Farming Systems and Sustainable Agriculture

Dr.V.Praveen Rao
Dr.R.Veeraraghavaiah
Dr.S.Hemalatha
Dr.B.Joseph

Course outline

1. Course No. : AGRO 303
2. Course Title : **Farming Systems and Sustainable Agriculture**
3. Credit Hours : 2 (1+1)
4. General Objective : (i) To impart knowledge to the students on the fundamentals of farming systems and sustainable agriculture
   (ii) To study the various components of organic agriculture
5. Specific Objectives

a) Theory

By the end of the course, the students will be able to

i. learn the fundamental principles of farming systems and sustainable agriculture and how to improve the economic condition of the farmer

b) Practical

By the end of the practical exercises, the students will be able to

i. learn skills involved in vermiculture, sericulture, dairying, poultry, composting and biocontrol of pests
ii. learn the methods involved in preparation of cropping pattern and farming system to be adopted by the farmer

A) Theory Lecture Outlines

1. Sustainable agriculture – introduction – adverse effects of modern agriculture – definition – concept – goals – elements and current status of sustainable agriculture in India.
2. Factors effecting ecological balance and sustainability of agricultural resources – introduction – land / soil related problems – soil degradation, deforestation, accelerated soil erosion, siltation of reservoirs etc. – causes and extent of these problems in India and ameliorative measures.

3. Rise in water table – water logging – salinization and alkalization in command areas – extent of these problems in India and Andhra Pradesh – prevention, control and reclamation measures – sea water inundation and sand casting during cyclonic storms and their effects on agriculture.
4. Ground water development – resource availability in India and Andhra Pradesh – Groundwater development scenario – over exploitation problems and safe yield concept – artificial recharge methods
5. Environmental pollution – Introduction – greenhouse effect and potential effects on agriculture – depletion of ozone layer, methane emissions from rice fields and mitigation options
6. Fertilizers as a source of pollution and control measures – introduction – nitrate pollution in soil and ground water and eutrophication – management factors to reduce fertilizer pollution
7. Pesticides as source of pollution and control measures – bio-pesticides and bio-herbicides
8. Management of natural resources – introduction – land – water – irrigation problems – Impact on Low External Input Agriculture (ILEIA) and Low External Inputs for Sustainable Agriculture (LEISA) – vegetative cover – present scenario and management practices
9. Conjunctive use of water – definition – objectives – types – advantages and limitations – wasteland and their management – definition – classification – distribution in India and Andhra Pradesh – need for development and regenerative measures
10. Organic farming – definition – principles – relevance to modern agriculture and components of organic farming – integrated nutrient management
11. Organic farming – practices – weed management – pest management –
12. Farming systems – system and systems approach – farming system – determinants of farming system – cropping systems and related terminology
13. Study of allied enterprises – significance of integrating crop and livestock – dairying and sheep and goat rearing – breeds – housing – feed and fodder requirements – biogas plant

14. Study of allied enterprises – poultry farming – breeds – housing – feed and fodder requirements – apiculture – species and management

15. Study of allied enterprises – sericulture – moriculture and silkworm rearing – agro-forestry systems suitable for dryland farming

16. Biodiversity – importance – agricultural intensification and biodiversity – adverse impacts of genetic erosion – conservation of natural resources

B) Practical Class Outlines

1. Preparation of cropping scheme to suit different irrigated and garden land situations
2. Preparation of farming systems to suit to dryland situation
3. Compost making
4. Vermicompost
5. Preparation of enriched farmyard manure
6. Recycling of urban waste
7. Use of bio-pesticides
8. Preparation of project proposals for land development
9. Management of problematic soils
10. Management practices to prevent environmental deterioration for sustainable agriculture
11. Visit to wetland farm – observation on resource allocation, recycling of inputs and economics
12. Visit to garden land farm – observation on resource allocation, recycling of inputs and economics
13. Visit to dry land farm – observation on resource allocation, recycling of inputs and economics
14. Methods of profitable utilization of agricultural wastes
15. Methods of profitable utilization of agricultural by-products
16. Methods of profitable utilization of agro-industry wastes

References

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Lecture No.1

INTRODUCTION TO SUSTAINABLE AGRICULTURE

1.1 Introduction

Over the history of human settlements on the planet earth, agriculture has transformed in tune with the growing population and its challenging needs. The transformation has been quite remarkable since the end of World War II. Food and fibre productivity spared up due to adoption of new technologies viz, HYV, from mechanization, increased fertilizer & pesticide use, specialized farming practices, water resource development & improved irrigation practices and Government policies that favored maximizing production. It was in the early 1960s, the Green Revolution took shape in developing countries, especially India. It led to the attainment of self- sufficiency in food grain production. This has been described by Donald plunkett (1993), scientific adviser to the CGIAR, as the greatest agricultural transformation in the history of humankind, and most of it has taken place during our lifetime. The change was brought about the rise of Science-based agriculture which permitted higher and more stable food production, ensuring food stability and security for a constantly growing world population'. A major problem was that these benefits have been poorly distributed'. Many people have missed out and hunger still persists in many parts of the world. Estimates by the FAO and WHO (1992) and the Hunger Project (1991) suggest that around 1 billion people in the world have diets that are 'too poor to abstain the energy required for healthy growth of children and minimal activity of adults'. The causes are complex and it is not entirely the fault of overall availability of food. Nonetheless, the process of agricultural modernization has been an important contributing factor, in that the technologies have been more readily available to the better-off.

Modern agriculture begins on the research station, where researchers have access to all i.e., necessary inputs of fertilizers, pesticides and labour at all the appropriate times. But when the package is extended to farmers, even the best performing farms cannot match the yields the researchers get. For high productivity per hectare, farmers, need access to the whole package – modern seeds, water, labour, capital or credit, fertilizers and pesticides. Many poorer farming households simply cannot adopt the whole package. If one element is missing, the seed delivery system fails or the fertilizer arrives late, or there is insufficient irrigation water, then yields may not be much better than those for traditional varieties. Even if farmers want to use external resources, very often delivery systems are unable to supply them on time.

Where production has been improved through these modern technologies, all too often there have been adverse environmental and social impacts in both the advanced and developing countries including India. These include the following:

1.2 Adverse effects of modern high- input agriculture

- Overuse of natural resources, causing depletion of groundwater, and loss of forests, wild habitats, and of their capacity to absorb water, causing waterlogging and increased salinity:
- Contamination of the atmosphere by ammonia, nitrous oxide, methane and the products of burning, which play a role in ozone depletion, global warming and atmospheric pollution:
- Contamination of food and fodder by residues of pesticides, nitrates and antibiotics.
- Contamination of water by pesticides, nitrates, soil and livestock water, causing harm to wildlife, disruption of ecosystems and possible health problems in drinking water;
- Build up of resistance to pesticides in pests and diseases including herbicide resistance in weeds
- Damage of farm and natural resources by pesticides, causing harm to farm workers and public, disruption of ecosystems and harm to wildlife.
- Erosion of genetic diversity – the tendency in agriculture to standardize and specialize by focusing on modern varieties, causing the displacement of traditional varieties and breeds:
- New health hazards for workers in the agrochemical and food-processing industries

Added to the above adverse effects, the increasing human as well as cattle population is imposing intense pressure on available natural resources. Accordingly, a challenge has emerged that required a new vision, holistic approaches for ecosystem management and renewed partnership between science and society.

In December 1983, the UN General Assembly established the World Commission on Environment and Development. In 1987, on 27th of April, at the queen Elizabeth Hall in London, the Prime Minister of Norway, Mrs. Brundtland, who is also the Chairman of the World Commission of Environment and development, released the publication of " **Our Common Future**" by the World Commission on Environment and Development (WCED) and said: " Securing our common future will require new energy and openness, fresh insights, and an ability to look beyond the narrow bounds of national frontiers and separate Scientific disciplines. The young are better at such vision than we, who are too often constrained by the traditions of former, more fragmented World. We must tap their energy, their openness, their ability to see the interdependence of issues…" She suggests that we must adopt a new paradigm based on a completely new value system. " Our generation has too often been willing to use the resources of the future to meet our own short- term goals. It is a debt we can never repay. If we fail to change our ways, these young men and women will suffer more than we, and they and their children will be denied their fundamental right to a healthy productive, life-enhancing environment." Her speech made it clear that we are consuming resources, which must be transferred to the next generation. We must recognize that, because resources are limited, we need a sustainable way of life.

Almost at the same time the realization of prime importance of staple food production for achieving food security for future generations has brought the concept of "Sustainable Agriculture" to the forefront and began to take shape in the following three points.

1. The interrelatedness of all the farming systems including the farmer and the family.
2. The importance of many biological balances in the system.
3. The need to maximize desired biological relationships in the system and minimize the use of materials and practices that disrupt these relations.

Sustainability of agricultural systems has become a global concern today and many definitions so Sustainable Agriculture have become available.

1.3 Definition of Sustainable Agriculture

Sustainable Agriculture refers to a range of strategies for addressing many problems that effect agriculture. Such problems include loss of soil productivity from excessive soil erosion and associated plant nutrient losses, surface and ground water pollution from pesticides, fertilizers and sediments, impending shortages of non- renewable resources, and low farm income from depressed commodity prices and high production costs. Furthermore, “Sustainable” implies a time dimension and the capacity of a farming system to endure indefinitely.

(**Lockertz, 1988)**
The successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the (Natural resource- base and avoiding environmental degradation) **(TAC-CGIAR, 1988)**

A sustainable Agriculture is a system of agriculture that is committed to maintain and preserve the agriculture base of soil, water , and atmosphere ensuring future generations the capacity to feed themselves with an adequate supply of safe and wholesome food’ **(Gracet, 1990)**

‘A Sustainable Agriculture system is one that can indefinitely meet demands for food and fibre at socially acceptable, economic and environment cost’

(Crosson, 1992)

A broad and commonly accepted definition of sustainable Agriculture is as follows:

Sustainable Agriculture refers to an agricultural production and distribution system that:

- Achieves the integration of natural biological cycles and controls
- Protects and renews soil fertility and the natural resource base
- Reduces the use of nonrenewable resources and purchased (external or off-farm) production inputs
- Optimizes the management and use of on- farm inputs
- Provides on adequate and dependable farm income

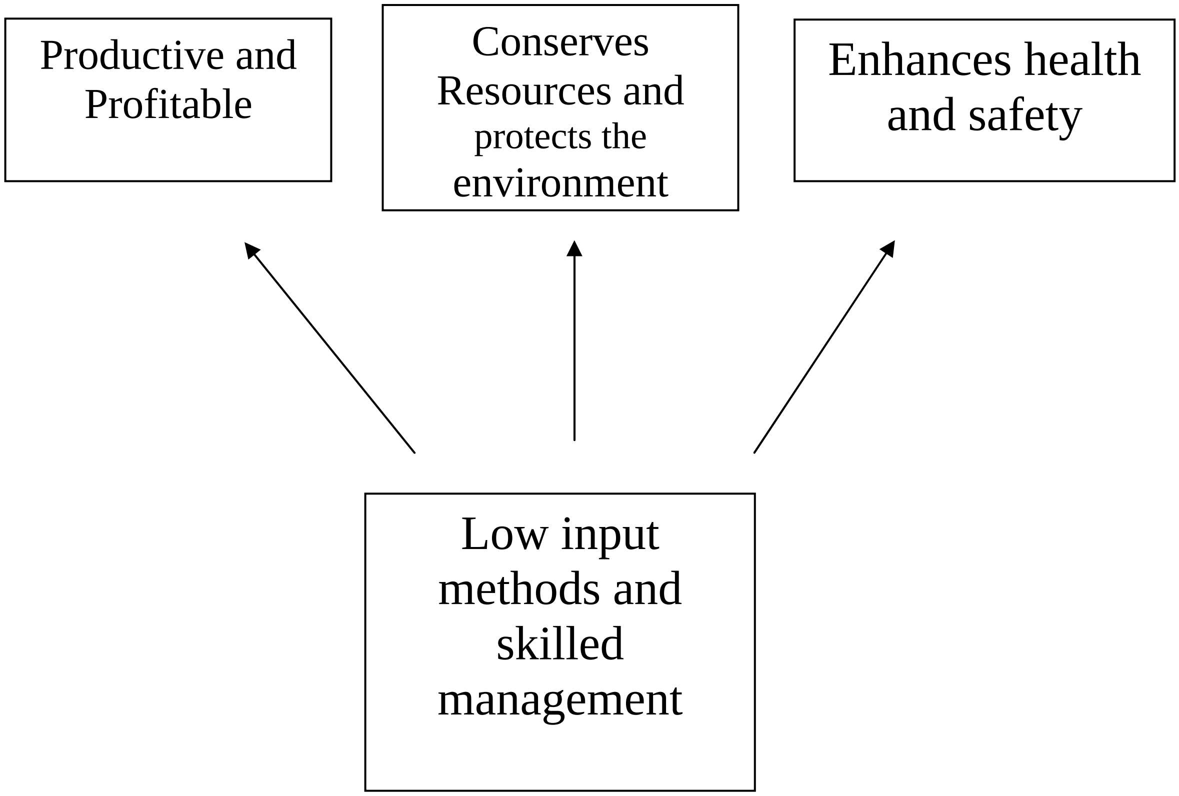
- Promotes opportunity in family farming and farm communities, and
- Minimizes adverse impacts on health, safety, wildlife, water quality and the environment

1.4 Current concept of sustainable agriculture

A Current concept of sustainable Agriculture in the United States showing the ends and the means of achieving them through low- input methods and skilled management is shown in Fig.1.1.

The ultimate goal or the ends of sustainable agriculture is to develop farming systems that are productive and profitable, conserve the natural resource base, protect the environment, and enhance health and safety, and to do so over the long-term. The means of achieving this is low input methods and skilled management, which seek to optimize the management and use of internal production inputs (i.e., on-farm resources) in ways that provide acceptable levels of sustainable crop yields and livestock production and result in economically profitable returns. This approach emphasizes such cultural and management practices as crop rotations, recycling of animal manures, and conservation tillage to control soil erosion and nutrient losses and to maintain or enhance soil productivity.

Low-input farming systems seek to minimize the use of external production inputs (i.e., off-farm resources), such as purchased fertilizers and pesticides, wherever and whenever feasible and practicable: to lower production costs: to avoid pollution of surface and groundwater: to reduce pesticide residues in food: to reduce a farmer’s overall risk:; and to increase both short-term and long-term farm profitability. Another reason for the focus on low- input farming systems is that most high-input systems, sooner or later, would probably fail because they are not either economically or environmentally sustainable over the long-term.



1. Reduceduse of synthetic
2. chemical inputs
3. Biological pest control
4. Soil and water conservation practices
5. Use of animal and green manures
6. Biotechnology
7. Crop rotations
8. Use of Organic wastes
9. Crop- livestock diversification
10. Mechanical cultivation
11. Naturallyoccurring processes

Fig.1.1 A current concept of sustainable Agriculture in The United States

1.5 Goals of sustainable Agriculture

A sustainable Agriculture, therefore, is any system of food or fiber production that systematically pursues the following goals:

- A more thorough incorporation of natural processes such as nutrient cycling nitrogen fixation and pest-predator relationships into agricultural production processes:
- A reduction in the use of those off-farm, external and non-renewable inputs with the greatest potential to damage the environment or harm the health of farmers and consumers, and more targeted use of the remaining inputs used with a view to minimizing variable costs:
- The full participation of farmers and rural people in all processes of problem analysis and technology development, adoption and extension.
- A more equitable access to predictive resources and opportunities, and progress towards more socially just forms of Agriculture:
- A greater productive use of the biological and genetic potential of plant and animal species:
- A greater productive use of local knowledge and practices, including innovation in approaches not yet fully understood by scientists or widely adopted by farmers:
- An increase in self-reliance among farmers and rural people
- An improvement in the match between cropping patterns and the productive potential and environmental constraints of climate and landscape to ensure long-term sustainability of current production levels: and
- Profitable and efficient production with an emphasis on integrated form management: and the conservation of soil, water, energy and biological resources

1.6 Elements of sustainability

There are many ways to improve the sustainability of a given farming system, and these vary from region to region, However, there are some common sets of practices among farmers trying to take a more sustainable approach, in part through greater use of on-farm or local resources each contributing in some way to long- term profitability, environmental stewardship and rural quality of life.

a) Soil conservation- Many soil conservation methods, including contour cultivates contour bunding, graded bunding, vegetative barriers, strip cropping cover cropping, reduced tillage etc help prevent loss of soil due to wind and water erosion

b) Crop diversity- Growing a greater variety of crops on a farm can help reduce risks from extremes in weather, market conditions or crop pests. Increased diversity crops and other plants, such as trees and shrubs, also can contribute to soil conservation, wildlife habitat and increased populations of beneficial insects

c) Nutrient management- Proper management of nitrogen and other plant nutrients con improve the soil and protect environment. Increased use of farm nutrient sources such as manure and leguminous cover crops, also reduces purchased fertilizer costs.

d) Integrated pest management (IPM)- IPM is a sustainable approach to managing pests by combining biological, cultural, physical and chemical tools in way that minimizes economic, health and environmental risks.

e) Cover crops- Growing plant such as sun hemp, horse gram, pillipesara in the off season after harvesting a grain or vegetable crop can provide several benefits, including weed suppression, erosion control, and improved soil nutrients and soil quality .

f) Rotational grazing- New management- intensive grazing systems take animals out barn into the pasture to provide high-quality forage and reduced feed cost .

g) Water quality & water conservation- Water conservation and protection have **i**mportant part of Agricultural stewardship. Many practices have been develop conserve Viz., deep ploughing, mulching, micro irrigation techniques etc.., protect quality of drinking and surface water .

h) Agro forestry- Trees and other woody perennials are often underutilized on ----covers a range of practices Viz., ogi-silvicuture, silive-pastoral, agri-silvi-pagri-horticulture, horti/silvipastoral, alley cropping, tree farming , lay farm that help conserve, soil and water.

i) Marketing- Farmers across the country are finding that improved marketing -----way to enhance profitability, direct marketing of agricultural product from farmers to consumers is becoming much more common, including through Rythu bazaar rod side stands .

1.7 Status of sustainable Agriculture in India

The survival and well being of the nation depends on sustainable development. It is a process of social and economic betterment that satisfy needs and values of interest groups without foreclosing options. Suitable Development of India demands access to state of are 'clean' technologies and have as strategic role in increasing the capabilities of the country both o the environment as well as to provide thrust towards conservation and sustainable agriculture. Current research programmes towards sustainable agriculture are as follows:

1. Resistant crop varieties to soil, climatic and biotic stresses
2. Multiple cropping system for irrigated areas and tree based farming system rainfall area.
3. Integrated nutrient management
   a. Combined use of organic and inorganic sources of nutrients
   b. Use of green manures (Sesbania, Crotalaria etc)
   c. Inclusion of pulse crops in crop sequence
   d. Use of bio fertilizers
4. Integrated pest management
   a. Microbial control
   b. Use of botanicals
   c. Use of predators
5. Soil and water conservation
   a. Watershed management
   b. Use of organics as mulch and manure
   c. Use of bio-fencing like vettiver
6. Agroforestry systems in dry lands/ sloppy areas and erosion prone areas
7. Farm implements to save energy in agriculture
8. Use of non-conventional energy in Agriculture
9. Input use efficiency
   a. Water technology
   b. Fertilizer technology
10. Plant genetic resource collection and conservation.

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Lecture No.2

FACTORS AFFECTING ECOLOGICAL BALANCE AND SUSTANABILITY OF AGRICULTURAL RESOURCES

2.1 Introduction

Technology generated and implemented for increasing Agricultural productivity during past three decades resulted in depletion of natural resource base besides creating several environmental and ecological problems. In contrast the demand scenario features a growth rare in food requirements to meet the ever-increasing demand of the growing population. The total food grain demand of India by 2020 is estimated at 294 million tones as against the present 224 million tonnes (2010-11), which has to come from the almost static net cultivated area of about 142 million ha. This improvement in food grain production has to be achieved while dealing with the factors affecting the ecological balance and sustainability of Agricultural resources.

Major factors affecting the ecological balance and sustainability of agricultural resources are:

a) Land/soil related problems

- Soil degradatiom
- Deforestation
- Accelerated soil erosion
- Siltation of reserves
- Wind erosion

b) Irrigation related problems

- Rise in groundwater table & water logging
- Soil salinization & alkalization
- Over- exploitation of groundwater

c) Indiscriminate use of agro-chemicals

- Fertilizer pollution
- Pesticide pollution

d) Environmental pollution

- Greenhouse effect
- Depletion emissions
- Methane emission
- Eutrophication

e) Erosion of genetic biodiversity

2.2 Land/soil related problems
2.2.1 Soil degradation

Soil degradation refers to decline tin the productive capacity of land due to decline in soil quality caused through processed induced mainly by human activities. It is a global problem. The Global Assessment of the Status of Human-induced soil Degradation (GLASOD) was the first worldwide comparative analysis focusing specifically on soil degradation. Worldwide around 1.96. Billion ha are affected by human-induced soil degradation, mainly caused by water and wind erosion (1094 and 548 million ha respectively). Chemical degradation accounted for 240 million ha, mainly nutrient decline (136 million ha) and salinization (77 million ha), physical degradation occurred on 83 million ha, mainly as a result of compaction, sealing and crusting.
It is also a very important problem in India, which shares only 2.4% of the world's land resource and supports more than 18% of the world's human population and 15% of livestock population. Estimates of soil degradation are varied depending upon the criteria used.

The soil degradation through different processes is shown in Fig.2.2. The processes leading to soil degradation are generally triggered by excessive pressure on land to meet the competing demands of growing population for food, fodder, fibre and fuel.
Therefore, the direct causes for soil degradation are unsustainable land use and inappropriate land management. The most common direct causes include:

- Deforestation of fragile lands
- Over cutting and grazing of vegetation
- Extension of cultivation on to lands of low capability/potential
- Improper crop rotations
- Unbalanced fertilizer use
- Non-adoption of soil conservation practices
- Inadequacies in planning and management of irrigation resources
- Overdraft of groundwater in excess of capacity to recharge

The strategies for improving soil quality and sustainability include – skilled management, crop rotation, soil and water conservation,

conservation tillage integrated nutrient management, integrated water management, integrated pest management and integrated (crop & livestock system) farming systems,

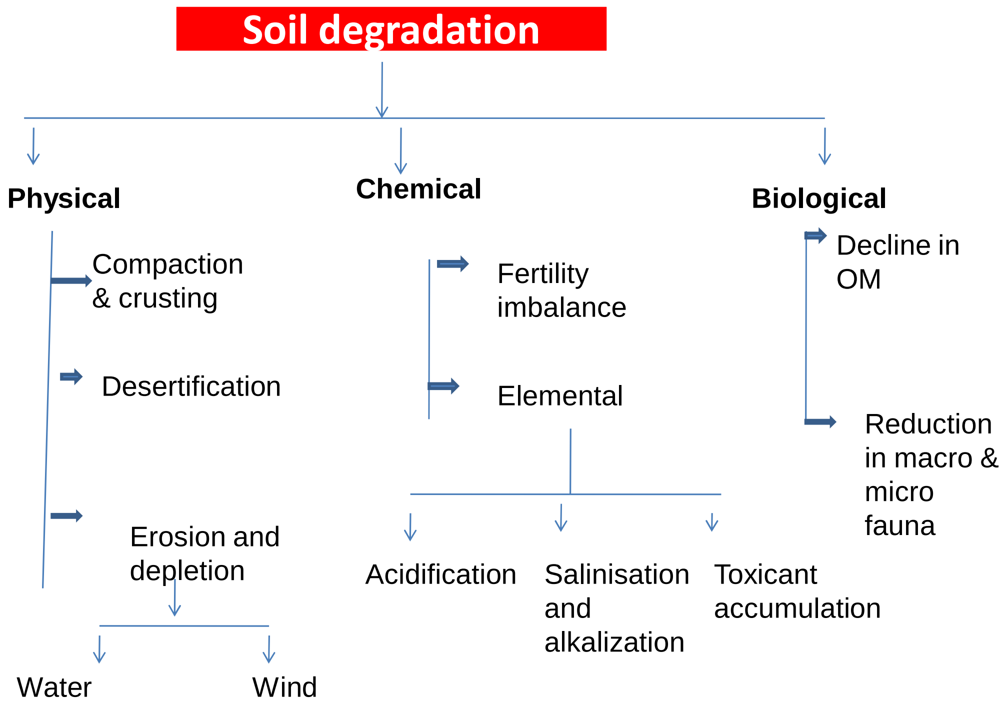

Fig 2.2 Soil degradation through different processes

Fig 2.2 Soil degradation through different processes

Wind Erosion

Water erosion

2.2.2.Deforestation

Deforestation, in strict sense of the term, refers to the transfer of forest land to non-forest uses and includes all land where the forest cover has been stripped off and the land converted to such uses as permanent cultivation, shifting cultivation, human settlements, mining, reservoirs etc. Deforestation continues to threaten and erode the area under forest cover in several countries of the World.

The underlying causes of deforestation are rooted in a complex web of social, economic and institutional problems. They include:

(i) The combined effects of poverty, skewed land distribution, and rising population pressure

(ii) Increased demand for tropical timber and Agricultural products, and

(iii) International debt obligations, which can lead developing countries to accelerate the pace of forest exploitation in order to earn needed foreign exchange

The forest area in India has shrunk from 33% in 1947 to 22.6 % at present. As per the recommended norm of the National Forest Policy 1988, about 33% of the geographical area should be under the forest cover, which comes to about 110 million ha compared to 68.83 million ha presently under the forest cover in India

Deforestation, together with over grazing, is modifying the climate, and accelerating the erosion of biodiversity, which in turn posing the threat to ecological sustainability and food security .

India has established an organization called the National Afforestation and Ecodevelopment Board (NAEB) in 1992 to take up afforestation programmes and bring back the productivity from the degraded forestlands.


DEFORESTATION
Because i want wood!

WHAT IS DEFORESTATION?

Deforestation is the process of clearing large areas of forest across the earth and involves the cutting down, burning, and damaging of forests.

2.2.3 Accelerated Soil erosion

Agricultural productivity depends largely on the topsoil (up to 20 cm thickness), as it serves many functions such as – support for rooting, supply of plant nutrients, storage and release of soil moisture etc. The loss of the topsoil usually instigated by the activities of man, termed as accelerated soil erosion, is the most serious form of land degradation. Some erosion, however, takes place through natural processes slowly but some natural processes of 11decay and regeneration replace this loss. A balance is maintained between soil loss and soil formation, but when vegetation is stripped away, as in deforestation and shifting cultivation, the soil becomes vulnerable to damage by wind and water and the slow rate of natural erosion is accelerated. (Under accelerated erosion, soil loss takes place much faster than new soil can be formed as a result soil productivity goes down (Table 2.3).

India is one of the few countries in the World, which has an audit of land degradation due to soil erosion; soil erosion estimates in India are given below in the Table 2.4.

Table 2.4. Soil Erosion estimates in India

Parameter	Erosion (million tonnes)	Per cent
Total soil loss	5334	100
Transported from one place	3282	61
Deposited in the reservoirs	480	10
Lost into the sea	1572	29

The analyses of the existing soil loss date indicate that soil erosion takes place at an average rate of 16.35 tonnes/ha/year totaling 5.334 million tones/year. Nearly 29% of the total eroded soil was permanently lost to the sea; and nearly 10% was deposited in multipurpose reservoirs, resulting in the reduction of their storage capacity by 1-2% annually. The remaining 61% of the eroded soil was transported from one place to another. Along with the eroded topsoil, three major plant nutrients viz., Nitrogen, phosphorus, and potassium ranging from 4.4 to 8.4 tonnes are also lost. Crop yields are reduced by erosion through less supply of plant nutrients, shallow depth of soil, poor structure, surface sealing and crusting, which leads to reduced water infiltration and poor seedling establishment , In addition to this on-site effects, the off-site effects of erosion are also of serious concern for the sustainability of Agricultural productivity.

2.2.4 Siltataion of Reservoirs

Siltation of reservoirs is the major off-site effect of soil erosion by water. The process of deposition of soil particles carried by water is called **sedimentation or siltation.** Sedimentation or siltation is both a serious and growing problem, but its severity varies from one reservoir to another. Usually, every reservoir is provided with certain storage capacity to accommodate for the natural sedimentation rate, which capacity is called its dead storage. Sediment accumulation is not controlled in most of the reservoirs and they are irreversibly getting filled with sediment and constitute the most non-sustainable water resource system in India today.

Table 2.5. Soil loss in different catchments of India

Catchment	Loss of soil (t/ha/year)
Snow clad deserts	5.0
Shiwalik hills	80.0
Ravines of Chambal and other river	4.0
Western Ghats	20.0-30.0
Shifting cultivation of N.E. states	740.0

Source: Kanwar(2000)

The life of many irrigation reservoirs has been reduced by accelerated soil erosion in the catchment's area (Table 2.5) and increased the rates of siltation more than the assumed rates at the of planning stage (Kanwar,2000). These increased rates of siltation are adversely affecting capacity of the reservoirs to sustain the gains in productivity achieved over the past decades. In addition to the drastic reduction in life of the projects involving huge investments, these accelerated rates of siltation of reservoirs and other water storage sites are causing floods that effect life and property quite often. The area annually are causing floods that effect life and property quite often. The area annually flooded, including cropland, has increased from an average of 6.86 m ha in fifties to 16.57 m ha in the eighties (Table 2.7). Published data on 116 large dams showed that by the year 2020 over 20% of India's reservoirs will lose 50% of their storage capacity due to fast rates of silting up.

Table 2.7. Trends in flood havoc in India

Decade	Av.Annual area Affected(m ha)	Av. Annual flood Affected population	Av. Annual total flood damage (m Rs)
1950s	6.86	2.08	923
1960s	5.86	2.47	1041
1970s	11.19	5.55	6741
1980s	16.57	6.91	15904

Source: Centre for Science and Environment, 1991

Efficient reservoir maintenance calls for thorough survey of the factors affecting sediment load from the catchment's area and to take up measures to prevent sedimentation. Soil type and degree of vegetative cover in the catchment's area mostly influence the rate of siltation (Table2.8). The rate of sedimentation in some reservoirs of Andhra Pradesh is less if forest cover mostly covers the catchment's area. In general, the erosion hazard of cropland is estimated to increase sharply from class I through class IV soils.

Table 2.8. Sedimentation rate of reservoirs as influenced by soil type in the catchments

Name of the reservoir	Sedimentation rate (ha-m/100 km^2/ year	Area covered (1% of the catchment)		
		Forest	**Clay soil**	**Red soil**
Kalyani	0.57	98	1	1
Kinnerasani	0.62	90	2	3
Wyra	4.51	30	10	60
Osman sagar	5.02	20	10	70
Kotapally	5.43	30	5	65
Nizam sagar	6.67	22	57	21
Pampa	6.70	24	57	19
Himayatsagar	6.94	20	57	23

Upper Manair	8.53	8	80	12
Sriramsagar	9.07	3	94	1

The conditions indicative of high sediment yield potential from cropland and other sources in the catchment's area are given below:

(I) Cropland

- Long slopes farmed without terraces or run-off diversions
- Crop rows planted up and down on moderate or steep slopes
- No crop residues on soil surface after seeding a new crop
- No crop cover between harvest and establishment of new crop canopy
- Poor crop stands or poor quality of vegetation

(II) Other sources

- Gullies
- Residential or commercial constructions
- Road or railway tract construction
- Poorly managed range, wastelands or wooded lands
- Un-stabilized road or railway tract banks
- Surface mining areas, etc

Usually, it is better to take steps that prevent sedimentation, either engineering or agronomic, rather than clearing the sediments mechanically, which is not only very expensive but also highly impractical. Some engineering and agronomic measures suggested for prevention of salutation reservoirs are given below:

a). Engineering Measures

- Provision of scour sluices in the body of dam and whose opening from to time clear of the sediments
- Construction of small impounding tanks in the valley upstream to break up water flow rate and shared silt load before the flow reaches final storage

b). Agronomic Measures

- Cover crops
- Afforestation
- Pastures
- Contour cultivation
- Contour bunding
- Live bunding
- Grassed waterways

2.3. Effects- Social, economic and crop production

Although India has successfully achieved self-sufficiency in food grain production, the problem of resource degradation poses a serious threat and challenge to our ability to do so in future. The tragedy of the depletion of our natural resource and its impact can be shown below (Fig. 2.8). Although precise and quantitative estimates of the impacts of degradation are lacking, there are several pointers to the overall effects.

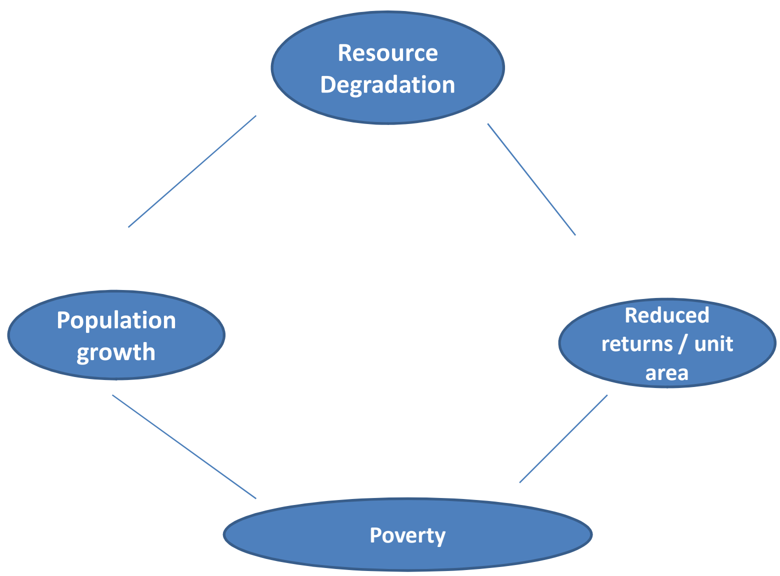

Fig.2.8 Vicious circle of natural resource degradation

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Lecture No .3

RISE IN WATE TABLE, WATER LOGGING, SALANIZATION & ALKALIZATION AND SEA WATER INUNDATION & ITS EFFECTS ON AGRICULTURE

3.1 Rise in ground water table

A feature common to many irrigation commands of surface water projects is excess recharge over discharge of groundwater, leading to rise in water table. The irrigation command areas are recharged not only by rainfall infiltration, but also by seepage from reservoirs, canals, distributaries and field channels, and return circulation of irrigation water. At Haryana Agriculture University Farm, where the groundwater table used to be at 15.6 m below the ground level in 1967 at the time of introduction of irrigation under Bhakra canal system had gone up to 2.0m below the ground level (Kumar and singh, 1994). The rate of rise of groundwater table in different irrigation commands in India is given in Table 3.1.Overall the rise in groundwater table appears to be a common feature once the irrigation is introduced in canal commands. The rise in groundwater table ultimately leads to waterlogging, salinization & alkalization in irrigation commands.

Table 3.1. Rate of rise in groundwater table indifferent irrigation commands

Irrigation command	**Rise in water table (m/year)**
Mahi Right Bank Canal, Gujarat	0.28
Rajasthan Canal	0.29-0.88
Western Yamuna & Bhakra Canal, Haryana	0.30-1.00
Sirhand canal, Punjab	0.10-1.00
Sarada Sahayak Canal, Uttar Pradesh	0.68
Malprabha Canal, Karnataka	0.60-1.20
Nagarjuna Sagar Project, Andhra Pradesh	0.32

Sriram Sagar Project, Andhra Pradesh	0.26

3.2 Waterlogging

Presence of excess water in or near the root zone or standing water above the soil surface for any substantial period of time known as water logging. Water logging is said to occur when the water table rises to within the root zone of crops. The water table which is considered harmful would depend upon the type of crop, soil type and water quality. The actual depth of water table, when it starts affecting the crop yield adversely, may from zero for rice to about 1.5m for other crops. The norms for characterization of water logging are given below in Table 3.2:

Table 3.2. Norms for characterization of Water logging

Depth of water table (m)	Nomenclature
< 2.0	Waterlogged
2.0-3.0	Potentially waterlogged
> 3.0	Safe

Ministry of agriculture estimates indicate that about 11.6 million ha, representing 3.5% of the geographical area of India, has been suffering from physical deterioration caused by waterlogging (Kanwar,2000).

The National Commission on Agriculture (1976) estimated the area affected by waterlogging in Andhra Pradesh at 3.39 million ha.

3.3 Salinization & Alkalization

The most well understood problem is of salinization and alkalization of soils, which is reported to extend to **10.1** million ha in India. The problem is increasing at an alarming rate in the canal-irrigated areas through increase in water table, poor water management practices and lack of drainage. The rate of increase of the problem is fast in the black soil regions of heavy texture, with serious drainage problem. The vast irrigation development without drainage, adequate field channels and water management technology has seriously reduced the effectiveness of irrigation system and aggravated the problem of salinity, alkalinity and waterlogging. The irrigation induced waterlogging and salinity assessed by the Ministry of Water Resources (1993) is evident from Table 3.3

Table 3.3. Irrigation-induced waterlogging and salinity

Region	**Type of problem**	**Affected area (million ha)**
North- West India	Waterlogging and solinity	0.7-1.0
Coastal Peninstular area	Waerlogging and incidental salinity	0.1-0.2
Estern plains and Delhi	Waterlogging	1.0-1.5
Coastal Gujarat	Coastal salinity	0.75
Usar land western Gangetic plains	Semi-natural sodic soil	1.25

Gupta (1998) estimated that out of 8.56 million ha area affected by salinity & alkalinity, 3.0 million ha or 35% is in canal command area. Likewise, out of 4.5 million ha of water logged area nearly 2.2 million ha or 5.% is in coastal command areas. The Ministry of Water Resources reported that in the major and medium command areas is about 2.4 million ha was affected by water logging and 3.3 million ha by salinity. Thus the canal irrigation is the cause and effect of salinity, alkalinity and water logging increase, but it can also be cured if conjunctive use of surface and groundwater irrigation, drainage and scientific water management system are adopted. It hardly needs to be emphasized that 1/3 to half of the land is getting degraded through salinization, alkalization and waterlogging due to the canal irrigation. It is indeed too high a price that the nation is paying for the big irrigation projects. Added to this, is the rapidly impossibility of repair or amelioration of the problem at advanced age of the dam is another problem.

Saline soils, also known as solanchalk, are characterized by pH of the saturated soil paste < 8.2, exchangeable sodium percentage (ESP) < 15 and electrical conductivity (EC) of the saturated paste > 4.0 dS/m. Excessive amounts of soluble salts, mainly Cl and SO_4 of Na, Ca and Mg limit optimal crop growth due to direct toxic effects of salts and increased osmotic stress which physiologically inhibits the availability of soil water. Parent material, brackish groundwater, seepage from canals and form irrigation systems, injudicious on-farm water use, high cropping intensities and replacement of low water requiring crops of high water demand gradually result in higher water table and associated secondary salinization of soils.

Alkali soils, also known as sodic or solonetz soils are characterized by an ESP > 15 and PH of > 8.2. The EC of these soils is variable but is normally less than 4 dS/m in the surface soil and a hard $CaCo_3$ kankar pan in the subsoil. These soils are highly dispersed and have poor water and air permeability affecting plant growth. The groundwater quality is generally good but in some cases it may contain high residual sodium carbonate (RSC).

Several workers have opined and concluded that more construction of dams and canal is not enough and there is on urgent need to focus attention on improved water management, command area development system. Our big irrigation projects are considered engineering monumental, but seem to be ending up in increasing woes of agriculture and low payoff from investment. The increasing concern and debate on big dams versus small water resource development structures should be ignored as the high cost, low pay-off and consequential soil degradation problems following in the wake of call for change in strategy and policy of irrigation systems development, lest the history repeats itself and civilization meets the same fate as many old irrigation civilizations of the past.

3.4 Prevention, control and reclamation measures

Salinity, alkalinity and water logging in canal command areas can be controlled by adopting suitable measures to reduce the recharge to and increase the discharge from the problem area. The various measures by which this can be achieved are enumerated below (Karanth, 1986).

a) Control of surface drainage into the area – Surface runoff entering the problem area accelerates water logging, salinity & alkalinity. Diversion coursed may be provided to divert runoff from the problem are.

b) Provision of an efficient surface-drainage system- An efficient surface-drainage system should be provided by constructing open ditches and field drains to drain away the storm flow and excess irrigation water. Proper land grading and maintenance of surface slopes improves drainage of farmland. Slopes of draining courses may be improved and phreatophytes and other vegetation, if preventing the drainage channel, may be cleaned to relieve congestion. Pools, ponds and marshes should be connected to watercourses. Where permissible fro considerations of quality, drain water may be utilized for irrigation. This will provide higher gradients for subsurface drainage.

c) Improving subsurface drainage- Waterlogged agricultural lands can be relieved of excess ground water by providing underground drains or collecting excess ground water in surface for disposal into water.

d) Conjunctive use- Pumping from wells serves the dual purpose of lowering the water table and salinity and releasing additional quantities of water for use conjunctively with surface water.

e) Planning and adoption of rational agricultural practices- Selection and rotation of crops, depending on their water requirements, are important agricultural practices helpful in ameliorating water logging, salinity & alkalinity conditions. Certain crops like rice require more water, while certain others like wheat, millets and cotton require much less. Likewise certain crops are tolerant and sensitive to salinity. Proper crop/variety selection assumes significance under adverse conditions. If crops with high water requirements are always sown and canal water is used for irrigation continuously, the chances are high that the area will become waterlogged and buildup salinity takes place sooner than one realizes. When such crops are to be raised, they should not be raised on highly permeable soils. Alfalfa and eucalyptus, because of their high intake of water, have ameliorative characteristics.

f) Lining of canals and water courses- Seepage from canals, distributaries and field channels should be prevented or minimized by lining or spreading impervious layers.

g)Adopting judicious water-management practices-Planning and controlling use of water to avoid excessive and wasteful applications is important measure that involve no extra expenditure. Excessive application of water is as detrimental to crop growth as inadequate application, a maxim many farmers are unaware of any need to be educated about.

h) Adoption of water use efficient application methods like sprinkler and drip systems in high value crops

i) Reclamation of saline and alkaline soils-

- For saline soils with efflorescence of salts at the surface: Scraping of the surface salts and flushing with water to wash away the excess salts
- For saline soils with high concentration of soluble salts into great depth but with deep water table: Impounding rain or irrigation water for leaching salts to a safe limit and subsurface drains coupled with flushing to remove salts both by surface & subsurface drainage
- For saline soils with high concentration of soluble salts into great depth but with high water table: Lowering of water table either by pumping or subsurface drainage
- For alkali soils: Treating the soils with chemical amendments like gypsum & sulphur, addition of organic material viz., FYM, crop residues, green manuring etc, leaching the products of reaction after amendments are added, deep ploughing to break the hard pan for improving drainage.

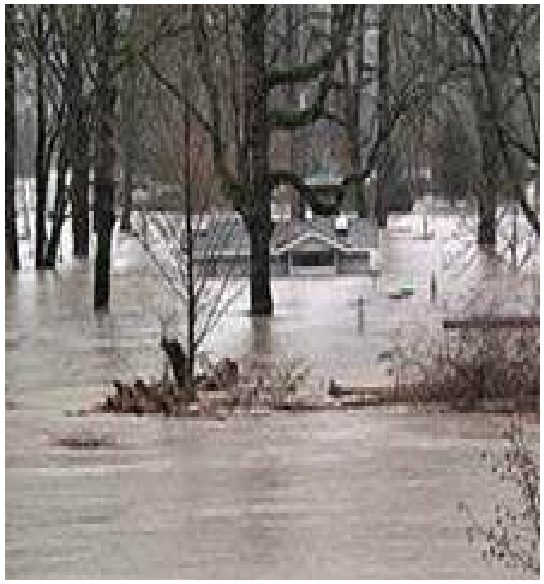
After reclamation of the salt affected soils, it is necessary to prevent their resalinization and alkalization. Maintaining a salt balance, drainage and controlling the depth of water table will achieve this.

3.5 Seawater inundation and Sand casting

Natural calamities, like cyclones and floods, affect nations all over the world. Because of the large geographical size of the country. India often faces natural calamities like floods, cyclones and droughts, occurring fairly frequently in different parts of the country. At times, the same area is subjected to cyclones & floods in successive seasons or years.

Cyclonic storm arising from Bay of Bengal often cross the east-coast plains of Orissa, Andhra Pradesh and Tamil nadu during October-January resulting in wide spread damages to standing crops besides other losses. The cyclones cause and ingression of sea water/ tidal waves. The latter cause the problem of soil salinity and sand casting of varying depths in lower reaches.

Cyclone damage



Flood damage

3.5.1 Nature of damages caused by cyclones to agricultural crops

1. Mortality of plants
2. Suppression of tillering in rice
3. Complete or partial lodging in rice, cotton, sugarcane, vegetables, tobacco etc
4. Uprooting of plants in coconut, banana, sugarcane, orchards and field crops
5. Yellowing and shedding of leaves
6. Excessive vegetative growth in cotton
7. Increased virulence of pests and diseases. For Example sheath blight, bacterial leaf blight, brown plant hopper in rice, pod borers, die-back, fruit rot in vegetables like chillies and tomato, helicoverpa incidence and rotting of bolls in cotton and wilting of plants.
8. Shattering of grains/pods where the crop is in ripening or maturity phase
9. Nutritional disorders and toxicities
10. Wetting of harvested rice sheaves in the field
11. Soil salinity build up and soil erosion in varying degrees depending upon the land topography.
12. Water logging of cultivated lands
13. Sand casting in land areas due to tidal waves lashing the coast
14. Difficulty in threshing, cleaning and drying of agricultural Produce

3.5.2 Economic consequences of cyclones

1. Land degradation and loss of soil productivity
2. Considerable expenditure on land reclamation
3. Reduction in total agricultural production
4. Damage to the ecosystem
5. Disruption of roads, transport, communication and human settlements
6. Reduction in aquaculture activity

Erosion Degradation

Soil erosion, which is the movement of soil particles from one place to another by wind or water, is considered to be a major environmental problem.

Man has the capacity for major destruction of our landscape and soil resources.

Highway washed away after a heavy rainfall

3.5.3 Mitigation options

a) Rice

1. If the crop is caught in cyclone or tidal waves at maturity stage, drain the paddies and thresh the rice sheaves immediately. Use of threshers/mechanical dryers to quick threshing, cleaning and drying of grain need to be explored.
2. Reclaim the salinated fields, by flooding with good quality irrigation water leaching the salts and draining the fields followed by puddling. Apply SSP @ 100 kg/ha to hasten the decomposition of stubbles for preparing the field in time for second crop. Raise nurseries on non-saline soil.
3. In fodder nurseries situations due to complete failure of rice crop raise fodder crops like pillipesera, cowpea, sun hemp etc., in marginal lands unfit for rice cultivation.
4. In area where rice cultivation is not possible, raise alternate crops like groundnut, maize, rabi redgram, blackgram, rabi castor etc.
5. Control rodents through community approach

b) Cotton and chillles

1. Carryout the earthing up by carefully lifting the lodged plants
2. Raise coriander or Chickpea or Black gram or sunnhemp in fields where the cotton crop is completely damaged due to uprooting
3. Spray 2% urea on cotton plants having foliage

c) Banana

1. Remove the damaged plants by leaving two suckers
2. Fertilize the plants for four months @ 80 g urea and 80g muriate of potash/plant.
3. Cover the bunches on damged plants with leaves and harvest them within 15 to 20 days

d) Coconut

1. Cut and remove the twisted leaves
2. Provide support to hanging bunches
3. Apply a booster fertilizer dose @ 0.5 kg Diammonium phosphate, 0.5 kg Urea and 1.5 kg muriate of potash per plant to bearing palm trees

e**) Acid lime**

1. Uplift the fallen trees and carryout the earthing up
2. Remove the damaged branches and apply Bordeaux paste

Sand casting

Deposition of sand particles on the agricultural fields due to natural calamities is termed as sand casting

1. Where sand casting is about 15 cm, incorporate the same into the soil by ploughing with wooden or mould board or disc plough. This may be followed by normal cultivation.
2. Where the sand casting is between 15 to 60 cm, sand may be removed using bulldozers. This may be followed by normal cultivation.
3. Where sand casting is more than 60 cm, no reclamation or removal of sand is suggested, since this would be costly and

difficult to dump the sand so removed in the nearby fields: in such cases, plant horticultural crops like cashew nut, coconut and casuarinas etc, in *situ*,

SAND CASTING

- The natural calamities like tsunami , cyclones and tides etc., bring the sand along with water on to the agricultural lands.
- This sand obstructs the cultivable land.

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Lecture No.4
GROUNDWATER DEVELOPMENT
4.1 Introduction

Groundwater is a significant source of water supply for roughly half of the country’s net irrigated area. Groundwater irrigation (using dug wells, bore wells, and dug- cum-bore wells) began to expand rapidly with the advent of HYV technology in the second half of the 1960s. according to estimates (Dains & Power 1987) 70-80% of the value of the irrigated agricultural production in the country may depend on groundwater irrigation. Besides being a key contributor to agricultural GDP, the spread of groundwater irrigation supports employment generation and thus rural development and poverty alleviation.

4.2 Groundwater resources availability in India

1. The groundwater resource has two components *viz.,* in-storage and replenishable. The in-storage fresh groundwater resources i.e.(aquifer zones below the zone of water table fluctuation) of the country have been estimated as 10812 billion m3 (1081.2 Mha-m). The replenishable component,which is replenished annually, has been assessed as 432 billion m3 (43.2 Mha-m) (CGWB, 1995). As per the National Water Policy, development of groundwater resources is to be limited powaterlicy therefore forbids utilization of in-storage resources to prevent groundwater mining. After making a provision of 71.2 billion m3 (7.12 Mha-m) for domestic, industrial and other uses, the available groundwater resource for irrigation is assessed as 360.8 billion m3 (63.08 Mha-m). Based on crop water requirements and availability of cultivable land, utilizable irrigation potential has been estimated at 64 million ha. State- wise availability of replenish able groundwater, utilizable irrigation potential and irrigation potential created from groundwater resources are shown in Table 4.1.

Table 4.1 Ground water: instorage, replenishable, available and draft and irrigation potential

State	Groundwater (Mha-m/year			Irrigation potention (Mha)		
	Replenshible	**Availabele**	**Draft**	**Utilizable**	**Created**	**Balance**
Andhra pradesh	3.52916	2.99978	1.01318	3.9601	1.9290	2.0311
Arunachal Prades	0.14385	0.12227	-----	0.0180	0.0021	0.159
Assam	2.47192	2.10113	0.13455	0.9000	0.1800	0.7200
Bihar	3.35213	2.84931	0.78108	4.9476	1.4276	3.5200
Goa	0.02182	0.01855	0.000219	0.0293	0.0017	0.0273
Gujarat	2.03767	1.73202	1.02431	2.7559	1.8406	0.9153
Haryana	0.85276	0.72484	0.86853	1.4616	1.5879	0.0000
Himachal Pradesh	0.03660	0.02929	0.00757	0.0685	0.0153	0.0532
Jammu & Kahmir	0.44257	0.37618	0.00713	0.7080	0.0129	0.6951
Karnataka	1.61857	1.37578	0.61443	2.5728	0.7284	1.8444
Kerala	0.79000	0.65868	0.14374	0.8792	0.1572	0.7220
Madhya Pradesh	5.08892	4.32560	1.01866	9.7325	1.8743	7.8582
Maharashtra	3.78673	2.54701	1.10576	3.6520	1.2901	2.3619
Manipur	0.31540	0.26810	-----	0.3690	0.0004	0.3686
Meghanlaya	0.05397	0.04587	0.00260	0.0635	0.0092	0.0543
Mizoram	-------	------	-------	-----	-------	
Nagaland	0.07240	0.06150	-------	-------	-----	
Crissa	2.00014	1.700012	0.20447	4.2026	0.3931	3.8095
Punjab	1.86550	1.67898	2.25109	2.9171	5.1170	0.0000
Rajasthan	1.27076	1.0713	0.77483	1.7779	1.5052	0.2727
Sikkim	------	-----	--------	------	-------	
Tamilnadu	2.63912	2.24326	1.93683	2.8321	1.9631	0.8680
Tripura	0.06634	0.05639	0.02692	0.0806	0.0199	0.0607
Uttar Pradesh	8.38210	7.12467	3.83364	16.7990	14.0000	2.7990
West Bengal	2.30923	1.96281	0.067794	3.3179	1.3203	1.9976
Total states	43.14769	36.073550	16.42963	64.0452	35.3753	30.9951
Union territories	0.040760	0.007132	0.023360	0.0051	0.0008	0.0043
GRAND TOTAL	43.188450	36.080682	16.45272	64.05.0	35.3761	30.9994

The total groundwater reserves in the state are estimated to be 3.52 Mha-m out of which the present exploitation is 1.01 million ha meters through dug wells and tube wells (Table 4.1). This leaves a balance of 2.51 Mha-m of exploitable groundwater potential, which can bring at least 2 million ha under assured irrigation supplies to availability of power for lifting of groundwater.

Source: CGWB, Ministry of Water Resources, GOI, Faridabad (2000)

The district wise groundwater potential estimated by Rao (1987) is shown in Table 4.2. The maximum groundwater potential available is in Nellore district and lowest in Rangareddy district. With regard to net draft of water, the Niazamabad district ranks first with 44.4% followed by Karimnagar (42.9%) and Chittoor district (41.7%).

Table 4.2. Districtwise groundwater potential in Andhra Pradesh

District	Groundwater potential (million ha meters)			
	Total	Utilizable for Irrigation	Actual utilization	
			M.ha.m	Per cent
1.Nellore	0.30	0.23	0.08	34.8
2.Guntur	0.28	0.22	0.02	9.1
3.West Godavari	0.23	0.18	0.05	27.7
4.East Godavari	0.21	0.16	0.02	12.5
5.Nalgonda	0.20	0.15	0.05	33.3
6.Khamman	0.19	0.14	0.02	14.3
7.Karimnagar	0.18	0.14	0.06	42.9
8.Prakasam	0.18	0.14	0.02	14.3
9.Warangal	0.17	0.13	0.05	38.5
10.Chittoor	0.16	0.12	0.05	41.7
11.Mahaboobnagar	0.15	0.11	0.04	36.4
12.Adilabad	0.14	0.10	0.02	20.0
13.Srikakulam	0.13	0.10	0.02	20.0
14.Medak	0.13	0.10	0.03	30.0
15.Nizamabad	0.12	0.09	0.04	44.4
16.Krishna	0.12	0.09	0.02	22.2
17.Kurnool	0.12	0.09	0.02	22.2
18.Anantapur	0.12	0.10	0.04	40.0
19.Vizianagaram	0.11	0.09	0.01	11.1
20.Cuddapah	0.11	0.08	0.03	37.5
21.Vishakapatnam	0.09	0.11	0.02	22.2
22.Rangareddy	0.07	0.06	0.02	33.3
Total	**3.53**	**2.71**	**0.73**	

4.4 Groundwater development scenario

Over the past five decades, Government policies of subsidizing credit and rural energy supplies, liberal funding from Institutional Finance Agencies improvement in availability of electric power and diesel, good quality seeds, fertilizers etc., have encouraged rapid development of groundwater resources. Further during periods of droughts, additional dependence is laid on this resource in view of dwindling storage levels in surface reservoirs. (Table 4.3).

Table 4.3. Growth of groundwater abstraction structures and irrigation Potential

Year	Groundwater abstraction Structures (million)
March,1951	3.865
March,1980	9.951
March, 1985	12.147
March, 1990	14.224
March, 1992	15.566
March,1997	17.334

Source: CGWB, GOI, Faridabad (2000)

4.5 Over exploitation of groundwater

In many arid and hard rock areas, overdraft and associated quality problems are increasingly emerging. In 231 blocks (out of total 4272) in various states in the country, besides 6 Mandals in and12 Taluqs in Gujarat, situation of overdraft exists, i.e., the stage of groundwater development has exceeded the annual replenishable resource. In addition, in 107 blocks all over the country besides 24 Mandals in Andhra Pradesh 14 Taluqs in Gujarat and 34 watersheds in Maharashtra, the stage of groundwater development has exceeded 85% of the annual replenishable resource.

The over draft of groundwater has resulted in:

- Failure of shallow wells,
- Shortage of water supplies
- Deepening of wells
- Increased pumping lights and pumping costs
- Increased energy requirements
- Sea water ingress in coastal areas
- Increased inland salinity in groundwater
- Land subsidence due to compression of the aquifers

Although groundwater is a renewable resource, it in not inexhaustible. If groundwater supplies are to be maintained perennially, the recharge must balance discharge. However, all that recharged is not necessarily recoverable. The groundwater withdrawal must be limited to **safe yield**, which is defined as the amount of water that can be withdrawn annually from a groundwater basin without producing an undesired result. While the **permissive sustained yield** is the maximum rate at which water can be economically and legally withdrawn perennially from a specified source, without bringing about some undesired result. It is always less than natural recharge and in limited by physical or other constraints.

Overdraft (or over development) of aquifers occurs if groundwater extraction exceeds the sustained yield. Perennial pumping more than natural drainage may lead to decline in water levels without any indication of water levels stabilizing, diminishing yields and sometimes deterioration in water quality. The areas which suffer from non- availability of groundwater due to perennial over draft are known as **dark areas**. For example, widespread declines have been reported from several places in India viz., Mehasana and Ahmedabad in Gujarat, Rangareddy and Chittoor in Andhra Pradesh and Coimbatore in Tamilnadu State. Many water supply wells in Ahmedabad and Rangareddy have ceased functioning due to persistent decline in water levels to the extent of nearly 30-300m.

Overdraft may be reduced or controlled by changing over to less water consuming crops, industrial processed etc., providing alternate sources of supplies and most importantly by artificial recharge. Administrative and legislative measures to discourage / prohibit further exploitation become indispensable before critical overdraft is reached.

4.6 Artificial recharge of groundwater

Artificial recharge may be defined as the process by which infiltration of surface water into groundwater systems in increased by altering natural conditions of replenishment. Artificial recharge implies diverting of excess surface water resources (which otherwise would go as runoff and unexploited) to the needs areas and provide for infiltration into the groundwater zones. In the context of man's ever increasing demands on water resources, artificial recharge of groundwater is gaining importance as one of the strategies of water management. Several methods of artificial recharge are in vogue, the choice being dictated by local conditions:

- Spreading methods
- Recharge through pits
- Recharge by irrigation and agricultural practices
- Percolation thanks
- Recharge through well
- Other methods of artificial recharge include, high blasting of rocks to cause intensive fracture system in the near impervious zones, into water could be disposed of by infiltration and deep percolation.

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Lecture No.5
ENVIRONEMTNTAL POLLUTIION
5.1 Introduction

The major environmental problem today is global warming or climatic change due to accumulation of several gases like carbon dioxide, and nitrous oxide, Chlorofluorocarbons, along with water vapour in the atmosphere causing greenhouse effect and depletion of ozone layer in stratosphere affecting the several aspects of humanity on planet earth.

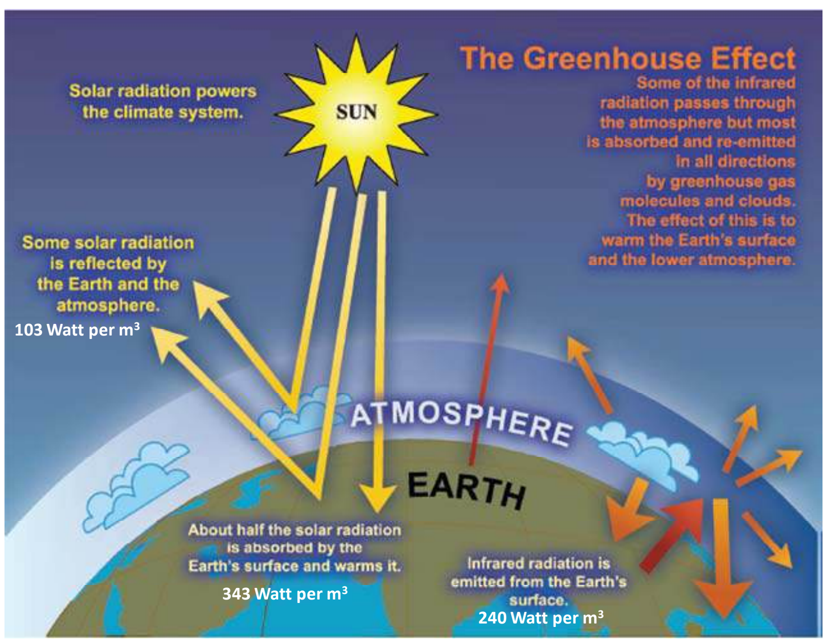
5.2 Greenhouse effect

The earth receives energy from the sun, which warms the earth's surface, as this energy passes through the atmosphere, a certain percentage (about 30) gets scattered. Some part of this energy is reflected back into the atmosphere from the land and ocean surface. The rest (70%) actually remains behind to heat the earth. In order to establish a balance, therefore, the earth must radiate some energy back into the atmosphere. As the earth is much cooler than the sun, it does not emit energy as visible light. It emits thorough infrared or thermal radiation. However, certain gases in the atmosphere form a sort of blanket around the earth and absorb some of this energy emitted back into the atmosphere. Without this blanket effect, the earth would be around 30^{o}C colder than it normally is. These gases like carbon dioxide, methane, and nitrous oxide, along with water vapor, comprise less than one per cent of the atmosphere. They are called "greenhouse gases", as the working principle is same as that which accurs in a greenhouse. Just as the glass of the greenhouse prevents the radiation of excess energy, this "gas blanket" absorbs some of the energy emitted by the earth and keeps temperature levels intact. This effect was first recognized by a French Scientist, Jean Baptiste Fourier, who pointed out the similarity in what happens in the atmosphere and in a greenhouse. Hence the term the "greenhouse" effect. The greenhouse effect is essentially a positive, life-giving process that maintains the earth's temperature at levels tolerable by its life forms.

This gas blanket has been in place ever since the creation of the earth. Since the industrial revolution, human activities have been releasing more and more of these greenhouse gases into the atmosphere. This leads to the blanket becoming thicker and upsets the “natural greenhouse effect”. Activities that generate greenhouse gases are called ‘source’ and those that remove them are known as ‘sinks’. A balance between ‘sources’ and ‘sinks’ maintains the levels of these.

Humankind upsets this balance when new sources that interfere with the natural sinks are introduced. Carbon dioxide is released when we burn such fuels as coal, oil, and natural gas. In addition, when we destroy forests, the carbon stored in the tree escapes as carbon dioxide into the atmosphere. Increasing agriculture activities, changes in land-use patterns, and other sources lead to rising levels of carbon dioxide, methane and nitrous oxide . Industrial processes also release artificial and new greenhouse gases like CFCs (chloroflurocarbons).The resulting enhanced greenhouse effect is more commonly referred to as global warming or climate change.

Greenhouse effect



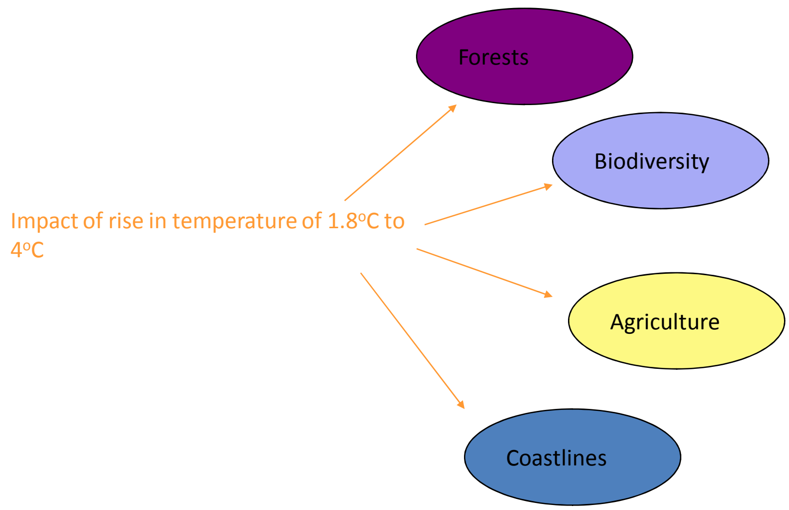
Source: Intergovernmental Panel on Climate Change

5.3 Potential Effects of Greenhouse effect or Global Warming

Some potential effects on agriculture and others associated with climate change are listed in the following (From U.S. Climate Action report). Therefore, climate change is a threat to humanity!

1. **Biomass production-** decrease in productivity of crops and grazing lands directly through changes in temperature and precipitation, frequency of droughts/floods and indirectly through changes in soil quality, pests, and diseases, shifts in agro ecological zones. Alteration in the species diversity and die-back of tropical forests and grasslands due to change in the pattern of rainfall etc.
2. **Decline in soil quality-** due to decline in soil structure, increased soil crusting and compaction, accelerated soil erosion, leaching & acidification, salinization, and organic carbon decline and nutrient depletion.
3. **Water resources & quality-** warmer climate will change rainfall & snowfall patterns leads to increased droughts & floods, melting of glaciers and polar ice sheets resulting in accelerated sea- level rise affecting freshwater resources, coastal agriculture, fisheries & aquaculture, forests, natural ecological systems, human settlements, loss of land due to inundation & erosion, salt-water intrusion, increased sediment load, eutrophication etc.
4. **Air quality-** increase dust concentrations, greenhouse gases, industrial pollution etc.
5. **General –** warmer and wetter climate will favour the growth and spread of vector borne diseases like malaria & dengue affecting human health increased frequency of storm and other extreme event caouse decrease in hydro-power generation, loss of infrastructure, tourism, disruption in transport routes, human settlements, industries, building

Impacts of Climate Change



5.4 Depletion of Ozone layer

The earth atmosphere is made of numerous gases. In 1983. C.F.Schonbein first discovered the presence of ozone molecules in the central part of the atmosphere between altitudes of 15-35 km (from the ground level) in the stratosphere and that it absorbed the harmful ultraviolet rays of the sun. The ozone layer by absorbing the harmful ultraviolet rays of the sun determines the temperature structure of the stratosphere and safeguards life on the planet. It is believed that for millions of years the atmospheric composition had not undergone much change. However, in the past half-century humans have upset the delicate balance of nature by releasing into the atmosphere harmful chemicals that are gradually destroying the lie-protecting layer.

The WMO has played a major role in identifying the problem of ozone depletion. The UNEP, United Nations Environment Programme, initiated the Vienna Convention, attended by more than 30 countries. This led to the landmark protocol on Substances that deplete the Ozone layer, which was depletion of the ozone and called Montreal. It listed the substances, which cause depletion of the ozone and called for about 50% reduction of CFCs by the year 2000. Chloroflorocarbon or CFC is said to be one of the main gases responsible for the depletion of ozone layer and greenhouse effect. It is emitted mainly from air conditioners, refrigerators and aerosols or spray can propellants. Another widely used chemical that is a threat to the ozone layer is methyl bromide. This can release bromide, which is 30 to 50 times as destructive to ozone as chlorine. It is used as a fumigant (fumes used as disinfectants for control of soil-borne pathogens) for soil and commodities and as a transport fuel additive.

It has to be clearly stated that the expected recovery of the ozone layer would have been impossible without the Montreal Protocol on Substances that Deplete the Ozone Layer (1987), which called for a phased reduction of all ozone depleting substances. .

5.5Methane Emission from Rice Fields

Wetland rice fields have recently been identified as a major source of atmospheric methane. Methane is produced as the terminal step of the anaerobic breakdown of organic matter in wetland rice soils. In a natural wetland, flooding a rice field cuts off the oxygen supply from the atmosphere to the soil, which results in anaerobic fermentation of soil organic matter. Methane is a major end product of anaerobic fermentation. It is released from submerged soils to the atmosphere by diffusion and ebullition and through roots and stems of rice plants. Recent global estimates of emission rates from wetland rice field's range from 20 to 100 Tg/year (IPCC 1992). The current burden of methane in the atmosphere is is approximately 4700 Tg (1 Tg=1 million tons), and the global annual emission is estimated to be 500 Tg with an apparent net flux of 40 Tg/year. Continued increase in atmospheric methane concentrations at the current rate of approximately 1% per year is likely to contribute more to future climatic change than any other gas except carbon dioxide. Methane is exclusively produced by methanogenic bacteria that can metabolize only in the strict absence of free oxygen and at redox potentials of less than- 150 mV. In tropical flooded rice soils, where soil temperatures are 25-30^{o}C, methane production is rapid in alkaline and calcareous soils(may start hours after flooding)and slow in acid soils (formed five or more weeks after flooding). Methane production is negatively correlated with a soil redox potential and positively correlated with soil temperature, soil carbon content, and rice growth. Easily degradable crop residues, fallow weeds, and soil organic matter are the major source for initial methane production. At later growth stages of rice, root exudates, decaying roots, and aquatic biomass seem to be more important.

5.5.1 Conditions favouring methane production and emission in rice fields

- Anaerobic conditions in wetland soils
- Disturbance of wetland soil by cultural practices favours soil trapped methane to escape to atmosphere through ebullition
- Use of organic amendments
- Application of chemical fertilizers

5.5.2 Mitigation options

- Prevent of submergence of rice fields where ever feasible without affecting the rice productivity
- Increased adoption of direct seeding (wet and dry seeding) instead of transplanting
- Crop diversification in rice based cropping systems
- Water management- intermittent drying and mid-season drainage in controlled water situations
- Growing rice cultivars having traits with low methane emission potential
- Use of sulfate-containing fertilizer reduces methane emission
- Minimization of soil disturbance during growing season to reduce escape of entrapped methane
- Use of properly composted organic amendments

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Lecture No.6
FERTILIZER AS A SOURCE OF POLLUTION AND CONTROL MEASURES

6.1Introduction

Throughout human history, increasing population growth and changing dietary patterns have resulted in more and more land moving from forest or grasslands into agricultural production. Over the past few decades, the greatly increased use of chemical fertilizers plus changes in irrigation practices and improved crop varieties, have enabled land already under cultivation to be farmed much more intensively. Synthetic fertilizers have played a dominant role in agricultural intensification in industrialized and developing countries like India for decades. Both fertilizers and pesticides have become widely distributed in the environment and most of the concern today related to the health consequences of agriculture now centers on these two (as a source of environmental pollution).

6.2 Fertilizers as a source of pollution

India has come a long way, since independence, in respect of production and consumption of fertilizers. In the year 1951-52 the country produced a mere 27,000 tonnes of fertilizers, which now rose to a level of 13,4 million tone (2000-01). Likewise the per ha consumption of fertilizers, which was as low as 1,5 kg/ha during 1951-52 has now increased to 94 kg/ha in 2000-01. the increased use of fertilizers beginning with the year 1966-67 was due to intensification of agriculture, particularly in irrigated areas.

Several problems linking excessive use of fertilizer with environment have been identified. The increase of nitrates in the drinking water, a development about which general public is greatly concerned, and believed to be due to excessive use of N fertilizers and animal manures, is regarded as most important fertilizer related pollution issue. Nutrient enrichment, eutrophication and deterioration of surface water quality due to transpiration of nutrients applied through fertilizers via leaching and /or runoff and sediment erosion is another problem. The contamination of soils by heavy metals through fertilizers such as cadmium from phosphatic fertilizers, is also receiving increasing attention of environmentalists.

6.2.1 Pollution due to excessive nitrate in soil

Nitrate can be absorbed by crop plants, lost beyond the rooting zone of the crops via leaching or denitrified to N_2O gases. Nitrate leaching below the root zone of crop constitutes a potential pollution threat for surface and groundwater bodies. The production of N_2O through nitrification- denitrification reaction represents a potential danger in terms of damage to both stratospheric ozone layer and the greenhouse effect. Nitrate can also be absorbed in large amounts by plants, particularly fodders and vegetables, and result in nitrate toxicity to the consumers. Thus a majority of the environmental issues related to N-use in agriculture revolve around transformations leading to the production of nitrate in soil.

6.2.2 Nitrate pollution of groundwater

Two major factors controlling the leaching losses of nitrate are (i) the concentration of nitrate in the soil profile at the time of leaching, and (ii) the quantity of water passing through the soil profile. High soil nitrate levels and sufficient downward movement of water to move nitrate below the rooting depth is often encountered in high intensity irrigated agriculture combined high levels of nitrate-N can lead to methemoglobinemia (blue baby syndrome) particularly in infants (< 6 months old). The WHO standard for drinking water is 10 mg NO_3- N/L. The effects of nitrate on livestock are similar to those on human beings. Cattle are more susceptible to nitrate poisoning than sheep and if pregnant, may abort. An excessive ingestion of nitrates may also increase the risk of cancer in human population through i*n vivo* formation of carcinogenic nitrosamines by the reaction of ingested amines with nitrates in the human stomach. Nitrate concentrations in groundwater have increased in several parts of the world in recent years.A significant correlation exists between the amount of fertilizer-N applied per unit area per your and nitrate-N concentration of well water in Punjab. At many places, nitrate levels have exceeded the safe limit of 10 mg NO3-N/L (Table 6.1 and 6.2)

Table 6.1. Nitrate- N content (mg N/L) in tube wells and hand pumps in four blocks of Ludhiana district in July 1999

Block	Tube wells		Hand pumps	
	Range	Mean	Range	Mean
High fertilizer use Jagraon Samrala	2.46-16.16 1.44-8.73	6.49 4.06	3.57-49.74 0.92-29.58	12.6 12.4
Low fertilizer use pakhowal Dehion	1.67-4.41 1.32-9.25	2.82 4.29	2.95-13.19 0.15-20.64	6.75 8.67

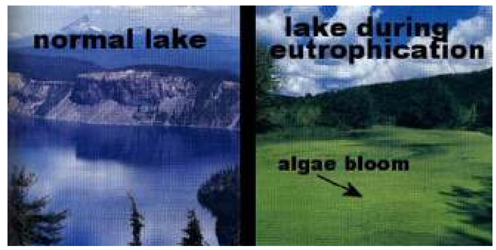
Source: Roopna- Kaur (2000)

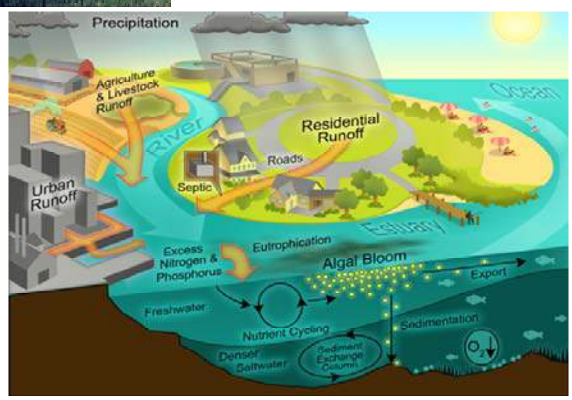
Table 6.2. Nitrate concentrations in water supplies of few cities of India

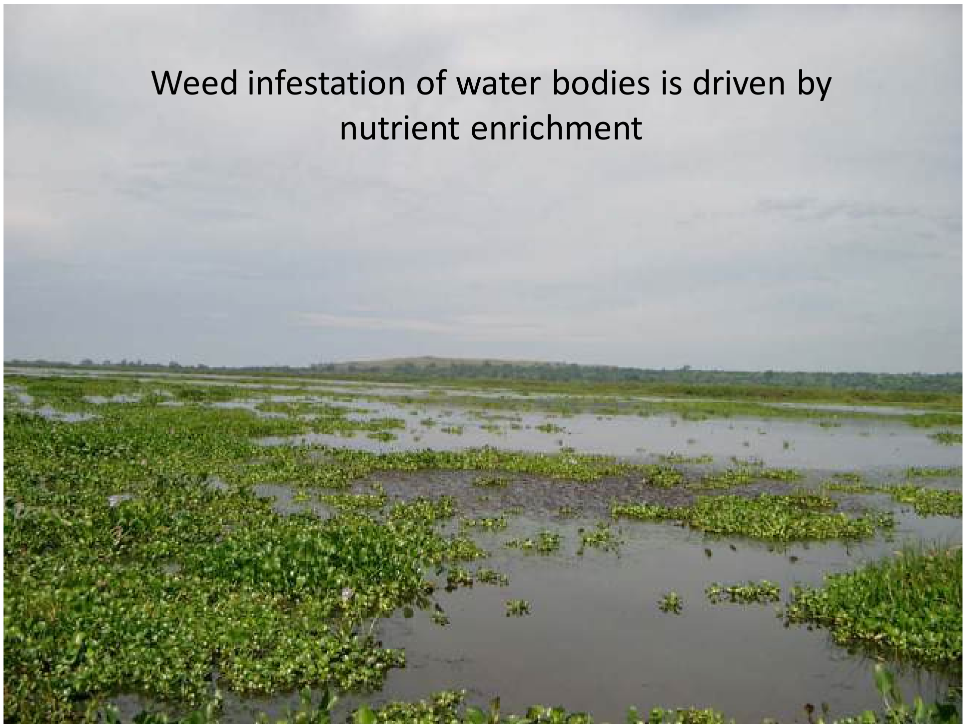
Location	Highest nitrate level Observed (mg/L
Churu, Rajasthan	530
Meerut, Uttar Pradesh	156
Jaipur, Rajasthan	180
Nagpur, Maharashtra	77
Hyderabad, Andhra Pradesh	78

6.2.3 Eutrophication

Eutrophication refers to the process of enrichment of watercourses or surface water bodies by inorganic plant nutrients. Estimates indicate that more than 72% of the N entering surface waters originates from a agricultural lands. Both N and P are important in stimulating eutrophication. This artificial eutrophication has already happened in many parts of the world including India. Causes of eutrophication include natural run-off of nutrients from the soil and the weathering of rocks, accelerated runoff of inorganic fertilizer & manures (containing nitrates and phosphates) from agricultural lands, runoff from areas following mining, construction work or poor land use, discharge of detergents (containing phosphates) through domestic wastewater.







6.2.3.1 Effects of eutrophication

- Excessive growth of phytoplankton and filamentous algae
- Increase in aquatic plant life
- Increase in turbidity (cloudiness) of water
- Increase in rate of sedimentation
- Development of anoxic conditions (low oxygen levels)
- Decrease in species diversity, and an
- Increase in the frequency of algae blooms causing a dearth of oxygen and a change in fish species composition

6.2.3.2 Measures to reduce artificial eutrophicaion

- Reducing the use of phosphates as builders in detergents
- Reducing the use of nitrate containing fertilizers
- Using tertiary sewage treatment methods to remove phosphate and nitrate before discharging the effluent into rivers and lokes
- Directing waste water away from lakes to safe treatment & disposal sites
- Aerating lakes and reservoirs to prevent oxygen depletion particularly during algal blooms

- Removing phosphate- rich plant material from affected lakes
- Removing phosphate rich sediments by dredging

1.3 Management practices to reduce fertilizer pollution by N

Some of the management practices that can reduce environmental pollution by N originating from agricultural lands are listed below:

1. Improved fertilizer use efficiency

- Apply optimum dose of N
- Timing the fertilizer N applications to coincide with the crop needs
- Apply N fertilizer in split doses
- Apply balanced doses of N,P and K
- Incorporate or deep place fertilizer N into soil
- Use slow release fertilizers
- Use urea and nitrification inhibitors

2. Land management techniques

- Adopt crop rotation and catch crops
- Improve irrigation scheduling to encourage plant growth and minimize leaching
- Conservation tillage to control surface runoff
- Crop residue recycling
- Use of terrace, contouring and retention bases to catch sediments
- Genetic manipulation of plant material to be more efficient at N-recovery and N2 fixation

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Lecture No.7
PESTICIDES AS A SOURCE OF POLLUTION AND CONTROL MEASURES

7.1. Introduction

In 1995, world pesticide consumption reached 2.6 million metric tons of “active ingredients”, the biologically active chemicals at the heart of commercial pesticide formulations, with a market value of $38 billion (US dollars). Roughly 85% of this consumption was used in agriculture. India is currently the largest manufacturer of pesticides and the second largest producer of agrochemicals in Asia.

The use of pesticides (insecticides, fungicides, herbicides) in India is increasing at the rate of 2 to 5% per annum. The pesticide demand is close to 90,000 MT per annum. The per capita consumption is 600 gm per hectare as compared to 10-12 kg/ha in developed economies. Yet, the problem of pesticide use has assumed serious proportions in India because of the non-uniform use of the plant protection chemicals in different regions, cropping systems and crop and indiscriminate use and misuse and abuse of these chemicals. Obviously, there is a mismatch between pesticide use and cropped area. Cotton, rice, fruits and vegetables, which account for less than 35 per cent of the cropped area, consume 84 per cent of the pesticides. On the other extreme, wheat, coarse cereals, millets and pulses contributing to 54 per cent of the cropped area consume only 3per cent of the pesticides used. Insecticide (73%) dominates the market, followed by herbicide (14%) and fungicide (11%). Although it is expected that herbicide will grow faster in the future, insecticides will continue to dominate the market. Cotton, rice and wheat growers account for almost 70% of pesticide consumption, and the states consuming more in the decreasing order are Andhra Pradesh, Punjab, Karnataka and Gujarat.

Pesticides were considered as panacea to contain pestilence on crops. This attitude led to a phenomenal growth of pesticide use in agriculture. The pesticides upset natural balance and ecosystem and also affect the field workers. If the residues go undetected, the consumer may also be affected. Pesticides residues in soil, water, environment, foods etc, are of serious environmental concern.

7.2 Insecticides

In almost all the soils that have been surveyed for insecticide residues in India, the most common chemical, and the one that is found in the largest amounts is DDT, followed by HCH and dialdrin. In a study in Punjab, out of 106 soil samples, 91 were found contaminated with insecticide residues. The highest level of 0.08 mg/g DDT-R was found in cotton growing areas, which is four times its permitted level of 0.02 mg/g. The presence of cholinesterase inhibitors in 19% soil samples indicated contamination with organophosphates and carbamate insecticides. Data collected by Acharya N.G. Ranga Agricultural University Scientists over years indicated presence of high and toxic amounts of pesticide residues in food grains fruits, vegetables, milk and milk products, eggs, soils, water etc. (Table 7.1). Even human breast milk is reported to contain pesticide residues.

Pesticide residues in food items, which are on the increase, have become a matter of threat to man. Even small quantities of these residues ingested daily along with food can build-up high levels in the body fat. The long-term effects of these residues in the human body include carcinogenicity, high infant mortality and varied metabolic and genetic disorders. The major source of dietary intake of DDT residues is through milk and milk products followed by oils and fats, in both vegetarian and non-vegetarian diet. The dietary intake of HCH is also mainly through milk and milk products followed by meat and eggs for the non-vegetarian diet, whereas it is through cereals followed by milk and milk products in vegetarian diet .

Table 7.1. Pesticide residues identified in various food, fodder and feed items

Pesticide	Items of food having residues of taxic levels
HCH	RiCe , milk, eggs, tomato, carrot, cucumber, onion, raddish, brinjal, okra, bitter, gourd, green chillies, dry chilles, chillinpowder, rice bran, rice straw, water samples, rice growing soils Certain brands of cooking oils, milk, milk products like skimmed milk, milkpowder,

	butter, cheese, every day whiteners Poultry feed-maize, cakes, bran, fish, feed mix Livestock feed-eggs, fish, corn cakes, wheat+jowar+groundnut cake
DDT	Cooking oil, milk, butter, maize, fish, feed mixture, eggs, human breast milk, livestock feed
Monocrotophos	Tomato, onion, cooking oil (one brand)
Cypermethrin	Cooking oil (certain brands)
Quinolphos	Fish, cooking oil (one brand)
Aldrin	Maize, fish, feed mix, livestock feed, eggs, human breast milk
Endosulphan	Livestock concentrated feed, fish

Source: Rao (1994)

The reactions, movements and degradation of insecticides affect the persistence of these chemicals in soils and determine the risk of soil pollution. The relative mobility of pesticides in soils is given in Table 7.2 (Jayraj, 1997). Large number of pesticide compounds have a mobility class value of 1 indicating their high immobility. This group includes compounds such as phorate, parathion, ethlon, zineb, benomyl, paraquat, trifluralin, heptachlor, endrin, aldrin, chlordane, toxaphene, DDT, etc. Some of these are already banned for use in agriculture. The commonly used herbicides such as atrazine, alachlor, propachlor, simazine, prpanil, diuron, etc, have moderate to high immobility indicating greater persistence in soil. When the pesticides are used repeatedly in each crop season and those applied to soils, which are poor in organic matter and microbial biodiversity, the chemicals are bound to accumulate for longer periods of time causing much environmental pollution and yield depressions, the biochemical degradationby soil organisms is the single most important mechanism that can remove insecticides from the soil. Before pesticides are completely inactivated, they may adversely affect the functioning of non-target microbes and other forms of life inhabiting the soil. They may also be taken up by the plants or get translocated in the aquatic system by leaching or run-off, thus contaminating the plankton, fish, invertebrate and other form of life using the pesticide contaminated water.

Tabel 7.2. Relative mobility of pesticides in soils

MOBILITY	DECREASING ORDER
VERY MOBILE	Dalapon, Chloramben
	Picloram,2,4-D
De easing order	Propachlor, Atrazine, Simazine, Ipazine, Alachlor, Ametryne, Propazine
	Propanil, Diuron, Azinphosmethyl, Diazinon
IMMOBILE	Lindane, Phorate, Parathion, Ethinon, Isodrin, Benomyl, Dieldrin, Paraquat, Trifluralin, Heptachlor, Endrin, Aldrin, Chordane, Toxaphene, DDT

7.3 Fungicides

The residues of fungicides based on the inorganic compounds of sulphur copper, and mercury accumulate in soil because the heavy metals contained in them are irreversibly adsorbed on soil colloids. Under certain conditions, toxicity from the accumulation of copper and sulphur containing fungicides may render the soil useless for growing crops and cause significant yield depressions. Depressing effect of fungicides on the nodule formation and yields of groundnut were also reported.

7.4 Herbicides

In intensive and diversified cropping rotation systems, the herbicide applied to one crop may persist in the soil at concentrations high enough to damage the subsequent sensitive crops. Under Indian conditions, when a herbicide dose of 0.5 to 2.0 kg/ha is applied, it results in a buildup of residues in the range of 0.25 to 1.0 mg/g/, which is safely below the potential residual effect. But the same herbicide when applied repeatedly it starts building undesirable residues in the soil. For example, fluchloralin, metabenzthiazuron and atrazine were detected in amounts that could adversely affect not only other crop plants but also several processes in soil leasing to inefficient nutrient management and in turn, reduced crop yields. The herbicide, 2, 4-D, restricts the growth of azotobacter, Lindane applied at normal rates considerably reduces the number and weight of nodules in groundnut.

7.5 Control measures to reduce pesticide pollution

- Application of easily decomposable organic matter
- Use of large quantities of organic manures
- Raising high N cover crops
- Growing of crop plants that a tendency to accumulate the pesticide
- Follow soil management practices leading to increased leaching of pesticides
- Adoption of biological control methods
- Use of biochemical pesticides
- Need based plant protection

7.6 Biopesticides and bioherbicides

7.6.1 Introduction

Biological control is defined as applied natural control wherein man intervenes to improve the efficiency of natural enemies including parasites, predators, and pathogens of pest species by introductions, conservation, or augmentation to maintain pest populations below economically injurious levels.

Biological control by means of entomopathogens and other microbial pest control agents involves the application of microorganisms on to the crop for ingestion by insect’s pests or directly on the noxious insects, fungus or weed with the objective of destroying the, these bio control agents include bacteria, protozoa, fungi, viruses and nematodes.

7.6.2 Biopesticdes

Biopesticides also known as biological pesticides are certain types of pesticides dervived from such materials as animals, bacteria, and certain minerals. These are an important group of pesticides that can reduce pesticide risks.

7.6.2.1 Characteristics of Bio-pesticides

- Have a narrow target range and a very specific mode of action
- Are slow acting
- Have relatively critical application times
- Suppress, rather than eliminate, a pest population
- Have limited field persistence and short shelf life
- Are safer to humans and the environment than conventional pesticides
- Present no residue problems

7.6.2.2 Advantages of using bio-pesticides

- Biopesticides are inherently less harmful than conventional pesticides
- Biopesticides are designed to affect only one specific pest or, in some cases, a few target organisms, in contrast to broad spectrum, conventional pesticides that may affect organisms as different as birds, insects, and mammals
- Biopesticides often are effective in very small quantities and they decompose quickly thereby resulting in lower exposures and largely avoiding the pollution problems caused by conventional pesticides
- When used as a component of integrated pest Management (IPM) programs, biopesticides can greatly decrease the use of conventional pesticides while crop yields remain high
- To use biopesticides effectively; however, users need to know a great deal about managing pests

7.6.2.3 Microbial pesticides

Microbial pesticides contain a microorganism (bacterium, fungus, virus. Protozoon or algae) as the active ingredient. They suppress pests by

- Producing a toxin specific to the pest;
- Causing a disease;
- Preventing establishment of other microorganisms through competition; or
- Other modes of action

An example of microbial pesticide is *Bacillus thuringiensis* ot Bt. *Bacillus thuringiensis* is a naturally occurring soil bacteria that is toxic to the larvae of several species of insects but non-toxic to non-target organisms. *Bacillus thuringiensis* can be applied to plant foliage or incorporated in to the genetic material of crops eg. Bt cottons. *Bacillus thuringiensis* as discovered is toxic to the caterpillars (larvae) of moths and butterflies. Several strains of Bt have been developed and now strains are available that control fly larvae. These can be used in controlling mosquitoes and black flies. Microbial pesticides need to be continuously monitored to ensure they do not become capable of harming non-target organisms, including humans. Other examples of microbial pesticides include the following:

- *Bacillus thuringensis* against caterpillars of Heliothis, Earias, Spodoptera etc
- *Pseudomonas fluoroscenes* against *Pythium* spp., *Rhizoctonia* spp., *Fusarium* spp.
- Nematodes like Green commandoes and Soil commandoes against caterpillars & grubs
- Nuclear Polyhedrosis Virus(NPV)
- *Trichoderma virdi* against many common diseases of vegetables and spices
- Weevils *Neochitina eichorniae* & N bruchi against water hyacinth
- Beetle Zygogramma biocolorata against Parthenium

7.6.2.4 Biochemical pesticides

These are naturally occurring substances that control pests by non-toxic mechanisms. (Conventional pesticides, by contrast, are synthetic materials that usually kill or inactivate the pest). Biochemical pesticides include substances that interfere with growth or mating, such as growth regulators, or substances that repel or attract pests, such as pheromones. Pheromones are often used to detect or monitor insect populations, or in some cases, to control them.

7.6.3 Bioherbicides

The biological control of weeds involves the use of living organisms such as plant pathogens, insects and mites, herbivorous fish, nematodes, other animals and competitive plants to limit their infestation. The objectives of biological control are not eradication, rather the reduction and, regulation of weed population below the levels of economic injury. A successful bio-agent is host specific, rapid destroyer of the target weed, effective on several taxa of the weed in question, adjustable to new environment and easy to multiply. Biological control of weeds has had a long and successful record in the United States and several other countries.

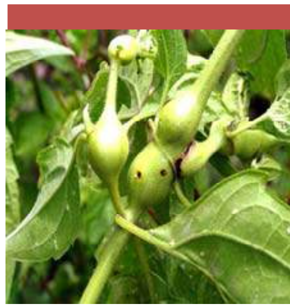
“A bioherbicide is a plant pathogen used as a weed control agent through inundative and repeated application of its inoculums or by augmentation of natural, seasonal disease levels through small releases of inoculums. The bioherbicide can provide an effective, safe and viable method of weed control”. A list of bioherbicides is presented in Table 7.3.

A bioherbicide can often live in the environment and wait for the next growing season when there will be more weeds to infects. This reduces the farmer’s cost of applying herbicides year after year. A new range of bioherbicides may essentially allow farmers to replace or reduce the expensive chemical herbicides that they now use. They also allow farmers to get rid of weed that interfere with their crop’s productivity without threatening the environment.

PHEROMONE TRAP

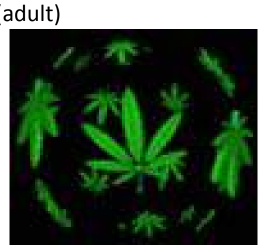
Bracon hebetor **larval parasitoid**

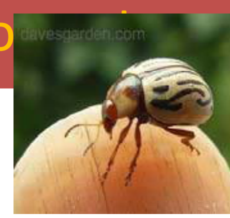
Trichogramma **sps**



Siam weed affected and its growth stunted by Gall Fly - an example of successful bio-control of invasive weeds

Hyles euphorbiae (adult)





Parthenium Beetle,
Pallister Beetle (*Zygogramma bicolorata*

Table7.3. Registered and approved bioherbicides since 1980

Biohebicide	Kind of bioagent	Target weed	Crop
Devine	*Phytophthora palmivora*	*Morrenia odorata*	Citrus groves
Collego	*Colletorichum gloeosporioides sp. Aeschynomene*	*Aeschynomene virginica*	Rice
Biomal	*Colletorichum gloeosporioides sp. Malvae*	*Malva pusilla*	Various row crops
Biopolaris	*Bipolaris sorghicola*	*Sorghum halopense*	Rice & Wheat
Biophos	*Streptomyces hygroscopicus*	General vegetation	
Comperico	*Xanthomonas campestris*	*Poa annua*	Golf course turfs
Biochon	*Chondrostereum purpureum*	*Prunus serotina*	Forests
Emmalocera spp.	Stem boring moth	*Echinocloa spp*	Rice & Wheat
Tripose	Plant pathogen	*Rumex spp.*	Rice & Wheat
Uromyces rumicis	Plant pathogen	*Rumex spp.*	Rice & Wheat
Gastrophysa viridula	Beetle	*Rumex spp.*	Rive & Wheat
Bactra verutana	Shoot boring moth	*Cyperus rotundus*	Rice & Wheat

The most common reason given for the limited commercial interest is that the market size for biocontrol agents is typically small and the market is often too regional, and consequently the financial returns from biocontrol agents are too small for big industries. The potential to use a bioherbicide in diverse crops and against several weeds might create commercial interest in this technology.

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Lecture No. 8
MANAGEMENT OF NATURAL RESOURCES
(SOIL, WATER, VEGETATION AND ENERGY)

8.1 Introduction

Man has been relaying on the natural resources to meet the basic requirements since time immemorial. With the unprecedented increase in the population during the last few decades, clearly mankind faces formidable problem to ensure food and nutritional security for all, considering reduced per capita land, reduced availability of water, depleting biodiversity and need to preserve ecology and environment. The physical and biological environment of the earth is so rich in its potential that is can support the need of its inhabitants for a long time to come. However, the man's greed rather than his needs is putting enormous pressure in the capacity of the biosphere resulting in over-exploitation of the natural resources, as the demand is not within the paradigm set by ecological constraints.

The natural resource management at most places in the world including India is inappropriate, exploitative and unscientifically planned. Even today, land and water are being exploited without restraint considering them inexhaustible, and wastes are discharged freely into air and water assuming that these have unlimited assimilative and carrying capacities. As a result, very disturbing trends of natural resource degradation have emerged. Human activities inflict harsh and often irreversible damage on the environment and on the critical natural resources. If not checked, many of our current practices will put, at serious risk, the future that we wish for human Society and the plant and animal kingdom.

Agenda 21 for Natural Resource management

The United Nations Conference on Environment and Development (UNCED) at the earth summit held in Rio-de-Janario, Brazil in 1992 focused attention on the harmful effect of development of the earth's life sustaining capacity. The conference also adopted Agenda 21- a global blue print for environmental action. It revolves around seven themes, one of which is “Efficient use of natural resources of land, water, energy, forests and biological resources”. This is unquestionably the theme for the survival of humanity and for the sustainability of future agriculture.

8.2 Management of natural resources

8.2.1 Land resource

India has only 2.4% of the land resource of the world to meet their basic requirements of 18% of the world’s population and over 25% of the world’s livestock. Nearly 57% of the land resource in India is facing degradation due to water erosion, wind erosion, loss of productivity and chemical and physical degradation. About 5.3 million ha of topsoil is displaced every year only through water erosion which also accounts for a loss of 8 million tones of plant nutrients. While most of the land resource faces nitrogen deficiency, nearly 50% and 20% of the land resource is deficient in phosphorus and potassium. Deficiencies of micronutrients have been widely reported. It is assessed that 8.6 million ha of agricultural land is affected by both the problems of water logging and soil salinity. About 65% of which is the most productive irrigated land resource. Added to these the per capita arable land which was 0.121 ha in 1990, 0.176 ha in 1996 and 0.163 ha in 2000 is projected to be 0.121 ha in 2025 and 0.087 ha when the population stabilizes by the year 2050 or later. Therefore, meeting all basic necessities from degrading and low per capita arable land area of 0.087 ha is bound to be major challenge and calls for appropriate soil restoration and conservation technologies.

The best means of improving and maintaining soil quality which determines soil productivity and environmental quality is adoption of alternative agricultural practices such as crop rotation, recycling of crop residues and animal manures, green manures, biofertilizers and intergrated nutrient management for encouraging balanced use of fertilizers and manures, and reduced use of pesticides. These are some of the components of a strategy for obtaining sustainable high productivity in any farming system. The relationship between the soil degradation processes and soil conservation practices as outlined by Hamick and Parr (1987) is shown in Fig.8.1.

Soil degradation Processes

- Soil erosion
- Nutrient
  Runoff loss
- Water logging
- Desertification

- Acidification
- Salinization
- Compaction
-

Soil Conservation processes

Conservation tillage
crop rotation

Improved drainage
Residue management

water conservation
Terracing
Contour farming

NEGATIVE Soil productivity **POSITIVE**

- Crusting
- Organic matter loss
- Nutrient depletion
  By leaching
- Toxicant application

Organic fertiliser
chemical fertiliser
Improved nutrient recycling
Improved system to Match soil, climate and cultivars

Fig.8.1.Relationship between soil degradation processes and soil conservation practices

8.3 Water resource

Water is one of the most important natural resources vital for economic development of a nation. The per capita water availability presently estimated at 2001 m3/annum is projected to come down to a stress level of 1700 m3/annum in the next 2-3 decades. The ultimate irrigation potential of the country has been estimated at 139.5 million ha comprising of 58.5 million ha from major and medium irrigation Schemes, 15 million ha from minor irrigation schemes and 66 million ha from groundwater exploitation. The present irrigated area in the country is about 53 million ha. It is estimated that even after achieving full irrigation potential nearly 50% of the total cultivated area will remain rain fed. During 1990 the total utilization of water for all uses, was about 51.8Mha-m or 609 m3/capita/year. The projected water demand to meet the requirement of domestic, industrial and irrigation is given in Table 8.1.

Table 8.1. Requirement of water for various uses

S.No	Category	Water (Mha-m)		
		2010	**2025**	**2050**
1	Irrigation	55.6	73.4	119.1
2	Domestic	6.1	7.8	10.4
3	Industires	3.7	7.9	11.6
		65.4	88.1	141.6

Table 8.2. Water demand for irrigation

Year	Low demand		Medium demand		High demand	
	Food grains (m tones)	Water (Mha-m)	Food grains (m tones)	Water (Mha-m)	Food grains (m tones)	Water (Mha-m)
2010	249	489	265	536	271	576
2025	322	619	349	688	365	734
2050	469	830	539	1088	605	1191

While the water demand for irrigation to maximize agricultural production with the maximum possible level of irrigation to achieve self sufficiency in food grains is given in Table 8.2.

Thus water is a limiting factor for crop production and scientific water management is the key for sustainable agriculture both irrigated and rain fed farming systems. Growing demand for fresh water supplies by industry, urban & civic uses, low water use efficiency, prohibitive costs of irrigation development, from poor water management makes agriculture a poor competitor for its use. Therefore the available water must be used most efficiently. The efficient use of this resource for crop production consists of:

i) **Water conservation-** it involves two steps (a) reduction of runoff losses and increasing its infiltration in the soil through land shaping, tillage mechanical structures and vegetative barriers to reduce water flow, proper crop rotations, application of soil amendments and mulching (b) reduction of losses through deep drainage (by increasing water storage capacity & soil moisture retentivity), and direct evaporation from soil (by following shallow tillage, straw mulching).

ii) Scheduling of irrigation to crops- the timing and amount of irrigation to crops plays a significant role in optimizing crop production with a given amount of water and avoiding effects of either over-irrigation or under irrigation on soil environment. Approaches to irrigation scheduling vary depending on situations e.g., water is adequate irrigation water is available on demand to secure potential yield and where available supplies fall short of the full irrigation water requirement of crops over the entire command area.

iii) Maximizing the utilization of resource by crop and maximizing returns per unit resource used by the crop- The World Bank (1999) in a working paper on irrigation sector observed that 25% improvement both in water use efficiency and crop yields (WUE rising from 35 to 43%) would generate an additional food grain production of 85 million tones, which represents an equivalent of 44% increase in food grain production by the year 2025. This is the latent potential which the country needs to exploit. The ICAR experts feel that irrigation water use from the present level of 40% is possible to increase to 60% with the adoption of water use efficiency technologies. Using technologies such as sprinkler irrigation and drip irrigation in commercial and horticultural crops, a WUE of 85 to 95% can be obtained.

iv) Conjunctive use of different sources of water for increasing the returns from available water resources and reducing soil-degrading effect. Conjunctive use of saline water and canal water can be effective in avoiding the deleterious effect of saline water on crops. Judging from the present trends it can be surmised that water quality will become most serious constraint in future and agriculture have to use more marginal quality water.

v) Participatory irrigation management-Promoting participatory irrigation management through establishment of Water User's Associations (WUA). The Government of Andhra Pradesh has established 10292 WUA for effective maintenance of irrigation- systems and use of waters.

For dryland agriculture, increased efficiency of rain-water is essential and it can be achieved in the following ways:

1. Retain precipitation in situ and minimize the run-off,
2. Reduce evaporation in relation to transpiration,
3. Growing drought tolerant crops that match the rainfall pattern
4. Recycle the run-off drainage water for high value crop adopting life saving irrigation approach
5. Watershed approach for maximization of rainwater harvesting and recycling and
6. Ensure farmers' cooperation by assuring equity in distribution of benefit and maximization of the profitability of cropping system.

The can be achieved by following practices viz., contour cultivation, bench terracing, strip-cropping and different types of land configuration: Storage structures viz., farm ponds, low earthern dams, nala bunds and percolation tanks: Agronomic practices viz., tillage practices, fallowing, crops and cropping systems versus water availability periods, mulching, manipulation of plant geometry etc.

8.4 Vegetative cover

Vegetation acts as a protective cover to the planet earth. Deforestation and over grazing have been causing tremendous soil erosion and landslides. At present (2000 A.D.), the per capita forest area in India is around 0.07 ha compared to the world's average of about 1 ha. Hardly 4% of the geographical in India is under pastures and grasslands. With the passing time the stress on vegetative cover in India is increasing with the growing demand for food, fodder, fuel and timber. The quantity of firewood that can be annually removed from forests on a sustainable basis is only 40 million m3 as against the existing demand for firewood in the country is 235 million m3. Similarly, about 90 cattle units graze in the forest while the carrying capacity of forests is estimated only at 31 million cattle units.

Measures to conserve and to improve vegetative cover are highly essential to restore ecological balance, maintain biological diversity, conserve soil and water, and to prevent flood havoc. To increase the vegetation in the country, plantation practices such as the following are encouraged:

1. **Afforestation:** establishment of forest by artificial means on an area from which forest vegetation has always or long been absent
2. **Reforestation:** restocking of felled or otherwise cleared woodland
3. **Social forestry:** adoption of forestry practices by the society to meet its common requirements such as fuel, fodder etc
4. **Agro forestry:** adoption of suitable land use systems that maintains or increases total yield by combining food crops (annuals) with tree crops (perennials)

These interventions reduce erosivity of rainfall/runoff and erodability of soil through dissipation of rainfall energy by canopy, surface litter, obstructing overland flow, root binding and improving physico-chemical conditions, restore ecological balance and reduce the risk of environmental degradation.

Forest (conservation) Act 1980 was enacted with a view to check indiscriminate destruction and diversion of forest-lands to non-forest purposes. The Forest (conservation) Act 1980 was amended in 1988 to incorporate stricter panel punishments against violators. Recent scientific thinking is that the pumped into atmosphere and to reduce or mitigate the effect of increased carbon dioxide content.

8.5 Energy and Agriculture

Agriculture has evolved as the largest and most important human enterprise, comprising not only production but also processing, packaging, transport and trade and distribution of food products. Energy is needed in all stages of agriculture from land preparation, water lifting and pumping to planting and transplanting, weed control, harvesting, transport and processing.

Sustainable management of the natural resources like land, water, air and biodiversity is the mantra for sustainable Agriculture. The ecological; services provided by nature regulate and sustain the stability of production in natural ecosystems. The quality and quantity of energy used are transformed and consumed all of which is vital to food security.

Energy use in agriculture follows two extreme patterns. High external input and highly mechanized factory metal of agriculture of the advanced countries is so times as in energy intensive as traditional agriculture.
Very low or nil external input agricultural that is a part of the subsistence agriculture prevalent in many of the stressed ecosystem(LEISA).

A direct relationship exists between energy consumption and agricultural yield. Traditional agriculture systems depend largely on the metabolic energy of human and animals and solar energy, where as the energy requirement of modern agriculture are almost completely met from fossil fuels mostly petroleum.

8.5.1 <u>Impact of low energy use in Agriculture</u>

Farmers depend on traditional fuels such as wood and agricultural residues for cooking and heating and on human and animal power for primitive agricultural operations. Aquequate and appropriate energy for income-generating opportunities is not available primitive energy sources are used inefficiently and without concern for health hazards, yet have heavy costs in terms of time, money, drudgery and poverty. Lack of energy input in agriculture has also led to enormous land degradation in the form of erosion and deputation of soil organic matter and soil fertility, which has further lowed productivity and increased environmental pollution.

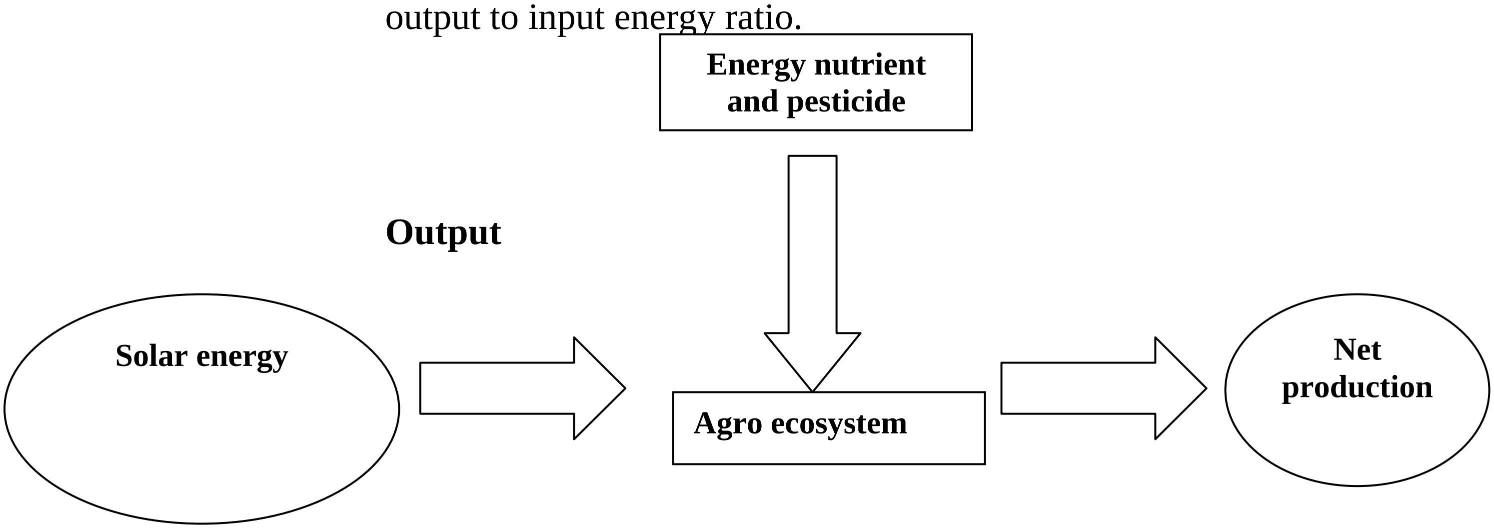
8.5.2 Energy and agricultural sustainability

Thus, both high external input and low-energy primitive agriculture systems are unsustainable in the long run. The former are flovoured in their overdependence on fossil fuel and because of the ecological, environmental and social stress they create, and the letter because of their inadequate land and labour productivity to sustain food security and livelihoods.

8.5.3 Sustainable energy management in High – Input Agriculture

Following the principles of thermodynamics, a key indicator of sustainability is the ratio of energy equivalents of all the outputs and inputs. The higher this ratio the more sustainable the system is

Energy budget in crop production on: sustainability = high output to input energy ratio.



The basic way to improve the sustainability of modern agriculture is to decrease both the direct and embodied external energy component by increasing their efficiency of use in all possible agricultural practices. Maintaining high productivity with an acceptable impact on resources, environmental and economics is the key to sustainability the used non-polluting alternative sustainability.

A multipronged approach to achieving better energy efficiency along with resource conservation environmental safety and economic prudence has been adopted in the post decade through technologies that are holistic and make integrated use of natural ecological processes and external inputs. Conservation tillage, integrated pest management, integrated plant nutrient supply, crop rotation, micro irrigation techniques and precision agriculture belong to this category.

Conservation tillage practices were initially introduced to reduce the cost of mechanization but have turned out to offer several ecological and economic benefits such as low soil erosion, reduced runoff, more natural pest control, greater water storage and infiltration, increased cropping intensity and savings on inputs. Conservation tillage has become very popular where farms are large.

Similarly managing water more efficiently using drip and sprinkler irrigation and using mulching to improve water storage and reduce ET are simple ways of improving the productivity of water, which is likely to be the most limiting resource for agriculture in the future.

These practices not only result in energy savings but also attract other bonuses such as lower nutrient loss, higher efficiency of input use, and freedom from waterlogging & salinization. IPM combines several virtues, including cost reduction, environmental and human safety, prevention of pesticide resistance and post resurgence, with a favourable energy balance.

Biodiversity enhancement through polyculture, crop rotation, mixed cropping and strip cropping has been shown to have a variety of positive effects such as conservation. Efficiency of use of nutrients and water, erosion control, biological pest and disease control and improvement of soil quality. Integrated technologies are the best way to balance all factors related to the sustainability, stability and productivity of agro ecosystems.

8.5.4 Bio mass energy

Biomass is stored energy that is not subject to seasonal vagaries, it can produce all forms of energy, such as heat, electricity, gas and liquid fuel. These can be harnessed to create small and big industries in rural areas to employment and also to increase the profitability of the agricultural sector.

8.5.5 Other renewable sources of energy

Solar energy, wind energy, biomass energy and hydro and geothermal tidal energies are being evolved as potential forms of renewable energy. They are non-polluting, non-emission sources and are suitable for small to medium-scale operations, especially in rural and remote areas.

Solar, wind and bio energy are particularly useful in rural areas because of this local availability, adaptability to dispersal small and medium scale energy requirements, reliability and environmental safety.

Solar energy is the second fastest growing source of energy.

Wind energy is one of the fastest growing forms of alternative energy.

Conclusion

Energy has been identified as the second most critical factor, next only to water, for sustainable development. Attention to the quantity and quality of energy and the efficiency of its use in agriculture is crucial for sustainability.

Energy overuse leaves dirty ecological foot prints whereas energy poverty creates serious impediments to food security, livelihoods and human development.

Energy poor systems require energy infusion, preferably of renewable kind such as solar, wind and biomass energy.

Exploiting the food-energy nesses by converting agricultural by-products to heat or other forms of energy can create livelihood opportunities in the form of small commercial enterprises and also mitigate climate change, as biomass is a carbon-natural resource.

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Lecture.9
CONJUNCTIVE USE OF WATER

9.1 Definition

The term “Conjunctive use “of water resource implies the **coordinated and harmonious** development for increased efficiency of water from different resources. Thus Conjunctive use of water resource can be defined as “ the management of multiple water resources in a coordinated operation such that, the water yield of the system over a period of time exceeds, the sum of yields of the individual components of the system, resulting from in-coordinated operation”.

It is not mutely providing groundwater supply and distribution system as a back up for a surface water system or vice versa, rather it is a concept in which one system complements and supplements the other to compensate for the inadequacies of both “.

It is integrated management of both surface and ground water components in order to make best use of the complement ary potential of each and to optimize the use of water resources.

9.2 Objectives

1. Mitigating the effect of shortages in canal water supply
2. Increasing the dependability of existing water supply
3. Alleviating the problem of high water table and salinity
4. Facilitating the use of high salinity ground water
5. Mitigating the damages due to drought
6. Increasing the efficiency of surface water system

9.3 Systems of conjunctive use

Abrol et al. (1988) listed the following systems of conjunctive use:

1. Canal water and ground water system
2. Rainfall and irrigation water system
3. Saline water and fresh water system

9.4 Advantages

1. Use of ground water helps reduce peak demands for irrigation, size of canals, and hence construction costs
2. Supplemental supplies from groundwater ensure proper irrigation scheduling raising multiple crops and early sowing even if rainfall is delayed
3. Increased water resources ensure supply to tail end areas of higher elevation.
4. Ground water exploitation lowers the water table and reduces danger of water logging and consequent wastage of water for leaching of soils
5. Surface and subsurface out flows are minimized causing reduction in peak run off and flood discharge
6. Conjunctive use when integrated with an artificial recharge project the need for lining of canals is reduced as seepage from canals recharges ground water
7. During periods of peak water demand irrigation requirement can be met by surface water sources, so power saved can be diverted to other sectors
8. Conjunctive use is an attractive benefit considering the difficult political and environmental challenges facing many surface water storage projects

9.5 Constraints

1. Possibility of deterioration in ground-water quality due to influx of salts leached down from the soil which may be quite marked as a result of recycling within cones of depressions and / or upward and lateral migration of saline water intro fresh water zones in response to pumping.
2. Increased power consumption to sustain pump age from wells. Possible dislocation of groundwater supplies due to power failure in critical periods, and decrease in pump efficiencies supplies due large fluctuations in water levels.
3. Operation, supervision and control of conjunctive use and artificial recharge projects are more complex
4. Administrative difficulties in evolving acceptable and equitable water rates, providing motivation and incentives to accept groundwater use when surface water is available

(Aquifer storage and Recovery (ASR) is a form of conjunctive use where excess water is stored under ground is a suitable aquifer later as needed).

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Lecture No.10
WASTELANDS AND THEIR MANAGTEMENT

10.1 Definition

Wasteland is defined as “degraded land which can be brought under vegetative cover with reasonable effort, and which is currently under utilized and land which is deteriorating for lack of appropriate water and soil management or on account of natural causes. Wastelands can result from inherent/imposed disabilities such as by location, environment, chemical and physical properties of the soil or financial or management constraints”.

10.2 Classification of Wastelands

Confronted by various estimates by different agencies including data thrown up by latest technological tools like Remote Sensing, it become evident that a precise definition of wastelands of various categories is required. Therefore, a technical Task force Group was constituted by planning Commission and National Wasteland Development Board (NWDB) to arrive at precise definition of categories. The classification system developed by the Technical Task Force Group and subsequently slightly modified into 13 categories of wastelands are as follows:

1. Gullied and /or Ravinous land
2. Land with or without scrub
3. Waterlogged and marshy land
4. Land affected by salinity/alkalinity-Coastal or inland
5. Shifting cultivation area
6. Underutilized / degraded notified forest land
7. Degraded pastures/grazing land
8. Degraded land under plantation crops
9. Sands-Desertic/ coastal
10. Mining/ industrial wastelands
11. Barren rocky/ stony waste/sheet rock area
12. Steep sloping area
13. Snow covered and/ or glacial area

10.3 Need for development of wastelands

India is the seventh largest and the second most populous country in the world with unique physical landscape has resulted in different types of land which are subjected to different types of land which are subjected to different types of utilization. Due to increasing pressure of population, there is an excessive demand of more land both for agricultural and non-agricultural use. This has resulted in uncontrolled exploitation of land resources resulting in vast stretches of wastelands such as degraded land, soil salinity, waterlogging, desertification, soil erosion etc., and also led to decrease in per capita availability of cultivable land besides ecological imbalances. Keeping this in view, the then Prime Minister of India said, “Continuing deforestation has brought us to face all the major ecological and socio-economic crises. The trend must be halted. Hence, he proposed to set up a National Wasteland Development Board with the objective of bringing 5 million ha of land every year under fuel wood and fodder plantations. This has resulted in the formation of NWDB in 1985.

10.4 Distribution of Wastelands

10.4.1 India

The total wastelands area in districts (584) in India is estimated at 6.38518.31 Km^2 accounting for 20.17% of the geographical area (Table 10.1). The very high percentage of area under wasteland in Jammu an Kashimr (64.55%), Himachal Pradesh (56.87%) are due to snow cover and degraded forest; Nagaland(50.69%), Assam (25.52%), Manipur (58%) ,Meghalaya (44.16), Mizoram (19.31%) are due to shifting cultivation; Sikkim (50.30%) is due to degraded forest and in Rajasthan (30.87%) die to sandy area. Among all the states Kerala has a minimum 2.73% and Jammu and Kashmir has a maximum 64.55% of area under wastelands. The category-wise distribution of wastelands shows that highest percentage (6.13%) belongs to the category land **“with or without scrub”** followed by **“under utilized forestland”** (4.44%) (Table 10.2). The former is mainly distributed in the southern states of India whereas the later is distributed throughout the country.

10.4.2 Andhra Pradesh

The total wastelands area in the Andhra Pradesh state is estimated at 51750.19 Km^2 **accounting** for 18.81% of the geographical area (Table 10.3). The very high percentage of wastelands area (38.76%) is in Chittoor district closely followed by Nellore (37.61%), while the lowest is in Hyderabad (0.0%) belongs category wise distribution of lands shows that highest percentage (8.08%) belongs to "**degraded notified forest land"** followed by "**land with or without scrub"** (7.36%) (Table10.4).

10.5 Regeneration of wastelands

Regeneration of wastelands involves the following aspects:

- Pasture development for fodder supply and erosion control
- Tree plantation for fuel and timber purpose
- Social forestry for labour employment
- Silve-pastroal programme for fodder, fuel, timber purposes
- Agri-horticulture system for income generation
- Medicinal and Aromatic plants for revenue generation
- Grasslands and fish farming in low lying areas

Table 10.1 State wise waste lands of India

S.No	State	Wasteland area (Km^2)	% of geographical area
1	Andhra Pradesh	51750.19	18.18
2	Arunachal Pradesh	18326.25	21.88
3	Assam	20019.17	25.52
4	Bihar	20997.55	12.08
5	Goa	613.27	16.57
6	Gujarat	43021.28	21.95
7	Haryana	3733.98	8.45
8	Himachal Pradesh	31659.00	56.87
9	Jammu & Kashmir	65444.24	64.55
10	Karnataka	20839.28	10.87
11	Kerala	1448.18	3.73
12	Madhya Pradesh	69713.75	15.72
13	Maharashtra	53489.08	17.38
14	Manipur	12948.62	58.00
15	Meghalaya	9904.38	44.16
16	Mizoram	4071.68	19.31
17	Nagaland	8404.10	50.69
18	Orissa	21341.71	13.71
19	Punjab	2228.40	4.42
20	Rajasthan	105639.11	30.87
21	Sikkim	3569.58	50.30
22	Tripura	1276.03	12.17
23	Tamil Nadu	23013.90	17.70
24	Uttar Pradesh	38772.80	13.17
25	West Bengal	5718.48	6.44
26	Union Territory	574.30	5.23
	TOTAL	**638518.31**	**20.17**

S.No	Category	Wasteland Area (Km^2)	% of geographical Area covered
1	Gullied and /or Ravinous land	20553.35	0.65
2	Land with or without scrub	194014.29	6.13
3	Waterlogged and marshy land	16568.45	0.52
4	Land affected by salinity /alkalinity coastal/inland	20477.38	0.65
5	Shifting cultivation area	35142.20	1.11
6	Underutilized/ degraded notified forest land	140652.31	4.44
7	Degraded pastures/grazing land	25978.91	0.82
8	Degraded land under plantations	5828.09	0.18
9	Sands- Desertic/ coastal	50021.65	1.58
10	Mining/ industrial wastelands	1252.13	0.04
11	Barren rocky/stony waste/ sheet rock area	64584.77	2.04
12	Steep sloping area	7656.29	0.24
13	Snow covered and / or glacial area	55788.49	1.76
	TOTAL	**638518.31**	**20.17**

Table 10.2.Category wise wastelands of India

Table 10.3. Districtwise wastelands of Andhra Pradesh

S.No	State	Wasteland area (Km2)	% of geographical area
1	Adilabad	2455.61	15.23
2	Aanantapur	3233.45	16.90
3	Chittoor	5872.71	38.76
4	Cuddapah	4897.59	29.93
5	East Godavari	1449.75	13.41
6	Guntur	1676.36	14.72
7	Hyderabad	0.00	0.00
8	Karimnagar	1469.29	12.43
9	Khamman	1746.50	10.90
10	Krishna	921.21	10.56
11	Kurnool	3879.14	21.97
12	Mahaboobnagar	2496.12	13.54
13	Medak	1137.60	11.73
14	Nalgonda	1729.17	12.14
15	Nellore	4918.18	37.61
16	Nizamabad	1487.45	18.70
17	Prakasam	3783.05	21.46
18	Rangareddy	1461.13	19.50
19	Srikakulam	1102.41	18.89
20	Vishakapatnam	3151.38	28.84
21	Vizianagarma	1348.92	20.63
22	Warangal	1493.79	11.63
23	West Godavari	339.38	4.38
	TOTAL	**51750.19**	**18.81**

Table 10.4. Categorywise wastelands of Andhra Pradesh

S.No	Category	Waste land area (Km^2)	% of geographical Area covered
1	Gullied and /or Ravinous land	692.68	0.251
2	Land with or without scrub	20256.64	7.365
3	Waterlogged and marshy land	1035.02	0.376
4	Land affected by salinity / alkalinity coastal/inland	603.26	0.219
5	Shifting cultivation area	13.80	0.005
6	Underutilized / degraded notified forest land	22237.78	8.084
7	Degraded pastures/ grazing land	709.29	0.257
8	Degraded land under plantations	52.91	0.019
9	Sands- Desertic/ coastal	464.70	0.168
10	Mining/ industrial wastelands	98.88	0.035
11	Barren rocky/ stony waste/ sheet rock area	5196.27	1.889
12	Steep sloping area	388.96	0.141
13	Snow covered and / or glacial area	0.00	0.000
	TOTAL	**51750.19**	**18.81**

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Lecture No.11
ORGANIC FARMING

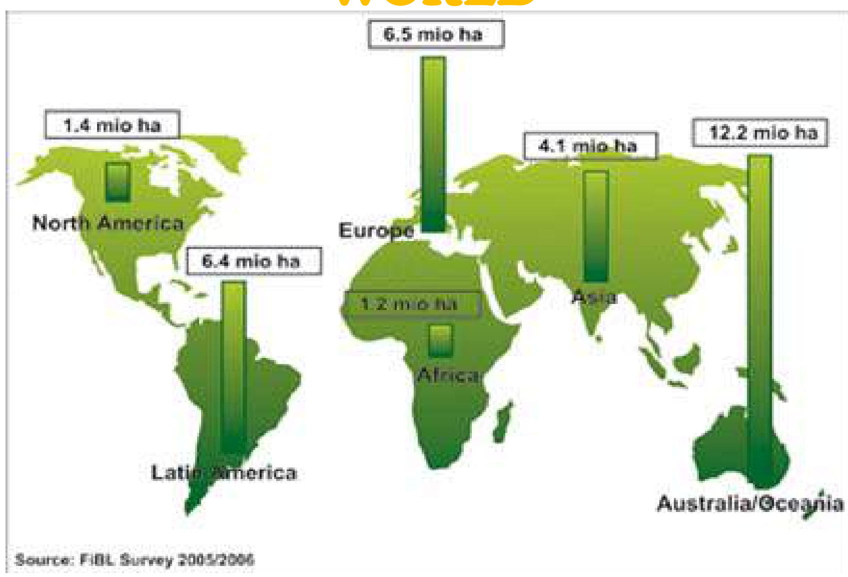
11.1 Definition

Organic farming “is a production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators, and livestock feed additives. To the maximum extent feasible, organic agriculture systems rely upon crop rotations, crop residues, animal manure, legumes, green manure, off-farm organic wastes, mechanical cultivation, mineral bearing rocks, and aspects of biological pest control to maintain soil productivity, tilth, to supply plant nutrients, and to control insects, weeds, and other pests”. (USDA,1980).

The concept of the soil as a living system which must be “fed” in a way that does not restrict the activities of beneficial organisms necessary for recycling nutrients and producing humus is central to this definition.

“Organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including bio-diversity, biological cycles and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using wherever possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system”(Codex, 1999).

ORGANIC FARMING IN WORLD



11.2 Principles of organic farming

1. To produce food of high nutritional quality in sufficient quantity
2. To interact in a constructive and life enhancing way with all natural systems and cycles
3. To encourage and biological cycles with in the farming system, involving micro-organisms, soil flora and fauna, plants and animals and careful mechanical intervention
4. To maintain and increase long-term fertility of soils
5. To promote the healthy use and proper care of water, water resources and all life therein
6. To help in the conservation of soil and water
7. To use, as far as is possible, renewable resources in locally organized agricultural systems
8. To work, as far as possible, within a closed system with regard to organic matter and nutrient elements
9. To work, as far as possible, with materials and substances which can be reused or recycled, either on the farm or elsewhere
10. To give all livestock conditions of life which allow them to perform the basic aspects of their innate behavior
11. To maintain all forms of pollution that may result from agricultural practices
12. To maintain the genetic diversity of the production system and its surroundings including the protection of wild life habitats
13. To allow everyone involved in organic production and processing a quality of life confirming to the UN Human Rights Charter, to cover their basic needs and obtain an adequate return and satisfaction from their work, including a safe working environment
14. To consider the wider social and ecological impact of the farming system
15. To produce non-food products from renewable resources, which are fully degradable
16. Weed, disease and pest control relaying primarily on crop rotation, natural predators, diversity, organic manuring, resistant varieties, and limited (preferably minimal) thermal, biological and chemical intervention

17. To create harmonious balance between crop production and animal husbandry
18. To encourage organic agriculture associations to function along democratic lines and the principle of division of powers
19. To progress towards an entire production, processing and distribution chain which is both socially just and ecologically responsible

11.3 Relevance of organic farming

Interest in organic agricultural methods is growing, especially in areas where the present modern farming system has unleashed many agro-ecological and environmental problems both on and off the farm, which threaten food security. The following are some examples:

a) Degradation of soil quality (structured & fertility)
b) Pollution of soil, water and food with pesticides and nitrates
c) Health effects on farmers, farm workers, farm families, rural communities (apart from concerns about the non-intended effects of pesticides on human beings in general, sound use of pesticides requires a technical knowledge which is often lacking in developing countries)
d) Resistance of pests to pesticides
e) Dependence on off-farm agricultural inputs which can increase poor farmers' dependence on credit facilities (to purchase synthetic fertilizers, pesticides and seed), which may result in decreased local food security and self-reliance

Further consumer awareness of the environmental costs of agriculture is increasing. The awareness of environmental quality and health is often promoted by environmental groups, especially in developed countries. The resulting demand for organic products creates the opportunity to sell organic products at premium prices, enabling organic farmers to continue, and often expand. Some governments have begun to recognize the possibility that it may be cheaper to support organic agriculture than to rectify problems associated with certain resource- destruction production practices. For this reason, several governments have introduced subsidies for organic agriculture. For example, in Indonesia where, after a period of subsidies on pesticides, the use of this input was prohibited while efforts were put in IPM programmes. In China, pesticide problems in products both on the domestic and export market has resulted in government involvement in certification organizations for “green food”, including also a small amount of organic produce. Both these policies facilitate a shift towards organic agriculture.

Relative characteristics of Modern and Organic Farming systems

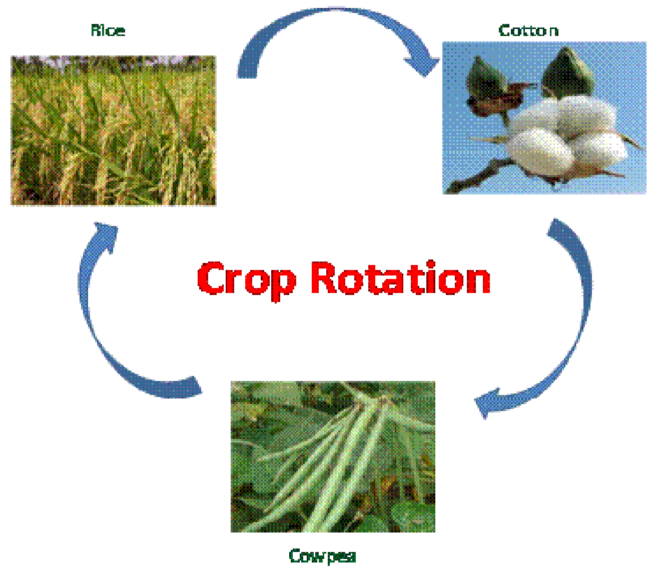
Production factor	**Modern**	**Organic**
Productivity	High	High
Sustainability	Low	High
Farming system	Simple	Complex
Bio-diversity	Uniform	Diverse
Production orientation	Market	Subsistence/market
Usage of external inputs	High	Low
Fertilization	Inorganic	Organic
Plant protection	Curative & inorganic	Preventive & organic
Energy balance	Negative	Positive

11.4 Components of organic farming

Thus organic agriculture is comparatively free from the complex problems identified with modern agriculture. It is basically a farming system, devoid of chemical inputs, in which the biological potential of the soil and the underground water resources are conserved and protected from the natural and human induced degradation or depletion by adopting suitable cropping models including agro-forestry and methods of organic replenishment, besides natural and biological means of pest and disease management, by which both the soil life and beneficial interactions are also stimulated and sustained so that the system achieves self regulation and stability as well as capacity to produce agricultural outputs at levels which are profitable, enduring over time and consistent with the carrying capacity of the managed agro-ecosystem.

Crop production and health in organic farming systems is attained through a combination of structural factors and tactical management components to ensure products of sufficient quality and quantity for human and livestock consumption.

11.4.1 Diverse crop rotations: Crop diversification can deliver many agronomic and ecological benefits simultaneously, while maintaining or enhancing the scale and efficiency of production. Benefits of diverse crop rotations include yield stability, reduction in disease incidence & severity, reduced pest incidence, improved weed control, reduced soil erosion, recycling of nutrient reserves, transfer or nitrogen from nitrogen fixing species, structural improvement etc . There are many different forms of crop diversification viz., rotational cropping, sequential cropping, intercropping, multistoried cropping system etc., and in practice these can be combined within the farming system. Crop and variety choice and their spatial and temporal design are critical in ensuring an effective rotation. The inclusion of crops, which are able to fix atmospheric through symbiotic relationship with N-fixing bacteria that nodulate on crop roots, enables organic farming systems to be self sufficient in nitrogen.



11.4.2 Soil fertility management: The aim of nutrient or soil fertility management within organic farming systems is to work, as far as possible, with in a closed system .Organic farming aims to manage soil fertility through use of organic manures (FYM & farm compost, vermicompost), recycling of crop residues such as straw, plant residues, grasses etc., dung and urine from domesticated animals and wastes from slaughter houses, human excreta & sewage, biomass of weeds, organic wastes from fruit and vegetable production & processing units and household wastes, sugarcane trash, oil cakes, press mud and fly ash from thermal power plant. Biological nitrogen fixation through blue green algae, azolla for rice, rhizobium for legumes, azatobactor & azospirillum for other crops, green manuring & green-leaf manuring, manure form biogas plants, legumes in crop rotations & intercropping systems.

11.4.3 Weed control: Organic farmers often identify weeds as their key problem. Within organic systems an integrated approach to weed control using a combination of cultural and direct techniques is necessary. Appropriate soil cultivation viz., deep ploughing in summer, harrowing, inter-cultivation using mechanical hoes and harrows, and the timing of field operations and good crop establishment are vital for successful control of weeds. Mulching the soil surface can physically suppress weed seedling emergence. Soil solarization, to heat field soil under plastic sheeting to temperatures high enough to kill weed seeds (>65 ^{o}C) can also be used for weed, control in some parts of India. Good seedbed preparation, timely sowing, line sowing, crop rotation, smoother crops & intercropping systems etc., suppress the weed growth and favour normal growth and development of crops in organic systems.

11.4.4 Natural pest and disease control: One of the important features of organic farming is the exclusion of plant protection chemicals for pest and disease control. The system relies on the on-farm diversity, improved health of the soil and crops, protective influence of beneficial soil organisms against soil borne pathogens and use of plant based insecticides and biological control measures. The population of naturally occurring beneficial insects and other organisms which act as bio control agents multiplies making natural control of pests possible when the system is free from the indiscriminate use of chemicals. Few examples are:

a) Manipulation of crop rotations, to minimize survival of crop-specific pests (in the form of, for example insect eggs, fungi) which can infest the next crop
b) Strip cropping, to moderate spreading of pests over large areas
c) Manipulation of the moisture level or pH level of the soil (in irrigated areas)
d) Manipulation of planting dates, to plant at a time most optimal for the crop, or least beneficial for the pest
e) Adjustment of seeding rate, to achieve an optimal density given the need to check weeds or avoid insects
f) Use of appropriate plant varieties for local conditions
g) Biological control methods, to encourage natural enemies of pests by providing habitat or by breeding and releasing them in areas where they are required.
    - *Bacillus thuringensis* against caterpillars of *Heliothis, Earias, Spodoptera* etc
    - *Pseudomonas fluoroscenes* against *Pythium spp., Rhizoctonia spp., Fusarium spp.*

- Nematodes like Green commandoes and Soil commandoes against caterpillars & grubs
- Nuclear Polyhedrosis virus (NPV) against caterpillars
- *Trichoderma virdi* against many common diseases of vegetables and spices
- Weevils *Neochitina eichorniae* & *N. bruchi* against water hyacinth
- Beetle *Zygogramma biocolorata* against parthenium

h) Trapping insects, possibly with the use of lures such as pheromones

i) Use of domesticated birds

j) Biological pesticides (for example neem oil, nicotine) of which the active ingredient is short-lasting, and which may be produced locally

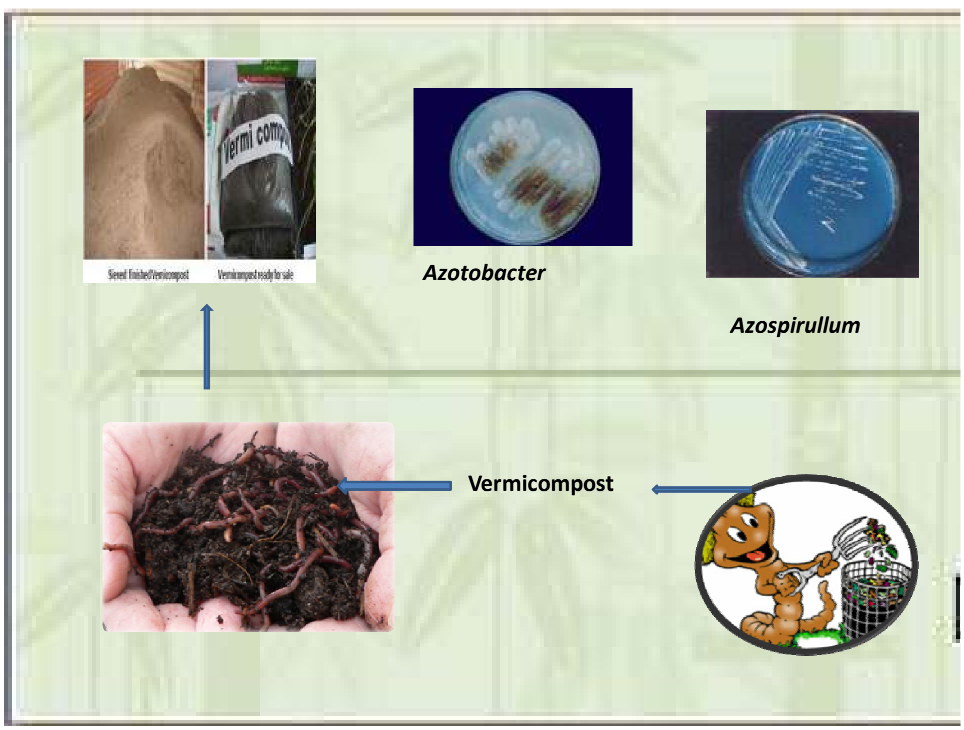
11.5 Integrated nutrient management

Integrated nutrient management system envisages conjunctive use of organic manures, crop residues, biofertilizers, legumes in crop rotation and green manuring. It combines traditional and improved technologies to gain from the symbiosis and synergy of crop- soil-environment bio-interactions. The concept is for optimization of all available sources of plant nutrients to improve soil fertility availing nature's gifts. Development of INM system involving and appropriate mix of organics, biological N fixation, phosphate solubilising microbes, and need based chemical fertilizers would be crucial for sustainability of production and soil as a resource base for it.

11.5.1 Bulky organic manures: In India, the estimate production of rural compost is about 226 million tons and urban compost of 6.6 million tons annually. Aggregate stability, decrease in pH, resistance to compaction, infiltration and water holding capacity. Proper methods of preparation of FYM/Compost therefore have to be popularized.

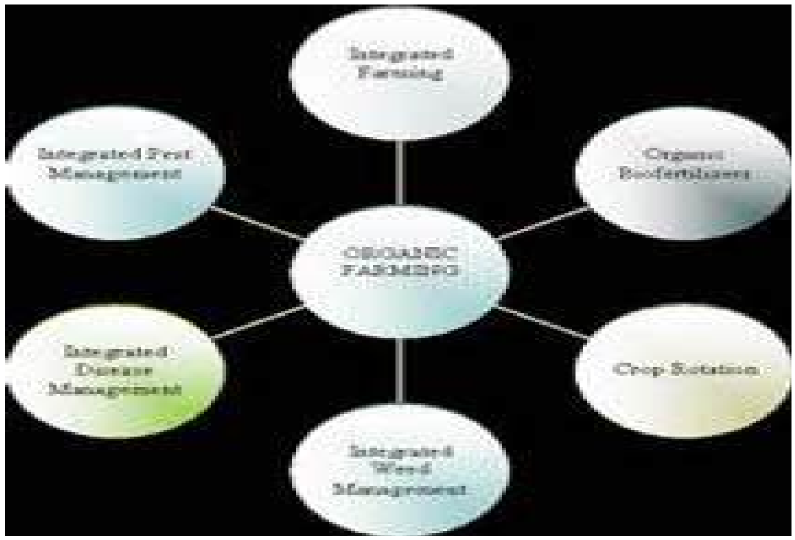
11.5.2 Recycling of organic wastes: Substantial quantities of crop residues (350 million tons) are produced in India every year. Crop residues in combination with organics have been shown to improve availability of plant nutrients, soil organic matter, aggregate stability, infiltration rate, microbial population etc.

11.5.3 Bio-fertilizers: Bio-fertilizers such as rhizobium culture is an effective source of N supply to leguminous corps. Azotobacter and Azospirillium help in N fixation and supply to crops like rice, wheat, sorghum, maize, cotton, sugarcane, fruit corps and vegetables. Phosphate solubilising bacteria viz., *Bacillus aspergillus* help in making available soil P to the crops and increase the solubility of indigenous sources of P like rock phosphate. Blue green algae and Azolla have shown promise in low land rice. These are renewable and environment friendly supplementary sources of nutrients and are presently being used in quantities between 8-10 tons per year. *Vesicular arbuscular mycorrhiza* (VAM) has beneficial effect on plant growth, particularly in P deficient soils. Improved uptake of water, production of plant hormones and microbial activity are the prime benefits of mycorrhizal inoculations.



11.5.4 Green manuring: Green manuring is a cheap alternative to the use of fertilizer N. The process also makes a positive contribution to the maintenance of soil organic matter at a satisfactory level. The stem nodulating green manure plant, *Sesbania rostrata* (Danchia) can fix 100-250 kg/N/ha in 45 to 55 days and has great scope in rice culture. There is also greater scope for green-leaf manuring for rice and other crops from the lopping of various multipurpose trees popularized through afforestation and agro-forestry systems.

Popularization of bio-gas plants, encouraging legumes in crop rotation and intercropping system and use of sewage, sludges and effluents for agriculture can also be the components of INMS.


Integrated Farming
Integrated Pest Management
ORGANIC FARMING
Integrated Disease Management
Crop Rotation
Integrated Weed Management

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Lecture No.12
FARMING SYSTEMS-I

12.1 What is a System?

A system is a group of interacting components, operating together for a common purpose, capable of reacting as a whole to external stimuli: it is unaffected directly by its own outputs and has a specified boundary based on the inclusion of all significant feedbacks.

For example, the human body is a system-it has a boundary (e.g., the skin) enclosing a number of components (heart, lungs) that interact (the heart pumps blood to the lungs) for a common purpose (to maintain and operate the living body).

Collection of unrelated items does not constitute a system. A bag of marbles is not a system: if a marble is added or subtracted, a bag of marbles remains and may be almost completely unaffected by the change. The marbles only behave as a whole if the whole bag is influenced, for example by dropping it, but if it bursts the constituent parts go their own ways. It is the properties of the system that chiefly matter and they may be summarized in the phrase 'behavior as a whole in response to stimuli to any part'.

12.2 Systems approach

In system approach all the components and activities are linked, they affect each other. It is not sensible to look at one component by itself without recognizing that what it does and what happens to it will affect other parts of the system. For example consider what happens when you stub your toe: the whole body may react and different parts may respond differently. Eyes may water, the voice may make appropriate sounds, the pulse rate may increase and hands may try to rub the damaged toe. It would be very rash to alter any component of a system without regard to the consequences and reactions elsewhere.

You cannot, for example, improve a car (system) by doing research on one wheel and then making it rather bigger than the rest. Or increase the power and size of the engine without regard to the ability of the chassis to support it.

These things are common sense in such familiar contexts- they also apply to biological and agricultural systems.

In agriculture, management practices were usually formulated for individual corp. However, farmers are cultivating different crops in different seasons based on their adaptability to a particular season, domestic needs and profitability. Therefore, production technology or management practices should be developed in view all the crops grown in a year or more than one than one year if any sequence or rotation extends beyond one year. Such a package of management practices for all crops leads to efficient use of costly inputs, besides reduction in production cost. For instance, residual effect of manures and fertilizers applied and nitrogen fixed can considerably bring down the production cost if all the crops are considered than individual crops.

12.3 Farming system

Farming system is a complex inter-related matrix of soil, plants, animals implements, power, labour, capital and other inputs controlled in part by farm families and influenced by varying degrees of political, economic, institutional and social forces that operate at many levels. In other words it is defined as unique and reasonably stable arrangement of farm enterprises that the household manages according to its physical, biological, economic and socio-cultural environment in accordance with the household's goals, preferences and resources. Conceptually it refers to a set of elements or components that are interrelated which interact among themselves. At the center of the interaction is the farmer exercising control and choice regarding the type and result of interaction.

It is a resource management strategy to achieve economic and sustained production to meet diverse requirement of farm household while preserving resource base and maintaining a high level of environmental quality.

For example it represents integration of farm enterprises such as cropping systems, animal husbandry, fisheries, forestry, sericulture, poultry etc for optimal utilization of resources bringing prosperity to the farmer. The farm products other than the economic products, for which the crops are grown, can be better utilized for productive purposes in the farming systems approach.

12.4 Farming systems concept

In farming system, the farm is viewed in a holistic manner. Farming enterprises include crops, dairying, poultry, fishery, sericulture, piggery, apiary tree crops etc. a combination of one or more enterprises with cropping when carefully chosen, planned and executed, gives greater dividends than a single enterprise, especially for small and marginal farmers. Farm as a unit is to be considered and planned for effective integration of the enterprises to be combined with crop production activity, such that the end-products and wastes of one enterprise are utilized effectively as inputs in other enterprise. For example the wastes of dairying viz., dung, urine, refuse etc are used in preparation of FYM or compost which serves as an input in cropping system. Likewise the straw obtained from crops (maize, rice, sorghum etc) is used as a fodder for dairy cattle.

Further, in sericulture the leaves of mulberry crop as a feeding material for silkworms, grain from maize crop are used as a feed in poultry etc.

Sustainability is the objective of the farming system where production process is optimized through efficient utilization of inputs without infringing on the quality of environment with which it interacts on one hand and attempt to meet the national goals on the other. The concept has an undefined time dimension. The magnitude of time dimension depends upon ones objectives, being shorter for economic gains and longer for concerns pertaining to environment, soil productivity and land degradation.

12.5 Principles of farming system

- Minimization of risk
- Recycling of wastes and residues
- Integration of two or more enterprises
- Optimum utilization of all resources
- Maximum productivity and profitability
- Ecological balance
- Generation of employment potential

- Increased input use efficiency
- Use of end products from one enterprise as input in other enterprise

12.6 Characteristics of farming system

1. Farmer oriented & holistic approach
2. Effective farmers participation
3. Unique problem solving system
4. Dynamic system
5. Gender sensitive
6. Responsible to society
7. Environmental sustainability
8. Location specificity of technology
9. Diversified farming enterprises to avoid risks due to environmental constraints
10. Provides feedback from farmers

12.7 Objectives of farming system

1. **Productivity-** Farming system provides on opportunity to increase economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises. Time concept by crop intensification and space concept by building up of vertical dimension through crops and allied enterprises.
2. **Profitability -** The system as a whole provides an opportunity to make use of produce/waste material of one enterprise as an input in another enterprise at low/no cost. Thus by reducing the cost of production the profitability and benefit cost ratio works out to be high.
3. **Potentiality –** Soil health, a key factor for sustainability is getting deteriorated and polluted due to faulty agricultural management practices viz., excessive use of inorganic fertilizers, pesticides, herbicides, high intensity irrigation etc. In farming system, organic supplementation through effective use of manures and waste recycling is done, thus providing an opportunity to sustain potentiality of production base for much longer time.

4. **Balanced food-** In farming system, diverse enterprises are involved and they produce different sources of nutrition namely proteins, carbohydrates, fats & minerals etc form the same unit land, which helps in solving the malnutrition problem prevalent among the marginal and sub-marginal farming households.
5. **Environmental safety-** The very nature of farming system is to make use or conserve the byproduct/waste product of one component as input in another component and use of bio-control measures for pest & disease control. These eco-friendly practices bring down the application of huge quantities of fertilizers, pesticides and herbicides, which pollute the soil water and environment to an alarming level. Whereas IFS will greatly reduces environmental pollution.
6. **Income/cash flow round the year-** Unlike conventional single enterprise crop activity where the income is expected only at the time of disposal of economic produce after several months depending upon the duration of the crop, the IFS enables cash flow round the year by way of sale of products from different enterprises viz., eggs from poultry, milk from dairy, fish from fisheries, silkworm cocoons from sericulture, honey from apiculture etc. This not only enhances the purchasing power of the farmer but also provides an opportunity to invest in improved technologies for enhanced production.
7. **Saving energy-** Availability of fossil fuel has been declining at a rapid rate leading to a situation wherein the whole world may suffer for want of fossil fuel by 2030 AD. In farming system, effective recycling of organic wastes to generate energy from biogas plants can mitigate to certain extent this energy crisis.
8. **Meeting fodder crises-** In IFS every inch of land area is effectively utilized. Alley cropping or growing fodder legume along the border or water courses, intensification of cropping including fodder legumes in cropping systems helps to produce the required fodder and greatly relieve the problem of non-

availability of fodder to livestock component of the farming system.

9. **Solving timber and fuel crises-** The current production level of 20 million m^3 of fuel wood and 11 million m^3 of timber wood is no match for the demand estimated or 360 m^3 of fuel and 64,4 million m3 of timber wood in 2000 AD.Hence the current production needs to be stepped up several-fold. Afforestation programmes besides introduction of agro-forestry component in farming system without detrimental effect on crop yield will greatly reduce deforestation, preserving our natural ecosystem.
10. **Employment generation-** Various farm enterprises viz., crop +livestock or any other allied enterprise in the farming system would increase labour requirement significantly and would help solve the problem of under employment. An IFS provides enough scope to employ family labour round the year.
11. **Scope for establishment of agro- industries-** When once the produce from different components in IFS is increased to a commercial level there will be surplus for value addition in the region leading to the establishment of agro-industries.
12. **Enhancement in input use efficiency** – An IFS provides good scope for resource utilization in different components leading to greater input use efficiency and benefit- cost ratio.

FARMING SYSTEMS - II

12.8 Determinants of farming system

There are three major groups of factors, which in combination determine the type of farming system employed by framers in a given region. These factors are illustrated in Fig. 12.1 and discussed below.

Factor A represent the physical and biological elements which set limits to the type of agricultural produce to be produced in the given region. The physical elements include land, soil quality, topography, climate, water, location, distance etc. The biological elements include crops and livestock physiology, diseases etc., which determine the potential farm enterprises. These elements can be altered by limited intervention by the farmers and scientists. For instance scientists can evolve improved production technology and farmers can adopt it partially or in full package.

Factor B represent endogenous human elements, which greatly influence the type of farming system adopted in a particular region. The system revolves around the farmer whose family and means of livelihood are intricately linked. The farm family has available resources under their control in terms of land, labour, capital and management. The quantity and quality of these resources are conditioned by the characteristics of the family (size, age etc), education and management skills, available labour, capital, power, attitudes and goals of the family. The farmers goals and attitudes are initial factors that determine the nature of farming system specially where there is a range of alternative operations and enterprises to increase productivity consistent with existing technical elements. The farmer could combine available resources in a manner that will maximize the goals of the family.

Factor C represents the exogenous human variables, which govern the allocation of available resources by the farmers. Farm producers need incentives to change their farming methods and production patterns in desirable directions.

12.9 Cropping System Related terminology

12.9.1 ***Cropping system*****:** A cropping system refers to the principles and practices of cropping and their interaction with farm resources, technology, aerial and edaphic environment to suit the regional or national or global needs and production strategy. It is an important component of farming system.

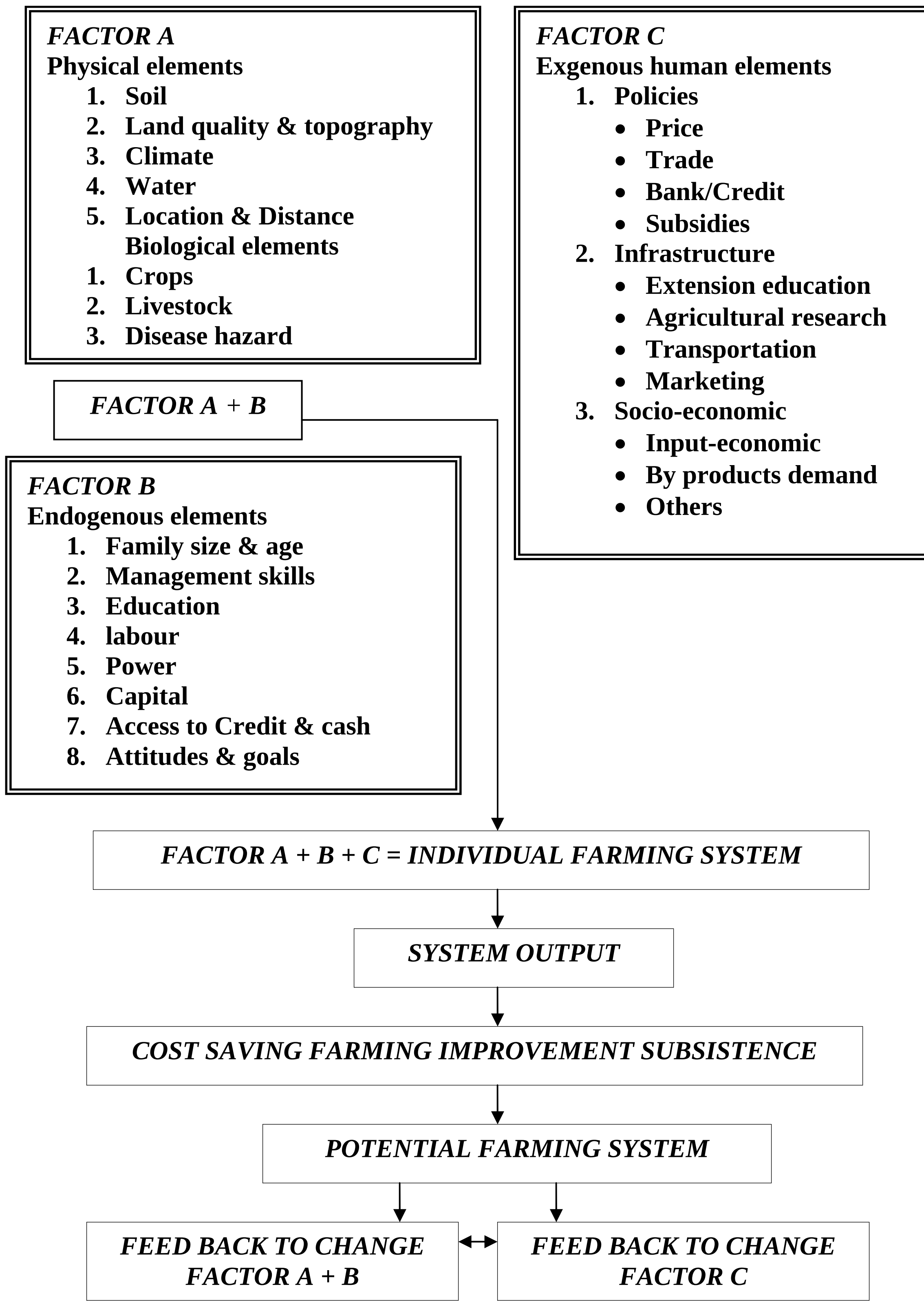

Fig.12.1. Determinants of farming system

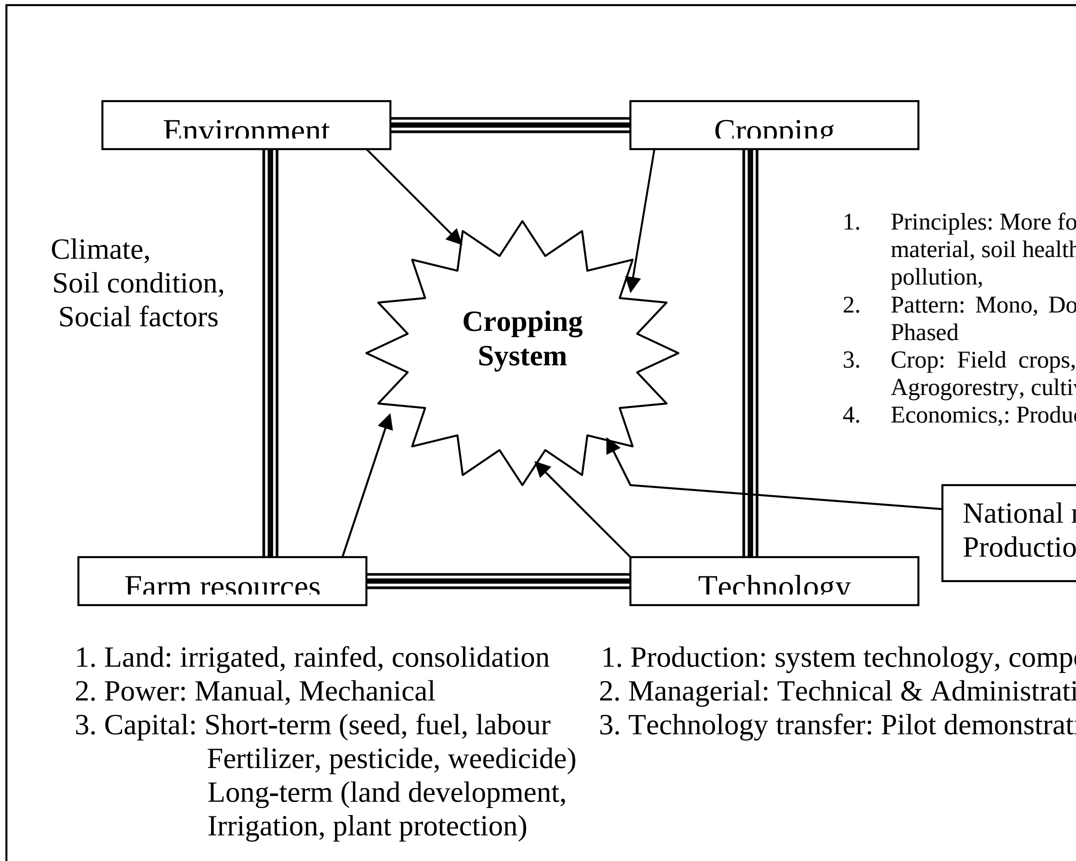

Fig.12.2. Elements of cropping system

Its components have been diagrammatically represented in Fig.1. A perusal of the Fig.12.2, would reveal that the cropping systems, by and large, are affected by the national food need and the strategies planned to boost agricultural productivity. Cropping systems are the resultant product of principle and practices of cropping, resources, environment and available package of technology (production & management).

12.9.2. Cropping pattern: The yearly sequence and spatial arrangement of crop or of crops and fallow on a given area (a farm), region, province or country apportioning due consideration to natural features (soil and climate), crop efficiency, and capability, socio-economic structure, technological and extension infra-structure (changeable) and the national agricultural policy.

12.9.3 Multiple cropping

Multiple cropping refers to intensification of cropping both in time and space. It includes sequential cropping, inter-cropping and mixed cropping.

a) Sequential cropping: Growing two or more crops in a sequence on the same field in a farming year (twelve months) for irrigated land and is limited to the period of adequate soil moisture availability for crop growth in semi-arid & arid areas. The succeeding crop is planted after the preceding crop has been harvested. Crop intensification is only in time dimension. There is no inter-crop competition. Farmers manage only one crop at a time in the same field.

b) Intercropping : It refers to growing of two or more dissimilar crops simultaneously on the same piece of land, base crop necessarily in distinct row arrangement. The recommended optimum plant population of the base crop is suitably combined with appropriate additional plant density of the associated/component crop. The objective is intensification of cropping both in time and space dimensions and to raise productivity per unit area and inputs by increasing the pressure of plant population. The following four types of inter-cropping are identified.

i) **Mixed inter-cropping:** Growing component crops simultaneously with no distinct row arrangement. This is commonly used in labour intensive subsistence farming situations.

ii) **Row inter-cropping:** Growing component crops simultaneously in different row arrangement. This is used in mechanized agriculture.

iii) **Strip inter-cropping:** Growing component crops in different strips wide enough to permit independent cultivation but narrow enough to the crop to interact agronomically.

iv) **Relay inter-cropping:** Growing component crops in relay, so that growth cycles overlap. It necessarily does not mean planting of succeeding crop before flowering stage of preceding crop or attainment of reproductive stage of preceding crop. It refers to planting of succeeding crop before the harvest of preceding crop, planting of succeeding crop may be done before or after flowering before or after attainment of reproductive stage, completion of active life cycle, senescence of leaves or attainment of physiological maturity.

12.9.4 Mixed cropping: Mixed cropping is growing of two or more crops simultaneously on the same piece of land seeded either after the seeds of the crops intended to be grown mixed or sowing alternate rows in various replacement ratios. This may or may not have distinct row arrangement and the mixed plant community faces inter and intra row competition with a different plant type/variety. The basic objective in mixed cropping is minimization of risk and insurance against crop failure due to aberrant weather conditions. In inter-cropping systems, pressure of plant density per unit are is more than that in a sole cropping system, while in mixed cropping the plant population pressure is generally equal to sole cropping and in some cases it may even be less than sole cropping system.

Besides the above few other terms commonly used in cropping systems approach are defined below:

12.9.5 Monoculture: The repetitive growing of the sole crop on the same piece of land. It may either be due to climatological limitation or due to specialization by a farmer to grow a particular crop.

12.9.6 Staggered planting: It means sowing of a crop is spread over and around optimum period of planting either to minimize risks or to use labour & machinery more effectively or to minimize competition (in inter-cropping) or to prolong the period of supply to the market or the factories.

12.9.7 Ratoon cropping: The cultivation of crops' re-growth coming out of roots or stalks of the preceding crop after harvest, although not necessarily for grain is termed as ratoon cropping/ratooning.

12.9.8 Mixed farming: It is defined as a system of farming on a particular farm (regardless of size) which includes crop production, raising of livestock, poultry, fish and bee keeping, and/or tress to sustain and satisfy as many necessities of the owner (farmer) as is possible. Subsistence is the objective here. It is based on the principle of give and take. Farm animals feed on farm produce and in return manure is given to the crops.

Lecture No.13
STUDY OF ALLIED ENTERPRISES – I
(DAIRYING AND SHEEP & GOAT REARING)

In an integrated farming system, it is always emphasized to combine cropping with other enterprises/activities. Many enterprises are available and these primarily include dairying, sheep & goat rearing, poultry, fisheries, sericulture, bee keeping etc. Any one or more can be combined with the cropping system.

13.1 Significance or integrating crops and livestock

Animals can perform numerous functions in smallholder systems. They provide products such as meat, milk eggs, wool etc. They serve socio-cultural functions, as bride wealth, for ceremonial feasts, and as gifts or loans, which strengthen social bonds. Integration of livestock into the farming system is particularly important for:

- Increasing subsistence security by diversifying the food generating activities of the farm family
- Transferring nutrient and energy between animals and crops via manure and forage from cropped areas via use of draught animals

Diversification into livestock keeping expends the risk reduction strategies of farmers beyond multiple cropping and thus increases the economic stability of the farming system. Livestock can enhance farm productivity by intensifying nutrient and energy cycles. Stubble in the fields and crop residues are important sources of forage in smallholder systems.Lower mature leaves stripped from standing crops, plants thinned from cereal stands and vegetation on fallow fields offer addional fodder resources related to food cropping. When animals consume vegetation and produce dung, nutrients are recycled more quickly than when the vegetation decays naturally. Grazing livestock transfer nutrients from range to cropland and concentrate them on selected areas of the farm.

Integrating agro-forestry and fodder production into crop rotations can enhance the sustainability of a farming system, particularly to the extent that perennial grasses and legumes, including shrubs and trees are involved. These may use nutrient and water from deeper soil fertility and protect the soil during periods when arable crops are not grown. Forage crops can play an important role in nutrient transfer also within the farm by providing better quality dung, which can be used as manure for crops. Part of the forage crop can also be used as green manure or mulch. Trees solve the problem of fuel and fodder requirement.

When animals are used for traction, some of the energy gained from grazing wasteland and temporarily uncultivated land can be exploited for crop production. Animals power can also be used to process farm products e.g, for threshing, and for transporting them from the fields to storage or market.

13.2 Dairying

Dairy farming is one of the economically viable enterprises that could provide constant income throughout the year to farmers when combined with cropping. The success of dairying depends solely on the availability of inputs like feed and fodder and better marketing facilities to milk. To maximize benefits from dairying selection of proper breed to suit the local conditions is very essential. The dairy cattle are broadly classified into the following 5 groups.

1. **Draft breeds:** The bullocks of these breeds are good draft animals, but the cows are poor milkers e.g, Nagore, Hallikar Kangeyam, Mali.
2. **Dairy breeds:** The cows are high milk yielders and the bullocks are with good draft work capacity e.g., Sahiwal, Sindhi, Gir.
3. **Dual Purpose:** The cows are fairly good milkers and the bullocks are with good draft work capacity e.g., Hariana, Ongole and Kankerj.
4. **Exotic breeds:** The exotic breeds are high milk yeilders, e.g., Jersey, Holstein-Friesian, Aryshire, Brown Swiss and Guernsey
5. **Buffaloes:** Important dairy breeds of buffalo are Murrah, Nili Ravi (Which has its home tract in Pakistan, Mehsana, Suti, Zafarabadi, Godavari and Bhadwari. Of these

Godavari has been evolved through crossing local buffaloes in coastal reins of Andhra Pradesh with Murrah.

- Jersey crossbred cows come up very well in most of the climatic conditons, consume less feed and fodder, give more milk with high fat content and possess comparatively better disease resistance.
- Holstein-Friesian could be reared for higher milk yield in places of cooler climate as they lack heat tolerance
- Buffaloes like Murrah could also be reared for milk production in semi-arid and arid regions, since they can digest more percentage of roughage than cows and thrive well on dry fodder.

Housing: It is important to provide good ventilation and an open shed of housing is always preferable. Dairy cattle shed should be located at an elevated place to facilitate easy drainage. The floor should be rough and gradient of 2.5 cm for every 25cm length. The Space requirement for dairy cattle is given in Table 13.1:

Table 13.1. Housing requirements of dairy cattle

S.No.	Particulars	Area (m^2)		Maximum Strength
		Shed	Open area	
1.	Calves	1	1	30
2.	Growing calves	2	4	30
3.	Cows	3.5	7	5
4.	Buffalos	4	8	50
5.	Pregnant animal	12	12	1
6.	Bull	12	120	1

Feed and fodder requirements: Of several types of input costs, feed and fodder play a significant role in the economy of dairying. Of the total expenditure, nearly 65% goes towards feeding of cattle. Cattle feed generally contains fibrous, coarse, low nutrient straw material called roughage and concentrates.

a) **Roughage:** Dairy cattle are efficient users of the roughage and convert large quantities of relatively inexpensive roughage into milk. Roughages are basic for cattle ration and include legumes, iron-legume hays, straw and silage of legume and grasses.
b) **Concentrates:** Grains and byproducts of grains and oil seeds constitute the concentrates. They are extensively used in dairy cattle ration. These include cereals (maize, sorghum, oats, barley), cotton-seeds, industrial wastes (bran of wheat & rice, and grain husk) and cakes of oil seeds (groundnut, sesame, rape seed, soybean linseed).
c) **Vitamins and mineral mixtures:** It is advisable to feed a supplement containing vitamin A and B besides mineral mixtures containing salt, Ca and P and feed additives.

Table 13.2. Samples of Ration/day/animal

Feed particulars	**Feed ratio/day**	
	Sample 1	**Sample 2**
Maize grain	3.0	---
Straw	---	4.8
Groundnut cake	2.0	1.0
Deoiled Rice bran	4.8	3.0
Sugarcane molasses		1.0
Mineral mixture	0.1	0.1
Salt	0.1	0.1
Urea	---	50g
Total	10.0	10.0
Water	32 Litres	32 Litres

Milk yield: Crossbred cows give a milk yield of about 2500 to 3000 Litres/annum compared to 500 to 600 Litres/annum by local cows.

Dung and urine: The amount of excreta (Dung and urine) produced by an individual animal depends on age & weight of the animals and daily feed (quantity of fodder and concentrates).

An approximate quantity of dung and urine produced per head annually is as follows.

Animal	Body weight (kg)	Urine (kg)	Dung (kg)	Total excreta (kg)
Cow	272	2187	5137	7324

13.3. Biogas (Gobar gas) Plant

Biogas plant is a system comprising of a gas-holder and a digestion chamber, in which "Gobar" (or cow dung) can be treated anaero bically to produce two important and useful items viz., fuel gas (or biogas) and organic manure. In this biochemical process the cellulotic material are broken down to methane and carbon-di-oxide by different groups of microorganisms. It is a clean, unpolluted and cheap source of energy, which can be obtained by a simple mechanism and little investment. India was the first country in the world to have developed a biogas plant on an experimental basis as early as 1939, followed by the installation of a commercial model in 1954. Later, the Khadi and Village Industries Commission (KVIC) adopted the biogas programme in 1962, and was instrumental for intiating biogas plants in India.

Types of biogas plant:

1. **Float dome type:** Different models are available in this category, e.g., KVIC vertical and horizontal, Pragathi model & Ganesh Model.
2. **Fixed dome type:** The gas plant is dome shaped under ground construction. The entire construction is made of bricks and cement. The models available in this category are Janata and Deen-Bandhu.

   The selection of a particular type depends on technical, climatological, geographical and economic factors.

Technical information

- Biogas is compsed mainly of methane (55 – 60%) and Carbon Dioxide (35 – 45%). Hydrogen and hydrogen sulphide can also be present in small amounts.
- Availability of fresh dung per stable bound medium sized animal per day is a follows: buffalo - 15kg; Cow – 10kg; and Calves – 5kg.

- Recommended size of biogas plant according to cow dung availability is shown in Table 13.3

Table 13.3. Size of biogas plant

Gas production (size) in M^3	Fresh cow dung required/day	No. of animals required
2	50	4 -5
3	75	6 – 8
4	100	9 – 11
6	150	14 -16
8	200	18 -22
10	250	24 -28

- The NPK content of the residual sludge in the dry state is equivalent of N = 1.4 - 1.8% ; $P_2 O_5$ = 1.1 – 2.0% ; K_2O = 0.8 – 1.2%
- From each kilogram of fresh dung charged in to the digester every day, gas production will be about 0.04 – 0.1 m^3 depending upon the day temperature. Gas production would be maximum at a temperature between 30-35^oC. If the ambient temperature falls below 10^oC, gas production is reduced drastically.
- One m^3 of biogas is equivalent to 0.62 litres of kerosene
- A 2 m3 biogas plant would cater to domestic needs of a family of 6 – 8 members

Site selection and management: The site of biogas plant should be close to the kitchen and cattle shed to cut down the cost on gas distribution system and transportation of cattle dung Land should be leveled and slightly above the ground level to avoid inflow or run-off of water. Plant should get clear Sunshine during most part of the day. Gas generation is a function of dung availability. The amount of gas production is considerably higher in summer followed by rainy and winter seasons.

Uses of biogas: It can be efficiently used for domestic cooking and lighting. It can also be a used as a substitute fuel for running diesel engine. It does not emit smoke and also does not soot on the vessels unlike other conventional forms of fuel viz., coal, fire-wood and kerosene.

Uses of bio-gas slurry: Slurry is obtained after the production of bio-gas. It is enriched manure containing NPK and humus. Another positive aspect of this manure is that even after weeks of exposure to the atmosphere, the slurry does not attract fleas and worms.

13.4 Sheep and goat rearing

Rearing sheep and goat is one of the important common livestock enterprises followed by small and marginal farm families and landless labourers in drought prone, hilly and desert areas. Goat farming needs less capital when compared to dairying, and the animals can be raised in small farms as well. This enterprise provides employment opportunities round the year for the farm household as well as for the unemployed and under employed rural population and forms one of the important practicable and profitable components of an integrated farming system. Not much financial inputs are required but steady income is assured throughout the year. Even with the poor grazing facilities and with minimum managerial resources sheep and goats can return high profits to farmers. They not only help the household with regular cash flow but also improve the health of family members by providing milk and meat regularly.

The sheep and goat have a high adaptability to extreme and different agro-climatic conditions, disease tolerance giving multiple kids with faster growth rate and excellent marketing facilities. Small and marginal farmers could easily maintain 20 animals with available fodder in one ha area. Per capita availability of meat is very poor in India. It is around 6g/person/day as against 57g worldwide. It indicates a tremendous scope for sheep and goat production potential in India. Goat milk constitutes about 2.4 per cent of the total milk production. Goat milk has excellent market value, as it is a scarce commodity for the preparation of many ayurvedic medicines and for human diet.

Breeds

Goats: Tellicherry, Jamunapari, Barberi, Osmanabadi, Malaberi, Kashmeri, Beetal, Surti, Gujarati. A few exotic goats such as Saanen, Toggenburg, Angora, Anglo-Nubian, British Alpine and

French Alpine have been found to be well adapted to Indian conditions.
Sheep: Himalayan region – Gurez, Karanah, Bhakarwal;
Western region – Bikanari, Marwari, Kathiawari, Kutchi;
Southern region – Deccani, Nellore, Bellary, Mandya & Bandur

Housing: Successful sheep and goat rearing depends on the selection of proper site. Sheep and goats do not thrive on marshy or swampy ground. They have to be provided with a dry, comfortable, safe and inclement weather. The kids of goats and lambs of sheep are kept under large inverted baskets until they are old enough to run along with their mothers. Males and females are generally kept together. The space requirement for a sheep and goats varies between 4.5 50 5.4 sq.m.

Feeding: The requirement of nutrients per head in respect of sheep and goats is relatively low. Hence, they are suitable for resource poor small farmers with marginal grazing lands.
Goats are essentially browsers and eat plants, which any other animals won't touch. They eat 4-5 times that of their body weight. Since the profit depends on weight addition, adequate proteins and calorie should be given to goats. They eat more of tree leaf fodder (Subabul, Acacia etc) and legume fodder (Lucerne, Berseem, Soyabean, Pillipeasera etc) @ 4kg/day and the rest with other grass species (Maize, Jowar, Bajra, Anjan grass, Sudan grass, Hybrid napier etc). Goats should be fed with concentrates of maize, wheat, horse-gram, groundnut cake, fish meal and wheat bran, Common salt and vitamin mixtures should also be added.
Sheep are excellent gleaners and make use of much of the waste feed. They consume large quantities of roughage, converting a relatively cheap food into a good cash product. The feed and fodder requirements of sheep include:
Green fodder: Legumes (Berseem, Lucerne, Stylo, Pillipesera, etc), Cereal (Maize, Jowar Ragi, Bajra besides Napier & Paragrass are also preferred), paddy and wheat straw mixed with urea and gur molasses.
Concentrates: Grains of maize, jowar, bajra, ragi, pulses, rice bran, wheat bran, maize bran, groundnut, seseme, sunflower, safflower and cotton seed cakes. A sheep requires about 1 -2 kg

of leguminous hay/day depending on the age of sheep and its body weight. Proteins may be supplied though concentrates such as groundnut cake, sesame cake or safflower cake when the pastures are poor in legumes or when scarcity conditions prevail. Feeding a mixture of common salt, ground limestone and sterilized bone meal in equal parts is required to alleviate deficiency of mineral in the feed.

Abundant clean fresh water (8 – 10 Litres/day) should be made available to both sheep and goats. Water should be changed every morning and evening. Fresh water is required for digestion, blood circulation and removal of waste from the body. Water is also required for regulation of the body temperature.

Few samples of sheep and goat's ration per day are given below in Table 13.4 and 13.5:

Table 13.4 Sheep: Feed requirement/day/anaimal

Feed	**Grownup**	**Young**
	Feed ratio	
Maize/Jowar grain	25.0	50.0
Groundnut cake	32.0	20.0
Rice or wheat bran	40.0	17.0
Mineral mixture	2.0	2.0
Salt	1.0	1.0
Fish/ Meat meal	---	10.0
Total	**100.0**	**100.0**

Table 13.5 Goats: Feed requirement/day/animal

Feed	**Ratio**	**Feed**	**Ratio**
Sample 1		**Sample 2**	
Maize grains	35.0	Maize/ Jowar/ Bajra grains	30.0
Redgram/Gram husk	15.0	Redgram/Gram husk	20.0
Wheat bran	22.0	Maize bran	10.0
Groundnut cake	25.0	Small millets	30.0
Mineral mixture	2.0	Gur molasses	7.0
Salt	1.0	Mineral mixture	1.0

Total	100.0	Total	100.0
Sample 3		**Sample 4 (For growing calves)**	
Maize/Jowar/Bajra grains	22.0	Maize grain	18.0
Redgram/Blackgram husk	20.0	Jowar/Bajra grain	39.0
Wheat bran	20.0	Groundnut cake	10.0
Groundnut/Gram cake	35.0	Fish meal	10.0
Mineral mixture	2.0	Gur molasses	10.0
Salt	1.0	Mineral mixture	2.0
		Salt	1.0
Total	**100.0**	**Total**	**100.0**

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LECTURE No. 14
STUDY OF ALLIED ENTERPRISES – II
(POULTRY FARMING, FISHERIES AND APICULTURE)

14.1 Poultry farming

Poultry farming is emerging as an important livestock activity in Farming system for enhancing economic stability, nutrition and providing regular employment and cash flow. Poultry meat accounts for about 27% of the total meat consumed world wide, and its consumption is growing at an average of 5% annually. The total egg production in India was worth Rs.5000 crores (2001). Broiler production is increasing at the rate of 12% per year. Nevertheless the present per capita consumption is very low, 100g/year. The average global consumption is 120 eggs per person per year and in India, it is only 32 – 33 eggs per capita per year. As per the nutritional recommendation, the per capita consumption is estimated at 180 eggs/year and 9 kg meat/year.

Breeds: Specific poultry stocks for egg and broiler production are available. A majority of the stocks used for egg production are crosses involving the strains or inbred lines of white Leghorn. Under good management the egg laying potential of these breeds is 280 – 310 eggs/annum. To a limited extent, other breeds like Rhode Island Red, California Grey and Australop are used. There are many hatcheries in Andhra Pradesh Supplying the strains/inbred lines of layers and broiler chicks (Table 14.1 & 14.2). Heavy breeds such as white Plymouth Rock, White Cornish and New Hampshire are used for cross-bred broiler chicken. Hence, it is essential to consider the strain within the breed at the time of purchase. Several commercial poultry breeders are selling day old chicks in India. It is best to start with the day old chicks.

Table 14.1. Hatcheries supplying chicks of layers

S.No	Hatchery	Breed
1.	ANGRAU, Hyderabad	ILR – 90 Jubliee
2.	AVN Hatcheries Private Limited, Secunderabad	BOWENS

3.	Balaji Hatcheries, Chittoor	BV – 300
4.	Sreenivasa Hatcheries Private Limited Vijayawada	BV – 300
5.	Systemic Hatcheries Private Limited, Hyderabad	BV – 300
6.	Tirumala Hatcheries Private Limited Warangal	BV -300
7.	Venkateswara Hatcheries Private Limited, Hyderabad	BV -300
8.	C & M Hatcheries, Hyderabad	HYLINE
9.	Pasuparthi Agro Industries Private Limited, Palmanair	

Table 14.2. Hatcheries supplying chicks of broilers

S.No.	Hatchery	Breed
1.	B.R Rai Private Limited Hyderabad	Hubchick
2.	Diamond hatcheries Private Limited, Hyderabad	Vencob
3.	Pioneer Farms Private Limited, Secunderabad	Vencob
4.	Sreenivasa Hatcheries Private Limited, Vijayawada	Vencob
5.	Tirumala Breeders Private Limited, Warangal	Vencob
6.	Chandra hatcheries, chittoor	Vencob
7.	Venkateswara hatcheries Private Limited, Hyderabad	Vencob
8.	Vijayanagara hatcheries Private Limited, Anantapur	Hubchick
9.	Pasuparthi Agro Industries Private Limited, Palmanair	Vencob

Housing: The poultry shed should be located in areas having good ventilation, water and power supply and reasonably cool in summer and warm during winter. It should be located on well-drained ground, free from floodwaters. The width of the poultry shed must not exceed 25 – 33’ of convenient length depending up on the number of birds. On side walls above 1.0’ fix a wire mesh. Roof normally consists of asbestos sheets. For protection from incident solar radiation layout the shed in east – west direction. Floor area of about 0.2 m^3 per adult bird is adequate for light breeds such as white Leghorn. About 0.3 -0.4 m^3 per bird is required for heavy breeds of broilers. Rearing of poultry birds (layers) in cages is a recent phenomenon and is found to be beneficial. It saves space, labour, feed expenses, protects the birds from diseases besides improving the management, egg size and production. A cage having dimensions of 15 – 20” length, 12” width and 18” height can accommodate 3 – 4 birds comfortably. Though broilers can also be raised in cage system, deep litter system is preferred in view of low yield potential in cage system.

Feed: The feed conversion efficiency of the bird is far superior to other animals. About 70 – 75% of the total expenditure on poultry farming is spent on the poultry feed. Hence, use of cheap and efficient ration will give maximum profit. Ration should be balanced containing carbohydrates, fats mineral and vitamins. Feed requirement varies with age of the bird. Feed to poultry birds must contain the following:

Age in weeks	*Calories*	*Proteins*
	Layers	
1 – 8	2700	22%
9 – 20	2600	16%
>21	2600	17%
	Broilers	
0 -4	2800	23%
>5	2900	20%

Some of the common feed stuff used for making poultry ration in India are: Cereals (Maize, barley, oats, wheat, pearl, millet, sorghum, rice-broken); cakes/meal (Oil cakes, maize-meal, fish meal, meat meal, blood meal); Minerals/salt (Limestone, Oyster shell, salt, manganese). Feed may be given 2-3 times a day. In addition to the food-stuffs, feed additives such as antibiotics and drugs may also be added to the poultry ration. Laying hens are provided with oyster shell or ground limestone. Riboflavin is particularly needed. The main difference in feed for layers and others is calcium and amino acids content in feed. For young ones it varies between 0.9 – 1.0% and for grown up it is 2.5 – 3.0%. The daily ration of layers and broilers for different growing periods is given below in Table 14.3 and 14.4 respectively.

Table 14.3 Layers: Feed requirement/day/bird at different growing periods

Feed particular	Units	Age in weeks		
		1 – 8	**9 – 18**	**> 18**
Maize grains	%	30.0	30.0	30.0
Jowar/Ragi/Bajra grains	%	20.0	30.0	20.0
Bran	%	10.0	10.0	10.0
Groundnut cake	%	18.0	8.0	4.0
Sunflower cake	%	10.0	10.0	16.0
Fish meal	%	10.0	10.0	10.0
Dicalcium phosphate	%	1.0	1.0	0.8
Calcium carbonate/oyster shell	%	1.0	0.8	9.0
Mineral mixture	%	0.1	0.1	0.1
Salt	%	-	-	-
Lysine	%	0.09	-	-
Methionine	%	0.1	-	0.2
Vitamin A_1 b_2, D_3, K	g/100 kg	10.0	10.0	10.0
Vitamin B Complex	g/100 kg	10.0	10.0	10.0
Vitamin B12 mix	g/100 kg	10.0	10.0	10.0
Colin chloride	g/100 kg	100.0	50.0	50.0
Dat/datplus/emicakx	g/100 kg	50.0	50.0	-
Zincbesitracin	g/100 kg	25.0	-	-

Maintenance and production: The chicks must be vaccinated against Ranikhet diseases with F1 Serain vaccine within the first 6-7 days of age. One drop of vaccine may be administered in the eye and nostril. When chicks get the optimum body weight of 1.0-1.5 kg in around six weeks, they can be marketed for broiler. Hens may be retained for one year for production i.e., up to the age of about 1.5 years. After that they are disposed off for table purpose. It may not be economical to keep the hens beyond 1.5 years since egg production would get reduced. One hen is capable of laying 180-200 eggs in a year staring from the sixth month. In addition, a laying hen produces about 230 g of fresh droppings (75% moisture) daily.

Table 14.4. Broilers: Feed requirement/day/bird at different growing periods

Feed particulars	Unit	Starter feed (0 – 4 weeks)			Finisher feed (> 5 weeks)		
		Sample			Sample		
		1	2	3	4	5	6
Maize grains	Kg	35.0	55.0	60.0	42.0	62.0	65
Jowar/Ragi/Bajra grains	Kg	20.0	-	--	20.0	--	--
Deoiled soyabean bran	Kg	--	10.0	29.4	--	10.0	24.4
Deoiled sunflower cake	Kg	33.2	22.2	--	26.2	15.2	--
Fish meal	Kg	--	5.0	7.0	--	5.0	7.0
Dicalcium phosphate	Kg	10.0	5.0	--	10.0	5.0	--
Calcium carbonate/oyster shell	Kg	1.0	1.6	2.0	1.0	1.6	2.0
Mineral mixture	Kg	0.1	0.1	0.1	0.1	0.1	0.1
Methionine	Kg	0.06	0.06	0.1	0.06	0.06	0.1
Vitamin A_1 b_2, D_3, K	grams	10.0	10.0	10.0	10.0	10.0	10.0
Vitamin B Complex	grams	10.0	10.0	10.0	10.0	10.0	10.0
Vitamin E 50%	grams	2.0	2.0	2.0	2.0	2.0	2.0
Colin chloride	grams	100.0	100.0	100.0	100.0	100.0	100.0

14.2 Fisheries

Ponds serve various useful purposes, viz., domestic requirement of water, supplementary irrigation source to cropping and fisheries. With the traditional management, farmers obtain hardly 300-400 kg of wild and culture fish per ha annually. However, poly-fish culture with the stocking density of 7500 fingerlings and supplementary feeding will boost the total biomass production.

Pond: The depth of the pond should be 1.5-2.0 m. This depth will help for effective photosynthesis and temperature maintenance for the growth of zooplankton and photosynthesis. Clay soils have higher water retention capacity and hence are best suited for fish rearing. Pond water should have appropriate proportion of nutrients, phosphate (0.2-0.4 ppm), nitrate (0.06-0.1ppm) and dissolved oxygen (5.0-7.0 ppm). Water should be slightly alkaline (pH 7.5-8.5). If the pH is less than 6.5, it can be adjusted with the addition of lime at an interval of 2-3days. Higher pH (>8.5) can be reduced with the addition of gypsum. Application of fresh dung may also reduce high pH in the water. Organic manure such as FYM and poultry droppings may also be applied to promote the growth of phyto and zooplankton. The area allocated for pond in rice – fish – poultry farming system varies between 10 – 33%.

Species of fish:

1. Among the Indian major carps, Catla (C*atla catla*) is the fast growing fish. It consumes a lot of vegetation and decomposing higher plants. It is mainly a surface feeder.
2. Rohu (*Labeo rohita*) is a column feeder and feeds on growing plants decomposing vegetation, large colonial algae, zooplankton and detritus to a small extent.
3. Calbasu (*Labea calbasu)* is a bottom feeder on detritus. Mrigal (Cirrhimus mrigale) is also a bottom feeder, taking dertritus on a large content, diatoms, filamentous and other algae and higher plants. Common carp (*Cyprinus carpio)* is a bottom feeder and omnivorous.
4. Silver carp (*Hypophthalmichlthya malitrix)* is mainly a surface and phytoplankton feeder and also feeds on microplants.
5. Grass carp *(Cyernus carpia)* is a specialized feeder on aquatic plants, cut grass and other vegetable matter. It is also a fast growing exotic fish.

Poly fish culture: The phytophagous fish (Catla, Rohu and Mrigal) can be combined with omnivorous (Common Carp), Plankton-feed (Silver Carp) and Mud-eaters (Mrigal and Calbasu) in a composite fish culture system. For example a combination of silver carp (surface feeder), Mrigal (bottom feeder), rohu (column feeder), and grass carp (specialized feeder on aquatic plants) can be successfully used in the ratio of 4:3:2:1 in poly fish culture. The recommended stocking density is 7500 fingerlings/ha

Management: The fish are to be nourished through supplementary feeding of rice bran, oil seed cakes and poultry excreta. This will enable faster growth and better yield. This stocking density will enable to get maximum yield of 2000 to 5000 kg/ha of fish annually.

14.3. Bee keeping (Apiculture)

Bee keeping is one of the most important agro-based industries, which does not require any raw material from the artisan like other industries. Nectar and pollen from flowers are the raw materials, which are available in plenty in nature.

Species : There are three species, *Apis cerana indica* (Indian Bee), *Apis dorsata* (Rock bee) and *Apis mellifera*, (Italian Bee), are complentary to each other but have different adaptations. *A. cerana* is better acclimatized to higher altitudes of the Himalayan region. *A. mellifera & Apis dorsata* is more profitable in the plains.

Management: The bee-keeper should be familiar with the source of nectar and pollen within his locality. The most important sources are nectar and pollen. The sources of nectar are Tamarind, Mango, Guava and most of the fruit crops. Whereas the sources of pollen include crops such as maize, sorghum & other millets, bulrush, sunflower and palm tree. The plants which will provide nectar and pollen for honey bees are known as bee pasturages. The bee keeping activity must begin with flowering season. The beginner should start with 2 and not more than 5 colonies. A minimum of 2 colonies is recommended because in the event of some mishap, such as the loss of the queen occurring in one, advantage may be taken with the other.

The bees are reared in beehives viz., Newtons beehive, Longstroth beehive. The beehive consists of floor-board, brood chamber, super chamber, top cover, inner cover, frames and entrance rod. These parts can easily be separated. The hive may be double walled or single walled. The single walled hive is light and cheap.

The most suitable time for commencing bee keeping in a locality is the arrival of the swarming season. Swarming is a natural tendency of bees to divide their colonies under conditions that are generally favourable for the survival of both parent colony and the swarm. The castes of bees include queen, king & droves. This occurs during the late spring or early summer.

Honey collection: Honey should have good quality to meet the national and international standards. Qualities such as aroma, colour, consistency and floral sources are important. Proper honey straining and processing are needed to improve the quality of the produce. Honey varies in the proportion of its constituents owing to the differences in the nectar produced by different plants. The nectar collected by bees is processed and placed in comb cells for ripening. During the ripening, sucrose is converted into glucose and fructose by an enzyme called invertase which is added to it by the bees. Honey is an excellent energy food with an average of about 3500 calories per kg. It is directly absorbed into the human blood stream, requiring no digestion.

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LECTURE NO. 15
STUDY OF ALLIED ENTERPRISES – III (SERICULTURE AND AGROFORESTRY SYSTEMS)

15.1 Sericulture

Sericulture is an agro-industry, the end product of which is silk Sericulture involves thee activities viz., Mulberry cultivation, Silkworm rearing, Reeling fo the silk from the cocoons formed by the worms. The first two activities are basically agriculture in nature and the later is an industry of different financial investments. India is the second largest producer of mulberry silk after china. It currently produces about 1, 27,495 tons of reeling cocoons and 14,048 tonnes of raw silk from a mulberry cropped area of 2,82,244 ha. The sericulture is practiced in India both in tropical (Karnataka, Andhra Pradesh, Tamilnadu and West Bengal) and temperate(Jammu and Kashmir)climates. The mulberry silk goods produced in India are mainly exported to USA, Germany, United Kingdom, France, Italy, Singapore, Canada, UAE, Switzerland, Netherlands, Spain, Japan, Thailand etc.

15.1.1.Moriculture: Cultivation of mulberry plants is called as moriculture. **Morus** is the Latin word for mulberry. The mulberry plant is exploited for commercial production of silk, since it constitutes the chief food for mulberry silkworm, ***Bombyx mori*.** Mulberry leaf protein is the source for the silkworm to bio-synthesize the silk, which is made up of two proteins, fibroin and sericin. Nearly 70 per cent to the silk proteins produced by a silkworm are directly derived from the proteins of the mulberry leaves. There are about 20 species of mulberry, of which four are commonly cultivated. They are *Morus alba, M. Indica, M. Serrata* and *M. latifolia*. It can be cultivated on wide range of soils. The recommended NPK dose is 120 – 50 – 50 kg/ha under rain fed and 300 -120 – 120 kg/ha under irrigated conditions. The important mulberry varieties are Kanva-2 (M_5), S_{13}, S_{30}, S_{36}, S_{41}, S_{54}, DD, V_1 and Ananta. A spacing of 90 cm X 90 cm under rainfed conditions (pit method) and 120cm x 60cm under irrigated conditions is commonly followed. It is mainly propagated by cuttings. The planting season is July – August. The crop can yield well for 12 years, after which they are pulled out and fresh planting is done yield of mulberry leaves is 30-40 t/ha/year.

15.1.2.Silk worm rearing

There are four types of silk worms viz., mulberry silk worm – *Bombyx mori*, Eri silk worm – *Philosamia ricini*, Tassar silk worm – *Antheraea mylitta*, Muga silk worm – *Antheraea assama*. The silkworm is reared in a rearing house. Maintenance of proper temperature (24 – 28 0C) and humidity (70 – 85%) depending upon the silkworm stage (i.e., instar) is very essential. Initially the disease free layings (DFLS) or egg cards are collected from a Government Grainage and kept for hatching in a dark and cool place. One DFL is equivalent to 400 eggs. After hatching brushing is done which is defined as transferring of hatched larvae into rearing trays. The rearing trays usually made up of bamboo/plastic. The space requirement for 100 DFLs varies from 4 -14 m^2 during 1^{st} during 1^{st} instar to 181 – 360 m^2 during 5^{th} instar. The newly hatched larvae after one hour of hatching get ready to feed on mulberry leaves. The leaf requirement of growing silkworms is estimated at 2-4kg during 1^{st} instar to 600 650 kg during 5^{th} instar for 100 DFLs. During the first three instars (which is known as chawki rearing) the silkworms are fed with tender chopped leaves, while during the late age rearing i.e., 4^{th} and 5^{th} instar the worms are fed with entire leaves without any chopping. During the 5^{th} instar i.e., after 5 days of the 4^{th} moult the silkworm becomes fully matured and ready to spin into a cacoon. This is the last stage of rearing operation. After this stage the mature silkworms are transferred on to the cocoon frames or mountages for spinning of cocoons. The mountages are popularly known as chandrke. Each chandrika can accommodate 1000 – 1200 worms depending upon the silkworm race. The spinning activity is completed within 2 days and the larvae enter into pupal stage which lasts for 6 -7 days. Within a week the cocoons are harvested and sent for stifling (killing of pupae before emergence) and storage.

On an average the cacoon yield is estimated at 55 to 60 kg for 100 DFLs per crop. Normally 5 to 6 crops are taken per annum. The length of silk filament per cacoon is about 350 meter in Indian multivoltine, whereas it is about 1800 m in case of Japanese bivoltine race.

15.2 Agro-forestry

Agro-forestry may be defined as an integrated self sustained land management system, which involves deliberate introduction/retention of woody components with agricultural crops including pasture/livestock, simultaneously or sequential on the same unit of land, meeting the ecological and socio-economic needs of people. An Agro-forestry system is more acceptable than tree farming alone, since the intercropped annuals regulate income when the tress are too young to yield beneficial produce. On the other hand, mature trees bring about more stability in the system because of their innate ability to withstand destructive aberrations in rainfall. Their perennial character helps make use of the non-seasonal rains. In addition an agro-forestry system provides to varied needs of the farmer – food, fuel, fodder and employment. Some Agro-forestry systems (agri-horticulture) enhance employment opportunities by spreading labour needs which otherwise are concentrated in the cropping season. Important agro-forestry systems relevant to farming systems approach are discussed below.

15.2.1.Agrisilviculture – In this system agricultural crops are intercropped with tree crops in the interspaces available between trees. Tree component gives fodder, fuel and timber including green leaf manure. It is ideal for Class IV soils of dry lands with annual rainfall around 750 mm. The positive associative effect of *Leucaena leucocephala* and *Sesbania aegyptica* has been found in crops like hybrid Napier, Lucerne, oat and several other cereal forages.

15.2.2 Silvi-pastoral system – The system is primarily meant for augmenting the scarce food supply. It integrates pasture and/or animals with tress. In Marginal lands (Class IV onwards), this system promotes sustainability via resource conservation and its efficient use, improvement in soil quality and by linking agriculture with cattle.

15.2.3 Agri-silvipastoral system – The system integrates crop and /or animal with trees. Woody perennials preferably of fodder value are introduced deliberately. Such systems can be used for food production and soil conservation besides providing fodder and fuel. It may be tree-livestock crop mix around homestead, wood-hedge rows for browsing, green-leaf manure and soil conservation or for an integrated production of pasture, crops animals and wood.

15.2.4 Agri-horticultural system – It is one form of agro-forestry in which tree component is fruit tree. It is also called as food-cum-fruit system. In which short duration arable crops are raised in the interspaces of fruit trees. Some of the fruit trees that can be considered are guava, pomegranate, custard apple, sapota and mango. Pulses are the important arable crops for this system. However, depending upon the requirements, others like sorghum and pearl millet can be grown in the interspaces of fruit trees. Reasons for this system not being widely adopted are:

- Economic position of farmers may not permit awaiting income for 5-6 years
- Watering of fruit trees, till their establishment is a problem in summer period
- Marketing problems for perishable horticultural produce

15.2.5 (a) . **Horti/silvipastoral system-** Class IV and above soils, uneconomical for arable crop production are termed as non-arable lands. Horti-Pastoral system is an agro-forestry system involving integration of fruit trees with pasture. When a top feed tree replaces fruit tree, it is called horti-pastoral system. Guava, custard apple and ber suits well in an horti-pastoral system with grasses like *Cenchrus ciliaris (“anjan”), C.setigerus (birdfoot), Panicum antidotale (blue panic), Dicanthium annulatum (marvel) and Chloris gayana (Rhodes), and legumes like Stylosanthes hamata, S. scabra (stylo) and Macroptilum atropurpurium (siratro).*

(b) **Top-feed trees ideal for Silvi-pastoral system are:** *Acacia nilotica(babul)* , *Acacia senagel(gum Arabica)* , *Bauhinea purpurea(khairwal)* , *Dalbergia sissoo(shisham)* , *Gmelina arborea(gummadi teak)* , *Hardwickia binata(yepi), Leucaena leucocephala(subabul), Sesbania grandiflora(avise).* Grasses and legumes indicated under horti-passtoral system are also suitable for silvi-pastoral system.

15.2.6 Alley cropping

Food crops are grown in alleys formed by hedgerows of trees or shrubs in arable lands. It is also known as "hedgerow" intercropping". Hedgerows are cut back at about one meter height at planting and kept pruned during cropping to prevent shading and to reduce competition with food crops. It is recommended for humid tropics, primarily as an alternative to shifting cultivation. In semi-arid regions of India, alley cropping provides fodder during dry period since mulching the crop with hedgerow pruning does not usually contribute to increased crop production. Advantages of this system are :

- Provision of green fodder during lean period of the year.
- Higher total biomass production per unit area than arable crops alone.
- Efficient use of off season precipitation in the absence of a crop.
- Additional employment during off-season.
- It serves as a barrier to surface runoff leading to soil and water conservation.

Based on the objectives , three types of alley cropping are recognized

(i)Forage alley cropping

(ii)Forage-cum-mulching alley system and

(iii)Forage-cum-pole system.

In all the three systems, crops are grown in alleys and forage obtained from the lopping of hedgerows. However, gross returns are higher in all the alley cropping systems than the sole crop system.

15. 2.7 Tree farming

Trees can flourish and yield abundantly where arable crops are not profitable. Farmers of dry lands are inclined to tree farming because of labour scarcity at peak periods of farm operations and frequent crop failure due to drought. A number of multipurpose tree systems (MPTS) have been tested for their suitability and profitability under different situations(Table 15.1)

Table 15.1. List of multipurpose trees for different rainfall conditions

Annual rainfall < 500 mm	**Annual rainfall 500 mm to 750 mm**
Acacia nilotica	*Acacia nilotica*
Acacia aneura	*Acacia ferruginea*
Acacia tortilis	*Albizia lebbeck*
Acacia albida	*Azadirachta indica*
Prosopis cineraria	*Casuarina equisetifolia*
Prosopis juliflora	*Cassia sturti*
Pithecalobium dulce	*Dalbergia sissoo*
	Leucaena leucocephala
	Tamarindus indica

15.2.8 Role of trees in farming system

- Improve land productivity
- Provides 3 Fs viz.fuel used, fodder and fruit
- Service functions like shade for the cattle, workers, conservation of soil fertility, fencing and water conservation
- Increase income earning oppurtunities
- Strengthen risk management through diversification

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LECTURE NO. 16
Bio-Diversity

16.1 Bio-diversity and sustainable Agriculture

What is Biodiversity?

Biodiversity refers to rich and diverse energy of living organisms of all species, the genes they contain and the ecosystem they constitute.

"Biological diversity means the variability among living organisms from all sources including, interalia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part, this includes diversity with in species, between species and of ecosystems"

Thus biodiversity is considered at three levels:

a) genetic diversity
b) species diversity
c) ecosystem diversity

a) Genetic diversity refers to the variation of genes between different populations of a species as well as between species.
b) Species/organismal diversity refer to the variety of living species.

c) Ecosystem biodiversity relates to the variety of habitats, biotic communities and ecological processes and the enormous diversity present within ecosystems interms of habitat differences and the variety of ecological processes.

16.2 Importance of biodiversity

Biodiversity is recognized as the most important natural resources, it directly and indirectly influences and regulates the functioning of the other natural resources of soil, water and air in the ecosystem.

Humans derive all of their food almost 40 percent of their medicines, and industrial products from the wild and domesticated components of biological diversity.

16.3 Human Impact on Biodiversity

Human interventions can alter biodiversity directly and indirectly through changes in land, water and atmosphere. Human impact is greater than that of most natural processes that lead to a decline in biodiversity. The most significant human impact on biodiversity and also the earliest was the domestication of plants and animals for food which started more than 10,000 years ago.

The root cause of human-induced biodiversity loss is actually the manner in which human society functions in the present global context with respect to its natural resources, trade and economic systems, and human and social values.

Human activities change biological diversity globally in two fundamental ways 1) by affecting a globally dynamic system such as the atmosphere directly and 2) through the collective consequences of individual effects in various places and at various times building up to globally significant impact. For instance, global warming is due to direct excessive emission of green house gasses from burning fossil fuels as well as to the cumulative effect of deforestation, land clearance and faculty agricultural practices in various parts of the world.

16.4 Reduction in Biodiversity and its ecological Implications

The truly irreversible nature of the loss of species and genetic diversity is the most serious cause for concern for human beings. The high intensity and rate of human Intervention increase the threat of a decrease in species populations. Which can eventually lead to their extinction. A decline in biodiversity can result in a perceptible deficiency in the quality and amount of ecological services provided by nature. Over exploitation of both natural and man made resources, such as timber extraction from natural forests and over utilization of crop lands, can lead to the disruption of ecosystem services and increased costs.

16.5 Importance of Agricultural Bio diversity

1. Recycling of nutrients
2. Control of microclimate
3. Regulation of local hydrological processes
4. Detoxification of waste and toxic chemicals
5. Regulation of the abundance of desirable and undesirable organisms.
6. Soil structure
7. Infiltration and run off Soil erosion
8. Natural pest and disease control
9. Pollination and
10. Genetic Introgression and hybridization

16.6 Agricultural Intensification & biodiversity

Agricultural activities have three types of impacts on biodiversity.

1. They alter the characteristics of natural ecosystems and their constituent species.
2. They impact the species and genetic variability of the chooses cultivated species themselves and also their nonfood components.
3. The affect on and off farm non food bio diversity through such adverse physiochemical effects as erosion, salinization and pesticide pollution. The magnitude of these impacts varies with the intensity of the intervention.

The magnitude of these impacts varies with the intensity of the intervention.

Population pressure and the concomitant decline in per capital land availability have made-productivity-oriented, chemically intensive, high-yielding-variety monoculture and irrigated agriculture unavoidable in large parts of the world. This has caused an incalculable loss of biodiversity both on and off-farm and at all levels.

Thus modern agriculture has evolved as a major threat to biodiversity in general and to diversity of importance to agriculture itself.

16.7 Impact of biodiversity reduction on modern agricultural systems

Species diversity:- Products of plant origin make up 93 percent of the human diet and 3000 species are regularly exploited for food. However modern agriculture has drastically shrunk the vast food basket provided by nature and put ot use by humans over thousand of years.

Only 103 species contribute 90 percent of the world's plant food supply just three crops Rice, wheat and maize-account for 90 percent of the calories and 56 percent of the proteins people derive from plants. The other thousands of species contribute the remaining 10 percent of the plant food supply, though they have considerable importance in the diet of poor people confined to more isolated areas.

<u>16.8 Reasons for the oversimplification of edible plant species.</u>

The factors responsible for the adoption of and extremely limited no. of species for the food security of a large segment of the global population are diverse: some have been deliberate and some by default. The discovery and wide spread use of modern technologies of production such as fertilisers, Pest control chemicals, mechanization and high-yielding these countries in terms of production and productivity. Apart from the fact that these regions are home to much more limited species diversity. Their commercial and economic insects were saved by the wide production and a part of a few popular species of crops.

The adoption of similar strategies became unavoidable in developing to meet the food scarcity.

16.8.1 Genetic erosion

Genetic erosion consists of the loss of genes, gene complexes and unique combinations of genes that occur in different land. The primary cause of the less of genetic diversity of the widely used plant crops and vegetables is the wide speed adoption of a limited number if modern varities that are generally bred for higher yield, resistance to insect pests and diseases, and high performance over a range of biophysical environment, thus reducing the need for specific local adaptations.

Further, advanced methods of cultivation using fertilizers, irrigation, and pest control chemicals have lowered the demand for land races, which have evolved largely through careful selection and area adapted to marginal growing conditions.

Without a rich reserve of varietal diversity, long term sustainability and food security and livelihoods of poor farmers in complex, diverse and risk prone areas will be jeopardized.

Modern agricultural production practices have created tensions related to different aspects of agricultural biodiversity such as

- Severe reduction in the no. of species of food plants cultivated.
- Loss of genetic diversity of the presently cultivated crops and vegetables.
- Destabilization of pest species in agro ecosystems.
- Deficiency in soul biodiversity and
- Erosion of cultural diversity, loss of indigenous knowledge of traditional farming systems and environmental degradation.

Thus the immense potential of soil biodiversity for agricultural productivity and sustainability is still undervalued and needs to be understood and harnessed. Assigning intellectual property heights to biological materials that have been nurtured and developed over thousands of years by traditional farmers is a contentious issue and cannot be divorced from considerations of human ethics and values.

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Abbreviations

FAO	-	Food and Agriculture Organisation
WHO	-	World Health Organisation
WCED	-	World commission of Environment and Development
GLASOD	-	Global Assessment of the Status of Human- induced Soil Degradation
NAEB	-	National Afforestation and Eco-development Board
ESP	-	Exchangeable Sodium Percentage
EC	-	Electrical conductivity
CGWB	-	Central Ground Water Board
WMO	-	World Meteorological Organisation
UNEP	-	United Nations Environment Programme
UNCED	-	United Nations Conference on Environment and Development
WUA	-	Water Users Association
NWDB	-	National Waste Land Development Board
USDA	-	United States Department of Agriculture
ICRISAT	-	International Crop Research Institute on Semi-arid Tropics
NABARD	-	National Bank for Agriculture and Rural Development
CGIAR	-	Consultative Group for International Agricultural Research
IREP	-	Integrated Rural Energy Progrmme
WTO	-	World Trade Organisation

CFC	-	Chlorofluorocarbons
IFOAM	-	International Federation for Organic Agricultural Movements
NDDB	-	National Dairy Development Board
DFL	-	Disease Free Layings
NBPGR	-	National Bureau for Plant Genetic Resources
IPM	-	Integrated Pest Management
CSSRI	-	Central Soil Salinity Research Institute
UNDP	-	United Nations Development Programme
KVIC	-	Khadi and Village Industries Board
NPV	-	Nuclear Poly hedrosis Virus
VAM	-	Vesicular Arbuscular Mycorrhiza
WALAMTARI	-	Water and Land Management Training Research Institute
CADA	-	Command Area Development Authority
NPBD	-	National Project on Biogas Development
MPTS	-	Multipurpose Trees systems
IPCC	-	Intergovernmental Panel on Climate Change
WSSD	-	World Summit on Sustainable Development
CBD	-	Convention on Biological Diversity