, both differentiation and growth of the embryo have to occur. In other species, the embryo is differentiated but not fully grown (underdeveloped) at dispersal, and embryo growth up to a species specific length is required before germination can occur. Examples of plant families where morphological dormancy occurs are Apiaceae, Cycadaceae, Liliaceae, Magnoliaceae and Ranunculaceae.
Morphophysiological dormancy includes seeds with underdeveloped embryos, and also have physiological components to dormancy. These seeds, therefore, require a dormancy-breaking treatments, as well as a period of time to develop fully grown embryos. Plant families where morphophysiological dormancy occurs include Apiaceae, Aquifoliaceae, Liliaceae, Magnoliaceae, Papaveraceae and Ranunculaceae. Some plants with morphophysiological dormancy, such as Asarum or Trillium species, have multiple types of dormancy, one affects radicle (root) growth, while the other affects plumule (shoot) growth. The terms "double dormancy" and "two-year seeds" are used for species whose seeds need two years to complete germination or at least two winters and one summer. Dormancy of the radicle (seedling root) is broken during the first winter after dispersal while dormancy of the shoot bud is broken during the second winter.
Physiological dormancy means the embryo, due to physiological causes, cannot generate enough power to break through the seed coat, endosperm or other covering structures. Dormancy is typically broken at cool wet, warm wet or warm dry conditions. Abscisic acid is usually the growth inhibitor in seeds, and its production can be affected by light.
Drying, in some plants, including a number of grasses and those from seasonally arid regions, is needed before they will germinate. The seeds are released, but need to have a lower moisture content before germination can begin. If the seeds remain moist after dispersal, germination can be delayed for many months or even years. Many herbaceous plants from temperate climate zones have physiological dormancy that disappears with drying of the seeds. Other species will germinate after dispersal only under very narrow temperature ranges, but as the seeds dry, they are able to germinate over a wider temperature range.

In seeds with combinational dormancy, the seed or fruit coat is impermeable to water and the embryo has physiological dormancy. Depending on the species, physical dormancy can be broken before or after physiological dormancy is broken.

Secondary dormancy is caused by conditions after the seed has been dispersed and occurs in some seeds when nondormant seed is exposed to conditions that are not favorable to germination, very often high temperatures. The mechanisms of secondary dormancy are not yet fully understood, but might involve the loss of sensitivity in receptors in the plasma membrane.

The following types of seed dormancy do not involve seed dormancy, strictly speaking, as lack of germination is prevented by the environment, not by characteristics of the seed itself (see Germination):

Photodormancy or light sensitivity affects germination of some seeds. These photoblastic seeds need a period of darkness or light to germinate. In species with thin seed coats, light may be able to penetrate into the dormant embryo. The presence of light or the absence of light may trigger the germination process, inhibiting germination in some seeds buried too deeply or in others not buried in the soil.

Thermodormancy is seed sensitivity to heat or cold. Some seeds, including cocklebur and amaranth, germinate only at high temperatures (30°C or 86°F); many plants that have seeds that germinate in early to midsummer have thermodormancy, so germinate only when the soil temperature is warm. Other seeds need cool soils to germinate, while others, such as celery, are inhibited when soil temperatures are too warm. Often, thermodormancy requirements disappear as the seed ages or dries.

Not all seeds undergo a period of dormancy. Seeds of some mangroves are viviparous; they begin to germinate while still attached to the parent. The large, heavy root allows the seed to penetrate into the ground when it falls. Many garden plant seeds will germinate readily as soon as they have water and are warm enough; though their wild ancestors may have had dormancy, these cultivated plants lack it. After many generations of selective pressure by plant breeders and gardeners, dormancy has been selected out.

For annuals, seeds are a way for the species to survive dry or cold seasons. Ephemeral plants are usually annuals that can go from seed to seed in as few as six weeks.

Seed persistence and seed banks

Further information: Seed hibernation

Seed germination

Germinating sunflower seedlings.

Seed germination is a process by which a seed embryo develops into a seedling. It involves the reactivation of the metabolic pathways that lead to growth and the emergence of the radicle or seed root and plumule or shoot. The emergence of the seedling above the soil surface is the next phase of the plant's growth and is called seedling establishment.

Three fundamental conditions must exist before germination can occur. (1) The embryo must be alive, called seed viability. (2) Any dormancy requirements that prevent germination must be overcome. (3) The proper environmental conditions must exist for germination.

Seed viability is the ability of the embryo to germinate and is affected by a number of different conditions. Some plants do not produce seeds that have functional complete embryos, or the seed may have no embryo at all, often called empty seeds. Predators and pathogens can damage or kill the seed while it is still in the fruit or after it is dispersed. Environmental conditions like flooding or heat can kill the seed before or during germination. The age of the seed affects its health and germination ability: since the seed has a living embryo, over time cells die and cannot be replaced. Some seeds can live for a long time before germination, while others can only survive for a short period after dispersal before they die.

Seed vigor is a measure of the quality of seed, and involves the viability of the seed, the germination percentage, germination rate and the strength of the seedlings produced.

The germination percentage is simply the proportion of seeds that germinate from all seeds subject to the right conditions for growth. The germination rate is the length of time it takes for the seeds to germinate. Germination percentages and rates are affected by seed viability, dormancy and environmental effects that impact on the seed and seedling. In agriculture and horticulture quality seeds have high viability, measured by germination percentage plus the rate of germination. This is given as a percent of germination over a certain amount of time, 90% germination in 20 days, for example. 'Dormancy' is covered above; many plants produce seeds with varying degrees of dormancy, and different seeds from the same fruit can have different degrees of dormancy. It's possible to have seeds with no dormancy if they are dispersed right away and do not dry (if the seeds dry they go into physiological dormancy). There is great variation amongst plants and a dormant seed is still a viable seed even though the germination rate might be very low.

Environmental conditions effecting seed germination include; water, oxygen, temperature and light.

Three distinct phases of seed germination occur: water imbibition; lag phase; and radicle emergence.

In order for the seed coat to split, the embryo must imbibe (soak up water), which causes it to swell, splitting the seed coat. However, the nature of the seed coat determines how rapidly water can penetrate and subsequently initiate germination. The rate of imbibition is dependent on the permeability of the seed coat, amount of water in the environment and the area of contact the seed has to the source of water. For some seeds, imbibing too much water too quickly can kill the seed. For some seeds, once water is imbibed the germination process cannot be stopped, and drying then becomes fatal. Other seeds can imbibe and lose water a few times without causing ill effects, but drying can cause secondary dormancy.

A number of different strategies are used by gardeners and horticulturists to break seed dormancy.

Scarification allows water and gases to penetrate into the seed; it includes methods to physically break the hard seed coats or soften them by chemicals, such as soaking in hot water or poking holes in the seed with a pin or rubbing them on sandpaper or cracking with a press or hammer. Soaking the seeds in solvents or acids is also effective for many seeds. Sometimes fruits are harvested while the seeds are still immature and the seed coat is not fully developed and sown right away before the seed coat become impermeable. Under natural conditions, seed coats are worn down by rodents chewing on the seed, the seeds rubbing against rocks (seeds are moved by the wind or water currents), by undergoing freezing and thawing of surface water, or passing through an animal's digestive tract. In the latter case, the seed coat protects the seed from digestion, while often weakening the seed coat such that the embryo is ready to sprout when it gets deposited (along with a bit of fertilizer) far from the parent plant. Microorganisms are often effective in breaking down hard seed coats and are sometimes used by people as a treatment; the seeds are stored in a moist warm sandy medium for several months under non sterile conditions.

Stratification, also called moist-chilling, breaks down physiological dormancy, and involves the addition of moisture to the seeds so they imbibe water, and they are then sublected to a period of moist chilling to after-ripen the embryo. Sowing outside in late summer and fall and allowing to over winter outside under cool conditions is an effective way to stratify seeds; some seeds respond more favorably to periods of oscillating temperatures which are part of the natural environment.

Leaching or the soaking in water removes chemical inhibitors in some seeds that prevent germination. Rain and melting snow naturally accomplish this task. For seeds planted in gardens, running water is best—if soaked in a container, 12 to 24 hours of soaking is sufficient. Soaking longer, especially in stagnant water, can result in oxygen starvation and seed death. Seeds with hard seed coats can be soaked in hot water to break open the impermeable cell layers that prevent water intake.

Other methods used to assist in the germination of seeds that have dormancy include prechilling, predrying, daily alternation of temperature, light exposure, potassium nitrate, the use of plant growth regulators, such as gibberellins, cytokinins, ethylene, thiourea, sodium hypochlorite, and others. Some seeds germinate best after a fire. For some seeds, fire cracks hard seed coats, while in others, chemical dormancy is broken in reaction to the presence of smoke. Liquid smoke is often used by gardeners to assist in the germination of these species.

Sterile seeds

Seeds may be sterile for few reasons: they may have been irradiated, unpollinated, cells lived past expectancy, or bred for the purpose.

Origin and evolution

The origin of seed plants is a problem that still remains unsolved. However, more and more data tends to place this origin in the middle Devonian. The description in 2004 of the proto-seed Runcaria heinzelinii in the Givetian of Belgium is an indication of that ancient origin of seed-plants. As with modern ferns, most land plants before this time reproduced by sending spores into the air, that would land and become whole new plants.

The first "true" seeds are described from the upper Devonian, which is probably the theater of their true first evolutionary radiation. The seed plants progressively became one of the major elements of nearly all ecosystems.

Economic importance

A variety of bean seeds.

Edible seeds

Further information: List of edible seeds

Many seeds are edible and the majority of human calories comes from seeds, especially from cereals, legumes and nuts. Seeds also provide most cooking oils, many beverages and spices and some important food additives. In different seeds the seed embryo or the endosperm dominates and provides most of the nutrients. The storage proteins of the embryo and endosperm differ in their amino acid content and physical properties. For example the gluten

of wheat, important in providing the elastic property to bread dough is strictly an endosperm protein.
Seeds are used to propagate many crops such as cereals, legumes, forest trees, turfgrasses and pasture grasses. Particularly in developing countries, a major constraint faced is the inadequacy of the marketing channels to get the seed to poor farmers. Thus the use of farmer-retained seed remains quite common.
Seeds are also eaten by animals, and are fed to livestock. Many seeds are used as birdseed.

Poison and food safety

While some seeds are edible, others are harmful, poisonous or deadly. Plants and seeds often contain chemical compounds to discourage herbivores and seed predators. In some cases, these compounds simply taste bad (such as in mustard), but other compounds are toxic or break down into toxic compounds within the digestive system. Children, being smaller than adults, are more susceptible to poisoning by plants and seeds.
A deadly poison, ricin, comes from seeds of the castor bean. Reported lethal doses are anywhere from two to eight seeds,though only a few deaths have been reported when castor beans have been ingested by animals.
In addition, seeds containing amygdalin—apple, apricot, bitter almond, peach, plum, cherry, quince, and others—when consumed in sufficient amounts, may cause cyanide poisoning. Other seeds that contain poisons include annona, cotton, custard apple, datura, uncooked durian, golden chain, horse-chestnut, larkspur, locoweed, lychee, nectarine, rambutan, rosary pea, sour sop, sugar apple, wisteria, and yew. The seeds of the strychnine tree are also poisonous, containing the poison strychnine.
The seeds of many legumes, including the common bean (Phaseolus vulgaris), contain proteins called lectins which can cause gastric distress if the beans are eaten without cooking. The common bean and many others, including the soybean, also contain trypsin inhibitors which interfere with the action of the digestive enzyme trypsin. Normal cooking processes degrade lectins and trypsin inhibitors to harmless forms.

Other uses

Cotton fiber grows attached to cotton plant seeds. Other seed fibers are from kapok and milkweed.
Many important nonfood oils are extracted from seeds. Linseed oil is used in paints. Oil from jojoba and crambe are similar to whale oil.
Seeds are the source of some medicines including castor oil, tea tree oil and the cancer drug, Laetrile.
Many seeds have been used as beads in necklaces and rosaries including Job's tears, Chinaberry, rosary pea, and castor bean. However, the latter three are also poisonous.

Other seed uses include:

Seeds once used as weights for balances.
Seeds used as toys by children, such as for the game Conkers.
Resin from Clusia rosea seeds used to caulk boats.
Nematicide from milkweed seeds.
Cottonseed meal used as animal feed and fertilizer.

Seed records

The massive fruit of the coco de mer.

The oldest viable carbon-14-dated seed that has grown into a plant was a Judean date palm seed about 2,000 years old, recovered from excavations at Herod the Great's palace on Masada in Israel. It was germinated in 2005. (A reported regeneration of Silene stenophylla (narrow-leafed campion) from material preserved for 31,800 years in the Siberian permafrost was achieved using fruit tissue, not seed.
The largest seed is produced by the coco de mer, or "double coconut palm", Lodoicea maldivica. The entire fruit may weigh up to 23 kilograms (50 pounds) and usually contains a single seed.
The earliest fossil seeds are around 365 million years old from the Late Devonian of West Virginia. The seeds are preserved immature ovules of the plant Elkinsia polymorpha.

Manures

"Animal waste" redirects here. For other types of animal waste, see Urine.
This article is about organic material used as soil fertilizer. For animal dung used for other purposes, see feces.

Animal manure is often a mixture of animal feces and bedding straw, as in this example from a stable

Manure is organic matter used as organic fertilizer in agriculture. Manures contribute to the fertility of the soil by adding organic matter and nutrients, such as nitrogen, that are trapped by bacteria in the soil. Higher organisms then feed on the fungi and bacteria in a chain of life that comprises the soil food web. It is also a product obtained after decomposition of organic matter like cow-dung which replenishes the soil with essential elements and add humus to the soil.
In the past, the term “manure” included inorganic fertilizers, but this usage is now very rare.

Animal manures

Cement reservoirs, one new, and one containing cow manure mixed with water. This is common in rural Hainan Province, China.

Most animal manure is feces. Common forms of animal manure include farmyard manure (FYM) or farm slurry (liquid manure). FYM also contains plant material (often straw), which has been used as bedding for animals and has absorbed the feces and urine. Agricultural manure in liquid form, known as slurry, is produced by more intensive livestock rearing systems where concrete or slats are used, instead of straw bedding. Manure from different animals has different qualities and requires different application rates when used as fertilizer. For example horses, cattle, pigs, sheep, chickens, turkeys, rabbits, humans (sewage), and guano from seabirds and bats all have different properties. For instance, sheep manure is high in nitrogen and potash, while pig manure is relatively low in both. Horses mainly eat grass and a few weeds so horse manure can contain grass and weed

seeds, as horses do not digest seeds the way that cattle do. Chicken litter, coming from a bird, is very concentrated in nitrogen and phosphate and is prized for both properties.
Animal manures may be adulterated or contaminated with other animal products, such as wool (shoddy and other hair), feathers, blood, and bone. Livestock feed can be mixed with the manure due to spillage. For example, chickens are often fed meat and bone meal, an animal product, which can end up becoming mixed with chicken litter.

Compost containing turkey manure and wood chips from bedding material is dried and then applied to pastures for fertilizer.

Compost

Compost is the decomposed remnants of organic materials. It is usually of plant origin, but often includes some animal dung or bedding.

Plant manures

Green manures are crops grown for the express purpose of plowing them in, thus increasing fertility through the incorporation of nutrients and organic matter into the soil. Leguminous plants such as clover are often used for this, as they fix nitrogen using Rhizobia bacteria in specialized nodes in the root structure.
Other types of plant matter used as manure include the contents of the rumens of slaughtered ruminants, spent hops (left over from brewing beer) and seaweed.

Uses of manure

Manure on a wall
Animal dung has been used for centuries as a fertilizer for farming, as it improves the soil structure (aggregation), so that it holds more nutrients and water, and becomes more fertile. Animal manure also encourages soil microbial activity, which promotes the soil's trace

mineral supply, improving plant nutrition. It also contains some nitrogen and other nutrients that assist the growth of plants.

Manures with a particularly unpleasant odor (such as human sewage or slurry from intensive pig farming) are usually knifed (injected) directly into the soil to reduce release of the odor. Manure from pigs and cattle is usually spread on fields using a manure spreader. Due to the relatively lower level of proteins in vegetable matter, herbivore manure has a milder smell than the dung of carnivores or omnivores. However, herbivore slurry that has undergone anaerobic fermentation may develop more unpleasant odors, and this can be a problem in some agricultural regions. Poultry droppings are harmful to plants when fresh but, after a period of composting, are valuable fertilizers.

Manure is also commercially composted and bagged and sold retail as a soil amendment. Sometimes even human sewage sludge is used, as is the case for Dillo Dirt, a product that has been sold by the city of Austin, Texas municipal wastewater department since 1989.

Precautions

Manure generates heat as it decomposes, and it is possible for manure to ignite spontaneously if stored in a massive pile. Once such a large pile of manure is burning, it will foul the air over a very large area and require considerable effort to extinguish. Therefore, large feedlots must take care to ensure that piles of fresh manure do not get excessively large. There is no serious risk of spontaneous combustion in smaller operations.

There is also a risk of insects carrying feces to food and water supplies, making them unsuitable for human consumption.

Livestock antibiotics

In 2007, a University of Minnesota study indicated that foods such as corn, lettuce, and potatoes have been found to accumulate antibiotics from soils spread with animal manure that contains these drugs.

Organic foods may be much more or much less likely to contain antibiotics, depending on their sources and treatment of manure. For instance, by Soil Association Standard 4.7.38, most organic arable farmers either have their own supply of manure (which would, therefore, not normally contain drug residues) or else rely on green manure crops for the extra fertility (if any nonorganic manure is used by organic farmers, then it usually has to be rotted or composted to degrade any residues of drugs and eliminate any pathogenic bacteria — Standard 4.7.38, Soil Association organic farming standards). On the other hand, as found in the University of Minnesota study, the non-usage of artificial fertilizers, and resulting exclusive use of manure as fertilizer, by organic farmers can result in significantly greater accumulations of antibiotics in organic foods.

Irrigation system

Pakistan, a country of enchanting landscapes offers a combination of beaches, mountains, beautiful deserts and valleys. Its vast farm lands are sustained by the Indus Basin Irrigation System (IBIS), the largest contiguous irrigation system in the world. The IBIS irrigates 45 million acres of farm land which produces wheat, rice, fruits, vegetables, sugarcane, maize and cotton in abundance for local use as well as for export.

This report provides the historical context in which the IBIS was developed. It discusses the economic impact of the IBIS on Pakistan, and provides recommendations for some current problems related to insufficient drainage and inefficient farming practices.

Historical Background

The Indus Valley has been the host to one of the most ancient civilization of human history, the Indus Valley Civilization. After the extinction of the Indus Civilization, new settlements especially in doabs grew slowly. New irrigation systems started to evolve. Inundation canals and small dams were constructed and population grew all around this area. In order to reduce the occurrence of low irrigation water supply the British authorities, towards the middle of the last century, started modernizing and expanding the irrigation system of the Indus Basin.

Treaty Between Pakistan and India

In 1947, the Indian sub continent was partitioned by the British into two independent states – Pakistan and India. After the partition a commission was set up to resolve any issue that may emerge as a consequence of the partition. The matter of utilization of water resources of Indus Basin was raised by Pakistan. The boundary commission, chaired by Sir Cyril Radcliff, awarded control barrages (situated very close to the border) to India, while 90 percent of irrigated land lay in Pakistan.

After a protracted negotiation of ten years through facilitation of the World Bank, the Indus Basin Treaty was signed by India and Pakistan in 1960 for distribution of water resources in the Indus Basin. According to the terms of the treaty India was given the exclusive use of the waters of the eastern rivers namely Ravi, Sutlej and Beas. Pakistan was not given its full historic share and was allocated only 75 percent of its legitimate share of the waters in Indus Basin. Consequently, Pakistan agreed to embark upon a gigantic project nicknamed as "Indus Basin Replacement Works". The extensive undertaking involved the construction of two major dams, five barrages and eight link canals.

Pakistan's IBIS

Pakistan's economy is largely based on its agricultural produce. Water is therefore a critical resource for its sustained economic development. In order to fully utilize the river water resources, the IBIS has emerged as the largest contiguous irrigation system in the world. The IBIS comprises of three large dams, eighty five small dams, nineteen barrages, twelve inter-river link canals, forty-five canal commands and 0.7 million tube wells In monetary terms, this network is the biggest infrastructure enterprise of Pakistan accounting for approximately US$ 300 billion of investment.

Water Ability of the IBIS

There are three main sources of water availability in the Indus Basin:

A. The average annual flow of Western Rivers of Indus Basin is approximately 142 million acre feet (MAF). About 104 MAF of this water is diverted for irrigation purposes and about 35 million acre feet outflows to the Arabian Sea.

B. Rain Water:

Another source of water is the rain fall. Irrigated areas of Indus Basin receive on average 40 million acres feet of water annually.

C. Ground Water:
The third source of water is the ground water. It provides approximately 40 percent of crop water requirements of the country.

Challenges in Indus Basin Irrigation System

For any sustainable irrigation system that is dependent on river water supplies, it is necessary to have a system of affluent disposal. However, when the British engineers designed and constructed the barrages and canals in Punjab and Sindh, they did not install an affluent disposal system. This lack of an affluent disposal system gave rise to the twin problems of water logging and salinity. The problem is currently being addressed through construction of a network of disposal drains, many of which have been completed while more are under execution.

The Economic Impact of Indus Basin Irrigation System

The agricultural produce, in addition to providing food security constitutes:

A. 23 percent of GDP

B. 70 percent of total export earnings

C. 54 percent employment of labour force

The overwhelming majority of its produce comes from the areas irrigated in the Indus Basin. The IBIS is therefore essential in sustaining the agriculture and consequently economic well-being of Pakistan. The Indus Basin now serves as the bread basket of Pakistan. Its land use is furnished below.

Current Problems and Recommendations

Farmers in Pakistan receive their share of irrigation waters on a rotational basis. To protect the right of share of their water, the farmers are using more than the optimum quantity of water required for healthy crops. Lack of modern irrigation techniques and agricultural practices further add to the wastage of irrigation water. Some solutions outlined below can potentially serve to address this issue:

Increase plantation of fruit trees.

Expand forested areas.

All existing dams small and large should be used for fish breeding and harvesting.

Develop agricultural based industries and timber factories in the rural areas to provide employment to small farmers and increase the percentage of value added goods for export.

Group small farms into larger units for cooperative farming using the latest irrigation and farming techniques and modern agricultural practices.

Increase the production of beans, lentils and edible oil seeds to reduce their imports.

Develop pastures for cattle farming and increase milk and meat production.

Big land holdings more than five thousand acres of area should be made available for co operative farming.

The level and standard of research should be enhanced in the existing agricultural universities of Pakistan.

PLANT PROTECTION

Plant protection is the science and practice of managing invertebrate pests and vertebrate pests, plant diseases, weeds and other pest organisms that damage agricultural crops and forestry. Agricultural crops include field crops (maize, wheat, rice, etc.), vegetable crops (potatoes, cabbages, etc.) and fruit and horticultural crops. It encompasses:

Pesticide-based approaches such as herbicides, insecticides and fungicides

Herbicides:

Herbicides also commonly known as weed killers, are pesticides used to kill unwanted plants Selective herbicides kill specific targets, while leaving the desired crop relatively unharmed. Some of these act by interfering with the growth of the weed and are often synthetic mimics of natural plant hormones. Herbicides used to clear waste ground, industrial sites, railways and railway embankments are not selective and kill all plant material with which they come into contact. Smaller quantities are used in forestry, pasture systems, and management of areas set aside as wildlife habitat.
Some plants produce natural herbicides, such as the genus Juglans (walnuts), or the tree of heaven; such action of natural herbicides, and other related chemical interactions, is called allelopathy.
Herbicides are widely used in agriculture and landscape turf management. In the US, they account for about 70% of all agricultural pesticide use

An **insecticide** is a chemical used against insects. They include ovicides and larvicides used against the eggs and larvae of insects, respectively. Insecticides are used in agriculture, medicine, industry, and general home use. The use of insecticides is believed to be one of the major factors behind the increase in agricultural productivity in the 20th century.[1] Nearly all insecticides have the potential to significantly alter ecosystems; many are toxic to humans; and others are concentrated in the food chain.

The classification of insecticides is done in several different ways:

- Systemic insecticides are incorporated by treated plants. Insects ingest the insecticide while feeding on the plants.
- Contact insecticides are toxic to insects brought into direct contact. Efficacy is often related to the quality of pesticide application, with small droplets (such as aerosols) often improving performance.
- Natural insecticides, such as nicotine, pyrethrum, and neem extracts are made by plants as defenses against insects. Nicotine-based insecticides are still being widely used in the US and Canada, however they are barred in the EU.
- Plant-incorporated protectants (PIPs) are insecticidal substances produced by plants after genetic modification. For instance, a gene that codes for a specific Baccilus thuringiensis biocidal protein is introduced into a crop plant's genetic material. Then, the plant manufactures the protein. Since the biocide is incorporated into the plant, additional applications, at least of the same compound, are not required.
- Inorganic insecticides are manufactured with metals and include arsenates, copper compounds and fluorine compounds, which are now seldom used, and sulfur, which is commonly used.

- Organic insecticides are synthetic chemicals that comprise the largest numbers of pesticides available for use today.
- Mode of action—how the pesticide kills or inactivates a pest—is another way of classifying insecticides. Mode of action is important in predicting whether an insecticide will be toxic to unrelated species, such as fish, birds, and mammals.

For products that repel rather than kill insects see insect repellents.

Fungicides are biocidal chemical compounds or biological organisms used to kill or inhibit fungi or fungal spores. Fungi can cause serious damage in agriculture, resulting in critical losses ofyield, quality and profit. Fungicides are used both in agriculture and to fight fungal infections in animals. Chemicals used to control oomycetes, which are not fungi, are also referred to as fungicides as oomycetes use the same mechanisms as fungi to infect plants.

Fungicides can either be contact, translaminar or systemic. Contact fungicides are not taken up into the plant tissue, & only protect the plant where the spray is deposited; translaminar fungicides redistribute the fungicide from the upper, sprayed leaf surface to the lower, unsprayed surface; systemic fungicides are taken up & redistributed through the xylem vessels. Few fungicides move to all parts of a plant. Some are locally systemic, and some move upwardly.

Most fungicides that can be bought retail are sold in a liquid form. A very common active ingredient is sulfur, present at 0.08% in weaker concentrates, and as high as 0.5% for more potent fungicides. Fungicides in powdered form are usually around 90% sulfur and are very toxic. Other active ingredients in fungicides include neem oil, rosemary oil, jojoba oil, the bacterium Bacillus subtilis, and the beneficial fungus Ulocladium oudemansii.

Fungicide residues have been found on food for human consumption, mostly from post-harvest treatments. Some fungicides are dangerous to human health, such as vinclozolin, which has now been removed from use. A number of fungicides are also used in human health care.

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- Biological pest control approaches such as cover crops, trap crops and beetle banks

Biological control is a bioeffector-method of controlling pests (including insects, mites, weeds and plant diseases) using other living organisms. It relies on predation, parasitism, herbivory, or other natural mechanisms, but typically also involves an active human management role. It can be an important component of integrated pest management (IPM) programs. There are three basic types of biological pest control strategies: importation (sometimes called classical biological control), augmentation and conservation.

Natural enemies of insect pests, also known as biological control agents, include predators, parasitoids, and pathogens. Biological control agents of plant diseases are most often referred to as antagonists. Biological control agents of weeds include herbivores and plant pathogens.

A trap crop is a plant that attracts agricultural pests, usually insects, away from nearby crops. This form of companion planting can save the main crop from decimation by pests without the use of pesticides. Trap crops can be planted around the circumference of the field to be protected, or interspersed among them, for example being planted every ninth row.

usage

Trap crops, when used on an industrial scale, are generally planted at a key time in the pest's lifecycle, and then destroyed before that lifecycle finishes and the pest might have transferred from the trap plants to the main crop.

Examples of trap crops include:

Alfalfa planted in strips among cotton, to draw away lygus bugs, while castor beans surround the field, or tobacco is planted in strips among it, to protect from the budworm Heliothis.

Rose enthusiasts often plant Pelargonium geraniums among their rosebushes because japanese beetles are drawn to the geraniums, which are toxic to them.

Chervil is used by gardeners to protect vegetable plants from slugs.

Rye, sesbania, and sicklepod are used to protect soybeans from corn seeding maggots, stink bugs, and velvet green caterpillars, respectively.

Mustard and Alfalfa planted near strawberries to attract lygus bugs, a method pioneered by Jim Cochran

operation

Recent studies on host-plant finding have shown that flying pests are far less successful if their host-plants are surrounded by any other plant, or even "decoy-plants" made of green plastic, cardboard or any other green material. The host-plant finding process occurs in three phases.

The first phase is stimulation by odours characteristic to the host-plant. This induces the insect to try to land on the plant it seeks. But insects avoid landing on brown (bare) soil. So if only the host-plant is present, the insects will quasi-systematically find it by landing on the only green thing around. This is called an "appropriate landing". When it does an "inappropriate landing", it flies off to any other nearby patch of green. It eventually leaves the area if there are too many "inappropriate" landings.

The second phase of host-plant finding is for the insect to make short flights from leaf to leaf to assess the plant's overall suitability. The number of leaf-to-leaf flights varies according to the insect species and to the host-plant stimulus received from each leaf. But the insect must accumulate sufficient stimuli from the host-plant to lay eggs; so it must make a certain number of consecutive "appropriate" landings. Hence if it makes an "inappropriate landing", the assessment of that plant is negative and the insect must start the process anew.

Thus it was shown that clover used as a ground cover had the same disruptive effect on eight pest species from four insect orders. An experiment showed that 36% of cabbage root flies laid eggs beside cabbages growing in bare soil (which resulted in no crop), compared to only 7% beside cabbages growing in clover (which allowed a good crop). Also that simple decoys made of green card disrupted appropriate landings just as well as did the live ground cover.

Bettele bank

A beetle bank, in agriculture and horticulture, is a form of biological pest control. It is a strip planted with grasses (bunch grasses) and/or perennial plants, within a crop field or a garden, that fosters and provides habitat for beneficial insects, birds, and other fauna that prey on pests.

Usage

Beetle banks are typically made up from plants such as sunflowers, Vicia faba, Centaurea cyanus, coriander, borage, Muhlenbergia, Stipa, and buckwheats (Eriogonum spp.). Beetle banks are used to reduce or replace the use of insecticides, and can also serve as habitat for birds and beneficial rodents. For example, insects such as Chrysoperla carnea and the Ichneumon fly can prey on pests. The concept was developed by the Game & Wildlife Conservation Trust in collaboration with the University of Southampton.

Other important benefits can be providing habitat for pollinators and endangered species. If using local native plants, endemic and indigenous flora and fauna restoration ecology is supported

- Barrier-based approaches such as agrotextiles and bird netting
- Agro textiles
- A Technical textile is a textile product manufactured for non-aesthetic purposes, where function is the primary criterion.
- It is a large and growing sector and supports a vast array of other industries.
- Technical textiles include textiles for automotive applications, medical textiles (e.g., implants), geotextiles (reinforcement of embankments), agrotextiles (textiles for crop protection), and protective clothing (e.g., heat and radiation protection for fire fighter clothing, molten metal protection for welders, stab protection and bulletproof vests, and spacesuits).
- Over all, global growth rates of technical textiles are about 4% per year greater than the growth of home and apparel textiles, which are growing at a rate of 1% per year.

- In present market opportunities and in free quota system the importance of technical textile materials is increasing to accommodate the needs of requirement. Nowadays the most widely technical textile materials are used in filter clothing, furniture, hygiene medicals and construction material.
- Applications
- Nowadays it can be found in the market, technical fabrics which protect of:
- High temperatures (insulating, firefighters)
- Burns (flame, convective and radiant heat, firefighters, ATEX area)
- Electric arc flash discharge (plasma explosion, Electric companies)
- Molten metal impacts (foundries)
- Metal sparks (welding)
- Acid environment (petrochemical, gas, refineries, chemical)
- Bullet impact (military, security)
- Cut resistant (gloves, glass industry)
- Astronaut's suits
- These fabrics are made of different kind of fibers, because every blend apports different technical characteristics to the fabric:
- Meta-Para aramides – Nomex: high resistance, tear, tensile strength, expensive,
- Wool viscoses polyamide – marlan : repelency of molten metal, heat insulation, transparency.
- Glass fiber - High resistance, insulating.
- Modacrylic cotton – Marko wiki: Marko : electric arc flash protection, comfort, flame-resistant, multinorm, efficient, skin friendly, antistatic.
- Polyamide – Kevlar : extreme resistance, low ageing
- Bird netting
- **Usage**

Bird netting or anti-bird netting is a form of bird pest control. It is a net used to prevent birds from reaching certain areas.

Crop protection

Bird nets are used to prevent bird damage of vegetable and fruit crops as well as seedlings.

Fish protection

Bird netting may be used to protect fisheries and fish wildlife reserves from predator birds.

Building protection

Bird netting is one of the most effective and long lasting ways of bird proofing buildings and other structures against all urban bird species. It provides a discreet and impenetrable barrier that protects premises without harming the birds. Bird netting can be particularly effective for large open areas such as roofs and loading bays. Design considerations include the type and material of the fixings utilised and the bird species requiring exclusion

Animal psychology-based approaches such as bird scarers

A **bird scarer** is any one of a number devices designed to scare birds, usually employed by farmers to dissuade birds from eating recently planted arable crops.

They are also used on airfields to prevent birds accumulating near runways and causing a potential hazard to aircraft.

Scarecrow

Hawk kite

Helikites

- Biotechnology-based approaches such as plant breeding and genetic modification
- **Biotechnology** is the use of living systems and organisms to develop or make useful products, or "any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products or processes for specific use
- Depending on the tools and applications, it often overlaps with the (related) fields of bioengineering and biomedical engineering.
- Definition
- The concept of 'biotech' or 'biotechnology' encompasses a wide range of procedures (and history) for modifying living organisms according to human purposes — going back to domestication of animals, cultivation of plants, and "improvements" to these through breeding programs that employ artificial selection and hybridization. Modern usage also includes genetic engineering as well as cell and tissue culture technologies. Biotechnology is defined by the American Chemical Society as the application of biological organisms, systems, or processes by various industries to learning about the science of life and the improvement of the value of materials and organisms such as pharmaceuticals, crops, and livestock. In other words, biotechnology can be defined as the mere application of technical advances in life science to develop commercial products. Biotechnology also writes on the pure biological sciences (genetics, microbiology, animal cell culture, molecular biology, biochemistry, embryology, cell biology). And in many instances it is also dependent on knowledge and methods from outside the sphere of biology including:

Plant breeding

Plant breeding is the art and science of changing the traits of plants in order to produce desired characteristics. Plant breeding can be accomplished through many different techniques ranging from simply selecting plants with desirable characteristics for propagation, to more complex molecular techniques.

Plant breeding has been practiced for thousands of years, since near the beginning of human civilization. It is now practiced worldwide by individuals such as gardeners and farmers, or by professional plant breeders employed by organizations such as government institutions, universities, crop-specific industry associations or research centers.

International development agencies believe that breeding new crops is important for ensuring food security by developing new varieties that are higher-yielding, resistant to pests and diseases, drought-resistant or regionally adapted to different environments and growing conditions.

Genetic engineering, also called **genetic modification**, is the direct manipulation of an organism's genome using biotechnology. New DNA may be inserted in the host genome by first isolating and copying the genetic material of interest using molecular cloning methods to generate a DNA sequence, or by synthesizing the DNA, and then inserting this construct into the host organism. Genes may be removed, or "knocked out", using a nuclease. Gene targeting is a different technique that uses homologous recombination to change an endogenous gene, and can be used to delete a gene, remove exons, add a gene, or introduce point mutations.

An organism that is generated through genetic engineering is considered to be a genetically modified organism (GMO). The first GMOs were bacteria in 1973; GM mice were generated in 1974. Insulin-producing bacteria were commercialized in 1982 and genetically modified food has been sold since 1994. Glofish, the first GMO designed as a pet, was first sold in the United States December in 2003.

Genetic engineering techniques have been applied in numerous fields including research, agriculture, industrial biotechnology, and medicine. Enzymes used in laundry detergent and medicines such as insulin and human growth hormone are now manufactured in GM cells, experimental GM cell lines and GM animals such as mice or zebrafish are being used for research purposes, and genetically modified crops have been commercialized.

CROP ROTATION

ROTATION

Concept and importance of crop rotation:

Crop rotation is the strategy of raising crops from a piece of land in such an order or succession that the fertility of the land suffers minimally and the farmer’s profits are not reduced. This system is in contrast with practice of growing the same crop year to year. Crop rotation systems have been practiced in Pakistan from time immemorial and every farmer is quite familiar with it.

The main benefits of a scientific rotation are:

1. By rotating crops of different seasons, it is easy to control weeds. Some weeds (johnsongrass, nut grass) are much more troublesome in summer than in winter, and can be suppressed by growing rabi crops after summer fallowing. Similarly, some crops like potato

and fodder (berseem,alfalfa) when included in rotation exert a useful weed smothering influence.
2. By planned, regular, and careful succession of crops, it is easy to keep plant diseases and insect pests under control. Some fungi and insect pests attack only particular genera or orders of plants, and become especially troublesome when such crops are grown on the same land every year. Rotation, therefore, offers an easy way to keep such pest in check.
3. By growing crops in a suitable order it is possible to maintain the fertility of the land. The reasons are:
a. As different crops remove different plant nutrients in different quantities from the soil, a proper balance of nutrients cannot be maintained if the same crop is grown year to year on the same land. Those nutrients which are removed in large quantities by that particular crop will be exhausted and the land will not be able to produce a decent crop, even though there may be plenty of other nutrients in the soil to grow other crops.
b. Differences in the root systems of various crops affect the quantities of nutrients removed from the soil. Shallow-rooted crops remove more plant food from the surface, while deep-rooted crops open up the subsoil and take food from the lower layers as well.
c. Leguminous crops have the property of fixing atmospheric nitrogen with the help of bacteria present in the nodules of their roots. Their inclusion in the rotation is therefore very helpful in maintaining fertility.
d. Soil fertility is closely linked with its humus content. This is very important in hot climates and also with extreme type of soils like sands and clays. By including green manuring crops in the rotation at regular intervals, the humus content of the soil can be kept up.
4. Growing a variety of crops with different sowing and harvesting periods enables the farmer to distribute his labour force more evenly. It also ensures some return on capital at different times of the year for domestic requirements and farm needs. Proper marketing of the commodity and availability to the consumers is assured.

Principles of crop rotation:

In view of the advantages of rotation, the following basic principles should be kept in mind while planning a scientific rotation programme.

1. Crops of the same natural order (family) should not follow each other.
2. Crops of the same type of root system (shallow or deep) should not follow each other.
3. Leguminous crops should be included in the rotation at least every three to four years.
4. Green manuring and forage crops should be given a place in the rotation at regular intervals.
5. Crops like potato, sugarcane, and seasonal vegetables which require more thorough cultivation than others should be included in the rotation, as their cultivation makes a very good preparation for the following crop.
6. Alternating crops susceptible to certain diseases with those that are resistant helps control pests and diseases.

Limitations of crop rotation:

Rotation can not be considerd a complete replacement for manures and fertilizers needed for the production of various crops. In the vicinity of large cities, where fruits, vegetables, and fodder crop are more remunerative than other crops, it is difficult to follow desirable rotation principles completely. In rainfed areas also, because of scarcity of water, rotation cannot be followed in some seasons of the year. Farming has become so commercially oriented that in the vicinity of sugar and ginning mills sugarcane and cotton are grown in close succession using high inputs.

Choice of rotation:

The choice of a crop rotation pattern is determined by the following factors.

1. Physical condition of the soil
2. Prevalence of weeds
3. Supply of plant food
4. Availability of desired quantity of good quality water
5. Economic and political conditions
6. Financial condition of the farmer

Choice of crop:

The choice and sequence of rotation crops depends on the nature of the soil, the climate, and precipitation which together determine the type of plants that may be cultivated. Other important aspects of farming such as crop marketing and economic variables must also be considered when deciding crop rotations.

Crop rotations may include two to six or more crop rotations over numerous seasons. A two crop rotation such as corn and soybean in cash grains or corn and alfalfa in forage systems use legumes to help fix nitrogen in the soil for utilization over the long term. Multiple cropping systems, such as intercropping or companion planting, offer more diversity and complexity within the same season or rotation. Carrots can be shaded by tomatoes and loosen soil below them. Double cropping is common where two crops, typically of different species, are grown sequentially in the same growing season. Winter rye and barley can be sown after oats or rice and harvested before the next crop goes in of oats or rice. These systems can maximize benefits of the rotation as well as available land resources.

More complex rotations commonly utilize people for greater use of on-farm nutrient management and additional farm products. A soil-feeding crop of clover could be replaced or aided by an application of manure to set up a field for a double crop of winter grains after potatoes. Soil building and pest population management benefits can be further utilized with different complexities of crop rotation. In general the complexity of a field's rotation is limited by what soil, climate, and other environmental conditions permit. This also includes the current or desired management tools and goals of the farm

1. Incorporation of animals

In Sub-Saharan Africa, as animal husbandry becomes less of a nomadic practice many herders have begun integrating crop production into their practice. This is known as mixed

farming, or the practice of crop cultivation with the incorporation of raising cattle, sheep and/or goats by the same economic entity, is increasingly common. This interaction between the animal, the land and the crops are being done on a small scale all across this region. Crop residues provide animal feed, while the animals provide manure for replenishing crop nutrients and draft power. Both processes are extremely important in this region of the world as it is expensive and logistically unfeasible to transport in synthetic fertilizers and large-scale machinery. As an additional benefit, the cattle, sheep and/or goat provide milk and can act as a cash crop in the times of economic hardship. Using some forms of crop rotation farmers can keep their fields under continuous production, instead of letting them lie fallow, as well as reducing the need for artificial fertilizers, both of which can be expensive.
A general effect of crop rotation is that there is a geographic mixing of crops, which can slow the spread of pests and diseases during the growing season. The different crops can also reduce the effects of adverse weather for the individual farmer and, by requiring planting and harvest at different times, allow more land to be farmed with the same amount of machinery and labour.
Agronomists describe the benefits to yield in rotated crops as "The Rotation Effect". **There are many found benefits of rotation systems:** however, there is no specific scientific basis for the sometimes 10-25% yield increase in a crop grown in rotation versus monoculture. The factors related to the increase are simply described as alleviation of the negative factors of monoculture cropping systems. Explanations due to improved nutrition; pest, pathogen, and weed stress reduction; and improved soil structure have been found in some cases to be correlated, but causation has not been determined for the majority of cropping systems.
Other benefits of rotation cropping systems include production costs advantages. Overall financial risks are more widely distributed over more diverse production of crops and/or livestock. Less reliance is placed on purchased inputs and over time crops can maintain production goals with fewer inputs. This in tandem with greater short and long term yields makes rotation a powerful tool for improving agricultural systems.

2. Disadvantages

Some crops are picky in the type of soil they need for maximum profitability. Crop rotation is centered around the needs of the soil and not of the crop. Planting picky crops on not-preferred soil will lead to a lower yield in a specific growing season.

3. Nutrients

Rotating crops adds nutrients to the soil. Legumes, plants of the family Fabaceae, for instance, have nodules on their roots which contain nitrogen-fixing bacteria called rhizobia bacteria. It therefore makes good sense agriculturally to alternate them with cereals (family Poaceae) and other plants that require nitrates. An extremely common modern crop rotation is alternatingsoybeans and maize (corn). In subsistence farming, it also makes good nutritional sense to grow beans and grain at the same time in different fields.

4. Pest control

Crop rotation is also used to control pests and diseases that can become established in the soil over time. The changing of crops in a sequence tends to decrease the population level of pests. Plants within the same taxonomic family tend to have similar pests and pathogens. By regularly changing the planting location, the pest cycles can be broken or limited. For example, root-knot nematode is a serious problem for some plants in warm climates and sandy soils, where it slowly builds up to high levels in the soil, and can severely damage plant productivity by cutting off circulation from the plant roots. Growing a crop that is not a host for root-knot nematode for one season greatly reduces the level of the nematode in the soil, thus making it possible to grow a susceptible crop the following season without needing soil fumigation.

It is also difficult to control weeds similar to the crop which may contaminate the final produce. For instance, ergot in weed grasses is difficult to separate from harvested grain. A different crop allows the weeds to be eliminated, breaking the ergot cycle.

This principle is of particular use in organic farming, where pest control may be achieved without synthetic pesticides.

5 Soil erosion

Crop rotation can greatly affect the amount of soil lost from erosion by water. In areas that are highly susceptible to erosion, farm management practices such as zero and reduced tillage can be supplemented with specific crop rotation methods to reduce raindrop impact, sediment detachment, sediment transport, surface runoff, and soil loss.

Protection against soil loss is maximized with rotation methods that leave the greatest mass of crop stubble (plant residue left after harvest) on top of the soil. Stubble cover in contact with the soil minimizes erosion from water by reducing overland flow velocity, stream power, and thus the ability of the water to detach and transport sediment. Soil Erosion and Cill prevent the disruption and detachment of soil aggregates that cause macrospores to block, infiltration to decline, and runoff to increase. This significantly improves the resilience of soils when subjected to periods of erosion and stress.

The effect of crop rotation on erosion control varies by climate. In regions under relatively consistent climate conditions, where annual rainfall and temperature levels are assumed, rigid crop rotations can produce sufficient plant growth and soil cover. In regions where climate conditions are less predictable, and unexpected periods of rain and drought may occur, a more flexible approach for soil cover by crop rotation is necessary. An opportunity cropping system promotes adequate soil cover under these erratic climate conditions. In an opportunity cropping system, crops are grown when soil water is adequate and there is a reliable sowing window. This form of cropping system is likely to produce better soil cover than a rigid crop rotation because crops are only sown under optimal conditions, whereas rigid systems are not necessarily sown in the best conditions available.

Crop rotations also affect the timing and length of when a field is subject to fallow. This is very important because depending on a particular region's climate, a field could be the most vulnerable to erosion when it is under fallow. Efficient fallow management is an essential part of reducing erosion in a crop rotation system. Zero tillage is a fundamental management practice that promotes crop stubble retention under longer unplanned fallows when crops cannot be planted. Such management practices that succeed in retaining suitable soil cover in areas under fallow will ultimately reduce soil loss.

6. Additional soil improvements

The use of different species in rotation allows for increased soil organic matter (SOM), greater soil structure, and improvement of the chemical and biological soil environment for crops. With more SOM, water infiltration and retention improves, providing increased drought tolerance and decreased erosion. Soil aggregation allows greater nutrient retention and utilization, decreasing the need for added nutrients. Soil microorganisms also improve nutrient availability and decrease pathogen and pest activity through competition. In addition, plants produce root exudates and other chemicals which manipulate their soil environment as well as their weed environment. Thus rotation allows increased yields from nutrient availability but also alleviation of allelopathy and competitive weed environment.

Harvest

Harvest is the process of gathering mature crops from the fields. Reaping is the cutting of grain or pulse for harvest, typically using a scythe, sickle, reaper. The harvest marks the end of the growing season, or the growing cycle for a particular crop, and social importance of this event makes it the focus of seasonal celebrations such as a harvest festival, found in many religions. On smaller farms with minimal mechanization, harvesting is the most labor-intensive activity of the growing season. On large, mechanized farms, harvesting utilizes the most expensive and sophisticated farm machinery, like the combine harvester. Harvesting in general usage includes an immediate post-harvest handling, all of the actions taken immediately after removing the crop—cooling, sorting, cleaning, packing—up to the point of further on-farm processing, or shipping to the wholesale or consumer market.

Other uses

Harvest commonly refers to grain and produce, but also has other uses. In addition to fish and timber, the term harvest is also used in reference to harvesting grapes for wine. Within the context of irrigation, water harvesting refers to the collection and run-off of rainwater for agricultural or domestic uses. Instead of harvest, the term exploit is also used, as in exploiting fisheries or water resources. Energy harvesting is the process by which energy (such as solar power, thermal energy, wind energy, salinity gradients and kinetic energy) is captured and stored. Body harvesting, or cadaver harvesting, is the process of collecting and preparing cadavers for anatomical study. In a similar sense, organ harvesting is the removal of tissues or organs from a donor for purposes of transplanting.

Harvesting or Domestic Harvesting in Canada refers to hunting, fishing and plant gathering by First Nations, Métis and Inuit in discussions of aboriginal or treaty rights. For example, in the Gwich'in Comprehensive Land Claim Agreement, "Harvesting means gathering, hunting, trapping or fishing..." Similarly, in the Tlicho Land Claim and Self Government Agreement

"'Harvesting' means, in relation to wildlife, hunting, trapping or fishing and, in relation to plants or trees, gathering or cutting."

Combine harvester

The **combine harvester**, or simply **combine**, is a machine that harvests grain crops. The name derives from its combining three separate operations comprising harvesting—reaping, threshing, and winnowing—into a single process. Among the crops harvested with a combine are wheat, oats, rye, barley, corn (maize), soybeans and flax (linseed). The waste straw left behind on the field is the remaining dried stems and leaves of the crop with limited nutrients which is either chopped and spread on the field or baled for feed and bedding for livestock.

Combine harvesters are one of the most economically important labor saving inventions, enabling a small fraction of the population to be engaged in agriculture.

A **harvest festival** is an annual celebration that occurs around the time of the main harvest of a given region. Given the differences in climate and crops around the world, harvest festivals can be found at various times at different places. Harvests festivals typically feature feasting, both family and public, with foods that are drawn from crops that come to maturity around the time of the festival. Ample food and freedom from the necessity to work in the fields are two central features of harvest festivals: eating, merriment, contests, music and romance are common features of harvest festivals around the world.

In North America, Canada and the US each have their own Thanksgiving celebrations in October and November. Certain religious holidays, such as Sukkot, have their roots in harvest festivals.

In Britain, thanks have been given for successful harvests since pagan times. Harvest festival is traditionally held on the Sunday near or of the Harvest Moon. This is the full Moon that occurs closest to the autumn equinox (about Sept. 23). In two years out of three, the Harvest Moon comes in September, but in some years it occurs in October. The celebrations on this day usually include singing hymns, praying, and decorating churches with baskets of fruit and food in the festival known as Harvest Festival, Harvest Home or Harvest Thanksgiving.

In British and English-Caribbean churches, chapels and schools, and some Canadian churches, people bring in produce from the garden, the allotment or farm. The food is often distributed among the poor and senior citizens of the local community, or used to raise funds for the church, or charity.

In the United States, many churches also bring in food from the garden or farm in order to celebrate the harvest. The festival is set for a specific day and has become a national holiday known as Thanksgiving which falls on the fourth Thursday in November. In both Canada and the United States, it has also become a national secular holiday with religious origins, but in Britain it is both a Church festival giving thanks to God for the harvest and a more secular festival remembered in schools.

Harvest festivals in Asia include the Chinese Mid-Autumn Festival, one of the most widely spread harvest festivals in the world. In India,Makar Sankranti, Thai Pongal, Uttarayana, Lohri, and Magh Bihu or Bhogali Bihu in January, Holi in February–March, Vaisakhi in April and Onam in August–September are a few important harvest festivals.

Over harvesting

Overexploitation, also called **over harvesting**, refers to harvesting a renewable resource to the point of diminishing returns. Sustained overexploitation can lead to the destruction of the resource. The term applies to natural resources such as: wild medicinal plants, grazing pastures, game animals, fish stocks, forests, and water aquifers.

In ecology, overexploitation describes one of the five main activities threatening global biodiversity. Ecologists use the term to describe populations that are harvested at a rate that is unsustainable, given their natural rates of mortality and capacities for reproduction. This can result in extinction at the population level and even extinction of whole species. In conservation biology the term is usually used in the context of human economic activity that involves the taking of biological resources, or organisms, in larger numbers than their populations can withstand. The term is also used and defined somewhat differently in fisheries, hydrology and natural resource management.

Overexploitation can lead to resource destruction, including extinctions. However it is also possible for overexploitation to be sustainable, as discussed below in the section on fisheries. In the context of fishing, the term overfishing can be used instead of overexploitation, as can overgrazing in stock management, overlogging in forest management, overdrafting in aquifer management, and endangered species in species monitoring. Overexploitation is not an activity limited to humans. Introduced predators and herbivores, for example, can overexploit native flora and fauna.

Threshing is the process of loosening the edible part of cereal grain (or other crop) from the scaly, inedible chaff that surrounds it. It is the step in grain preparation after harvesting and before winnowing, which separates the loosened chaff from the grain. Threshing does not remove the bran from the grain.

Threshing may be done by beating the grain using a flail on a threshing floor. Another traditional method of threshing is to make donkeys or oxen walk in circles on the grain on a hard surface. A modern version of this in some areas is to spread the grain on the surface of a country road so the grain may be threshed by the wheels of passing vehicles.

Hand threshing was laborious, with a bushel of wheat taking about an hour. In the late 18th century before threshing was mechanized, it took about one-quarter of agricultural labor.

Industrialization of threshing began in 1784 with the invention of the threshing machine by Scotsman Andrew Meikle. Today, in developed areas, it is now mostly done by machine, usually by a combine harvester, which harvests, threshes, and winnows the grain while it is still in the field.

The cereal may be stored in a threshing barn or silos.

often held over multiple days and includes flea markets, activity booths, hog wrestling and dances.

Wind winnowing is an agricultural method developed by ancient cultures for separating grain from chaff. It is also used to remove weevils or other pests from stored grain. Threshing, the loosening of grain or seeds from the husks and straw, is the step in the chaff-removal process that comes before winnowing. "Winnowing the chaff" is a common expression

In its simplest form it involves throwing the mixture into the air so that the wind blows away the lighter chaff, while the heavier grains fall back down for recovery. Techniques included using a winnowing fan (a shaped basket shaken to raise the chaff) or using a tool (a winnowing fork or shovel) on a pile of harvested grain.

Winnowing can also describe the natural removal of fine material from a coarser sediment by wind or flowing water, analogous to the agricultural separation of wheat from chaff.

Crop processes and storage

Grain stores upto 30,000 tons with full cleaning, destoning, ventilation and temperature monitoring.

Specialized rice and pulses cleaning systems including a full range of processes:
Primary cleaning
Precision cleaning- gravity separators for light and heavey foreign material
Air washing to remove the adhered dust
Length grading- indented cylinders
Electronic color sorting
Conventional packing and form-fill-seal plastic

Specialized chilled floor storage for storage of maize for specialized processing including:
Intake
Primary cleaning
Floor store filling to a pre-determined level surface
Out loading system from the floor store
Specialized precision cleaning and grading
Dispatch in bulk, one tone IBC and 5o kg bags

Flour mills for specialized wheat flour production for whole meal and other style flours, full system with packing in conventional paper bags form-fill-seal.

Agro based industries

Cotton textile Industry

The **textile industry** or **apparel industry** is primarily concerned with the production of yarn, and cloth and the subsequent design or manufacture of clothing and their distribution. The raw material may be natural, or synthetic using products of the chemical industry.

Cotton manufacturing

Cotton is the world's most important natural fibre. In the year 2007, the global yield was 25 million tons from 35 million hectares cultivated in more than 50 countries. There are five stages

- Cultivating and Harvesting
- Preparatory Processes
- Spinning- giving yarn
- Weaving- giving fabrics
- Finishing- giving textiles

Synthetic fibres

Artificial fibres can be made by extruding a polymer, through a spinneret into a medium where it hardens. Wet spinning (rayon) uses a coagulating medium. In dry spinning (acetate and triacetate), the polymer is contained in a solvent that evaporates in the heated exit chamber. In melt spinning (nylons and polyesters) the extruded polymer is cooled in gas or air and then sets. All these fibres will be of great length, often kilometers long.
Artificial fibres can be processed as long fibres or batched and cut so they can be processed like a natural fibre.

Natural fibres

Natural fibres are either from animals (sheep, goat, rabbit, silk-worm) mineral (asbestos) or from plants (cotton, flax, sisal). These vegetable fibres can come from the seed (cotton), the stem (known as bast fibres: flax, Hemp, Jute) or the leaf (sisal). Without exception, many processes are needed before a clean even staple is obtained- each with a specific name. With the exception of silk, each of these fibres is short being only centimeters in length, and each has a rough surface that enables it to bond with similar staples.

Sugar industry

Sugar is the generalized name for a class of chemically-related sweet-flavored substances, most of which are used as food. They are carbohydrates, composed of carbon, hydrogen and oxygen. There are various types of sugar derived from different sources. Simple sugars are called monosaccharides and include glucose (also known as dextrose), fructose and galactose. The table or granulated sugar most customarily used as food is sucrose, a disaccharide (in the body, sucrose hydrolyses into fructose and glucose). Other disaccharides include maltose and lactose. Chemically-different substances may also have a sweet taste, but are not classified as sugars. Some are used as lower-calorie food substitutes for sugar described as artificial sweeteners.

Sugars are found in the tissues of most plants, but are only present in sufficient concentrations for efficient extraction in sugarcane and sugar beet. Sugarcane is a giant grass and has been cultivated in tropical climates in the Far East since ancient times. A great expansion in its production took place in the 18th century with the lay out of sugar plantations in the West Indies and Americas. This was the first time that sugar became available to the common people who previously had to rely on honey to sweeten foods. Sugar beet is a root crop, is cultivated in cooler climates, and became a major source of sugar in the 19th century when methods for extracting the sugar became available. Sugar production and trade have changed the course of human history in many ways. It influenced the formation of colonies, the perpetuation of slavery, the transition to indentured labour, the migration of peoples, wars between sugar trade-controlling nations in the 19th century, and the ethnic composition and political structure of the new world.

The world produced about 168 million tonnes of sugar in 2011. The average person consumes about 24 kilograms of sugar each year (33.1 kg in industrialised countries), equivalent to over 260 food calories per person, per day.

Since the latter part of the twentieth century, it has been questioned whether a diet high in sugars, especially refined sugars, is bad for human health. Sugar has been linked to obesity, and suspected of, or fully implicated as a cause in the occurrence of diabetes, cardiovascular disease, dementia, macular degeneration and tooth decay. Numerous studies have been undertaken to try to clarify the position, but with varying results, mainly because of the difficulty of finding populations for use as controls that do not consume, or are largely free of any sugar consumption.

Types of sugar

Monosaccharides

Glucose, fructose and galactose are all simple sugars, monosaccharides, with the general formula $C_6H_{12}O_6$. They have five hydroxyl groups (−OH) and a carbonyl group (C=O) and are cyclic when dissolved in water. They each exist as several isomers with dextro- and laevo-rotatory forms which cause polarized light to diverge to the right or the left.

Glucose, dextrose or grape sugar occurs naturally in fruits and plant juices and is the primary product of photosynthesis. Most ingested carbohydrates are converted into glucose during digestion and it is the form of sugar that is transported around the bodies of animals in the bloodstream. It can be manufactured from starch by the addition of enzymes or in the presence of acids. Glucose syrup is a liquid form of glucose that is widely used in the manufacture of foodstuffs. It can be manufactured from starch by enzymatic hydrolysis.

Fructose or fruit sugar occurs naturally in fruits, some root vegetables, cane sugar and honey and is the sweetest of the sugars. It is one of the components of sucrose or table sugar. It is used as a high fructose syrup which is manufactured from hydrolized corn starch which has been processed to yield corn syrup, with enzymes then added to convert part of the glucose into fructose.

Galactose does not generally occur in the free state but is a constituent with glucose of the disaccharide lactose or milk sugar. It is less sweet than glucose. It is a component of the antigens found on the surface of red blood cells that determine blood groups.

Disaccharides

Sucrose, maltose and lactose are all compound sugars, disaccharides, with the general formula $C_{12}H_{22}O_{11}$. They are formed by the combination of two monosaccharide molecules with the exclusion of a molecule of water.

Sucrose is found in the stems of sugar cane and roots of sugar beet. It also occurs naturally alongside fructose and glucose in other plants, particularly fruits and some roots such as carrots. The different proportions of sugars found in these foods determines the range of sweetness experienced when eating them. A molecule of sucrose is formed by the combination of a molecule of glucose with a molecule of fructose. After being eaten, sucrose is split into its constituent parts during digestion by a number of enzymes known as sucrases.
Maltose is formed during the germination of certain grains, most notably barley which is converted into malt, the source of the sugar's name. A molecule of maltose is formed by the combination of two molecules of glucose. It is less sweet than glucose, fructose or sucrose. It is formed in the body during the digestion of starch by the enzyme amylase and is itself broken down during digestion by the enzyme maltase.
Lactose is the naturally occurring sugar found in milk. A molecule of lactose is formed by the combination of a molecule of galactose with a molecule of glucose. It is broken down when consumed into its constituent parts by the enzyme lactase during digestion. Children have this enzyme but some adults no longer form it and they are unable to digest lactose.

Production

Sugar beet

A pack of sugar made of sugar beet.
Sugar beet (Beta vulgaris) is an annual plant in the Family Amaranthaceae, the tuberous root of which contains a high proportion of sucrose. It is cultivated in temperate regions with adequate rainfall and requires a fertile soil. The crop is harvested mechanically in the autumn and the crown of leaves and excess soil removed. The roots do not deteriorate rapidly and may be left in a clamp in the field for some weeks before being transported to the processing plant. Here the crop is washed and sliced and the sugar extracted by diffusion. Milk of lime is added to the raw juice and carbonatated in a number of stages in order to purify it. Water is evaporated by boiling the syrup under a vacuum. The syrup is then cooled and seeded with sugar crystals. The white sugar which crystallizes out can be separated in a centrifuge and dried. It requires no further refining.

Sugarcane

Sugarcane (Saccharum spp.) is a perennial grass in the family Poaceae. It is cultivated in tropical and sub-tropical regions for the sucrose that is found in its stems. It requires a frost-free climate with sufficient rainfall during the growing season to make full use of the plant's great growth potential. The crop is harvested mechanically or by hand, chopped into lengths and conveyed rapidly to the processing plant. Here it is either milled and the juice extracted with water or the sugar is extracted by diffusion. The juice is then clarified with lime and heated to kill enzymes. The resulting thin syrup is concentrated in a series of evaporators after which further water is removed by evaporation in vacuum containers. The resulting supersaturated solution is seeded with sugar crystals and the sugar crystallizes out, is separated from the fluid and dried. Molasses is a by-product of the process and the fiber from the stems, known as bagasse, is burned to provide energy for the sugar extraction process. The crystals of raw sugar have a sticky brown coating and can either be used as they are or can be bleached by sulphur dioxide or treated in a carbonatation process to produce a whiter product.

Refining

Sugars; clockwise from top left: White refined, unrefined, brown, unprocessed cane

Cane sugar requires further processing to provide the free-flowing white table sugar required by the consumer. The sugar may be transported in bulk to the country where it will be used and the refining process often takes place there. The first stage is known as affination and involves immersing the sugar crystals in a concentrated syrup which softens and removes the sticky brown coating without dissolving them. The crystals are then separated from the liquor and dissolved in water. The resulting syrup is either treated by a carbonatation or a phosphatation process. Both involve the precipitation of a fine solid in the syrup and when this is filtered out, a lot of the impurities are removed at the same time. Removal of colour is achieved by either using a granular activated carbon or an ion-exchange resin. The sugar syrup is concentrated by boiling and then cooled and seeded with sugar crystals causing the sugar to crystallize out. The liquor is spun in a centrifuge and the white crystals are dried in hot air, ready to be packaged or used. The surplus liquor is made into refiners' molasses. The International Commission for Uniform Methods of Sugar Analysis sets standards for the measurement of the purity of refined sugar, known as ICUMSA numbers; lower numbers indicate a higher level of purity in the refined sugar.

Producing countries

The five largest producers of sugar in 2011 were Brazil, India, the European Union, China and Thailand. In the same year, the largest exporter of sugar was Brazil, distantly followed by Thailand, Australia and India. The largest importers were the European Union, United States and Indonesia. Currently, Brazil has the highest per capita consumption of sugar, followed by Australia, Thailand and the European Union.

World sugar production (1000 metric tons)

Country	**2007/08**	**2008/09**	**2009/10**	**2010/11**	**2011/12**
Brazil	31,600	31,850	36,400	38,350	35,750
India	28,630	15,950	20,637	26,650	28,300
European Union	15,614	14,014	16,687	15,090	16,740
China	15,898	13,317	11,429	11,199	11,840
Thailand	7,820	7,200	6,930	9,663	10,170
United States	7,396	6,833	7,224	7,110	7,153
Mexico	5,852	5,260	5,115	5,495	5,650
Russia	3,200	3,481	3,444	2,996	4,800
Pakistan	4,163	3,512	3,420	3,920	4,220
Australia	4,939	4,814	4,700	3,700	4,150
Other	38,424	37,913	37,701	37,264	39,474
Total	**163,536**	**144,144**	**153,687**	**161,437**	**168,247**

Forms and uses

Rock candy crystallised out of a supersaturated sugar solution

Granulated sugars are used at the table to sprinkle on foods and to sweeten hot drinks and in home baking to add sweetness and texture to cooked products. They are also used as a preservative to prevent micro-organisms from growing and perishable food from spoiling as in jams, marmalades and candied fruits.

Milled sugars are ground to a fine powder. They are used as icing sugar, for dusting foods and in baking and confectionery.

Screened sugars are crystalline products separated according to the size of the grains. They are used for decorative table sugars, for blending in dry mixes and in baking and confectionery.

Brown sugars are granulated sugars with the grains coated in molasses to produce a light, dark or demerara sugar. They are used in baked goods, confectionery and toffees.

Sugar cubes are white or brown granulated sugars pressed together in block shape. They are used to sweeten drinks.

Liquid sugars are strong syrups consisting of 67% granulated sugar dissolved in water. They are used in the food processing of a wide range of products including beverages, ice cream and jams.

Invert sugars and syrups are blended to manufacturers specifications and are used in breads, cakes and beverages for adjusting sweetness, aiding moisture retention and avoiding crystallization of sugars.

Syrups and treacles are dissolved invert sugars heated to develop the characteristic flavors. Treacles have added molasses. They are used in a range of baked goods and confectionery including toffees and licorice.

Low calorie sugars and sweeteners are often made of maltodextrin with added sweeteners. Maltodextrin is an easily digestible synthetic polysaccharide consisting of short chains of glucose molecules and is made by the partial hydrolysis of starch. The added sweeteners are often aspartame, saccharin, stevia or sucralose.

Polyols are sugar alcohols and are used in chewing gums where a sweet flavor is required that lasts for a prolonged time in the mouth.

In winemaking, fruit sugars are converted into alcohol by a fermentation process. If the must formed by pressing the fruit has a low sugar content, additional sugar may be added to raise the alcohol content of the wine in a process called chaptalization. In the production of sweet wines, fermentation may be halted before it has run its full course, leaving behind some residual sugar that gives the wine its sweet taste.

Consumption

In most parts of the world, sugar is an important part of the human diet, making food more palatable and providing food energy. After cereals and vegetable oils, sugar derived from sugar cane and beet provided more kilocalories per capita per day on average than other food groups. According to the FAO, an average of 24 kilograms (53 lb) of sugar, equivalent to over 260 food calories per day, was consumed annually per person of all ages in the world in 1999. Even with rising human populations, sugar consumption is expected to increase to 25.1 kilograms (55 lb) per person per year by 2015.

Data collected in multiple nationwide surveys between 1999 and 2008 show that the intake of added sugars has declined by 23.4 percent with declines occurring in all age, ethnic and income groups.

World sugar consumption (1000 metric tons)

Country	**2007/08**	**2008/09**	**2009/10**	**2010/11**	**2011/12**	**2012/13**
India	22,021	23,500	22,500	23,500	25,500	26,500
European Union	16,496	16,760	17,400	17,800	17,800	17,800
China	14,250	14,500	14,300	14,000	14,400	14,900
Brazil	11,400	11,650	11,800	12,000	11,500	11,700
United States	9,590	9,473	9,861	10,086	10,251	10,364
Other	77,098	76,604	77,915	78,717	80,751	81,750
Total	**150,855**	**152,487**	**153,776**	**156,103**	**160,202**	**163,014**

The per capita consumption of refined sugar in the United States has varied between 27 and 46 kilograms (60 and 100 lb) in the last 40 years. In 2008, American per capita total consumption of sugar and sweeteners, exclusive of artificial sweeteners, equalled 61.9 kilograms (136 lb) per year. This consisted of 29.65 kg (65.4 lb) pounds of refined sugar and 31 kg (68.3 lb) pounds of corn-derived sweeteners per person.

Addiction

Sugar addiction

Sugar addiction is the term for the relationship between sugar and the various aspects of food addiction including: "bingeing, withdrawal, craving and cross-sensitization". Some scientists assert that consumption of sweets or sugar could have a heroin addiction like effect.

Hyperactivity

There is a common notion that sugar leads to hyperactivity, particularly in children, but studies and meta-studies tend to disprove this. Some articles and studies do refer to the increasing evidence supporting the links between refined sugar and hyperactivity.The WHO FAO meta-study suggests that such inconclusive results are to be expected when some studies do not effectively segregate or control for free sugars as opposed to sugars still in their natural form (entirely unrefined) while others do. One study followed thirty-five 5-to-7-year-old boys who were reported by their mothers to be behaviorally "sugar sensitive". They were randomly assigned to experimental and control groups. In the experimental group, mothers were told that their children were fed sugar, and in the control group, mothers were told that their children received a placebo. In fact, all children actually received the placebo, but mothers in the sugar expectancy condition rated their children as significantly more hyperactive. This suggests that the real effect of sugar is that it increases worrying among parents with preconceived notions.

Medicinal usage

Sugar is effective in wound cleaning. In 2013, Murandu et al. found clinically that sugar is an antibiotic, and pouring granulated sugar on necrotic wounds can help ulcers heal faster.

Measurements

Different culinary sugars have different densities due to differences in particle size and inclusion of moisture.
The Domino Sugar Company has established the following volume to weight conversions:

- Brown sugar 1 cup = 48 teaspoons ~ 195 g = 6.88 oz
- Granular sugar 1 cup = 48 teaspoons ~ 200 g = 7.06 oz
- Powdered sugar 1 cup = 48 teaspoons ~ 120 g = 4.23 oz.

Bulk density

- Dextrose sugar 0.62 g/mL (= 620 kg/m^3)
- Granulated sugar 0.70 g/mL
- Powdered sugar 0.56 g/mL
- Beet sugar 0.80 g/mL

Tobacco industry

Tobacco is a plant within the genus Nicotiana of the Solanaceae (nightshade) family. There are more than 70 species of tobacco. Products manufactured from dried tobacco leaves include cigars and cigarettes, snuff, pipe tobacco, chewing tobacco and flavored shisha tobacco. Further uses of tobacco are in plant bioengineering and as ornamentals, and chemical components of tobacco are used in some pesticides and medications.
The chief commercial species, N. tabacum, is believed to be native to tropical America, like most nicotiana plants, but has been so long cultivated that it is no longer known in the wild. N. rustica, a species producing fast-burning leaves, was the tobacco originally raised in Virginia, but it is now grown chiefly in Turkey, India, and Russia. The addictive alkaloid nicotine is popularly considered the most characteristic constituent of tobacco but the harmful effects of tobacco consumption can also derive from the thousands of different compounds generated in the smoke, including polycyclic aromatic hydrocarbons (such as benzopyrene), formaldehyde, cadmium, nickel, arsenic, tobacco-specific nitrosamines (TSNAs), phenols, and many others. Tobacco also contains beta-carboline alkaloids which inhibit monoamine oxidase.
Tobacco cultivation is similar to other agricultural products. Seeds are sown in cold frames or hotbeds to prevent attacks from insects, and then transplanted into the fields. Tobacco is an annual crop, which is usually harvested mechanically or by hand. After harvest, tobacco is stored for curing, either by hanging, bundling or placing in large piles with tubular vents to allow the heat to escape from the center. Curing allows for the slow oxidation and degradation of carotenoids. This allows for the agricultural product to take on properties that are usually attributed to the "smoothness" of the smoke. Following this, tobacco is packed into its various forms of consumption, which include smoking, chewing, snuffing, and so on. Most cigarettes incorporate flue-cured tobacco, which produces a milder, more inhalable

smoke. Use of low-pH, inhalable, flue-cured tobacco is one of the principal reasons smoking causes lung cancer and other diseases associated with smoke inhalation.

In consumption, it most commonly appears in the forms of smoking, chewing, snuffing, or dipping tobacco. Tobacco had long been in use as an entheogen in the Americas, but upon the arrival of Europeans in North America, it quickly became popularized as a trade item and a widely abused drug. This popularization led to the development of the southern economy of the United States until it gave way to cotton. Following the American Civil War, a change in demand and production techniques allowed for the development of the cigarette. This new product quickly led to the growth of tobacco companies.

The usage of tobacco is an activity that is practiced by some 1.1 billion people, and up to 1/3 of the adult population. Rates of smoking have leveled off or declined in developed countries, but continue to rise in developing countries.

According to the World Health Organization (WHO), tobacco is the single greatest cause of preventable death globally. In a 2008 report, WHO estimated that it causes 5.4 million deaths per year. Tobacco use leads most commonly to diseases affecting the heart, liver and lungs, with smoking being a major risk factor for heart attacks, strokes, chronic obstructive pulmonary disease (COPD) (including emphysema and chronic bronchitis), and cancer (particularly lung cancer, cancers of the larynx and mouth, and pancreatic cancer). Also, because of the powerfully addictive properties of tobacco, tolerance and dependence develop.

vegetable ghee industry are the agro-based industries in Pakistan.

Environmental pollution and health hazards

Ozone (O3)

Nature and Sources of the Pollutant: Ground-level ozone (the primary constituent of smog) is the most complex, difficult to control, and pervasive of the six principal pollutants. Unlike other pollutants, ozone is not emitted directly into the air by specific sources. Ozone is created by sunlight acting on nitrogen oxides (NOx) and volatile organic compound (VOC) emissions in the air. There are literally thousands of sources of these gases. Some of the more common sources include gasoline vapors, chemical solvents, combustion products of various fuels, and consumer products. They can originate from large industrial facilities, gas stations, and small businesses such as bakeries and dry cleaners. Often these "precursor" gases are emitted in one area, but the actual chemical reactions, stimulated by sunlight and temperature, take place in another. Combined emissions from motor vehicles and stationary sources can be carried hundreds of miles from their origins, forming high ozone concentrations over very large regions. Approximately 50 million people lived in counties with air quality levels above EPA's health-based national air quality standard in 1994. The highest levels of ozone were recorded in Los Angeles. High levels also persist in other heavily populated areas like the Texas Gulf Coast and much of the Northeast.

Health and Other Effects:

Scientific evidence indicates that ground-level ozone not only affects people with impaired respiratory systems (such as asthmatics), but healthy adults and children as well. Exposure to ozone for 6 to 7 hours, even at relatively low concentrations, significantly reduces lung function and induces respiratory inflammation in normal, healthy people during periods of moderate exercise. It can be accompanied by symptoms such as chest pain, coughing, nausea, and pulmonary congestion. Recent studies provide evidence of an association between elevated ozone levels and increases in hospital admissions for respiratory problems in several U.S. cities. Results from animal studies indicate that repeated exposure to high levels of ozone for several months or more can produce permanent structural damage in the lungs. EPA's health-based national air quality standard for ozone is 0.12 ppm (measured at the highest hour during the day). Ozone is also responsible for several billion dollars of agricultural crop yield loss in the U.S. each year. Ozone also damages forest ecosystems in California and the eastern U.S. Click here for more information on the health effects of ozone.

In 1997, the EPA promulgated a new ozone national ambient air quality standard of 0.08 ppm (8 hour averaging time).

Nitrogen Dioxide (NO2)

Nature and Sources of the Pollutant: Nitrogen dioxide belongs to a family of highly reactive gases called nitrogen oxides (NOx). These gases form when fuel is burned at high temperatures, and come principally from motor vehicle exhaust and stationary sources such as electric utilities and industrial boilers. A suffocating, brownish gas, nitrogen dioxide is a strong oxidizing agent that reacts in the air to form corrosive nitric acid, as well as toxic organic nitrates. It also plays a major role in the atmospheric reactions that produce ground-level ozone (or smog).

Health and Other Effects:

Nitrogen dioxide can irritate the lungs and lower resistance to respiratory infections such as influenza. The effects of short-term exposure are still unclear, but continued or frequent exposure to concentrations that are typically much higher than those normally found in the ambient air may cause increased incidence of acute respiratory illness in children. EPA's health-based national air quality standard for NO2 is 0.053 ppm (measured as an annual average). Nitrogen oxides are important in forming ozone and may affect both terrestrial and aquatic ecosystems. Nitrogen oxides in the air are a potentially significant contributor to a number of environmental effects such as acid rain and eutrophication in coastal waters like the Chesapeake Bay. Eutrophication occurs when a body of water suffers an increase in nutrients that reduce the amount of oxygen in the water, producing an environment that is destructive to fish and other animal life.

Particulate Matter (PM-10 and PM-2.5)

Nature and Sources of the Pollutants: Particulate matter is the term for solid or liquid particles found in the air. Some particles are large or dark enough to be seen as soot or smoke. Others are so small they can be detected only with an electron microscope. Because particles originate from a variety of mobile and stationary sources (diesel trucks, wood stoves, power plants, etc.), their chemical and physical compositions vary widely.

Health and Other Effects:

In 1987, EPA replaced the earlier Total Suspended Particulate (TSP) air quality standard with a PM-10 standard. The standard focuses on smaller particles that are likely responsible for adverse health effects because of their ability to reach the lower regions of the respiratory tract. The PM-10 standard includes particles with a diameter of 10 micrometers or less (0.0004 inches or one-seventh the width of a human hair). EPA's health-based national air quality standard for PM-10 is 50 micrograms per cubic meter (measured as an annual average) and 150 micrograms per cubic meter (measured as a daily average). In 1997, EPA promulgated a PM-2.5 standard which includes particles with a diameter of 2.5 microns or less. These smaller particles have the best chance of reaching the lower respiratory tract. The health-based national ambient air quality standard for PM-2.5 is 15 micrograms per cubic meter (measured as an annual average) and 65 micrograms per cubic meter (measured as a daily average).

Major concerns for human health from exposure to particulate matter are: effects on breathing and respiratory systems, damage to lung tissue, cancer, and premature death. The elderly, children, and people with chronic lung disease, influenza, or asthma, tend to be especially sensitive to the effects of particulate matter. Acidic particulate matter can also damage manmade materials and is a major cause of reduced visibility in many parts of the U.S.

Sulfur Dioxide (SO2)

Nature and Sources of the Pollutant: Sulfur dioxide belongs to the family of sulfur oxide gases (SOx). These gases are formed when fuel containing sulfur (mainly coal and oil) is burned, and during metal smelting and other industrial processes.

Health and Other Effects:

The major health concerns associated with exposure to high concentrations of SO2 include effects on breathing, respiratory illness, alterations in pulmonary defenses, and aggravation of existing cardiovascular disease. Major subgroups of the population that are most sensitive to SO2 include asthmatics and individuals with cardiovascular disease or chronic lung disease (such as bronchitis or emphysema) as well as children and the elderly. EPA's health-based national air quality standard for SO2 is 0.03 ppm (measured on an annual average) and 0.14 ppm (measured over 24 hours). Emissions of SO2 also can damage the foliage of trees and agricultural crops. EPA has a secondary SO2 national ambient air quality standard of 0.50 ppm (measured over 3 hours) designed to prevent this type of environmental deterioration. Together, SO2 and NOX are the major precursors to acid rain, which is associated with the acidification of lakes and streams, accelerated corrosion of buildings and monuments, and reduced visibility.

Lead (Pb)

Nature and Sources of the Pollutant: Smelters and battery plants are the major sources of the pollutant "lead" in the air. The highest concentrations of lead are found in the vicinity of nonferrous smelters and other stationary sources of lead emissions.

Health Effects:

Exposure to lead mainly occurs through inhalation of air and ingestion of lead in food, paint, water, soil, or dust. Lead accumulates in the body in blood, bone, and soft tissue. Because it is not readily excreted, lead can also affect the kidneys, liver, nervous system, and other organs. Excessive exposure to lead may cause anemia, kidney disease, reproductive disorders, and neurological impairments such as seizures, mental retardation, and/or behavioral disorders. Even at low doses, lead exposure is associated with changes in fundamental enzymatic, energy transfer, and other processes in the body. Fetuses and children are especially susceptible to low doses of lead, often suffering central nervous system damage or slowed growth. Recent studies show that lead may be a factor in high blood pressure and subsequent heart disease in middle-aged white males. Lead may also contribute to osteoporosis in postmenopausal women. EPA's health-based national air quality standard for lead is 1.5 micrograms per cubic meter [measured as a quarterly average].

Carbon Monoxide (CO)

Nature and Sources of the Pollutant: Carbon monoxide is a colorless odorless poisonous gas formed when carbon in fuels is not burned completely. It is a byproduct of motor vehicle exhaust, which contributes more than two-thirds of all CO emissions nationwide. In cities, automobile exhaust can cause as much as 95 percent of all CO emissions. These emissions can result in high concentrations of CO, particularly in local areas with heavy traffic congestion. Other sources of CO emissions include industrial processes and fuel combustion in sources such as boilers and incinerators. Despite an overall downward trend in concentrations and emissions of CO, some metropolitan areas still experience high levels of CO.

Health and Other Effects: Carbon monoxide enters the bloodstream and reduces oxygen delivery to the body's organs and tissues. The health threat from CO is most serious for those who suffer from cardiovascular disease. Healthy individuals are also affected, but only at higher levels of exposure. Exposure to elevated CO levels is associated with visual impairment, reduced work capacity, reduced manual dexterity, poor learning ability, and difficulty in performing complex tasks. EPA's health based national air quality standard for CO is 9 parts per million (ppm).