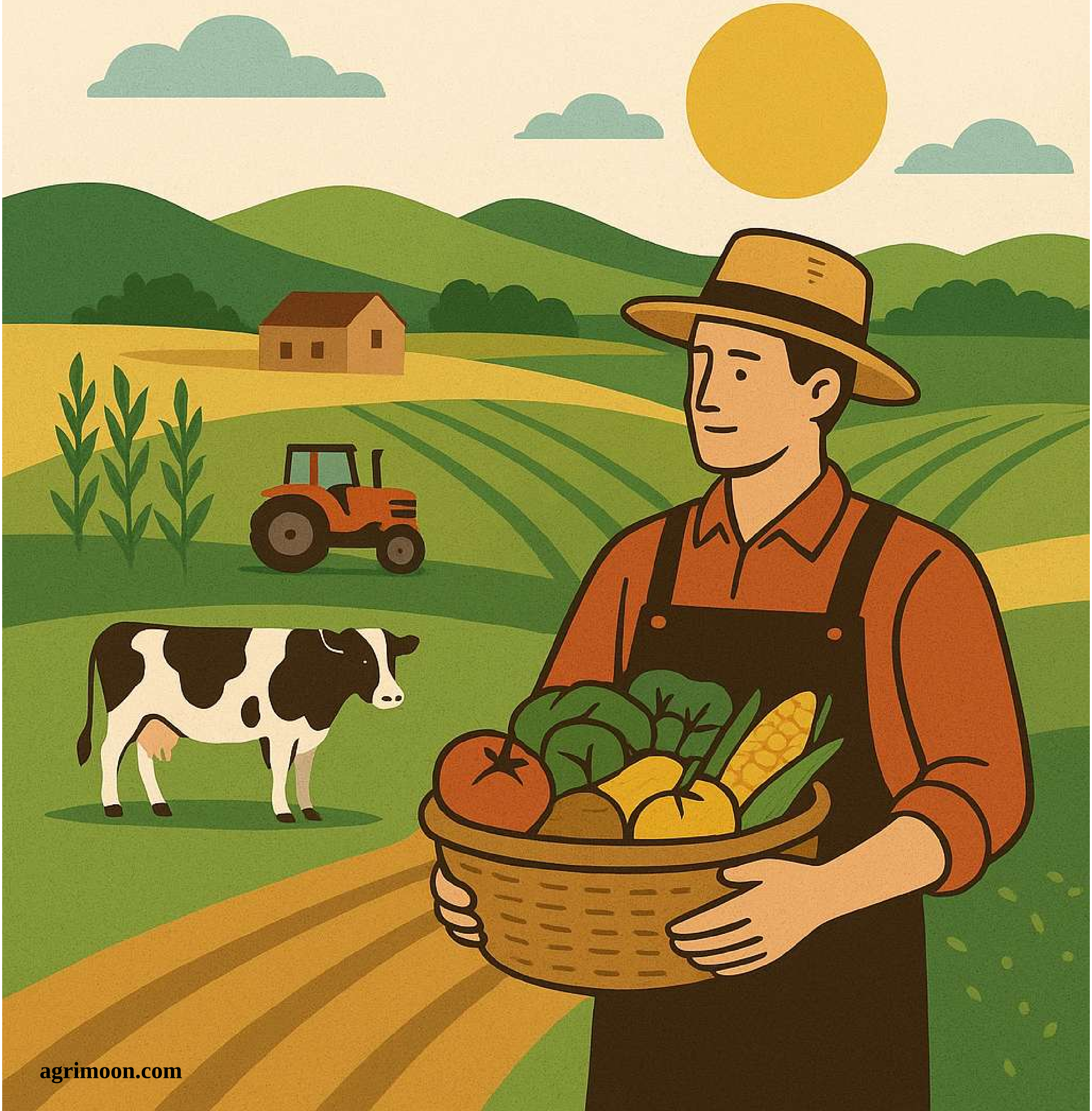
FARMING SYSTEMS AND SUSTAINABLE AGRICULTURE



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Farming System and sustainable Agriculture

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Chapter 1

Sustainable agriculture: Introduction, definition, goal and current concepts

Traditional farming systems are not static and being changed over the generations and particularly quickly over the last few decades. However, rapid changes in ecological, technological and demographic conditions demand adjustments in small holder farming systems. New market opportunities, promotion of chemical inputs and financial constraints may lead farmers to seek short term profits and pay less attention to keeping their agriculture in balance with the ecological conditions. In recent years, the negative environmental and soil impacts of High External Input Agriculture (HEIA) have become increasingly obvious (Wali, 1992; NRC, 1993). At the same time, many disadvantaged communities of small holders are being forced to exploit the resources available to them so intensively that environmental degradation is setting in. Hence, it is important to seek new approaches to less degradation of natural resources and restore degraded soils and ecosystem.

Sustainable agriculture is also known as : Alternative farming,
Regenerative agriculture,
Natural or Organic farming,
Eco-farming and
Permeaculture

Sustainable agriculture is a form of agriculture aimed at meeting the needs of present generation without endangering the resource base of the future generation. Sustainable agriculture has to prevent land degradation and soil erosion. It has to replenish nutrients and control weeds, pests and diseases through biological and cultural methods.

Sustainable agriculture is minimal dependence on synthetic fertilizers, pesticides and antibiotics. It is a system of cultivation with the use of manures, crop rotation and minimal tillage.

Sustainable agricultural system must maintain or enhance:

i) biological and economic productivity of crops,
ii) enhance the efficiency of use of inputs
iii) lesser adverse environmental impacts both on and off the farm
iv) minimize adverse environmental impacts on adjacent and downstream environments
v) minimize the magnitude and rate of soil degradation and to enhance soil quality and resilience so that the crop productivity can be sustained with minimum adverse impact on soil and environment and
vi) enhance compatibility with social and political conditions.

Modern agriculture is chemical based agriculture. In this agriculture, synthetic fertilizers are used to enrich the soil and chemical pesticides are used to control the pests.

Sustainability: The word 'sustainability' is now being widely used. It refers to keeping an effort going continuously. In context of agriculture, sustainability refers to the capacity to remain productive while maintaining the resource base.

According to World Commission of Environment and Development (1987) *sustainability* is a system which can be considered sustainable if it ensures that today's economic development is not at the expense of tomorrow's development prospects.

An agriculture is said to be sustainable if it is :

1. *Ecologically sound*, means health of soil, crops, animal and people is maintained and there is less pollution. Emphasis is on the use of renewable resources.
2. *Economically viable*, means that farmers can produce enough for self-sufficiency.
3. *Socially just*, means that resources and power are distributed in such a way that the basic needs of all members of society are met.
4. *Humane*, means that all the forms of life (plant, animal, human) are respected.
5. *Adaptable*, means that rural communities are capable of adjusting to the constantly changing conditions for farming.

Difference between sustainable agriculture and modern agriculture

Particulars	**Sustainable agriculture**	**Modern agriculture**
Plant nutrients	Farm yard manure, compost green manure, biofertilizers and crop rotations are used	Chemical fertilizers are used
Pest control	Cultural methods, crop rotation and biological methods are used	Toxic chemicals are used
Inputs	High diversity, renewable bio-degradable inputs are used	High productivity and low diversity chemicals are used
Ecology	There is stable ecology.	Fragile ecology
Use of resources	The rate of extraction from forests, fisheries, underground water sources and other renewable resources do not exceed the rate of regeneration	The rate of extraction exceeds the rate of regeneration
Quantity of food material	Food materials are safe	Food materials contain toxic residues.

Problems of modern agriculture

The developmental activities including agriculture causing so many problems

i) **Damage to Ozone layer :**

Due to release of chemicals such as CFC, nitrogen oxide and methane into the atmosphere, ozone concentration in stratosphere is declining and also bringing unpredictable changes in weather and climate.

ii) **CO_2 content** : CO_2 and water vapour plays a vital role in maintaining the heat balance which regularize temperature on the earth surface. Increasing content of CO_2 in the atmosphere causing global warming , rise in sea level and changing the rainfall pattern and climate.

iii) **Land degradation** : Soil erosion by water and wind is serious problem resulting in loss of productive soil and some unique flora and fauna of the region.

iv) **Denudation of Forests :** Denudation of forest causes soil erosion, floods, silting of tanks and reservoirs and increases the rate of runoff of water. Deforestation farming steep slopes and overgrazing of pastures are the main reasons for increase in volume and rate of runoff and water erosion.

v) Faulty Agricultural Practices:

- Due to improper management of irrigation water salinization and alkalization of soil occurs.
- Depletion of ground water due to excessive extraction of water
- Pollution of surface and ground water through pesticides and fertilizer residues
- Loss of biological diversity

Major components of Sustainable agriculture

i) *Soil and water conservation*-to prevent degradation of soil productivity and increasing the length of crop growing season for higher productivity.

ii) *Efficient use of limited irrigation water* – to avoid the problem of soil salinity, alkalinity and high ground water table.

iii) Crop rotations-reduce insect-pests disease and weed problems
- increase soil productivity
- minimize soil erosion

iv) *Integrated nutrient management*- Use of Organics, inorganics and biofertilizers reduces the need of chemical fertilizer, improves the soil health and minimize environmental pollution

v) *Integrated pest management*- It reduces the need of agrochemicals by crop rotation, weather monitoring, use of resistant cultivars, planting and biological pest control.

vi) *Good management practices* to control weeds by preventive measures, tillage, timely inter-cultivation and crop rotations.

Concept of sustainable agriculture

- Use of resources today should not reduce incomes in the future.
- It makes the efficient use of arable lands and water as well as development and adoption of improved agricultural practices and technologies to increase yield.
- Enhances the efficiency of use of inputs.
- Less adverse environmental impacts.
- Minimum soil degradation so that crop productivity is sustained.

Goals of sustainable agriculture

- Thorough incorporation of natural resources through nutrient cycling, nitrogen fixation etc.

- Reduction in the use of external and non renewable inputs.
- A more equitable access to productive resources and opportunities
- Productive use of biological and genetic potential of plants and animal.
- Long term sustainability of current production level.
- Integrated farm management and conservation of soil, water, energy and biological resources.

Chapter 2

FACTORS AFFECTING ECOLOGICAL BALANCE

1. Deforestation and over grazing of pasture land

Perennial vegetation such as trees and grasses prevent soil erosion and runoff. Forest influence climate of the region due to their effect on wind direction and therefore affect the rainfall of the region. Thus deforestation and overgrazing changes the climate and biodiversity besides loss of valuable genetic resources.

2. **Accelerated soil erosion** is a major environmental problem in tropical and subtropical areas due to population growth and their food demand. When once the vegetative cover is lost, the bare soil is exposed to the vagaries of wind and rains causing accelerated soil erosion. Thus productive soil is lost, making it unsuitable for crop production.
3. **Irrigation related problems:** Irrigation with poor quality water makes the soil saline or sodic. Similarly, if there is poor drainage it also causes same problems. Many canal irrigated lands have become unproductive due to salt problems and high ground water table.
4. **Over exploitation of ground water :** Depth of water table determines the economics of irrigation. Increase in number of wells resulted in more extraction of water from the limited acquifers, lowering of ground water table and ultimately permanent water deficit situation. Over irrigation also causes accumulation of harmful salts. Thus sustainable agriculture aims at maximization of the ground water recharge through minimization of surface runoff.
5. **Indiscriminate use of ago-chemicals**

   Chemical fertilizers : Over use of chemical fertilizers is adversely affecting the biological activity of soil. Intensive agriculture is one of the main sources of nitrate pollution.

   Pesticides : Use of pesticides including insecticides, fungicides and herbicides causing several problems such as pesticide resistance, environmental pollution etc. Pesticide residues are dispersing into the air, soil and water and other non-agricultural ecosystem from where they are taken directly or indirectly by animals and human having toxic effects on their life. Therefore, use of crop rotations and increasing the population of natural enemies is necessary for sustaining the system

Management practices for sustainable agriculture

The best optimal use of resources (land, water and climate is necessary for sustainable agriculture.

1. Soil management practices

(i) ***Soil degradation*** : Soil degradation is decline in the productive capacity of land due to water and wind erosion mainly by human activities. Water and wind erosion is the major problem causing loss of soil. Human induced chemical degradation causing salinization and loss of nutrients and organic matter from the soil. Therefore short and long term measures should be taken to check degradation and restore productivity for sustaining agriculture.

(ii) ***Soil and water conservation technology*** : Soil and water conservation practices for agricultural lands include contour farming, agronomical, cultural and biotic conservation measures, runoff cycling and mechanical measures such as contour bunding, graded bunding, contour ditches and bench terracing on slops. Alternate land use system such as pastures, fuel-fodder-timber etc. are to be followed on non-agricultural lands.

(iii) ***Watershed based approach*** : For the development of rainfed agriculture the watershed model can sustain agriculture. The drainage water can be easily stored in above ground storage structures for recycling during droughts or for growing additional crop. Thus the productivity of rainfed crop can be sustained.

(iv) ***Soil fertility management*** : Soil fertility depletion is one of the serious limitations for sustainable agriculture. The integrated nutrient management (INM) approach minimizes use of chemicals and maximizes the use efficiency. INM includes :

a) ***Recycling of organic wastes*** : Crop residues, dung and urine from domesticated animals and wastes from slaughter houses, human excreata and sewage, biomass of weeds, organic wastes from fruit and vegetable production and household wastes, sugarcane trash, oilcakes, pressmud and fly ash from thermal plants. Materials not suitable for direct application can be better applied by composting and vermi-composting.

b) ***Biological nitrogen fixation***: is through blue-green algae (BGA) and azolla for rice, *Rhizobium* for legumes, *Azotobacter* and *Azospirillium* for others. *Azotobacter* is used for rice, wheat, cotton, sugarcane, etc. Azospirillium is used for sorghum The available cultures of *Bacillus* spp. and Aspergillus niger (fungus) can solubilise the unavailable phosphorus and increase its availability to plants.

c) ***Green manuring*** is a practice for improving soil fertility and supplying nutrient to crops particularly nitrogen. Green leaf manuring for rice and other crops from various multipurpose trees is important for sustaining the soil fertility. *Susbania aculeate* (Dhaincha), *Crotalaria juncea* (Sannhemp) are important green manure crops. *Sesbania rostrata* is a stem nodulating green manure crop and fixes about 100-250 kg N/ha in 45-55 days.

Besides these, biogas plants, inclusion of legumes in crop rotations and inter cropping systems and use of sewage and sludge are important component of INMS and improve the soil fertility.

(v) ***Reclamation of salt affected soils***

Canal irrigation increases the accumulation of salts. Removal of excess salts from saline soil is done by simple leaching process with the good quality water. The best alternative is to grow salt tolerant crops (barley, bajra, sugarbeet, mustard, rice, sorghum, etc.). For alkali lands the main components are grading and bunding the fields, application of amendments (Gypsum-$CaSO_4.2H_2O$, Pyrites-FeS_2), judicious fertilizer use and growing rice and wheat in rotation.

2. Management of water Resources

The efficient management of water resources is of crucial importance. Sustainable recommendations for efficient use of irrigation water are:

(i) Proper land shaping, land leveling and efficient design and irrigation methods should be followed.
(ii) Use of pipe channels to prevent seepage losses.
(iii) Furrow/alternate furrow/skip furrow irrigation for all row crops.
(iv) Sprinkler and drip irrigation systems in water scarcity areas.
(v) Judicious and conjunctive use of surface and ground water and canal and tank water to solve drainage problems.
(vi) Provision of drainage facilities in canal command area for increasing the productivity of crops.
(vii) Adopting proper cropping systems in place of continuous low land rice.
(viii) Adoption of recommended production technology for crops and cropping systems
(ix) Integrated watershed development to use rain water, soil water, ground water, and runoff water efficiently.
(x) Recharging ground water during rainy season through basins, recharge wells, diversion of water to store on lands and by construction of check dams and percolation ponds.

3. Management of Rainwater

There is wide variability in rainfall occurrence over space and time. About 70 % of the cultivated area of the country depends entirely upon rainfall. Therefore efficient rainwater management is of prime importance. The options for sustainable agriculture are:

(i) Agro-climatic analysis to predict probability of rainfall.
(ii) Adoption of efficient cropping systems based on ago-climatic analysis
(iii) Contingent crop planning for aberrant weather conditions
(iv) Adoption of improved soil and water management practices
(v) In-situ soil moisture conservation practices
(vi) Runoff harvesting and recycling
(vii) Improved package of management practices for different cropping systems.

4. Integrated Pest Management

IPM is an ideal combination of agronomical, biological, chemical, physical and other methods of plant protection against pests, diseases and weeds with the object of bringing down the population of harmful organisms to economically insignificant levels with minimum interference on the activity of natural beneficial organisms. Bio-agents are integral part of IPM. Several parasitoides, predators, pathogens of pests are available but are not being extensively used because of quick knock down effect and easy availability of chemical pesticides instead of biopesticides and IPM. Several parasitoids and predators are effective in pest management. e.g. Predators – *Coccinella* spp., Parasitoids – *Trichogramma species.*

Agronomic components of IPM

1. **Land preparation** :Ploughing makes unfavourable conditions for multiplication of pests, diseases and weeds
2. **Cultivar selection**: High yielding cultivars resistant to pests and diseases should be selected.
3. **Time of sowing** : Adjustments in sowing dates may escape the crop from different losses. In general, early sowing in the season considerably reduce the pest and disease incidence.
4. **Plant population** : Dense plant population restricts wind movement within the plant canopy resulting in build up of higher humidity which provides congenial environment for the multiplication of pests and diseases.
5. **Inter-cultivation** :Mechanical and manual inter cultivation suppresses the pests, diseases and weeds which serves as alternate hosts to insect and pathogens.
6. **Manure & fertilizers** : Balanced fertilization application (NPK) help the crop to tolerate pest and diseases. Excessive nitrogen application increases the succulence of crop.
7. **Irrigation and Drainage** : Waterlogged condition increases the build up of pests and diseases.
8. **Intercropping**: Many crops can reduce the pest load population.
9. **Crop rotation**: Crop rotations reduce the infestation of insect-pests, diseases and weed.

Chapter 3
Land degradation and conservation of natural resources

Land degradation : Land degradation is loss of soil productivity and may be defined as a process which lower the current and /or potential capacity of soil to produce.

About 32.7 % area of total geographical area (328.73 m ha) is degraded.

About 65% land degradation occurs by water and wind erosion.

Net sown area : 141.89 m ha

Type of degradation in India

S.No.	Type of degradation	Area (mha)
1	Water erosion	57.16
2	Wind erosion	10.46
3	Ravines	2.68
4	Salt affected	6.32
5	Water logging	3.20
6	Mines and quarry wastes	0.25
7	Shifting cultivation	2.35
8	Degraded forest	24.9
9	Special problem (land slides, acid sulphate soils, sea erosion etc.)	0.09
	Total	107.43

Soil degradation may be broadly classified as :

- **Physical degradation:** In high intensive rainfall area and where soil is open soil slide occurs.
  - i) Soil erosion
  - ii) Soil slips
  - iii) Soil slides
  - iv) Mud flow
  - v) Water logging
- **Chemical degradation:** All causing serious hindrance in crop production.
  - i) Soil salanity
  - ii) Soil sodicity
  - iii) Soil acidity
- **Biological degradation:** Loss of soil organic matter due to high temperature and low water content.

Major factors affecting land degradation

1. **Unsustainable agricultural practices**
   - Extensive and frequent cropping of agricultural areas
   - Excessive use of fertilizers
   - Shifting cultivation without allowing adequate period of recovery
2. **Unsustainable water management**
   - Poor and inefficient irrigation practices
   - Over extraction of ground water causes salinity problem
3. **Conversion of land for other uses**
   - Prime forest into agriculture land
   - Agricultural and for other uses
   - Encroachment of cities and town into agriculture
4. **Deforestation**
   - Unsustainable forest management practices
   - Forest land clearance for agriculture
   - Other land-use changes (projects – energy, roadways, etc.)
   - Overgrazing excessive fuel-wood collection
   - Illegal felling of forest trees.
5. **Industrial, mining and other activities without satisfactory measures for prevention of land degradation**
6. **Human and livestock pressure**
7. **Frequent drought or failure of monsoon**

Soil erosion : Soil erosion is the process of detachment of soil particles from the parent body. Depending on the agents soil erosion is of 3 types :

- Wind erosion
- Water erosion
- Wave erosion: Erosion caused by combined action of wind and water. It occurs mainly in canal and river banks. It is controlled by lining canals.

Principles of soil erosion : -

The amount of soil erosion, depends upon a combination of the power of the rain or wind to cause erosion and the ability of the soil to withstand the impact. Thus, erosion is a function of the erosivity (of the rain) and the erodibility of the soil.

Erosion = f (erosivity) x (erodibility)

Erosivity : - is the potential ability of the rain to cause erosion.

Erodibility : - is defined as the vulnerability of the soil to erosion, which depends on inherent characteristics of soil viz., mechanical, chemical and physical composition of soil.

Factors influencing Erosion : - Rainfall, type of vegetation and soils are important factors.

1. **Rainfall** affects both detachment and transportation processes. Amount of rainfall, intensity, duration and its distribution influence runoff and erosion.

   Eg : - High intensity long rainfall – More erosion
2. **Vegetation** : - Vegetative cover is more important which influence the erosion. The type of vegetation, canopy and height affect the extent of erosion. As the crop grows and cover the ground, there will be causes more interception of rainfall and less erosion.
3. **Soils** : - Topography, physical, chemical and biological properties of soil influences the soil erodibility. Among them topography is the most important character than influence runoff of water and transport of particles. The degrees of slope and length of slope determine the amount of runoff and extent of erosion. Increasing the slope increases the erosion. (Erodibility is the susceptibility of soil to erosion.)

Losses due to erosion :

Loss of rain water : Rainwater is only source of crop production in dryland agriculture. So loss of rain water is the loss of an important natural resources from the fields.
Loss of fertile top soil : In India soil loss is occurring @ 16.35 t/ha annually which is more than the permissible limit i.e. 11 t/ha.
Nutrient losses : Plant nutrients available in the soil are lost due to erosion. The loss of nutrients depends on rainfall, soil fertility, amount of fertilizers applied and crops grown.
Silting of reservoirs **:** Depth of reservoir is gradually reduced as the sediment settles on the floor of the reservoir due to erosion. Thus the capacity of the reservoir to retain water is reducing. Eg. Narmada, Hirakund, Tungbhadra.

Water erosion :-

Soil erosion caused by water is of mainly thrice types –

i) Sheet erosion : - It is the first stage of erosion where top soil is removed uniformly in thin layer from the land by surface by the action of rainfall and runoff water.
ii) Rill erosion : - When small channels are formed due to runoff water. It is the second stage of erosion. These channels can be easier destroyed by tillage operations.
iii) Gully erosion : - It is the adviced stage of rills. Soil is removed by running water forming deep and wide channels that can not be easily formed for cultivation.

Universal soil-loss equation (USLE) :- It has been widely used in India to predict soil erosion from agricultural fields or watersheds. This equation is useful in conservation planning and for predicting soil loss due to water erosion. The soil-loss equation is :

A = R K L S C P

A = Predicted soil loss (t/acre/year)
R = Rainfall and runoff factor
K = Soil erodibility
L = Slope length
S = Slope gradient as steepness
C = Soil cover and management
P = Erosion control practice

Wind erosion : -

Saltation:- Bouncing of fine soil particles (0.1-0.5mm in diameter) by the direct presence of wind. About 50-70% of the wt. of the soil lost by wind erosion is carried in saltation.

Suspension : - It is movement of very fine soil particles or dust (< 0.1 mm in diameter) into the air by the action of saltation. About 5-25 % wt. of wind erosion by suspension.

Surface creep : - Soil particles (>0.5 mm in diameter but <1.0mm) are pushed along the surface by the impact of particles in saltation to form a surface creep. Only 3-4% erosion other.

Factors affecting wind erosion : -

1. ***Climate*** : - wind velocity is major factor causing erosion. Wind velocity more than 5-6 m/sec. is not desirable. Temperature and rainfall influence wind erosion through their effect on soil moisture.
2. ***Soil*** : - Soil texture, structure, cohesiveness, bulk density, organic matter, moisture content and surface roughness affect the wind erosion. Soils with large aggregates accounts less erosion.
3. ***Vegetation*** : - It soil is covered with vegetation erosion will be less. The height and density of vegetative cover will be affect the erosion.

Estimating soil-loss due to wind erosion :- To predict the amount of wind erosion under a given set of conditions, the equation is : E = I R K F C W D B

E = Soil loss by wind erosion
I = Soil cloudiness factor
R = Surface cover factor
K = Surface roughness factor
F = Soil textural class factor
C = Local wind factor
W = Field width factor
D = Wind direction factor
B = Wind barrier factor

NATURAL RESOURCE MANGEMENT

Though green revolution has played a major role in self sufficiency of food production in India, but now there is need for generating ever green revolution and in this context sustainability in agriculture has become a major issue. With limited land and water resources and increased stresses, it becomes imperative to boost farm productivity continuously in the coming year .

Natural resource management is a noble approach for sustainable agriculture. Sustainability is being threatened by poor natural resource management and use of excessive agro-chemicals like fertilizers, pesticides, synthetic growth regulators etc. in order to enhance productivity. There are several undesirable impacts due to indiscriminate exploitation of natural resources viz. loss of biodiversity, degradation of land and water resources, environmental pollution and climatic changes.

Loss of biodiversity

Biodiversity is the inherent property of nature. India is very rich in genetic resources. However, this diversity is on continuously declining due to natural as well as human induced extinction. Green revolution followed by mechanization has led to release of various green house gases (CO_2, CH_4, NO_2, etc.) which are responsible for global warming as well as depletion of ozone layer.

Degradation of land resources

Agricultural land is under deterioration due to faulty agricultural practices as well as environmental disasters.

Physical degradation : Land is often degraded mainly by wind and water causing erosion. Water logging is also a serious problem. Physically degraded lands also pose problem to adjacent productive crop land.

Chemical degradation : Processes like excessive salt accumulation, podsolisation and loss of organic matter and plant nutrients also cause deterioration in soil quality. Podsolisation process in green area results in acidity of soil. Problems of saline and alkali soils are common feature of canal irrigated areas with poorly developed drainage facility. Intensive cropping system has resulted in more removal of nutrients from the soil resulting in a negative balance of these nutrients.

Dwindling water resources

Water crisis is a very big problem, which has become more challenging due to several reasons :

- Limited scope of expansion of irrigation potential
- Non judicious use of existing water resources
- Poor efficiency of irrigation projects (only 30-40%)
- Greater conveyance losses
- Diversion of water for agricultural purposes to non-agricultural purposes
- Increasing ground water pollution, etc.

STRATEGIES FOR NATURAL RESOURCE MANAGEMENT

There is need to shift towards optimum resource utilization through better and efficient management system.

(i) **Conservation of biological diversity**:

The conservation of natural and biological diversity in plants is necessary to sustain and improve production of agricultural and selected enterprises. The basic objectives of conservation of biological diversity are :

a. To maintain essential ecological process and life support system
b. Preservation of genetic diversity
c. To ensure that any utilization of species and ecosystem is sustainable.

(ii) **Diversified and value added agriculture**

Crop diversification is important for agro-ecological balance. Integration of agriculture with other farm enterprises viz., dairy, fisheries, poultry, horticulture, forestry, etc. will certainly help in achieving the goal of sustainability. Besides these diversification also minimizes adverse effects of monoculture. It is helpful in ensuring

- Better soil health
- Better utilization of resources
- Nutrient recycling
- Efficient nutrient use.
- Aversion of risk and uncertainty
- Decreased weed infestation, etc.

3). Changes in existing farming system

There are several concept of improved farming practices –

i. *Integrated intensive farming system (IIFS*) – It involves use of farm resources which are ecologically sustainable. Such intensification replaces to the greater extent market purchased chemicals with farm grown biological inputs. Thus it helps in nutrient recycling.

ii. *Precision farming :-* Precision farming ensures most efficient use of inputs and production practices. It is always beneficial to apply fertilizers on the basis of soil test values as it will not only minimize cost of fertilizers, soil deterioration but also have less toxic effects on plants. Similarly, land leveling surveying and development of micro irrigation system will be helpful in better use of land and water resources. Inclusion of legumes in crop rotation compensate nutrient losses in soil.

iii. *Organic farming:* - It avoids use of synthetically compounded fertilizers, pesticides and other agricultural chemicals. Thus we can say that future green revolution will have to rely on sound and suitable farming system.

4). Soil management

The reclamation of land increases area of arable land and helps in enhancing productivity. The physical constraints of soil affecting productivity should be ameliorated by different ways viz. –

- Compaction of excessively permeable soil.
- Deep tillage for hard soil.
- Organic mulching for poorly structured soil.
- Neutralization of alkali soil, etc.
- Soil erosion activities, rehabilitation of sand dunes should be controlled through biological activities.
- Water logged area can be also be brought under cultivation through proper management practices.

5). Integrated water management

The saving of irrigation water as well as increasing water use efficiency is the main objective of IWM. This can be achieved by developing efficient irrigation schedules in terms of volume and time of application, suitable irrigation methods including micro-irrigation systems, better crop planning and judicious agronomic management. In India, about 68% of cropped area is still rainfed, where productivity can be increased or doubled, if irrigation facility is provided. For rainfed agriculture, both, in situ conservation as well as water harvesting are important measures to ensure efficient water management. Providing good drainage facility is also a basic component of efficient water use system.

6). Integrated pest management

Increased use of chemical pesticides to enhance crop production has resulted in ecological imbalance. Therefore, bio-intensive integrated pest management (BIPM), a more feasible and economical method of pest management has becomes popular particularly among small and marginal farmers. BIPM means conservation and augmentation of natural enemies of crop pests and adoption of all compatible cultural, mechanical, physical, genetic, selective chemical pesticides, biological, tolerant varieties along with legal methods.

<u>BIPM has the following benefits : -</u>

i. Lower production costs at farmer's level in comparison of chemical pest control.
ii. Reduced environmental pollution, particularly ground and water.
iii. Less risk owing to poisoning and health hazards.
iv. Ecologically sustainable, as conserves biodiversity.

Chapter 4

HIGH EXTERNAL INPUT AGRICULTURE (HEIA)

The basic aspect of conventional agriculture was to maintain subsistence level production
by using locally available resources. All resources had been naturally recycled and reused without wasting. But due to pressure of increasing population in developing countries steps
were taken to expedite food production deviating from the traditional pattern.

The pressure of world population explosion exerted more on the people of developing countries. In order to confront the pressure of world population explosion the farmers as well as the Researchers and Extensionists were compelled to join the "Seed – Manure" revolution born with the label "Green Revolution" The aim of this "Revolution" was to provide food for the increasing population by enhancing the harvest per unit and the intensification of the number of cultivation seasons. The "Green Revolution" introduced during the early part of the 6th decade of the 20th century accelerated food production of Sri Lanka.

The cropping intensity is defined on the basis of number of cultivations per year. If a land is cultivated 2 times a year (Yala and Maha seasons) the cropping intensity is 200%. If it is cultivated only in one season the cropping intensity is 100%. In response to the "Green Revolution practices, introduced in late 1960s our agricultural production increased significantly.

High yielding hybrid seeds which were introduced by Green Revolution were new to our environment. The growers had to practice new techniques to get higher production. Due to the fact that hybrid seeds were more sensitive to nutrients the growers were encouraged to use chemical fertilizer in large qualities as external inputs. As the new crops were foreign to the environment they were susceptible to pests and diseases. Consequently the necessity arose to apply chemicals, which became an additional burden to growers. Application of chemical fertilizer and pesticides increased the cost of production.

The hybrid varieties were dwarf in nature and could not compete with weeds Application of weedicides or manual weeding was essential to mitigate the competition between hybrid varieties and weeds. From land preparation to harvesting all agricultural practices, related to hybrid varieties were more labour intensive.

Mechanization was an integral component of Green Revolution. To increase the working efficiency of the production system machinery like tractors have been introduced. These machines required mineral fuel. The water consumption of new crops was also higher.

Therefore it was necessary to improve irrigation facilities. The external resources were used extensively in this agricultural system many of the resources used in High external input Agriculture were not recycled. This system failed to add anything to enrich the soil. Many resources were wasted and were beyond the control of the growers.

As long as external resources are pumped into the system the hybrid varieties gave maximum yields. Once the provision of resource is stopped the system collapsed and became unproductive. Therefore to maintain long term sustainability of the systems regular application of external inputs was essential.

Advantages of High External Input Agriculture (HEIA)

· Agricultural Production could be rapidly increased to meet the demand for food for the increasing population.

· As a result of availability of adequate food stuffs many problems related to diseases caused by mal-nutrition and deficiency were prevented or reduced.

· New improved varieties gave yields within a short period of time.

· Mechanization solves the problem of Labour shortage.

· Income and profit margins of the products were increased

· Productivity of land increased.

· Increased market facilities for production.

Disadvantages of (HEIA)

· Collapse of environmental balance due to lack of biodiversity by planting a few cash crops.

· Increase in soil erosion due to constant furrowing by machinery.

· Dependence on imported machinery, chemical fertilizer, pesticides, hybrid seeds and other inputs.

· Extensive use of pesticides disturbed the natural mechanism of controlling pest and diseases as the artificial pesticides kill both pests and their natural enemies.

· Use of artificial agro-chemicals adversely affected the soil pH, cation exchange capacity, soil structure, soil texture and soil organisms. Consequently the microbial activities of the soil tend to reduce forming dead soil.

· Although the need for high capital investment, the large scale farmers benefited while small scale farmers who were short of capital ran into debt.

· Neglecting environmental friendly traditional varieties of seeds and their genetic resources faced extinction due to introduction of hybrid varieties. Conventional agricultural knowledge and techniques were neglected and extinguished.

· The farmers in developing countries had to encounter a series of environmental, social economic and political problems as a result of the use of High External Input Agricultural practices. The following case study taken from an Indian experience illustrates the problems faced by farmers who practiced high external input Agriculture.

As a result of mechanization, use of new improved seed varieties and provision of irrigation. Water, the Agricultural production in Punjab Pradesh of India increased tremendously. Simultaneously many Problems cropped up. Frequent irrigation facilities had to be provided to the new improved varieties of crops due to their inability to withstand shortage of water. The farmers pumped water from agricultural wells. Excess pumping of water caused lowering of ground water table. Consequent upon frequent puddling of soil an impenetrable layers adjacent to the surfaces was formed and prevented sucking of water and nutrients.

Due to this restriction the farmers had to use more chemical fertilizer on this soil surface. Subsequently imbalance of nutrients and deficiencies of micro nutrients in the soil became a problem, excessive use of pesticides for plant protection caused contamination of food and plant residues threatening the health of human and animal lives.

Although the production had increased rapidly the demand for excess agricultural production in the market had not commensurately increased. The growers encountered with the problems in selling of their products and at the same time prices of food items were reduced.

As explained in this case study it could be stated that the developing countries had not reached at sagacious decisions before the introduction of the Green Revolution into these countries.

The possible problems of the farmers which would come out in future were not anticipated in planning.

The following are some of the short comings of the Green Revolution.

· Failure to foresee the fall of prices of surplus agricultural commodities due to the increase in production caused by the use of chemical fertilizer, fuel, pesticides, hybrid seeds etc., which were costly.

· Failure to realize long term dependency of the farmers on pesticides and chemical fertilizer and the consequent effect on ecology and human life.

·Quick response for growth and production and relatively lesser quantities required for one application promoted farmers to apply artificial manure. But the farmers were not aware of long terms consequences of chemical fertilizer.

· The efficiency of chemical fertilizer was below the expected level. It is found that 40% - 50% of Nitrogen in the chemical fertilizer applied in the tropical countries is wasted. This wastage further aggravates due to factors such as high rainfall, severe droughts, soil erosion and low content of organic matter in the soil.

· The chemical fertilizer directly affects on the nutrient balance and the biological activities of the soil. It disturbs the soil structure and expedites decomposition of soil organic matter. Application of acidic Nitrogen fertilizer like Ammonium Sulphate decreases the soil pH value and reduces the ability to use phosphorus by plants.

· Continuous application of Nitrogen, phosphorus and potassium fertilizer creates micro nutrients deficiencies in the soil. The plant display deficiencies of Zinc, Iron, Copper, Magnesium, Manganese, Molybdenum and Boron. The reasons for this are the barrier imposed by chemical fertilizer for micro nutrients to enter into the soil.

This situation results in the reduction of crop production and susceptibility to pests and diseases.

In addition as a result of using chemical fertilizer the developed and developing countries face global problems. The Nitrous oxide gas emitted enters into the atmosphere. Nitrous oxide gas so entered into the atmosphere adversely affects the ozone layer and the Green House effect.

Pesticides

The role of pesticides is killing and controlling plants and animal pests and pathogens. It is reported that in the year 1985 about 2300 Million Kgs of pesticides had been used all over the world. About 15% of this quantity was used by developing countries. Even though pesticides had immensely helped to sustain the High External Input Agriculture, the following adverse consequences could be observed.

· Annually a large portion of the world population becomes victims of pesticide poisoning. A major portion of them are in the third world countries.

· Some pests build up resistance to pesticides when the same pesticide is continuously applied. The necessity arises to introduce new pesticides to overcome this problem.

· Pesticides kill not only the targeted pests but also their natural enemies thereby creating biological imbalance in the system.
· Water, air, soil and food are contaminated by pesticides.
· Pesticides enter into the food chains and food webs causing threat to human lives.

During the period 1961 to 1985 the High external input Agriculture has contributed for an increase of 41%, 45% and 70% in respect of paddy, maize and wheat respectively. On the other hand a large extent of agricultural lands are becoming unsuitable for cultivation due to various reasons such as non adoption to appropriate soil conservation measures, soil erosion, by winds, and water, increasing acidity, salinity and alkalinity in the soil, deterioration of organic matter and weakening of soil structure and texture.

At present many advantages gained from High external input agriculture are progressively diminishing and the yield per unit is decreasing. Therefore the farmers, Researchers and Extensionists are compelled to contemplate towards a sustainable agricultural system free of high external inputs.

LOW EXTERNAL INPUT AND SUSTAINABLE AGRICULTURE (LEISA)

The world food production tremendously increased as a result of High External Input Agricultural practices introduced by the Green Revolution. But as a result of the need for excessive capital, unsustainability of the systems and negative impact on environment, the growers had to face many problems. Therefore development of an agricultural system using lesser external inputs, less expensive and environment friendly has become a need of many countries. Agricultural practices with lesser inputs have been developed by integrating selected traditional basic principles with new technological knowledge.

This system which is abbreviated as LEISA is frequently used for low external input and Sustainable Agriculture. The term which will be referred to as LEISA in the books follow an integrated agricultural system consisting of Bio-dynamics, Environmental, Natural, organic and regeneration sub systems.

LEISA is based on the following ecological principles

· Creating a favourable condition for growth and sustenance of plant-by stimulating of soil micro organisms as far as possible and adding organic matter sufficiently.
· Maintaining nutrient content at optimum level assuring the balance of nutrients in the soil by Nitrogen fixation, utilization of nutrients available in the deep soil layers, promotion of recycling process and addition of external fertilizer as and when necessary to complement deficient nutrients.
· Controlling the micro climatic conditions to minimize loss of resources, due to sunlight, air and water. Use of biological and mechanical methods to prevent soil erosion.
· Minimizing loss of resources caused by pests and diseases. Integration of pest control methods giving priority to natural biological control of pests by natural enemies on the principle that prevention is better than eradication.
· Promoting biodiversity and complexity Stimulating synergetic and symbiotic conditions between plants/ plants and plants/animals.

In agricultural activities the foregoing principles could be utilized by means of different technologies and methods.

The objective of LEISA system is to maintain the agricultural production at an optimum level using less external inputs in a eco-friendly environment. To achieve this objective the LEISA practices concentrated heavily on the following factors

1. Maintaining a living soil
2. Creating of bio-diversity
3. Recycling of resources.
4. Natural pest Management

1. Maintaining a living soil

Maintaining Biological characteristics of the soil. The climate, animals, plants and human being influence on the physical, chemical and biological characteristics of the soil.

Adequate amount of water, air and nutrients in the soil is essential to maintain crop production at a sustainable level.

Favourable soil structure is essential to retain water, nutrients and the growth of root systems of the plants. The soil temperature should exist for maintenance of living soil. It is important that soil should be free from poisonous substances.

The soil contains clay, gravel, air, water, organic matter and humus. Biological activities including breeding of many micro and macro organisms taking place in the soil is an important characteristic.

2. Creating of bio-diversity

Soil organisms

All animals and plants living in the soil are considered as soil organisms. Based on the sizes the soil organisms can be classified as follows.

Microflora - Bacteria, fungus and Algae
Microfauna - Protozoa
Mesofauna - Nematodes
Macro animals - Weevils, Centipede, Termites, Rats, Worms, Snakes

Functions of micro-organisms

· Decomposing soil organic matter into humus. The micro organisms depends on the organic matter and provide cost free labour to farmers converting organic matter into humus.
· Mineralization of humus into nutrients. There are freely available nutrients to plants. · Helping nitrogen fixation.
· Converting non-soluble phosphate into soluble forms.
· Helping plants to absorb nutrients
· Maintaining soil sanitation
· Protecting plants from harmful micro organisms, keeping the population of microorganisms at balance. Eg. Control of the spread of fungus by bacteria.
· It can be observed that micro-organisms are absent or present at minimum level when soil is continuously cultivated without proper management. Such soils are unsuitable for cultivation due to nonfunctioning of microbial activities or functioning at minimum level.

Humus

Soil organic matter is decomposed and ultimately converted into humus by soil microorganisms. Humus Performs a wide variety of tasks. The smaller soil particles are aggregated by humus to form clusters of soil particles improving the soil structure. These clusters of soil provides adequate space to retain air and water in the soil. This situation facilitates plants to survive even in a prolonged drought conditions. In addition humus improves the chemical properties of the soil. The soil nutrients are absorbed by humus and acts as a store for the plants for theirs consumption as and when necessary. Humus acts as a pool of plant nutrients minimizing nutrients losses through infiltration. The humus acts as a binding agent of micro nutrients. Therefore a soil with adequate quantity & humus will not show any nutrient deficiency. In a sustainable agricultural system it is necessary to assure availability of adequate quantity of humus in the soil.

In order to maintain productivity in a soil at optimum level the amount of nutrients removing from the soil should not exceed the in-flow of nutrients into the soil. This means that there should be mechanisms to maintain nutrient balance in the soil. The natural recycling process does it perfectly if the process is not disturbed by external agents. This process could be induced by nitrogen fixation, integrating organic manure with chemical fertilizer using appropriate crop rotation system and integrating animal husbandry into crop production. It is also important to minimize nutrient loses from the soil.

3. Cycling and recycling process in a farm

The natural forest ecosystem does not use external resources other than sunlight, air and water. In such systems the wastage of resources is minimized and instead the resources are being used again and again. Leaves, fruits, flowers, trunks and other vegetative and reproductive parts of plants together with animal wastes and dead bodies are decomposed to form humus. Humus provide nutrients to plants. If there are no external influences this process will continue forever. In a paddy field the paddy straw can be recycled to give nutrients. Promotion of recycling process will help to maintain the sustainability of the farming system.

The relationship between inputs and outputs in a high external input agricultural system is depicted below.

This process does not occur in a circular form either output or the residues are used as inputs in to the farm.

In a sustainable farm a recycling process of inputs and outputs exists as depicted below.

In sustainable farms some outputs and residues (wastes) are used as farm inputs. As an example, in maize cultivation, after harvesting the crop, most of the residues are recycled to give nutrients. In paddy cultivation paddy straw is recycled to enrich the soil fertility instead of burning them.

Minimization of external inputs is of paramount importance in sustainable agricultural system.

Another example of this process is farm where dairy farming and crops are integrated, the animals feed on grass converting grass into milk and flesh. Animal excreta and urine is manure for growth of grass. The wastes of one member of the system become input to another member because of the recycling process. Promotion of recycling process in a farm influences on the sustainability.

4. Natural crop protection methods

A series of actions such as reduction, prevention, extermination and controlling of pest attack can be used.

The seeds and planting materials should be treated to destroy, Pathogens, before planting them in the field. Sometimes hot water treatment will be sufficient for this purpose. Use of wood-ash and sun drying also possible. It is advisable to use farm implements hygienically as there are possibilities of transmitting pests and diseases. Infested fruits, plants leave ratoon crops and host plants of pests and diseases should be kept away from the farm.

Cultivation of resistance varieties

The crops resistance to pests and diseases should be selected for cultivation as far as possible. Natural pest control by predators is promoted in multiple cropping, where a variety of crops are integrated.

Pest control methods

Although there are several methods of pest control in sustainable agriculture, Priority is given to prevention of pests. Integrated pest control measures are given below.

- Biological methods
- Mechanical methods
- Use of natural pesticides
- Use of artificial pesticides

Biological methods

The pest population is controlled by using natural enemies in biological methods. The small scale farmers can control pests by cultivating a mixture of crops in the farm, where the pest population is balanced by natural enemies avoiding economic damage to crops.

Mechanical methods

In conventional agricultural practices mechanical methods are extensively used to control the pest population hand picking trapping and removing the infested parts of crops are common mechanical methods.

Natural pesticides

According to the mode of action natural pesticides can be classified as follows.

·Attractive: - the pests are attracted by odour, colour and taste of some parts of plants. Eg. Paramous can be used to kill fruit.

· Repulsive:- Repulsive means keeping away the pest from reaching plants and stored products. Some plants contain substances which do not alow pests to reach and eat them. Some plants reduce the appetite of pests as soon as they start eating the plant Eg. Neem leaves, Eg of natural pesticides: garlic, Big onion, Pepper, Tobacco, Neem.

<u>Diversity of agricultural systems</u>

Des**cription** **Traditional**	**High external input,**	**Less external input &**
 Agriculture	**agricultural system**	**sustainable agril system**
Productivity Average	High	High
Sustainability High	Low	High

Farming system Complex	Simple	Complex
Diversification High	Uniform	High
Production Objective Consumption	Market	Consumption Market
Use of external resource Low	High	Low
Use of fertilizer Organic	Inorganic	Inorganic and organic
Crop protection Prevention Organic	Controlling Killing Inorganic	Prevention Organic

Chapter 5

Irrigation Problems: Salinity, alkalinity and water logging

The major irrigation problems are:

- Soil salinity
- Soil alkalinity
- High water table
- Drainage problem or poor drainage

Most of the area in arid and semi-arid regions of water table and accumulation of salts. Excessive irrigation and poor water management are the main reasons of water logging and salt build up. This all-accounts unfavourable soils-water-air relationship and ultimately lower production and land is degraded or slowly it becomes uncultivable.

The main causes for development of salinity and alkalinity are: -

i. Use of saline irrigation water
ii. Depositions of salts on soil surface from high soil water table
iii. Seepage from canals
iv. Arid climate \
v. Poor drainage
vi. Back water flow of water in coastal areas

Effect of irrigation, soil management and crop management on soil salinity and alkalinity

The nature and extent of salt accumulation and the degree of soil alkalinity depends on-

i) The quality of irrigation water
ii) Frequency of irrigation
iii) Soil type and its permeability

iv) Salt tolerance characteristics of the plant and
v) Climatic conditions

Generally, soils of light texture are less salinized than those of medium and heavy textured soil. The soils irrigated with water having the same concentration of salts develop more alkalinity with water having higher proportion of sodium and bicarbonate ions. The presence of a hard pan of lime or clay further enhances the degree of alkalinity. The situation becomes more complex to predict when the depth of water table is high and the quality of water is poor. Under such situations, the final salt balance near the root zone is governed by the combined effect of the quality of irrigation water, irrigation management, climate and water transmission properties of the soil during the cropping period.

In flooded plains, deltas, coastal belts and in areas of high-water table, salt concentration is usually high. In such situations surface runoff is low and the drainage water evaporates, leaving the salts on the surface. In areas of high-water table salts move up under thermal gradient and are deposited on the surface. Saline ground water and high-water table are factors favouring soil salinity. However, rate of salinization by capillary action decreases when the depth of water table is low, say beyond 1.5 meters and the soil moisture content is also low.

In addition to the above factors, salinity and alkalinity also develop in areas where drainage facility is adequate but irrigation is insufficient to meet both crop needs and leaching requirements of the soil. Sometimes in spite of good quality irrigation water and good irrigation practices salinity develops because of poor physical conditions which impede drainage.

Poor quality water is one of the main factors turning good soils into saline or sodic soils. Provision of irrigation without adequate drainage leads to some problems as that with poor quality water. Many canal irrigated lands have become unproductive due to salt problems and high ground water table.

Causes of water logging and salinity

i) Poor natural drainage of subsoil
ii) Submergence under floods and deep percolation from rainfall
iii) Water transmission characteristics of soil
iv) Salt content of ground water and evaporative conditions of the region.
v) Topography of land

Chapter 6

Wasteland Development: -

soil is basic resource for all agricultural activities however, over time as biotic pressure is built up beyond the carrying capacity of this resource, there is misuse or over use of crop land. On account of disturbed harmony of natural environment, there are increasing instances of soil degradation.

Reasons for land degradation may be due to inherent or imposed disabilities or both such as location, environment, chemical and biological properties and even suffer from management conditions.

Failure in the restoration of degraded areas and increase in the population may reduce the available land area for productive use. Due to environmental destruction, the weaker section, particularly the rural poor and tribes, are affected mostly because their life revolves around constant search for food, fodder, fuel and water. As ecological conditions worsen, their survival becomes increasingly difficult. And continuing deforestation ha brought us face to face with a major ecological and socio-economic crisis. The trend must be halted. I propose immediately to set up a national wasteland development board with the objective of bringing 5.0 million ha of land every year under fuel wood and fodder plantation.

Wasteland is the area which is unfit for use. The lands which are unproductive and least utilized are termed as wastelands. This does not mean that they are unfit for use. Due to neglect or degradation, these lands are not utilized to their full potential. The wasteland survey and reclamation committee (1961) defined wastelands as those lands which are either not available for cultivation or left out as fallows and cultivable wastes.

According to the national wasteland development board, wastelands are defined as the lands which are currently lying unutilized due to different constraints. These include culturable and unculturable wastelands. The wastelands are also termed as degraded lands

Classification of wastelands

Out of 329 mha of total geographical area in india, about 158 mha comes under different kinds of land degradation.

1. Culturable Wastelands :-

The lands are capable or have the potential for the development of vegetative cover. However, they are not being used due to different constraints of varying degrees such as erosion, water-logging, salinization etc.

Most of these lands can be put to some productive use after proper treatment and reclamation measures. Actually these lands are problematic lands instead of wastelands.

2. Unculturable Wastelands:- The lands that cannot be developed for vegetative cover are called unculturable wastelands exa. Barren rocky areas, snow covered Glcial areas.

Another Classification of wastelands

Category	Spread
- Raverine land, coastal sandy areas, high altitude and steep sloping areas. - Salt affected areas	- Coastal region, interior mountainous regions, steep slopes in Himalayas steep slopes. - Semi-arid and indo-gangetic plains and other semi-arid areas in peninsular region.

- Waterlogged areas - Ravine land - Shifting cultivation - Barren hill ridges and rock outcrops	- low-lying areas in high rainfall regions and irrigated areas. - Gujrat, rajasthan, Madhya Pradesh and Uttar Pradesh - North-eastern region - Distributed in various states of the country

Management of wastelands

Raverine land:- rivers originating from Himalayas have twin actions erosion and deposition. Depending on the course of rivers and speed of flow, heavy load of sand and silt is carried by the gushing streams. They deposit large quantities of sediments on way to the sea. Raverine lands are called as 'khadar' in north India, 'diara' in eastern uttar Pradesh and 'char' in west Bengal. In Punjab and Haryana , they are called 'rao' and 'cho' which are most common in branched or multiple channel rivers. Development of such land is mainly based on adoption of suitable soil conservation measures. Planting live hrdge is most beneficial in controlling erosion and large deposition of sediments.

Coastal sandy areas

In such areas afforestation is necessary as it acts as a moderator of the effect of cyclone. All along the coastal areas, wide forest belt is to be created for moderating the effects of cyclones. Casuarinas is an important tree suitable for coastal belts as it can stand high degree of salinity and moisture stress.

High altitude and steep sloppy areas

In high altitude region of Himalayas, the soils suffer from excessive run off during monsoon, causing floods and there is moisture deficiency during the dry period. Indiscriminate grazing by cattle, especially sheep and goat including the nomadic herds, are the major cause for soil erosion in hilly areas. Hedge row planting is required under hilly terrain. Nitrogen fixing tree species and shrubs suitable for agro-forestry may be planted at close spacing. The space between trees and within the rows may be utilized for growing hedges with perennial grasses. Tree species such as acaia modest, A. catechu, populous alba, P. nigra, P. ciliate and P. candicuas are best suited.

Salt-affected soils in india :- In India, about 7.0 mha of otherwise productive land is salt affected and a large part of it has got out of cultivation. The problem is acute in semi-arid and sub-humid indo Gangetic plains.

Classification of salt affected soils (USDA)

Class of soil	EC (mmhos/cm)	ESP	pH
Saline	>4	<15	<8.5
Saline-alkali	>4	>15	>8.5
alkali	<4	>15	8.5-10.0

Characteristics of salt affected soils

Saline soil	Alkaline soil
Formed in arid and semi-arid having annual rainfall less than 55 cm	Formed in Indogangatic plains region.
Favourable condition a). High water table with a fairly high salt conc. b). High temperature c). Low rainfall	Occurs where mean annual rainfall 55-90 cm and relatively low lying areas with insufficient drainage
Reclamation	Reclamation

a). Leaching b). Ponding	a). Gypsum ($CaSO_4.2H_2O$) b). Iron Pyrite (Fes_2) c). Bulky Organic manures.
Management practices:- Are water management and cropping system. rice is grown during initial year of reclamation.	Management practices:- a). Cropping with Greenmanure Exa. Rice – Dhaincha in Uttar Pradesh Dhaincha – Rice – Berseem – in Punjab b). High dose of nitrogen because of volatilization losses c). Frequent irrigation with small quantities of water.

Different between saline and alkaline soils

Saline soil	Alkaline soil
Mainly Cl^- and SO_4^{2-} of Na^+ but also Cl^-, SO_4^{2-} and HCO^- of Ca^{2+} and Mg^{2+} in small amount	Mainy CO_3^{2-} of Na^+ but also CO_3^{2-} of K^+, Ca^{2+} and Mg^{2+} in small amount
Soluble salt conc. is equal to or more than 0.1%	Soluble salt conc. < 0.1%
Exchangeable sodium %(ESP) < 15%	Exchangeable sodium %(ESP) > 15%
pH< 8.5	pH > 8.5
EC > 4 mmho/cm	EC < 4 mmho/cm
White/light grey colour hence called white alkali	Black colour hence called black alkali
Flocculated soils therefore soil aeration and permeability is normal	Dispersed and compact soil aeration and permeability is low
Easy to manage because physical condition of soil is good	Such soil can be managed because physical condition is not so good
Organic matter or humus is always found in soil	Very less amount of organic matter or humus or even absent
Can be reclaimed by mechanical methods upto some extent	Use of amendments is must
In rainy season, some natural vegetation is grown	No any natural vegetation except some grasses

$$ESP = \frac{\text{Exchangeable sodium (in milli equivalent per 100g of soil)}}{\text{Total cation exchange cation exchange capacity (in m. eq/100g soil)}} \times 100$$

↑

It is also called soluble sodium percentage (SSP)

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

Organic farming Chapter 7

Concept of organic farming

Organic farming system in India is not new and is being followed from ancient time. Organic farming aims at achieving the regeneration and continuance of natural processes of plant growth in a given eco-system by making the eco-system as a self-sustainable system. In this process, organic sources that are available in a given eco-system would be used for supplying plant nutrients and control of pests and diseases along with various cultural practices. There may not be any possibility of evolving a common list of practices and common set of organic sources for all the crops and all the regions. The actual variations of components of organic farming may vary from place to place, crop to crop or even from time to time. But, the basic concept of making the whole system self-supporting for continued production will remain in all forms of organic farming.

As per the definition of the USDA study team on organic farming "organic farming is a system which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc) and to the maximum extent feasible rely upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection".

Aims of organic farming:-

Organic farming systems approach is based on the perception that tomorrow's ecology is more important than today's economy. Its aim is to stop degradation and re-establish natural balance. The economy must readjust to the primary production factors and not the other way round. Without ecology there is no economy. Other aims of organic farming are :

1. To work as much as possible within a closed system and draw upon local resources
2. To maintain long term productivity of the soil.
3. To avoid pollution problems due to agrochemicals use.
4. To minimise the use of fossil energy in agriculture.

<u>Principles of Organic Farming</u>

The basic principles of organic farming practices can be enumerated as follows:

1) A crop should be able to grow and yield successfully utilizing the nutrients supplied by the soil under ideal condition by enhanced microbial activities.
2) Pests and diseases of crops should be essentially controlled by natural enemies, predators, bio-control agents or by use of natural products/ bio-extracts.
3) All possible organic sources available in nature can be used in digested/ semi-digested/ undigested condition to supply the plant nutrients. This may result into

adoption of practices relating to manure/ compost preparation outside agricultural field or sometimes in situ decomposition in the field.

4) Natural resistance of some crops to pests and diseases should be conveniently exploited for the benefit of crop production. No practice, which would suppress the natural resistance, is encouraged.
5) The process of biological nitrogen fixation should be encouraged in all possible ways during the process of crop husbandry.
6) Biomass management to encourage self supportive natural system of providing nutrients in conjunction with enhanced biological activity should be a prioritized consideration in organic farming.

All above principle are summarized in four basic principles like

a). Principle of health

Organic Agriculture should maintain and increase the long fertility of soil as well as health of soil, plant, animal, human and planet as one and indivisible. Healthy soils produce healthy crops that foster the health of animals and people. Health is the wholeness and integrity of living systems. It is not simply the absence of illness, but the maintenance of physical, mental, social and ecological well-being. Immunity, resilience and regeneration are key characteristics of health. The role of organic agriculture, whether in farming, processing, distribution, or consumption, is to sustain and enhance the health of ecosystems and organisms from the smallest in the soil to human beings. In particular, organic agriculture is intended to produce high quality, nutritious food that contributes to preventive health care and well-being. In view of this it should avoid the use of fertilizers, pesticides, animal drugs and food additives that may have adverse health effects.

b). Principle of ecology

Organic Agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them. This principle roots organic agriculture within living ecological systems. It states that production is to be based on ecological processes, and recycling. Nourishment and well-being are achieved through the ecology of the specific production environment. For example, in the case of crops this is the living soil; for animals it is the farm ecosystem; for fish and marine organisms, the aquatic environment.

Organic farming, pastoral and wild harvest systems should fit the cycles and ecological balances in nature. These cycles are universal but their operation is site-specific. Organic management must be adapted to local conditions, ecology, culture and scale. Inputs should be reduced by reuse, recycling and efficient management of materials and energy in order to maintain and improve environmental quality and conserve resources. Organic agriculture should attain ecological balance through the design of farming systems, establishment of habitats and maintenance of genetic and agricultural diversity. Those who produce, process, trade, or consume organic products should protect and benefit the common environment including landscapes, climate, habitats, biodiversity, air and water.

c). Principle of fairness

Organic Agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities. Fairness is characterized by equity, respect, justice and stewardship of the shared world, both among people and in their relations to other living beings. This principle emphasizes that those involved in organic agriculture should conduct human relationships in a manner that ensures fairness at all levels and to all parties - farmers, workers, processors, distributors, traders and consumers. Organic agriculture should provide everyone involved with a good quality of life, and contribute to food sovereignty and reduction of poverty. It aims to produce a sufficient supply of good quality food and other products. This principle insists that animals should be provided with the conditions and opportunities of life that accord with their physiology, natural behaviour and well-being. Natural and environmental resources that are used for production and consumption should be managed in a way that is socially and ecologically just and should be held in trust for future generations. Fairness requires systems of production, distribution and trade that are open and equitable and account for real environmental and social costs.

d). Principle of care

Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment. Organic agriculture is a living and dynamic system that responds to internal and external demands and conditions. Practitioners of organic agriculture can enhance efficiency and increase productivity, but this should not be at the risk of jeopardizing health and well-being. Consequently, new technologies need to be assessed and existing methods reviewed. Given the incomplete understanding of ecosystems and agriculture, care must be taken. This principle states that precaution and responsibility are the key concerns in management, development and technology choices in organic agriculture. Science is necessary to ensure that organic agriculture is healthy, safe and ecologically sound. However, scientific knowledge alone is not sufficient. Practical experience, accumulated wisdom and traditional and indigenous knowledge offer valid solutions, tested by time. Organic agriculture should prevent significant risks by adopting appropriate technologies and rejecting unpredictable ones, such as genetic engineering. Decisions should reflect the values and needs of all who might be affected, through transparent and participatory processes.

Particulars	Conventional farming	Organic farming
Application of compost/FYM	✓	✓
Judicious application of inorganic fertilizers	✓	x
Biofertilizers	✓	✓

Pesticide application	✓	x
Fungicide application	✓	x

Components of organic farming

a). Biofertilizers:

The term "Biofertilizers" includes selective microorganisms like bacteria, fungi, and algae which are capable of fixing atmospheric N or convert insoluble phosphate in the soil into forms available to plants. Biofertilizers' are cost effective, eco-friendly and renewable sources of plant nutrients to supplement chemical fertilizers. Biofertilizers also play a vital role in long term soil fertility and sustainability.

S. No.	Groups	Examples
N_2 fixing Biofertilizers		
1.	Free-living	*Azotobacter, Beijerinkia, Clostridium, Klebsiella, Anabaena, Nostoc,*
2.	Symbiotic	*Rhizobium, Frankia, Anabaena azollae*
3.	Associative Symbiotic	*Azospirillum*
P Solubilizing Biofertilizers		
1.	Bacteria	*Bacillus megaterium var. phosphaticum, Bacillus subtilis*
2.	Fungi	*Penicillium sp, Aspergillus awamori*
P Mobilizing Biofertilizers		
1.	Arbuscular mycorrhiza	*Glomus sp.,Gigaspora sp.,Acaulospora sp.,*
2.	Ectomycorrhiza	*Laccaria sp., Pisolithus sp., Boletus sp., Amanita sp.*
3.	Ericoid mycorrhizae	*Pezizella ericae*
Plant Growth Promoting Rhizobacteria		
1.	Pseudomonas	*Pseudomonas fluorescens*

Rhizobium:-

Rhizobium is a soil habitat bacterium, which can able to colonize the legume roots and fixes the atmospheric nitrogen symbiotically. The morphology and physiology of Rhizobium will vary from free-living condition to the bacteroid of nodules. They are the most efficient biofertilizer as per the quantity of nitrogen fixed concerned. They have seven genera and highly specific to form nodule in legumes, referred as cross inoculation group.

Azotobacter:-

Azotobacter, A. chroococcum happens to be the dominant inhabitant in arable soils capable of fixing N2 (2-15 mg N2 fixed /g of carbon source) in culture media. The bacterium produces abundant slime which helps in soil aggregation. The numbers of *A.*

chroococcum in Indian soils rarely exceeds 105/g soil due to lack of organic matter and the presence of antagonistic microorganisms in soil.

Azospirillum:-

Azospirillum lipoferum and *A. brasilense* are primary inhabitants of soil, the rhizosphere and intercellular spaces of root cortex of graminaceous plants. They perform the associative symbiotic relation with the graminaceous plants. The bacteria of Genus *Azospirillum* are N2 fixing organisms isolated from the root and above ground parts of a variety of crop plants.

Cyanobacteria:-

Both free-living as well as symbiotic cyanobacteria (blue green algae) have been harnessed in rice cultivation in India. A composite culture of BGA having heterocystous Nostoc, Anabaena, Aulosira etc. is given as primary inoculum in trays, polythene lined pots and later mass multiplied in the field for application as soil based flakes to the rice growing field at the rate of 10 kg/ha. The final product is not free from extraneous contaminants and not very often monitored for checking the presence of desired algal flora. The benefits due to algalization could be to the extent of 20-30 kg N/ha under ideal conditions

Azolla:-

Azolla is a free-floating water fern that floats in water and fixes atmospheric nitrogen in association with nitrogen fixing blue green alga Anabaena azollae. Azolla fronds consist of sporophyte with a floating rhizome and small overlapping bi-lobed leaves and roots. Rice growing areas in South East Asia and other third World countries have recently been evincing increased interest in the use of the symbiotic N2 fixing water fern Azolla either as an alternate nitrogen sources or as a supplement to commercial nitrogen fertilizers. Azolla is used as biofertilizer for wetland rice and it is known to contribute 40-60 kg N/ha per rice crop.

Phosphate solubilizing microorganisms(PSM):-

Several soil bacteria and fungi, notably species of Pseudomonas, Bacillus, Penicillium, Aspergillus etc. secrete organic acids and lower the pH in their vicinity to bring about dissolution of bound phosphates in soil. Increased yields of wheat and potato were demonstrated due to inoculation of peat based cultures of Bacillus polymyxa and Pseudomonas striata. Currently, phosphate solubilizers are manufactured by agricultural universities and some private enterprises and sold to farmers through governmental agencies. These appear to be no check on either the quality of the inoculants marketed in India or the establishment of the desired organisms in the rhizosphere.

AM fungi:-

The transfer of nutrients mainly phosphorus and also zinc and sulphur from the soil milleu to the cells of the root cortex is mediated by intracellular obligate fungal endosymbionts of the genera Glomus, Gigaspora, Acaulospora, Sclerocysts and Endogone which possess vesicles for storage of nutrients and arbuscles for funneling these nutrients into the root system. Availability for pure cultures of AM (Arbuscular

Mycorrhiza) fungi is an impediment in large scale production despite the fact that beneficial effects of AM fungal inoculation to plants have been repeatedly shown under experimental conditions in the laboratory especially in conjunction with other nitrogen fixers.

Plant Growth Promoting Rhizobacteria (PGPR):-

The group of bacteria that colonize roots or rhizosphere soil and beneficial to crops are referred to as plant growth promoting rhizobacteria (PGPR). The PGPR inoculants currently commercialized that seem to promote growth through at least one mechanism; suppression of plant disease (termed Bioprotectants), improved nutrient acquisition (termed Biofertilizers), or phytohormone production (termed Biostimulants). These PGPR are referred to as Biostimulants and the phytohormones they produce include indole-acetic acid, cytokinins, gibberellins and inhibitors of ethylene production.

b). Manures

Manures are plant and animal wastes that are used as sources of plant nutrients. They release nutrients after their decomposition. Manures are organic materials derived from animal, human and plant residues which contain plant nutrients in complex organic forms. Manures have low nutrient content per unit quantity but has longer residual effect besides improving soil physical properties compared to fertilizer with high nutrient content. Major sources of manures are:

1. Cattle shed wastes- dung, urine and slurry from biogas plants
2. Human habitation wastes-night soil, human urine, town refuse, sewage, sludge and silage
3. Poultry litter, droppings of sheep and goat
4. Slaughterhouse wastes-bone meal, meat meal, blood meal, horn and hoof meal, Fish wastes
5. Byproducts of agro industries-oil cakes, biogases and press mud, fruit and vegetable processing wastes etc
6. Crop wastes-sugarcane trash, stubbles and other related material
7. Water hyacinth, weeds and tank silt, and
8. Green manure crops and green leaf manuring material

Manures are grouped into bulky organic manures and concentrated organic manures based on concentration of the nutrients.

Bulky organic manures

Bulky organic manures contain small percentage of nutrients and they are applied in large quantities. Farmyard manure (FYM), compost and green-manure are the most important and widely used bulky organic manures. Use of bulky organic manures has several advantages:

1. They supply plant nutrients including micronutrients.
2. They improve soil physical properties like structure, water holding capacity etc.
3. They increase the availability of nutrients.
4. Carbon dioxide released during decomposition effect the activities of plant parasitic nematodes and fungi by altering the balance of microorganisms in the soil.

Concentrated organic manures

Concentrated organic manures have higher nutrient content than bulky organic manure. The important concentrated organic manures are oilcakes, blood meal, fish manure etc. These are also known as organic nitrogen fertilizer. Before their organic nitrogen is used by the crops, it is converted through bacterial action into readily usable ammonical nitrogen and nitrate nitrogen. These organic fertilizers are, therefore, relatively slow acting, but they supply available nitrogen for a longer period. The examples of concentrated organic manures are-

- Edible oil cakes which can be safely fed to livestock; e.g.: Groundnut cake, Coconut cake etc.
- Non edible oil cakes which are not fit for feeding livestock; e.g.: Castor cake, Neem cake, Mahua cake etc.
- Blood meal
- Meat meal
- Fish meal
- Horn and Hoof meal
- Bone meal.

Farmyard manure

Farmyard manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. On an average well decomposed farmyard manure contains 0.5 per cent N, 0.2 per cent $P_2O_5$and .0.5 per cent K_2O.The present method of preparing farmyard manure by the farmers is defective. Urine, which is wasted, contains one per cent nitrogen and 1.35 per cent potassium. Nitrogen present in urine is mostly in the form of urea which is subjected to volatilization losses. Even during storage, nutrients are lost due to leaching and volatilization. However, it is practically impossible to avoid losses altogether, but can be reduced by following improved method of preparation of farmyard manure. Trenches of size 6 m to 7.5 m length, 1.5 m to 2.0 m width and 1.0 m deep are dug.

Farm yard manure preparation

Manure preparation

Trenches of 6 m long, 2 m wide and 1 m deep are dug. The material consisting of dung and urine soaked in it is collected daily and placed in these trenches. All available litter and refuse is mixed with soil and spread in the shed so as to absorb urine. The next morning, urine soaked refuse along with dung is collected and placed in the trench. Additions are normally applied in sections of one meter length. A section of the trench from one end should be taken up for filling with daily collection. When the section is filled up to a height of 0.5 m above the ground level, the top of the heap is made into a dome and plastered with cow dung earth slurry. Before plastering, it is important to apply 4-5 buckets of water in the pit. Plastering conserves *moisture* and nitrogen and also prevents housefly nuisance. The manure pit should be protected from sun and rain. The process is continued and when the first trench is completely filled, the other trenches are prepared in the same way.

The manure becomes ready for use in about four to five months after plastering. Chemical preservatives can also be used to reduce losses and enrich farmyard manure. The commonly used chemicals are gypsum and superphosphate. Gypsum is spread in the cattle shed which absorbs urine and prevents volatilization loss of urea present in the urine and also adds calcium and sulphur. Superphosphate also acts similarly in reducing losses and also increases phosphorus content. It is possible to obtain 5-6 tonnes of good quality manure per year per head of cattle.

Partially rotten farmyard manure has to be applied three to four weeks before sowing while well rotten manure can be applied immediately before sowing. Generally 10 to 20 t/ha is applied, but more than 20 t/ha is applied to fodder grasses and vegetables. In such cases farmyard manure should be applied at least 15 days in advance to avoid immobilization of nitrogen. The existing practice of leaving manure in small heaps scattered in the field for a very long period leads to loss of nutrients. These losses can be reduced by spreading the manure and incorporating by ploughing immediately after application.

Vegetable crops like potato, tomato, sweet-potato, carrot, raddish, onion etc., respond well to the farmyard manure. The other responsive crops are sugarcane, rice, napier grass and orchard crops like oranges, banana, mango and plantation crop like coconut.

The entire amount of nutrients present in farmyard manure is not available immediately. About 30 per cent of nitrogen, 60 to 70 per cent of phosphorus and 70 per cent of potassium are available to the first crop.

Sheep and Goat Manure

The droppings of sheep and goats contain higher nutrients than farmyard manure and compost. On an average, the manure contains 3 per cent N, 1 per cent P_2O_5 and 2 per cent K_2O.It is applied to the field in two ways. The sweeping of sheep or goat sheds are placed in pits for decomposition and it is applied later to the field. The nutrients present in the urine are *wasted* in this method. The second method is sheep penning, wherein sheep and goats are kept overnight in the field and urine and fecal matter added to the soil is incorporated to a shallow depth by working blade harrow or cultivator.

Poultry Manure

The excreta of birds ferment very quickly. If left exposed, 50 percent of its nitrogen is lost within 30 days. Poultry manure contains higher nitrogen and phosphorus compared to other bulky organic manures. The average nutrient content is 3.03 per cent N; 2.63 per cent P_2O_5 and 1.4 per cent K_2O.

D). Compost

Decomposed plant residues/farm wastes are known as farm compost. The waste materials that are available in urban areas can be made into compos called urban compost. The processes of composting facilitate narrowing down the C: N ratio of the material to 10 or 12: 1. The nutrient content of compost is 1.01 % N, 0.5% P205 and 0.8-0.9% K20. Applications of partially or fully decomposed materials quicken the nutrient release to the crops.

Methods of composting

There are two methods of compost making: aerobic and anaerobic.

Aerobic Method

A pit of one m deep, 2 m width and of convenient length is prepared. Organic wastes consisting of a mixture of crop wastes, weeds, leaves etc. that are collected in the farm are spread to a layer of 0.2 to 0.3 m deep. Cow dung solution is uniformly sprinkled to the top of the refuse. If the refuse is too dry, water is sprinkled over the material equal in weight of the refuse. Urine, earth, ashes and bone meal may also be spread in a thin layer. This process is continued till the heap rises to about 0.5 m over the ground. After a month, the heap is turned over, mixed well and refilled adding water if necessary. Two more turnings are given, one at the end of the second month and the other after the third month. Sufficient water should be added in each turning over. Decomposition is ordinarily completed within 4-5 months. In places of heavy rainfall or where the water table is high the compost heap may be prepared above ground level instead of pits.

Anaerobic method

A pit of convenient size (4.5 x 1.5 x 1.0 m) is prepared. Every day collections of mixed farm residues are spread in the pit to a thin layer. A mixture of fresh cow dung, ash and water is sprinkled and compacted. The pit is filled till the raw material stands about 0.5 m above the ground. Later, it is plastered to a thickness of 2.5 cm with mud and cow dung. Plastering helps to prevent housefly nuisance. Decomposition is completed within 4-5 months.

E). VERMICOMPOSTING

It is the process in which earthworms feed on waste organic substances and convert them into compost by passing through their gut in granular form called as vermicast (a mixture of worm castings, organic matter, live earthworms, their cocoons and other organisms).

Extensively used species are *Eudrilus eugeniae, Lambricus rubellus, Eisenia foetida & Perionyx excavatus.*

Average nutrient content of vermicompost & (FYM)

Sl. No.	Nutrients	Vermicompost	FYM
1	N (%)	1.6	0.75
2	P_2O_5 (%)	5.04	0.17
3	K_2O(%)	0.80	0.55
4	Ca (%)	0.44	0.91
5	Mg (%)	0.15	0.19
6	Fe (ppm)	175.20	146.50
7	Mn (ppm)	96.51	69.00
8	Zn (ppm)	24.43	14.50
9	Cu (ppm)	4.89	2.80
10	C:N ratio	15.50	31.28

VERMICOMPOST COMPONENTS:

- Collection of bio-mass/grass
- Cutting of grass/leaves
- Filling of bio-mass
- Cover with gunny bags
- Watering

  1^{st} week - 5 lit/pit (twice/day).

  2^{nd} week - 5 lit/pit (once/day).

Up to 3 months.

4th month - Ready to harvest.

Process of harvesting & separation of vermi worm:

- After 4 months – take out the compost & make it into a heap.
- Wait for 25-30 minutes, so that the earthworms gather at the bottom of the ground.
- After 25-30 minutes, spread the compost, collect the earthworms for the next preparation.
- Compost should be dried in shade for about 2-3 days.
- After drying, sieving is done.
- After which the compost should be packed in polythene bags or laminated plastic bags according to desired weight.

Doses of vermicompost application:

Horticulture crops – 1kg/plant

Vegetables & flowers -- 200-300 g/ plant

Field crops – 20q/ha.

Advantages of Vermicomposting:

- Huge quantities of domestic, agriculture & rural industrial organic wastes can be recycled.
- Substitution of fertilizers by vermicompost will reduce economic inputs.
- Extra production can be marketed for generating extra income.
- Prevents soil degradation & enhance soil fertility status.
- Vermicompost is rich in several micro flora which multiplies faster through digestive system of earthworm.

F). Green Manuring

Green manuring can be defined as a practice of ploughing or turning into the soil undecomposed green plant tissues for improving physical structure as well as soil fertility. It consists of growing a quick-growing crop and ploughing it under to incorporate it into the soil. The green-manure crop supplies organic matter as well as additional nitrogen, particularly if it is a legume crop, which has the ability to fix nitrogen from the air with the help of its root nodule bacteria. The green-manure crops also act as a protective action against erosion and leaching.

Growing a green manure is not the same as simply growing a legume crop, such as beans, in a rotation. Green manures are usually dug into the soil when the plants are still young, before they produce any crop and often before they flower. They are grown for their green leafy material, which is high in nutrients and protects the soil.

Benefits of using Green Manures

Green manuring offers an inexpensive way of improving crop yields and it takes little extra effort. Green manures are especially important on farms where there is not enough animal manure available, and when it is not possible to bring in natural fertilizers from elsewhere. Although the use of green manures may seem to create extra work, they provide following benefits:

1. Enhances soil fertility

Green manures recycle nutrients and add organic matter to the soil. They help prevent nutrients being washed out of the soil. The nutrients are taken up by the green manure and held inside the plant. When the nutrients are needed for the next crop, the plants are dug into the soil or used as mulch on top of the soil. This helps to increase crop yields. Legumes and other nitrogen fixing plants, which take nitrogen from the air to the soil, are particularly beneficial.

2. Supplement for nutrients

Different green manures and grain-legumes are used to increase the nitrogen content and texture of the soil. Among the green manures *Sesbania aculeata* accumulates the largest amount of bio-mass and nitrogen contribution and among the grain legumes, cowpea ranks first both in terms of grain yield and biomass addition. The available green manure crops and utilization pattern are as follows:

Nutrient potential of green manures

Green manure	Biomass (tonnes)	N accumulobase (Kg/ha)
Dhaincha *(Sesbania aculeata)*	22.50	145.00
S. rostrata	20.06	146.00
Sunhemp *(Crotalaria juncea)*	18.40	113.00
Tephrosia purpurea	6.80	6.00
Green gram (*Phaseolus aureus)*	6.50	60.20
Black gram (*Phaseolus mungo)*	5.12	51.20
Cowpea (*Vigna unguiculata)*	7.17	63.30

3. Improved soil structure

Green manures improve soil structure, letting more air into the soil and improving drainage. Green manures help sandy sol hold more water and not drain so quickly.

4. Prevention of soil erosion

Green manures help to stop the soil being carried away by wind and rain. The roots penetrate the soil and hold it in place.

5. Weed control

Green manures help to control weeds. Bare soils can become quickly overgrown with weeds, which can be difficult to remove. Green manures cover the ground well and stop weeds growing beneath them, by competing for nutrients, space and light.

Types of Green Manuring:

The adoption of green manuring depends upon the agroclimatic conditions. Broadly, the following two types of green manuring can be thought of:

Green Manuring In Situ

In this system, green manure crops are grown and buried in the same field which is to be green-manured, either as a pure crop or as an intercrop with the main crop. For proper decomposition of the green manure, it is necessary that the green material should be succulent and there should be adequate moisture in the soil. Plants at the flowering stage contain the greatest bulk of succulent organic matter with a low carbon/nitrogen ratio. The incorporation of the green-manure crop into the soil at this stage allows quick liberation of nitrogen in the available form. A leguminous crop producing 10-25 tonnes of green matter per ha will add about 60 to 90 kg N.

<u>Green Leaf Manuring</u> Green-leaf manuring refers to turning into the soil green leaves and tender green twigs collected from shrubs and trees grown on bunds, waste lands and nearby forest areas. The common shrubs and trees used are Glyricidia (*Glyricidia maculata*), *Sesbania speciosa*, Karanj (*Pongamia glabra*), etc. A number of leguminous and non-leguminous plants are grown on bunds or wastelands with the prime objective of utilizing their foliage as green manure such as-

Nutrient content of important green manure and green leaf manure crops

Crop	Nutrient content (% on dry weight basis) N	P	K
Green manure			
Sesbania aculeata	3.3	0.7	1.3
Crotalaria juncea	2.6	0.6	2.0
Sesbania speciosa	2.7	0.5	2.2
Tephrosia purpurea	2.4	0.3	0.8
Phaseolus trilobus	2.1	0.5	-
Green leaf manure			
Pongamia glabra	3.2	0.3	1.3
Glyricidia maculeata	2.9	0.5	2.8
Azadirachta indica	2.8	0.3	0.4
Calatropis gigantea	2.1	0.7	3.6

G). Animal husbandry

Before growing a crop or raising any livestock, consider the following: degree of difficulty to grow or raise the product organically, land and soil suitability, climate suitability, level of demand for the product, marketing challenges, capital required, current prices for conventional, transitional and organic products, and profitability over additional workload.

H). Crop rotation

Once the crops are chosen, carefully plan the crop rotation(s) and select the most suitable cover crops (green manure, winter cover crops, catch crops, smother crops, etc.). Crop rotations are extremely important management tools in organic farming. They can interrupt pest life cycles, suppress weeds, provide and recycle fertility, and improve soil structure and tilth. Some rotational crops may also be cash crops, generating supplemental income.

On some farms, land base availability may be a limiting factor when planning your crop rotations. The transitional plan should, therefore, include crop rotation strategies. Responding to external forces such as new market opportunities may also have a significant impact on crop rotations, so farmers need to consider the effect that growing new crops has on their crop rotations and land base availability.

I). Biological management

It is important to know the crop's most common pests, their life cycles and adequate control measures. For instance, Colorado potato beetle may be a pest of significant importance when growing potatoes; cucumber beetles in cucurbitaceous crops (cucumber, squash, and melons); flea beetle in many seedlings crops; clipper weevil and Tarnish Plant Bug in strawberry crops.

There are several measures available to reduce pest pressure: crop rotation, variety selection, sanitation, floating row covers, catch crops, flamers, introduction of beneficial insects, bio pesticides, and inorganic pesticides. Transitional growers should be prepared to use and experiment with some of these options. When considering a new type of production, discuss pest issues with your agrologists, IPM specialists and/or other existing organic producers to optimize your chances of success.

Availability of organic supplies has improved significantly over the past few years. New pest control products containing B.t., spinosad, kaolin clay are effective and currently available to organic growers. It is often reported that the types of weeds found on the farm evolve with time as growers change the way they grow their crops and control their weeds. By keeping track of the weed population, growers will be able to refine their crop rotations and improve their control measures.

Under organic livestock management, cattlemen must provide attentive care that promotes health and meets the behavioral needs of various types of livestock. With good herd health practices, farmers rarely need to rely on conventional medicine. Organic cattlemen should, however, try to familiarize themselves with alternative remedies such as herbal/aroma therapies, homeopathy, and immune system promoters.

Chapter 8

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.

Sustainability is the objective utilization of inputs without impairing the quality of environment with which it interacts. Therefore, it is clear that farming system is a process in which sustainability of production is the objective.

The overall objective is to evolve technically feasible and economically viable farming system models by integrating cropping with allied enterprises for irrigated, rained, hilly and coastal areas with a view to generate income and employment from the farm.

The Specific Objectives are:

1. To identify existing farming systems in specific areas and access their relative viability.
2. To formulate farming system. Model involving main and allied enterprises for different farming situations.
3. To ensure optional utilization and conservation of available resources and effective recycling of farm residues within system and
4. To maintain sustainable production system without damaging resources/environment.
5. To rise over all profitability of farmhouse hold by complementing main/allied enterprises with other.

Scope of Farming System

Farming enterprises include crop, livestock, poultry, fish, free, sericulture 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.

Integration of Farm Enterprises Depends on Any Factors Such as:

1. Soil and climatic features of the selected area.
2. Availability of the resources, land, labor & Capital.
3. Present level of utilization of resources.

4. Economics of proposed integrated farming system.
5. Managerial skill of farmer

Farming System and Its Characteristics

Farming systems research (FSR):

Originates from recognizing the inter- dependence and inter relationships of natural environment within the farming system. In FSR the farmers by participating the research process help in the identification of the research problems as well as take part in testing the possible solution.

Goals:

The growing concern on suitable development has led the FSR to compasses on sound management of farm resources to enhance farm productivity and reduce the degradation of environment quality or to develop sustainable land use, which will optimize farm resource, minimum degradation with consideration to regenerative capacity, increase income and employment for farm families and promote quality of life.

In the past decade, farming system research has emerged as a popular and major theme in international agricultural research. FSR evolved in post- green Revolution era with the growing perception of the failure of main stream agricultural research and extension institution to generate and disseminate technologies widely adopted by small scale, resources poor farmers. Clearly technology, even when sound by scientific standards, is of limited value if is not adopted. The diagnosis of the problems was that agricultural researches and development planners, the generators and disseminators of new technology, had employed a fundamentally top- down approach to technology development, which is not valid one. In response to this situation, FSR argued that: 1. Development of relevant and viable technology for small farmers must be grounded ina full knowledge of existingof the farmingsystem and

2. Technology should be evaluated not solely in terms of its technical performance, but in terms of its conformity to the goals, needs and socio- economic condition of small farm system as well.

Therefore, FSR concept was developed in 1970 in response to the observation that groups of small – scale farm families operation on harsh environment were not benefiting from conventional agricultural research and extension strategies. The tem FSR in its broadest sense is any research that views the farm in a holistic manner and considers interactions (between component and of components with environment) in the system.

Farming system research is a research method designated to understand farmer's priorities, strategies and resources allocation decisions. It is most often used in conjunction with on farm highly location specific research with multi and inter disciplinary in nature and uses a whole farm approach for improved technologies to enhance and stabilize agriculture production.

Points to be Considered while Choosing the Enterprises for Integrated Farming System (IFS):

1. Soil and climatic feature of an area/ locality.
2. Resource availability with the farmers.
3. Present level of utilization of resources.
4. Economics of proposed integrated farming system.
5. Farmers managerial skill.
6. Social customs precaling in the locality.

FARMING SYSTEM

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'.

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.

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.

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

Principal Involved: The FSR approach
includes: a) Viewing the farm as a whole,
b) Identifying the farming system, the interacting component and delineating boundaries boundaries,
c) Systematically investigation the nature and extent of interdependence among the enterprises and identifying constraint,
d) Applying the modern technical know- how to the system so as to make it yield optimum results,
e) Studying the equity gender income, employment and resources use efficiency, and f) Dealing with the issue at integration level through analysis and solution of problems towards sustainable farming system development.

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

The Characteristics of Farming System
Research 1. It is holistic or system oriented,
2. It is problems solving: involvement of farmers in problem identification and solving process,
3. It is farmer participatory,
4. It envisages location specific technology solutions,
5. It is for specific client group – small/ marginal farmer,
6. It adopts bottom up approach,

7. It compasses extensive on farm activities, collaboration between farmer and scientist,
8. It is gender sensitive,
9. It ultimate objective is sustainability,
10. It focuses on actual adoption,
11. It recognizes interdependence among multiple clients.

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 nonavailability of fodder to livestock component of the farming system.

9. **Solving timber and fuel crises-** The current production level of 20 million m3 of fuel

10. wood and 11 million m3 of timber wood is no match for the demand estimated or 360 m3 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 programmers besides introduction of agro-forestry component in farming system without detrimental effect on crop yield will greatly reduce deforestation, preserving our natural ecosystem.

11. **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.

12. **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.

13. **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.

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.

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.

Components of Farming Systems

In the integrated farming system, it is always emphasized to combine cropping with other enterprises/ activities, many enterprises are available and these includes cattle maintenance sheep or goat rearing, poultry, piggery, rabbit rearing, bee keeping etc. Any one or more can be combined with the cropping.

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. 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).

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.

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.

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:

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.

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.

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.

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.

2. **2.Dairying** 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.

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.

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 yielders, 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:

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 oilseeds 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 oilseeds (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.

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.

Important dairy breeds of buffalo are murrah, mehsana, zefarabadi, Godavari.

Feeding: Cattle feed generally contains fibrous coarse low nutrient straw material. Roughage is basic for cattle ration and includes legumes non- legume hays, straw and silage of legume and grasses. Per day requirement @ 1 kg concentrate per 2 lit of milk, green fodder (20- 30 kg), straw 5-7 kg & water – 32 lit.

3. 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 anaerobically 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 initiating 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

The NPK content of the residual sludge in the dry state is equivalent of N = 1.4-1.8% ; P_2O_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 m3 depending upon the day temperature. Gas production would be maximum at a temperature between 30-35 ^{0}C. If the ambient temperature falls below 10oC, gas production is reduced drastically.
- One m3 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.

Biogas is a clean, unpolluted and cheap source of energy, which can be obtained by a simple mechanism and little investment. The gas is generated from the cow dung during anaerobic decomposition. Biogas generation is a complex bio- chemical process, celluloytic material are broken down in methane and Co2 by different group of micro-organism. IT can be used for cooking purpose, buring lamps, etc. Biogas near to kitchen & cattle shed to reduce cost of gas transfer and cow dung transport, sunlight is important for temperature. Biogas slurry: slurry is obtained after the production of biogas. It is enriched manure; another positive aspect of this manure is that even after weeks of exposure to the atmosphere the slurry does not attract fleas and worms. Dry slurry contains about 1.8 % N, 1.10 %P& 1.50% K.

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.

In India, activity of goat rearing under different environments. The activity is also associated with different systems such as crop or animal based, single animal or mixed herd small or large scale. Goat is mainly reared foe meat, milk hide and skin meat preferred in India, A goat on hoof fetches a better price than a sheep on hoof. Feeding: per head nutrients requirement to goat is low. Hence they are suitable for resources poor small farmers with marginal grazing lands they eat plants and leaves of tree, which any other animals not touch. Goat eats 4- 5 times that of body weight concentrate of maize, groundnut cake etc. and clean and fresh water.

Sheep are well adapted to many areas. They are excellent gleaners and make use of much of waste feed. Consume roughage, converting a relative cheap food into a good cash product. Housing not expensive. Feeding: 1-2 kg of leguminous hay per day. Protein supplied through concentrate as groundnut cake. 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:

5. 5. Poultry farming

Poultry is one of the fatest growing food industries in the world. Poultry meat accounts for about 27% off total meat consumed world wide poultry industry in India is relatively a new agricultural industry. Egg production may reach up to 5000 crores and broiler meat production 330 thousand tones (by 2000) the average global consumption is 120 eggs per person/ year and in India it is only 32- 33 eggs per capita/ year. To meet the nutritional requirement the per capita consumption estimated at 180 eggs 9 kg meat/ year. Feed: The feed conservation efficiency of the bird is superior to other animals. About 60 – 70 % of the total expenditure on poultry farming is spent on the poultry feed. Hence, use of cheap and efficient ration will give maximum profit cereals- maize, barley, oats, wheat, rice – broken mineral/ salt – limestone, salt manganese.

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.

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 m3 per adult bird is adequate for light breeds such as white Leghorn. About 0.3 -0.4 m3 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:

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.

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 2-3 days.

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.

Ponds serve as domestic requirement of water, supplementary irrigation to crop and pisciculture with the traditional management, farmer obtain hardly 300 – 400 of wild and culture fish/ ha/ year. However, polyfish culture with the stocking density of 7500 fingerlings and supplementary feeding will boost the total biomass production. Species: cattle, Rohu, common carp, silver carp, and grass carp (feed on aquatic plants). Management: Pond depth – 1.5- 2.0 m, water should be slightly alkaline, PH- 7.5- 8.5. If the PH less than 6.5, it can be adjusted with addition of lime, higher PH (> 8.5) can be reduced with addition of Gypsum. Application of fresh dung may also reduce high PH in the water.

The fish are to be nourished with supplementary feeding with rice bran and oilseed cakes. This will enable faster growth and better yield. Each variety of crops stocked to 500 fingerlings with the total of 5000- 8000/ ha. This gives 2000 to 5000 kg/ha of fish annually.

6. 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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Bee keeping is one of the most important agro- based industries which do not required any raw material like other industries. Nectar and pollen from flower are the raw material, which available in plenty in nature. Bee keeping can be started with a single colony.

7. Sericulture

Sericulture is an agro-industry, the end product of which is silk Sericulture involves thee activities viz., Mulberry cultivation, Silkworm rearing, Reeling of 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.

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 (M5), S13, S30, S36, S41, S54, DD, V1 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.

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 ^{0}C) 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 m2 during 1st during 1st instar to 181 – 360 m2 during 5th 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 2-4 kg during 1st instar to 600 650 kg during 5th 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., 4th and 5th instar the worms are fed with entire leaves without any chopping.

During the 5th instar i.e., after 5 days of the 4th 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.

Sericulture is the keeping of silk moths and their larvae for the production of silk or Seri culture is defined as a practice of combining mulberry cultivation; silkworm rearing and silk reeling. Sericulture is a recognized practice in India. The total area under mulberry is 240 thousand ha in the country. It plays an important role in in socio-economic development of rural poor in some areas. Climate condition favorable for mulberry and rearing of silk worms throughout the year. Karnataka is the major silk producing state in India (temp 21 to 30 ^{o}C), in Kashmir climate suit from May to October. Moriculture: Cultivation of mulberry plants is called as Moriculture. The crop yield well for 12 years. Yield of mulberry leaves is 30-40 t/ha/year. Rearing: eggs are allowed to be laid over a cardboard. In Bamboo tray rice husk is spread. Tender chopped mulberry leaves are added to the tray. The hatched out larvae are transferred to the leaves it is important to change the leaves every 2 – 3 hours during the first 2 – 3 days. The cocoon constructed with silk. The cocoons required for further rearing are kept separately and moths are allowed to emerge from them.

8. 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.

Agri-silviculture – 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.

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.

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.

Agri-horticultural system – It is one form of agroforestry 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

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 hortipastoral 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.

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.

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)

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.

9.

10. **9. Rabbit Rearing:** In India is of recent origin though hunting of wild rabbits for meat is not uncommon. Rabbit can be easily reared with relatively less concentrate feed with high production rate.

10.**10. Duck rearing:** Ducks account for about 7 % of the poultry population in India. They are popular in cereal and logged states like west Bengal. Orissa, A.P, T. Nadu, they have production potential of about 130- 140 eggs/ bird/ year. These can rear in marshy riverside Westland. Duck farming can be a better alternative. Feeding: Eating fallen grains in harvested paddy fields, small fishes and other aquatic materials. A variety of crop residues and insects in the farm.

11. Turkey rearing: Turkey is a robust bird and can be reared in humid tropics. It actively feed on a variety of crop residues and insects in the farm.

12. Piggery: pigs are maintained for production of pork.

13. Mushroom Cultivation: Mushroom is an edible fungi great diversity in shape, size and colour. Essentially mushroom is a vegetable that is a cultivated that is cultivated in protected farms in a highly sanitized atmosphere; mushroom contains 90 % moisture with in quality protein, fairly good source of vitamin C and B complex. It is rich source of mineral like Ca, P, K & Cu. They contain less of fat and CHO and are considered good for diabetic and blood pressure patients.

Varieties: 1) Oyster mushroom 2) Paddy straw mushroom- *Volvarilla volvacea* 3) White button mushroom- *Agaricus gisporus* (var, A-11, Horst V3).

Chapter 9

Integrated Farming System (IFS) For Wetland System

Components are

1. Cropping (Rice- fish – poultry- mushroom)
2. Fish culture.
3. Poultry
4. Mushroom production.
5. Cropping 0.36 ha.
6. Fish pond 0.04 ha.

This farming system was compared with conventional cropping normally followed in the region. Rice – Rice – green gram and rice – rice – green manure (0.20 ha).

Component Description:

1. Fish pond area of 0.04 ha with 1.5 m depth.
2. Diff. finger lings of diff. fish species with total of 7500/ ha.
3. Harvesting of fish commenced from tench month. A poultry shed at corner of fish pond (shed 2.2 m^2).
4. Free fall of poultry dropping into the fish pond (Twenty Bapcock chicks of 18 weeks old reared).
5. The feed components were purchase only in 1st year of cropping.
6. The birds started laying eggs around 22nd weeks up to 72nd when they were culled out.
7. A mushroom shed of 5 * 3 m was constructed with local materials. Oyster mushroom was produced utilizing rice straw as the base material.

Economics- on an average net profit of Rs. 11, 755 was obtained in rice – poultry-mushroom system as compared to Rs. 6, 335 only from conventional system of cropping. Additional employment of 174 man days was generated due to IFS.

IFS – Tamil Nadu – Cauvery delta Zone (Crop – poultry- fish system).

Farmers of this zone are practicing monocropping of rice for two season followed by a rice fallow pulse. Among the different allied activities, pisciculture plays an important role in this zone since water is available in the canal about 7 – 8 months. Poultry farming is another feasible enterprise. By combing the enterprises of poultry – cum fish culture with rice cropping system the economic status of the small and marginal farmers could be improved.

Components: - One ha area has been selected.
- 0.04 ha area for fishpond
- Improved cropping as rice- rice cotton (0.76 ha) and
- Rice- rice – maize (0.20 ha).

Maize being a major constituent of poultry feed was included in the system. This system compared with the existing practice of rice- rice – black gram

Poultry unit: - 50 Bapocock's, Bu 300 hybrid layer bird of 21 weeks age were maintained till 43 Weeks. - 100 g/day/ bird through maize, rice bran, groundnut cake. **Fish culture:** Ponds near to poultry shed. Different fingerlings of fish in ponds, with density of population maintained were 10000 fingerlings / ha. The fish were harvested after six and half months.

Economic: A net return of Rs. 17,200 was obtained by integrating different enterprises by introducing poultry – cum – fish culture with cropping a total employment of 385 man- days was generated.

Integrated Farming System (IFS) for Irrigated Situations:

A model integrated farming system to suit the small and marginal farmers of garden land condition was studies at TNAU, Coimbatore, during 1988- 1993 (Rangaswami et al. 1995) An area of one ha was selected for IFS and compared with conventional cropping system(CCS).

Components of IFS:

	Cropping	Area (ha)
I.	Cotton = green gram maize + fodder cowpea- Bellary onion	0.56
II	Wheat = sunflower – maize + fodder cowpea- summer cotton + green gram	0.11
III	Grass Bajra Napier ((Co. I)	0.15
IV	Lucerne	0.05
V	150 Terrs of Leucaena (planted in the bunds)	0.05
	Total	1.00

Farm Stead:

Dairy Unit	3 jersey cows + 2 calves
Biogas Unit	2 m 3 capacity
Mushroom Production	1.5- 2.0kg/ha

The above integrate system was compared with the conventional cropping system of cotton sorghum- finger millet in 0.20 ha area.

Economic returns from the system: Maize flour, cottonseed and wheat bran obtained from the crop components were recycled for preparing dairy feed from the second year. About 45.5 t of to the animals. Dung was recycled for the biogas plant. Mean revenue of Rs. 34600/ ha was realized in IFS as compared to RS. 13950 obtained in CCS. Employment opportunity was also enhanced to the tune of 770 man- days per year under IFS as against conventional cropping.

Paddy-Cum-Fish Culture: Innovative idea for entrepreneurs in rural areas

Introduction:

In areas where paddy fields remain water for 3 to 8 months in a year, paddy cum fish culture can provide an additional supply of fish crop. The culture of fish in fields, which remain flooded even after the paddy is harvested, might also serve as an off-shore occupation for farmers. In recent years, however, with the advent of high yielding verities of paddy, the use of insecticide, pesticide, weedicide and fungicide, many of which even in minute quantities are highly toxic to aquatic life, has become widely prevalent. Fish culture, therefore, is no more compatible with paddy farming wherever the latest high yielding verities of paddy are cultivated. Paddy-cum-fish culture is an old practice in several countries as Japan, Malaysia, Italy, China and India. In some north eastern states of India it is practiced to an appreciable extent. As paddy fields remain flooded with water for several months, fish can be grown there at low cost in addition to rice. Over 80 million ha of land produce the worldâ€™s supply of rice, and in favorable situations at the end of the season, paddy-cum fish culture yields 3 Kg. or more of fish per ha for an inundation period of 3 to 8 months.

The species of fish commonly reared in the paddy cum fish culture are *Cyprinus carpio* (common carp)

a. *Cyprinus carpio var communis* (scale carp)
b. *Cyprinus carpio var specularis* (mirror carp) and
c. *Cyprinus carpio var nudus* (leather carp)

There is omnivorous bottom feeder spp and are characterized by deep bodied and short heads. The distinguishing features are small scale. Large shining and scattered scale and leather appearance due to absence of scales. The rice varieties cultivated in the plateau are not only posses strong roots but also withstand to floods. Hence, Paddy crops get not much disturbed in integrated culture with the fish. The fish farmers of the rural areas actively involved in fisheries activities to increase fish production.

Methodology for rice field preparation

Site selection: The site selection for paddy cum fish culture is low lying area where water flows easily and available at any time in needs. The soil of the paddy field is fertile organic manure and has highly water retaining capacity.

Preparation of paddy plots:

A. **Bundh construction:** The plots selected for paddy cum fish culture are normally prepared in the month of February by raising their embankment all along the plots. The paddy fields are suitable for fish culture at the areas because of strong bundh, which prevent leakage of water to retain water upto desired depth and also guarded the escape of cultivated fishes during the floods. The dykes should be built strong enough to make up the height due to geographical and topographic location of the paddy field. The bamboo screen mating done at the base of the bundh for its support.

B. **Dressing of paddy field:** after the completion of bundh construction the base of paddy fields are leveled with the help of spade and local made wooden plates called sampya. Manual weeding is done during the month of February folloed by construction of irrigated channel for easy passage, storage and draining of water. There are 2-3 channels constructed at the middle of paddy field for water management. That channel divides the paddy field perpendicular and horizontally bisect at a point. It is important to note that almost all paddy field have one or two inlets and more outlets. The former serve as entry of water required for the field and the later as outlets, one which remains at the bottom side of the dykes is meant for draining out the water for harvesting paddy crops and fishes. The remaining outlet constructed at the middle height of the dykes is meant for maintaining desirable water depth. Once the dressing work is over, the paddy field is ready for transplantation of rice seedling and fish seed stocking. However, the stocking of fish seed is done after 10-15 days of transplantation of rice seedling from its nursery bed.

Table 1: physicochemical characteristics of soil

S. No.	Parameters	Range
1.	Sand	85.71- 96.62(%)
2	Salt	3.12- 11.69(%)
3.	Clay	0.26-2.86(%)
4.	pH	5.00-5.70
5.	Organic carbon (%)	1.15-2.54(%)

6.	Organic matter	8.24
7.	Soil colour	Light brown, blackish
8.	Total nitrogen	0.22- 2.54(%)
9.	Texture class	Loamy soil, sandy
10.	Available phosphorous	2.90-4.50 mg/100 gm

Management of water supply: The farmers of the areas have sound knowledge of trapping water for paddy field. They construct barricades using wooden/bamboo poles across the stream, rivulets etc to divert water to irrigational channel for the paddy fields. The irrigational channel varies from 0.5 to 2 metres in wide.

Source of fish seed: The progressive fish farmers who normally produce adequate size of fish seeds by rearing in small size ponds for a period of about 1-2 months and sell it to the farmers who grow them directly in paddy fields and farms.

Organic fertilization of paddy fields: The plots utilized for rice-cum-fish culture is mainly based on organic fertilization with a verities of animal excreta such as poultry dropping, pig excerta, cow dung and waste of plants such as rice husks, waste product of local beer and ashes from household brunt and remains of burnt straws after the harvest is over and compost fertilizer like decomposed straws, weeds and rice stalks etc.

Stocking of fish seeds: Before releasing of fish seed to paddy field the paddy transplantation from rice seed beds to main paddy fields is done in the month of April, and there after paddy is left for two weeks for strengthening of paddy roots, the fish seed @ 2500 nos./ha area is released. The fish rearing period varied from 3-6 months and the paddy rearing period is 5-7 months.

Harvesting: Gears use for harvesting fishes is simple bamboo made basket called cane/bamboo. The fish culture for the period of 3-4 months in rice field, a production of 200-300 Kgs/ha achieved and while fish grown for the period of 5-6 months; 400-500Kgs/ha yield has been reported in the same season. Methodology used for harvesting used for harvesting, first the water is drained through outlet pipe, and thus allowing fishes and water accumulated in mid channel of paddy field, thereby the fishes are caught with the help of tasing puda, hand picking etc. and then stocking in large plastic bucket in live condition. After completion of fish harvesting the paddy harvesting followed. Normally paddy harvesting is made last part of Sept. & Oct. The paddy production range from 3500-4500 Kgs/ha from the same plot of land.

Marketing: fish harvested from the paddy field are marketed at the local market a live or fresh condition because of high market demand, live fish sold @ Rs. 120/- per Kg and fresh fish @ 100/- per Kg. during the lean season, the market price fluctuates. Marginal fish farmer sell their produce in fish market or in the paddy field itself. During the peak season, the fish production from these paddy fields also reaches in the capital markets. During the due rearing period paddy and fish no chemical insecticide/ pesticide/ fertilizer apply in the entire paddy field.

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III) Integrated farming system (IFS) for dryland situation:

Integrated farming system for dry lands suggested for Coimbatore and Aruppukottai, Tamil Nadu, are described below:

Model for Coimbatore, Tamil Nadu (mean Annual rainfall; 640 mm).

Crop components for one hectare:

	Cropping	Area (ha)
i)	Sorghum + cowpea both grain purpose	0.20
ii)	Sorghum + cowpea both fodder purpose	0.20
iii)	Leucaena (tree fodder)+ Cenchrus (grass fodder)	0.20
iv)	Aracia Senegal (tree fodder) + grass	0.20
v)	Prosophis cineraria (tree fodder) + grass	0.20

Animal Components: Telicherry goat: 6 (5 female+1 male– stallfed) Conventional cropping system= 0.20 ha (sorghum+cowpea- grain purpose). The animal components, tell cherry goat, numbering 6 (5 female+ 1 male) were kept in a shed (6*4 m). The goals were stall fed form the cropping components. Two kg each of green and dry fodder and 100 g of concentrate were given to each animal. At the end of second year. All the 4 male goats were disposed retaining one number. From the end of third year onwards, 20 female and one male were retained and remaining disposed. The litter form the goat shed was used for composting and recycled as manure. A farm pond was dug in an area of 300 m2 and the rain water harvested was utilized for pot watering the tree saplings. Economic returns from the system: men additional revenue of Rs. 3750ha / year was obtained from IFS over CCS. The employment generation under IFS was 153- man days/ ha / year whereas it was only 40- man days/ ha/ year in the CCS (sivasankaram *et al*. 1995).

IFS for island Ecosystem:

Integrated farming system models have been developed for the Andaman and Nikobar Islands –

1. Coconut – cum – fodder- cum – milch cattle: Mixed farming by raising fodder grass coconut has been founded profitable; grass in coconut has been found profitable, grass like hybrid Napier or leguminous fodder like Stylo in Coconut garden can support 4- 5 dairy animals. Animal supply large qualities of cattle manure applied to coconut garden improve the soil fertility.

2. Coconut – cum fish culture in salt affected lands: Coconut grows successfully even in salt affected paddy fields if the fields are within the approach of brackish water. The bunds of fields at water entrance gate should be raised to maintain the required level of water. Field bunds should also be raised a per the requirement. Water will be exchanged and thus fish raising can be taken up together with coconut in dry period. In rainy season, salinity tolerant rice varities could be cultivated in the same field with coconut and fish culture.

3. Fruits- fodder- milch cattle: The space available between the fruit trees can be utilized for growing fodder crops such as cow pear, rice bean, germ gram and black gram. The fodder could be used for feeding the cattle and cattle manure could be applied to the fruit trees and fodder crops.

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