Post Graduate Diploma in Agricultural Extension Management (PGDAEM)

AEM-205
Sustainable Livelihood in Agriculture
(3 Credits)

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Shri. B. Srinivas, IAS
Director General
National Institute of Agricultural Extension Management (MANAGE),
Rajendranagar, Hyderabad – 500 030,
Andhra Pradesh, India

Programme Coordinators

Dr. S. Senthil Vinayagam, Director (Agril. Extn.) & Principal Coordinator (PGDAEM)
Dr. K. Uma Rani, Deputy Director (Extn)
Dr. M.A. Kareem, Deputy Director (Agri. Extn)

Contributors (2008)

Mr. Syed Ahmad Hussain, Scientist (Agronomy), ANGRAU, HYD-30
Dr. M. Kalyanasundaram, Professor of Entomology, TNAU, Coimbatore - 3
Dr. S. Riyazuddin Ahmad, Principal Scientist (Soil Science), STCR, ANGRAU, HYD-30
Dr. M. Devender Reddy, Professor & Head, Water Technology Centre, ANGRAU, HYD-30
Dr. S. Vijaya Baskaran, Associate Professor (Agronomy), RRS, TNAU, Coimbatore - 3
Dr. V.R.K. Murthy, Associate Professor (Agronomy), ANGRAU, HYD-30
Dr. R.P. Ratan Singh, D.E, Birsa Agricultural University, Ranchi
Dr. K.H. Rao, Senior Scientist, HRD Division, NAARM, Rajendranagar, Hyd-30
Dr. B.S. Sontakki, Senior Scientist, NAARM, Rajendranagar, Hyderabad-30
Dr. A.G. Ponnaiah, Director, (CIBA), Chennai
Dr. P. Ravichandran, Principal Scientist, CIBA, Chennai.
Mr. M. Kathirvel, Principal Scientist, CIBA, Chennai
Dr. S.M. Pillai, Principal Scientist, CIBA, Chennai
Dr. M. Krishnan, Principal Scientist, CIBA, Chennai
Dr. M. Kailasam, Senior Scientist, CIBA, Chennai
Dr. K. Ponnusamy, Senior Scientist, CIBA, Chennai
Post Graduate Diploma in Agricultural Extension Management (PGDAEM)

Dr. M.K.Kumaran, Senior Scientist, CIBA, Chennai
Dr. K.K.Vass, Director, CIFRI, Kolkata
Dr. M.K.Das, Principal Scientist, CIFRI, Kolkata
Mrs. G.K. Vinci, Principal Scientist, CIFRI, Kolkata
Dr. B.C.Jha, Principal Scientist, CIFRI, Kolkata
Mr. N.P.Srivastava, Principal Scientist, CIFRI, Kolkata
Dr. P.K. Katiha, Senior Scientist, CIFRI, Kolkata
Dr. M.K.Bandopadhyay, Senior Scientist, CIFRI, Kolkata
Dr. M.A.Hassan, Senior Scientist, CIFRI, Kolkata
Dr. V.R. Suresh, Senior Scientist, CIFRI, Kolkata
Dr. S.K. Manna, Scientist, CIFRI, Kolkata
Mr. S.K. Saha, Scientist, CIFRI, Kolkata

Contributors (2013)
Dr. M.V.R.Subrahmanyam, Professor (Retd), Agronomy, ANGRAU, Hyderabad
Dr. B. Butcha Reddy, Associate Dean (Retd), ANGRAU, Hyderabad
Dr. A. Thammi Raju, Professor & University Head, College of Veterinary Sciences, SVVU, Proddutur, A.P.
Dr. S.T. Viroji Rao, Professor, Veterinary Sciences, SVVU, Hyderabad
Dr. P. Paul Pandian, Executive Director, NFDB, Hyderabad
Dr. T. Suguna, Associate Dean, College of Fisheries Sciences, SVVU, Nellore.
### AEM-205: Sustainable Livelihood in Agriculture (3 Credits)

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1.1 Basics of Sustainable Agriculture

1.1.1 Definition of sustainable agriculture.

Sustainable agriculture is a system of agriculture that is committed to maintain and preserve the natural resource base of soil, water and atmosphere ensuring future generations the capacity to feed them with an adequate supply of safe and wholesome food (Gracet, 1990).

Sustainable agriculture recommends a range of practices, which addresses many problems that arise due to the problems of modern agriculture such as loss of soil productivity, impacts of agricultural pollution, decreased income due to high production costs, and minimal or uneconomic returns.

1.1.2 Positive Aspects of

A) Modern Agriculture

- High yield / high and fast returns / profit oriented
- Increased mechanization
- Scope for intensive cropping
- New varieties of crop plants (pest/disease tolerant)
- Maximum utilization of land and water
- Meeting the need of sufficient and fast food production
- Immediate and direct supply of nutrients to the plant through chemical fertilizers (NPK).
- Better pest, disease and weed control
- Package of practices for different locations, situations, crops, agro climatic regions

B) Sustainable Agriculture
- Affordability by any farmer
- No sophisticated/imported and special technology is necessary
- Environmental conservation and protection
- Healthy atmosphere/healthy food
- Prevent / avoid ecological degradation.
- Prevent/avoid ecological degradation
- Security more through higher levels of disease and pest resistance
- Sustain soil fertility through organic recycling
- Greater Bio-diversity
- Efficient use of natural resources
- Self sustaining

1.1.3 Negative Aspects of

A) Modern Agriculture
- Short term benefit, operates law of diminishing returns
- Depletion of nutrient base of the soil, water and atmosphere quality
- Environmental (water, soil and air) pollution due to use of chemicals
- Health hazards due to entry of pesticides, toxins, antibiotics, heavy metals in to food chain
High cost of production

Increasing dependency on external inputs

Less diversification manifested through disappearance of genetic races because of monoculture leading to risks such as loss of biodiversity, pest and disease resistance and resurgence.

Poor quality of produce

Economic disparity in the society widens

Operates against principles of nature and ecology

Natural parasites, predators and beneficial insects are adversely affected and totally disappear over a period of time.

B) Sustainable Agriculture

- Takes longer time to realize the benefits of regenerative farming
- The change is gradual
- Relatively difficult to motivate farmers for change initially; once convinced, the adoption is easy.
- Comparatively labour intensive
- Needs proper planning for allocation/use of available resources
- Initial yield is low

1.1.4 Principles of Sustainable Agriculture

Basic principles of sustainable agriculture are as follows.

- Inter relatedness of all the farming systems including the farmer and the family
- Need to maximize desired biological relationships in the system and minimize the use of materials and practices that disrupt these relations.
- Application of prior experience and latest scientific advances to create integrated, resource conserving, equitable farming systems.
- Reduce environmental degradation, maintain agricultural productivity, promote economic viability in both short and long term, and maintain stable rural communities and quality of life.
No overburden on natural resource base and its carrying capacity.

1.1.5 Elements of Sustainable Agriculture

Sustainable Agriculture consists of elements, which are common in many regions. The methods to improve their sustainability may vary from one agro ecological region to another. However there are some common sets of practices among farmers trying to take a more sustainable approach by use of on farm or local resources. However each of them contributes to a grater extent to realize long term farm profitability, environmental stewardship and quality of life.

1. Soil Conservation: Soil conversation methods including contour cultivation, contour bunding, graded bunding, vegetative barriers, strip cropping, cover cropping, reduced tillage etc. help prevent loss of soil due to wind and water erosion.

2. Crop diversity: Increased crop diversity on farm can help reduce risks from extremes in weather, marketing conditions, pest and disease incidences. The increased diversity of crop and other plants such as trees, shrubs and pastures also contribute to soil conservation, habitat protection and increase populations of beneficial insects.

3. Nutrient management: Integrated management of essential nutrients can improve and sustain soil fertility and protect environment. Increased use of on farm (low cost) inputs such as organic manures, compost, green manures and crop residues not only reduces cost of production but also rejuvenates soil health.

4. Pest management: It is a sustainable approach to manage pests by integrating the available plant protection methods like cultural, physical, mechanical, biological and chemical methods, which optimizes the production costs, besides maintaining environmental balance.

5. Water quality & water conservation: Practices like zero tillage, deep ploughing, mulching and micro irrigation techniques help to optimize the water consumption or requirement besides conserving and augmenting the soil moisture on long term basis. It is also helpful in protecting the quality of drinking water and surface water.
6. Agro forestry: A combination of silvi-pastoral, agri-Silvi-pastoral, agri-horticulture, horti-silvi pastoral, alley cropping, ley farming help conserve soil and water, and profitability. Also lead to supply of fuel wood, horticultural products and achieve balanced nutrition to rural people.

7. Marketing: Improved marketing facilities can ensure remunerative and sustainable return to farmers. Direct marketing of produce can exclude intermediaries and ensure higher returns.

1.2. Farming Systems

1.2.1 Definitions

Agricultural System: Is an assemblage of components which are united by some form of interaction and interdependence and which operate within a prescribed boundary to achieve a specified agricultural objective on behalf of the beneficiaries of the system.

Farming System: Is defined as a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constrains, and for which similar development strategies and interventions would be appropriate (Food and Agriculture Organization).

Integrated Farming System (IFS): Is a resource management strategy to achieve economic and sustained production to meet diverse requirement of farm household while preserving resource base, ensuring environmental quality and maintaining desirable level of biological diversity.

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.
1.2.2 Farming systems concept

In farming system, the farm is viewed in a holistic manner. Farming enterprises include crops, dairying, poultry, fishery, sericulture, piggery, tree crops. 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 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) 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.

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 objectives, being shorter for economic gains and longer for concerns pertaining to environment, soil productivity and land degradation.

1.2.3 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
1.2.4 Objectives of farming system

- **Productivity**: Farming system provides an opportunity to increase economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises.

- **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.

- **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.

- **Balanced food**: In farming system, diverse enterprises are involved and they produce different sources of nutrition namely proteins, carbohydrates, fats & minerals from the same unit land, which helps in solving the malnutrition problem prevalent among the marginal and sub-marginal farming households.

- **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 farming system will greatly reduces environmental pollution.

- **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 farming system 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. This not only enhances the purchasing power of the farmer but also provides an opportunity to invest in improved technologies for enhanced production.

- **Saving Energy:** Availability of fossil fuel has been declining at a rapid rate leading to a situation where in 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.

- **Meeting fodder crises:** In farming system every inch of land area is effectively utilized. Alley cropping or growing fodder legume along the border/water courses, or intensification of cropping including fodder legumes in cropping systems helps to produce the required fodder and greatly relieve the problem of non-availability of fodder to livestock component of the farming system.

- **Solving timber and fuel crises:** The current production level of 20 million m³ of fuel wood and 11 million m³ of timber wood is no match for demand estimate of 360 million m³ fuel and 64.4 million m³ of timber wood in 2000 AD. Hence the current production needs to be stepped up several-fold. Afforestation programmes besides introduction of agro-forestry component in farming system without detrimental effect on crop yield will greatly reduce deforestation by preserving our natural ecosystem.

- **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. A farming system provides enough scope to employ family labour round the year.

- **Scope for establishment of agro-industries:** Once the produce from different components in farming system is increased to a commercial level, there will be surplus for value addition in the region leading to establishment of agro-industries.

- **Enhancement in input use efficiency:** A farming system provides good scope for resource utilization in different components leading to greater input use efficiency and benefit - cost ratio.
1.2.5 Cropping system related terminology

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.

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.

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

1) 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.

2) 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.

**Mixed cropping:** Mixed cropping is growing of two or more crops simultaneously on the same piece of land, either sown 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 area 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:

**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 a system of farming on a particular farm (regardless of size), which include crop production, raising of livestock, poultry, fish and bee keeping, and/or trees to sustain and satisfy as many necessities of the 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.

1.3. Sericulture and Agroforestry

1.3.1 Sericulture

Sericulture is an agro-industry, the end product of which is silk. Sericulture involves three 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 lakh tons of reeling cocoons and 0.14 lakh tons of raw silk from a mulberry cropped area of 2.82 lakh ha. The sericulture is practiced in India both in tropical (Karnataka, Andhra Pradesh, Tamil Nadu 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.

1.3.2 Moriculture

Cultivation of mulberry plants is called as moriculture. 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 of 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. india*, *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 300-120-120kg/ 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 X 90 cm under rain fed conditions (pit method) and 120 x 60cm under irrigated conditions is commonly followed. It is mainly propagated by cuttings. The planting season is July - August. The crop can give good yield for 12 years, after which they are pulled out and fresh planting is done. The yield of mulberry leaves is 30-40 t/ha/year.

1.3.3 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°C) and humidity (70 - 85%) depending upon the silk worm stage i.e. instar is very essential. Initially the disease free laying (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 (transferring of hatched larvae into rearing trays) is done. The rearing trays usually made up of bamboo/plastic. The space requirement for 100 DFLs varies from 4-14 m² 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 mould, the silkworm become fully matured and ready to spin into a cocoon. This is the last stage of rearing operation. After this stage, the mature silkworms are transferred on
to the cocoon frames or montages for spinning of cocoons. The montages are popularly known as chandrika. 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 cocoon 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 cocoon is about 350 m in Indian multivoltine, and 1800 m in case of Japanese bivoltine race.

1.3.4 Agro-forestry

1.3.4.1 Definition of Agroforestry

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 trees 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.

1.3.4.2. Concept

Adoption of integrated agro-forestry systems using multipurpose tree species (MPTs) and nitrogen fixing tree species (NFTs) including fruit trees with arable crops and / or pastures for sustainable development of degraded lands would help to solve
some of the pressing problems including food needs, amelioration of polluted
environment and simultaneously achieving the national target of 33% area under trees
and grass cover.

1.3.4.3 Multifunctional agro-forestry systems in India

a) Agro-forestry for small holdings

In India land holdings are less than 0.94 ha, labour is plentiful but less productive.
Hence agro-forestry, as a labour intensive, low input land use system is the ideal
alternative. Two agro-forestry practices have been proposed for small holdings. The
first relates to increasing soil productivity and land sustainability and the second to
improve and stabilize farm income. The former can be achieved through multi storey
cropping, agri-horticultural system, alley cropping or agri-silviculture.

b) Agro-forestry for soil buildup

Maintaining and enhancing the soil fertility of farmlands to grow foodgrains as
well as tree biomass can help to meet the demand in future. Ecologically sound agro-
forestry systems such as intercropping and mixed arable-livestock systems can increase
the sustainability of agricultural production, while reducing on-site and off-site
consequences and lead to sustainable agriculture. Alternate land use systems such as
agri-horticultural, agri-silvicultural and silvi-pasture are more effective for soil organic
matter restoration.

c) Agro-forestry for economic gain

Integration of fruit or economically important trees with arable crops is intended
to maximize the land use efficiency to generate supplemental income to medium level
farmers in semi arid tropics. Farmers in dryland areas are not getting sufficient net
returns from traditional dry land crops like sorghum and smaller millets due to weather
vagaries. Currently farmers are shifting towards other production systems. These shifts
are essentially driven by the market demand and social factors. Farmers prefer fruit
trees compared to fodder and fuel-wood trees. Further the economic returns are found
to be in favour of agri-horticultural systems compared to traditional farming in low and marginal rainfall areas.

d) Agro-forestry for water use efficiency

There is robust evidence that agroforestry systems have the potential for improving water use efficiency by reducing the unproductive components of the water balance (run-off, soil evaporation and drainage). For instance, a combination of crops and trees uses the soil water between the hedge rows more efficiently than the sole cropped trees or crops.

e) Agro-forestry as carbon sinks

Land management actions that enhance the uptake of CO₂ or reduce its emissions have the potential to remove a significant amount of CO₂ from the atmosphere. If the trees are harvested, accompanied by regeneration of the area, and sequestered carbon is locked through non-destructive (non-CO₂ emitting) use of such wood. Carbon management through afforestation and reforestation in degraded natural forests is an useful option, but agro-forestry is attractive because it sequesters carbon in vegetation and possibly in soils depending on the pre-conversion soil carbon. In India, average sequestration potential in agro-forestry has been estimated to be 25 t carbon per ha over 96 million ha, but there is a considerable variation in different regions depending upon the biomass production.

f) Agro-forestry for biodiversity

Agro-forestry is typically less diverse than native forests, but more diverse than agriculture. They do contain much greater number of plants and animal species than forest plantation. Some trees will support more diversity than other and the same species will invariably shelter and attract more wild fauna like in the natural habitat. Trees in agro-ecosystems in rajasthan and uttaranchal have been found to support threatened cavity-nesting birds, and offer forage and habitat to many species of birds. These systems also act as refuge to biodiversity after catastrophic events such as fire.
1.3.4.4 Agro-forestry systems for sustained agricultural production

a) Agri-silvicultural System

Agri-silvicultural system could be practiced in areas where wood lands can not be created. The planting consists of both annual crops and perennial trees. This type of approach is most commonly observed in the cultivated areas. The perennial tree species are planted in a single row or multiple of rows in strip at an inter space distance of 5-10 m between two strips. The interspace is utilized for growing annual / seasonal crops.  

_Ailanthus excelsa, Zyzphyus jujuba, Mahua_ etc. could be grown along with dry land crops viz., bajra, jowar, sesamum etc., without affecting crop production.

Growing trees in cultivated land will greatly help to improve the environment and increase biomass production. This practice can be grouped in to the following steps :

- _Row planting in cultivated land._ Trees can be grown in widely spaced rows to allow cultivation of field crops in between.
- _Farm boundary, bund or peripheral planting._ This system can effectively accommodate more than 200 plants/ha by utilizing the space productively resulting in protection of the bunds.
- _Block planting._ It means apportioning a certain part of the land for growing trees. This has inherent advantages of conservation and land improvement.

Suitable species.  _Acacia nilotica, Azadirachta indica, Dalbergia sissoo, Albizzia lebbeck, Casuarina equisetifolia, Eucalyptus hybrid, Leucaena leucocephala, Tamarindus indica._

b) Alley Cropping

Alley cropping is planting perennial trees / shrubs yielding forage, in rows at some distances in association with agricultural crops. This system with tree rows aligned along contours will also prove to be an effective means of erosion control and also impart stability to production. The hedge rows are pruned close to the ground leaving 15-20 cm stumps. The perennial trees/shrubs are planted thick enough to act as
barrier for runoff of excess water and soil erosion. The continuous barriers across the slope provide series of “Vegetative checks” for control of soil erosion and runoff.

Field crops are grown in alleys formed by rows of perennial vegetation. The system is relevant for higher biomass production. It also provides a barrier of perennial vegetation to check soil loss and runoff.

Suitable species, *Leucaena leucocephala* has been adopted for the system. *Glyricidia maculata* and *Sesbania aegyptiaca* could be promising. Sorghum, safflower, and groundnut (in light soils) are the promising agricultural crops.

c) Silvi-horti/Agri-horti system

The concept of silvi-horti / agri-horti or combination of agricultural crops, perennial tree and fruit species could profitably be adopted in both arable and non-arable marginal and sub-marginal lands. Useful fruit species such as cashew, ber, annonacea fruit species, phalsa, mango, sapota, guava, tamarind and jack fruit trees are planted in regular strips or interplanted with silvi component. In agri-horti system of land use, the distance between the two horticultural plants within the strip may be quite apart to avoid competition. The interstrip space between the two horticultural plants can be used for planting fast growing economic silvi-cultural species such as *leucaena, casuarina, Dalbergia, teak and Albizia*. The tree plants are cut for wood after 4-6 years so that the competition could be minimized. The idea behind planting tree species as an intercrop with horticultural plants is to obtain biomass production before horticultural plants attain full growth and later to obtain fodder or green manure material by frequent cutting and create thicker vegetation for better soil and water conservation.

d) Silvi-pastoral System

The system consisting of tree species with fuel and fodder value and grasses as under-storey, protect marginal lands.

In such land use systems, ideal species of woody perennial should be fast growing, hardy, with wide ecological aptitude, light crown with multilayer branching and leaf
orientation and of multiple use to the rural population. The forage component need to be very hard, easily colonizing, palatable, nutritious and with strong establishment through roots or self sown seeds. For arid and semi-arid areas species like Acacia tortilis, Albizzia amara, Hardwickia binata, Leucaena leucocephala, with Cenchrus ciliaris, Cenchrus setigerus, Dichanthium annulatum, Chrysopogon fulvus, Sehima nervosum etc. find greater adaptability. Legume species such as Stylosanthes spp, Macroptylum atropurpureum (siratro), Desmodium spp and Desmathus spp have been found very versatile. On difficult sites, Desmodium spp, Alcidcarpus spp and Sesbania spp would promise as primary colonizers.
Organic Farming for Sustainable Crop Production

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2.0 Organic Farming

2.1 Definitions of organic farming

Organic farming is a production system that integrates site-specific, cultural, biological and mechanized practices designed to foster the cycling of resources, ecological balance and biodiversity (USDA National Organic Programme - 2002).

An ecological production management system that promotes and enhances biodiversity, biological cycles, and soil biological activity. It is based on minimal use of off farm inputs and on farm management practices that restore, maintain, or enhance ecological harmony. The primary goal of organic farming is to optimize the health and productivity of interdependent communities of soil life, plants, animals and people (USDA National Organic Standard Board, 1997).

Organic farming avoids or largely excludes the use of synthetically manufactured fertilizers, pesticides, growth regulators and live stock feed additives. Organic farming
to the maximum extent feasible, rely on crop rotations, crop residues, animal manure, legumes, green manures, organic residual and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients and control insects, weeds and other pests.

2.2 Principles of Organic Farming

Organic farming/agriculture is one among the broad spectrum of production methods that are supportive of the environment. Following are the few basic principles of organic farming.

- Maintenance of soil fertility and soil organic matter by the use of naturally available organic materials/manures and effective residue/waste management.
- Minimising the use of external inputs.
- Stringent or rigid restriction on synthetic inorganic fertilizers and pesticides.
- Management of pest through crop rotation, crop planning, and use of bio control agents and botanicals (non-pesticidal methods).
- Encouraging the use of biofertilizers and natural mineral supplements.

2.3 Sources of organic manure

One of the major components of organic farming is the use of organic matter as soil ameliorant. Organic manure sources can be grouped in many ways such as bulky and concentrated or as on-farm and off-farm based upon the nature and availability.

2.3.1 On-farm sources

These materials are available within the farm premises and used as such or after decomposition. Application requires labour and on farm processing.

a. Farm yard manure

The resultant manure from the animals which usually has a combination of dung, urine and crop and other feed wastes. The availability under actual farming situations in
India are sub optimal. Organic FYM contains 0.5 to 0.6% N, 0.5 to 1.0% P and 0.75 to 1.5% K.

b. Green manure

It is considered as a good source of nitrogen and can be produced in situ. Upon addition, organic acid production due to decomposition can increase the availability of P, K, secondary and trace elements in the soil. The analysis will vary with the nature of the green manure and is around 2.0% N, 1.5% P and 1.5% K. If the green leaves are collected elsewhere and brought into the field, the practice is called as green leaf manuring.

c. Crop residues

Crop residues can be the inconsumable portion of a crop which cannot be used as a feed to animals. Usually, crop residues will have a wider C:N ratio and need composting before application to narrow the C:N ratio. The regular addition will improve soil physical and chemical properties.

d. Poultry manure

Manure from integrated farming system component or back yard can be grouped as on-farm. The decomposition rate of poultry manure is quick and contains 1.5% N, 1.2% P and 0.5% K, but has to be 'cured' before being applied to crops to avoid tip burning, root injury due to acidic nature.

e. Sheep and goat manure

The droppings of sheep and goat contain higher amounts of N-3%, P-1% and K-2%. The droppings can be collected and decomposed for application or penning can also be done which is more efficient and economic. Sheep and goat penning is very popular even in the present times in India.

f. Bio gas slurry and sludge
The residues from biogas plants make good fertilizer, which is devoid of weeds and seeds, and in a high decomposed state. It can be directly used for the crops.

g. Vermicompost

Vermicomposting is the biological degradation of organic matter contained in agricultural, urban and industrial wastes, occurring when earthworms feed on these materials. It contains the nutrients in a readily available state. Vermicompost is also rich in enzymes and plant hormones as well as several other photodynamic compounds. Its composition is very complex and varies from site to site depending on the type of raw material used (dung, crop residues, agro or agro industrial wastes) and the type of earthworms employed. The earthworm species employed for vermicomposting are surface feeder which improve only organic matter and not soil unlike the common earthworms found deep in wet soils.

2.3.2 Off-farm sources

These materials are available outside the farm. Most of the materials are from agricultural and allied industries. It involves labour and cost for the purchase. The materials may be organised naturally occurring elements which can be used as per the recommendations/ specifications.

a. Coir pith

The waste material from the coir industry can be decomposed and used for improving the physical properties of soil, namely porosity and water holding capacity.

b. Press mud

It is the by-product of sugar industry and is a good soil ameliorant for alkali soils. Calcium sulfate plays a major role in improving soil properties. If the press mud is thoroughly processed, it will have more calcium carbonate and can be used as an amendment for acid soils.
c. **Oil Cakes**

The resultant by product of both edible and non edible oil industry gives out a substantial quantity of oil cake, which are called as concentrated organic manures. Many oil cakes have pest repellent action and also serve as nitrification inhibitors. (neem cake, pongamia cake).

d. **Fly ash**

Fly ash is a solid waste of coal or lignite combustion from thermal power stations or even modern rice mills. It contains practically all the elements as that of soil except organic carbon and nitrogen. It is rich in P, Ca, Mg, K and S. The CEC is low with strong alkaline pH. Upon soil application, can reduce surface encrustation which is a problem in red soils. However the material should be used with care as they contain aluminum and trace elements in toxic concentrations.

e. **Bio compost**

It is a manure obtained by mixing press mud with distillery effluent, which is rich in humus. Bacterial inoculants are added over the windrow staked mixture. Bioconversion is allowed by frequent stirring with aerators to speed up the composting process. The quality can be enhanced by mixing with biofertilizers or naturally available rock phosphate and so on.

f. **Sewage and municipal waste**

Collection of city refuses and separating non decomposable materials will give an organic mixture. Upon curing, these materials can be used. A degree of caution needs to be exercised as they can be a source of major chemical and biological pollution.

g. **Minerals**

Under special conditions, natural gypsum, magnesium rock, pulverized rock, rock phosphate, basic slag and trace elements can be used restrictively.
h. **Blood meal/ fishmeal/ bone meal**

Dried blood meal is a by product of slaughter houses which contains 10-1 2% available N, 1 -1.55% P and 1.0% K. Non edible fish, carcasses of fish or dried fish as such or as powder are used in cropping. They are rich in available N 4-10%, P 3-9.5% and K 1.5%. Bone meal is the left out bone in the slaughter houses used for the supply of Ca and neutralization activities of problem soils. Their availability is dwindling because of alternative uses, more as livestock feed additives.

i. **Bio fertilizers**

The artificial in vitro production of biofertilizers such as azospirillum, azotobacter, rhizobium, PSB and VAM. They are efficient fixers of atmospheric N in the rhizosphere or mobilizers of P from the soil.

j. **Traditional preparations**

For example, panchakavya, dasakavya and so on is prepared by mixing many organic Products through fermentation and has a special mention now in organic farming.

2.3.3 **Prospects of bulk use of Fly Ash in Agriculture**

The annual generation of fly ash is projected to exceed 175 million tonne per annum by 2012 .This high volume of fly ash occupies large area of land and possesses threat to environment. As such, there is an urgent and imperative need to adapt technologies for gainful utilization and safe management of fly ash on sustainable basis.

Agriculture and waste land management have emerged as prime bulk utilization areas for fly ash in the country.

The field experiments on fly ash and pond ash as soil modifier / source of economical plant nutrients have revealed the following:

- Improves permeability status of soil
- Improves fertility status of soil (soil health) / crop yield
- Improves soil texture
- Reduces bulk density of soil
- Improves water holding capacity / porosity
- Optimizes pH value
- Improves soil aeration
- Reduces crust formation
- Provides micro nutrients like Fe, Zn, Cu, Mo, B, and Mn
- Provides macro nutrients like K, P, Ca, Mg, and S
- Works as a part substitute of gypsum for reclamation of saline alkali soil and lime for reclamation of acidic soils
- Surface cover of bio reclaimed vegetated ash pond get stabilized and can be used as recreational park
- Ash ponds provides suitable conditions and essential nutrients for plant growth, helps improve the economic condition of local inhabitants
- Works as a liming agent
- Helps in early maturity of crop
- Improves the nutritional quality of food crop
- Reduces pest incidence
- Conserves plant nutrients/water
- Carry over of trace & heavy metals & radioactivity is insignificant
- Crops grown on fly ash amended soil are safe for human consumption
- Groundwater quality is not affected.

Keeping the above important findings in view, pond ash at a dose of 30-50 tonne per hectare on one time basis along with recommended dose of fertilizers / manures is recommended for use in agriculture/ forestry sector/wasteland management or cultivation of different cereals / pluses/ oil seeds / vegetables etc,. Repeat application can be made after 4-5 years as it would have significant residual effect on the yield of succeeding crops over a period of 4-5 years. The abandoned ash ponds in the vicinity of
Thermal Power Plants could also be safely reclaimed via suitable amendments for forestry/floriculture purposes.

### 2.4 Methods of organic manure/waste recycling

There are many economic and efficient ways of recycling in farming. Few simple ways are:

#### 2.4.1 Composting

This is the age old practice of conservation of organic residues. The farm yard waste is heaped over the ground or in pits and allowed for natural decomposition. The materials can be used after 6-7 months. Here, weed seeds and other contaminating materials may present and no value addition is done. Value addition can be made done by addition of microbial consortia (mixture of microbial cultures of fungi and bacteria) @ 2.0 kg per ton of farm waste. This will quicken the ecomposing process and leave some materials (20 to 40%) undecomposed. Before field application, the biofertilizers and bioinoculants recommended for unit area can be mixed and incubated for a week with optimum moisture under shade, to have more microbial population.

#### 2.4.2 Vermicomposting

All the decomposable organic wastes can be used for vermicomposting. The materials are subjected to partial decomposition and earthworms are released with protection against sun and rain. Depending upon the population of earthworms within a two to three months castings can be collected and used @ 5.0 tons per ha of cropping. Vermiwash can also be prepared by passing drops of water at intervals over feed beds having worms. Collecting the excess water through an opening at the bottom of the bed will give vermiwash which can be applied on foliage of the crops.

#### 2.4.3 In situ composting

For perennial crops, in the inter row/ intra row spacing trenches, pits can be excavated with shallow depths of 50 - 60cm and width according to the spacing. All the
waste materials available are added to it. When the materials are filled up to the brim, it will be covered with soil. This will serve dual purpose of supplying nutrients and develop highly vigorous rooting system.

2.5 **Crop management in organic farming**

Maintenance of soil fertility and checking weed and pest problem and also soil and water conservation are important for sustaining soil and crop productivity. Following are few examples.

2.5.1 **Tillage and Cultivation**

Tillage and cultivation are tools that can accomplish a variety of objectives in farming systems: weed control, crop residue management, soil aeration, conservation of manures and other fertilizers, hard pan reduction, sanitation to destroy pest and disease habitat. Organic growers focus more on improving tillage and maximizing its benefits.

2.5.2 **Intercropping**

Growing two or more mutually beneficial crops in close proximity is one strategy for improving soil fertility. It typically involves alternating rows or a number of rows of compatible field crops, like a pulse crop in between millet or oilseed or even forage crops. It also applies to sowing multiple crops, without definite spacing like millets, oil seeds, pulses and forage crops in a field. They usually have different maturation period so that the soil space and nutrient competition is negligible or not existent.

2.5.3 **Crop rotation**

One of the main reason for the present day crisis is monocropping for seasons and years together. Rotation of crops in a complementary manner will add fertility to the soil and will have a positive bearing on pest and weed incidence, nutrient uptake pattern and soil moisture exploitation. Depending upon the situation and need crops, should be chosen.
2.5.4 Green Manures and Cover Crops

Green manuring: Incorporation of a crop grown into the soil, for the purpose of soil improvement. It is a practice with a long history. Green manuring has been ignored in recent years as an adaptable option for soil improvement because the traditional practice entailed planting a full-season cover crop. This excluded the field from commercial production for a whole season. Interest has returned, however, since green manuring strategies have been combined with cover cropping schemes.

Cover cropping: Growing a crop for the purpose of soil and nutrient conservation. It is a more contemporary concept than green manuring, in crop husbandry. The concepts of cover cropping and green manuring go together, as most cover crops are used as green manures prior to the planting of a commercial crop. The combined benefits become economically feasible, when the cover crop is grown during the off-season or inter-seeded with the main crop. It is more desirable when the cover crop includes nitrogen-fixing legumes.

2.5.5 Biological Pest Control

Organic farming relies heavily on populations of beneficial insect predators and parasites, insect-eating birds and bats, and other creatures, to help manage pest problems. These biological control components help keep pest numbers at levels where further cultural activities or relatively mild pesticides are (usually) adequate to assure a better crop. In some instances, biological control can be so effective that no additional action is needed by the farmer. Trap cropping or bait cropping is one of a better option for pest management to attract pests and manually destroying them by capturing from the host plants. Use of botanical pesticides helps in pest management. The botanical pesticides commonly employed are oil cakes, neem and pongamia oil extract of seeds, leaves and root extracts of some plant species.

In many organic systems, farmers sometimes purchase and release control agents like ladybird beetles, lacewings, trichogramma, wasps, etc.. Increasingly, growers are
designing and maintaining both permanent and temporary habitats specifically for beneficial insects, spiders, and other helpful species.

Biological: Bio pesticides present great hope for organic control of highly destructive pests. Among the most well-known bio pesticides are the Bacillus thuringenesis (Bt) formulations for control of lepidopterous pests and Colorado potato beetle.

2.5.6 Sanitation

Sanitation can take on many forms

- Removal, burning, or deep ploughing of crop residues that could carry plant disease or insect pest agents
- Destruction of nearby weedy habitats that shelter pests
- Cleaning accumulated weed seeds from farm equipment before entering a new field
- Sterilizing pruning tools

As in human and animal health, sanitation practices can go a long way in preventing crop pest problems. However, many practices such as clean cultivation, deep ploughing, and burning crop residues can increase erosion and reduce biodiversity. Thus, they may conflict with sustainability. Good organic growers recognize this and treat those practices as transitional or rescue options, rather than relying on them on an annual basis.

2.5.7 Mulching

Mulching is a practice often used by organic growers. Traditionally, it entails the spreading of large amounts of organic materials, such as straw, hay, crop wastes, etc. over bare soil between crop plant rows. Organic mulches regulate soil moisture and temperature, suppress weeds, and provide organic matter to the soil. Mulching is most appropriate to small, intensive operations with high-value annual or fruit crops.
A few systems of no-till organic farming have evolved from the concept of deep, permanent mulching. Plastic mulch, as long as it is removed at end of growing or harvest season, is permitted in certified organic production. Its use allows larger acreage to be brought more easily under herbicide-free management, though there are serious issues to be addressed like costs, economics and sustainability, in addition to deleterious effects on soils—prevention of heat escape from soils or making soils too cold.

2.6 National Standards for Organic Production

2.6.1 Crop Production

2.6.1.1. Choice of Crops And Varieties- General Principles

All seeds and plant material should be certified as organic.

Recommendations

The Species and varieties cultivated should be adapted to the soil and climatic conditions and resistant / tolerant to pests and diseases. In the choice of varieties, genetic diversity should be taken into consideration. Organic seed and plant materials shall be used, on their availability. The certification programme shall set time limits for the requirement of certified organic seed and other plant material. If certified organic seed and plant materials are not available, chemically untreated conventional materials shall be used. Alternately, chemically treated seed and plant material may be used. The certification programme shall define conditions for exemptions and set time limits for chemical treatment of seeds and plant materials. The use of genetically engineered seeds, pollen, transgenic plants or plant material is not allowed.

2.6.1.2 Diversity in Crop Production- General Principles

The basis for crop production in gardening, farming and forestry is related to the fertility of soil and surrounding ecosystem and to provide a diversity of species while minimizing nutrient losses.
Recommendations

Diversity in crop production is achieved by a combination of a versatile crop rotation with legumes an appropriate coverage of the soil during the year of production with diverse plant species.

Standards

The certification programme shall require that sufficient diversity is obtained in time or place in a manner that takes into account pressure from insects, weeds, diseases and other pests, while maintaining or increasing soil organic matter, fertility, microbial activity and general soil health.

2.6.1.3 Fertilizer Policy- General Principles

Sufficient quantities of biodegradable material of microbial, plant or animal origin should be returned to the soil to increase or at least maintain its fertility and the biological activity within it. Biodegradable material of microbial, plant or animal origin produced on organic farms should form the basis of the fertilizer programme.

Recommendations

Fertilizer management should minimise nutrient losses. Accumulation of heavy metals and other pollutants should be prevented. Non synthetic mineral fertilizers and brought in fertilizers of biological origin should be regarded as supplementary and not a replacement for nutrient recycling. Adequate pH levels should be maintained in the soil.

Standards

Biodegradable material of microbial plant or animal origin shall form the basis of the fertilization programme. The certification programme shall set limits to the total amount of biodegradable material of microbial plant or animal origin brought into the farm unit, taking into account local conditions and the specific nature of the crops. Brought-in material (including potting compost) shall be in accordance with the set standards. Manures containing human excreta shall not be used on vegetation for
human consumption. Procedures shall be in place which prevent transmission of pests, parasites and infectious agents. Mineral fertilizers shall only be used in a supplementary role to carbon based materials. Permission for use shall only be given when other fertility management practices have been optimized. Mineral fertilizers shall be applied in their natural form and shall not be rendered more soluble or processed, otherwise by chemical treatment. The certification programme may grant exceptions which shall be well justified. These exceptions shall not include mineral fertilizers containing nitrogen. The certification programme shall lay down restrictions for the use of inputs such as mineral potassium, magnesium fertilisers, trace elements, manures and fertilizers with a relatively high metal content and/ or other, unwanted substances, e.g. basic slag, rock phosphate and sewage sludge. All synthetic nitrogenous fertilizers, including urea, are prohibited.

2.6.1.4 Pest, Disease and Weed Management including Growth Regulators- General Principles

Organic farming systems should be carried out in a way which ensures that losses from pests, diseases and weeds are minimized. Emphasis is placed on the use of a balanced fertilizing programme, use of crops and varieties well adapted to the environment, fertile soils of high biological activity, adapted rotations, companion planting, green manures, etc. Growth and development of crop plants should take place in a natural manner.

Recommendations

Weeds, pests and diseases should be controlled by a number of preventive cultural techniques which limit their development, e.g. suitable rotations, green manures, a balanced fertilizer application, early seedbed preparations, mulching, mechanical control and the disturbance of pest development cycles. The natural enemies of pests and diseases should be protected and encouraged through proper habitat management of hedges, nesting sites etc. Pest management should be regulated by understanding and disrupting the ecological needs of the pests.
An ecological equilibrium should be created to bring about a balance in the pest-predator cycle.

**Standards**

Products used for pest, disease and weed management, prepared at the farm from local plants, animals and micro-organisms, are allowed. If the ecosystem or the quality of organic products might be jeopardised, the procedure to evaluate additional inputs to organic agriculture and other relevant criteria shall be used to judge if the product is acceptable. Brand name products must always be evaluated. Thermic weed control and physical methods for pest, disease and weed management are permitted. Thermic sterilization of soils to combat pests and diseases is restricted to circumstances where a proper rotation or renewal of soil cannot take place. Permission may only be given by the certification programme on a case by case basis. All equipment from conventional farming systems shall be properly cleaned and free from residues before being used on organically managed areas. The use of synthetic herbicides, fungicides, insecticides and other pesticides is prohibited. The use of synthetic growth regulators and synthetic dyes are prohibited. The uses of genetically engineered organisms or products are prohibited. Accredited certification programmes shall ensure that measures are in place to prevent transmission of pests, parasites and infectious agents.

**2.6.1.5 Contamination Control- General Principles**

All relevant measures should be taken to minimise contamination from outside and within the farm.

**Recommendations**

In case of risk or reasonable suspicion of risk of pollution, the certification programme should set limit for the maximum application levels of heavy metals and other pollutants. Accumulation of heavy metals and other pollutants should be limited.
Standards

In case of reasonable suspicion of contamination, the certification programme shall make sure that an analysis of the relevant products and possible sources of pollution (soil and water) shall take place to determine the level of contamination. For protected structure coverings, plastic mulches, fleeces, insect netting and silage rapping, only products based on polyethylene and polypropylene or other polycarbonates are allowed. These shall be removed from the soil after use and shall not be burnt on the farmland. The use of polychloride based products is prohibited.

2.6.1.6 Soil and Water Conservation - General Principles

Soil and water resources should be handled in a sustainable manner.

Recommendations

Relevant measures should be taken to prevent erosion, salinisation of soil, excessive and improper use of water and the pollution of ground and surface water.

Standards

Clearing of land through the means of burning organic matter, e.g. slash-and-burn, straw burning shall be restricted to the minimum. The clearing of primary forest is prohibited. Relevant measures shall be taken to prevent erosion. Excessive exploitation and depletion of water resources shall not be allowed. The certification programme shall require appropriate stocking rates which do not lead to land degradation and pollution of ground and surface water.

2.6.2 Food Processing and Handling - General Principles

Any handling and processing of organic products should be optimised to maintain the quality and integrity of the product and directed towards minimising the development of pests and diseases.
Recommendations

Processing and handling of organic products should be done separately in time or place from handling and processing of non-organic products. Pollution sources shall be identified and contamination avoided. Flavoring extracts shall be obtained from food (preferably organic) by means of physical processes.

Standards

Organic products shall be protected from co-mingling with non-organic products. All products shall be adequately identified through the whole process. The certification programme shall set standards to prevent and control pollutants and contaminants. Organic and non-organic products shall not be stored and transported together except when labelled or physically separated. Certification programme shall regulate the means and measures to be allowed or recommended for decontamination, cleaning-disinfection of all facilities where organic products are kept, handled, processed or stored.

2.6.2.1 Processing Methods-General Principles

Processing methods should be based on mechanized, physical and biological processes. The vital quality of an organic ingredient shall be maintained throughout each step of its processing.

Recommendations

Processing methods shall be chosen to limit the number and quantity of additives and processing aids.

Standards

The kinds of processes approved are: Mechanical and physical, biological, smoking extraction, precipitation, filtration.

Extraction shall only take place with water, ethanol, plant and animal oils, vinegar, carbon dioxide, nitrogen or carboxylic acids. These shall be of food grade quality,
appropriate for this purpose. Irradiation is not allowed. Filtration substances shall not be made of asbestos nor may be permeated with substances which may negatively affect the product.

2.6.2.2 Packaging- General Principles

The use of material for packaging shall be eco-friendly.

Recommendations

Unnecessary packaging materials should be avoided. Recycled and reusable systems shall be used wherever possible. Biodegradable packaging materials shall be used.

Standards

Material used for packaging shall not contaminate food. The certification programme shall have a policy to reduce the environmental effects of packaging material.

2.6.2.3 labelling-General Principles

Labelling shall convey clear and accurate information on the organic status of the product.

Recommendations

When the full standards requirements are fulfilled, products shall be sold as "produce of organic agriculture" or a similar description. The use of in-conversion labels may be confusing to the consumer and is not recommended. The name and address of the person or company legally responsible for the production or processing of the product shall be mentioned on the label.

Product labels should list processing procedures which influence the product properties in a way not immediately obvious. Additional product information shall be made available on request. All components of additives and processing aids shall be
declared. Ingredients or products derived from wild production shall be declared as such.

**Standards**

The person or company legally responsible for the production or processing of the product shall be identifiable. Single ingredient products may be labelled as "produce of organic agriculture" or a similar description when all standards requirements have been met. Mixed products where not all ingredients, including additives, are of organic origin may be labelled in the following way (raw material weight): Where a minimum of 95% of the ingredients are of certified organic origin, products may be labelled "certified organic" or similarly and should carry the logo of the certification programme. Where less than 95% but not less than 70% of the ingredients are of certified organic origin, products may not be called "organic". The word "organic" may be used on the principal display in statements like "made with organic ingredients" provided there is a clear statement of the proportion of the organic ingredients. An indication that the product is covered by the certification programme may be used, close to the indication of proportion of organic ingredients. Where less than 70% of the ingredients are of certified organic origin, the indication that an ingredient is organic may appear in the ingredients list. Such product may not be called "organic". Added water and salt shall not be included in the percentage calculations of organic ingredients. The label for conversion products shall be clearly distinguishable from the label for organic products. All raw materials of a multi-ingredient product shall be listed on the product label in order of their weight percentage. It shall be apparent which raw materials are of organic certified origin and which are not. All additives shall be listed with their full name. If herbs and/or spices constitute less than 2% of the total weight of the product, they may be listed as "spices" or "herbs" without stating the percentage. Organic products shall not be labeled as GE (Genetic Engineering) or GM (Genetic Modification) free in order to avoid potentially misleading claims about the end product. Any reference to genetic engineering on product labels shall be limited to the production method.
2.6.2.4 Storage & Transport-General Principles

Product integrity should be maintained during storage and transportation of organic products.

Recommendations

Organic Products must be protected at all times from co-mingling with non-organic products. Organic products must be protected at all times from contact with materials and substances not permitted for use in organic farming and handling.

Standards

Where only part of the unit is certified and other products are non-organic, the organic products should be stored and handled separately to maintain their identity. Bulk stores for organic product should be separate from conventional product stores and clearly labeled to that effect. Storage areas and transport containers for organic product should be cleaned using methods and materials permitted in organic production.
Integrated Nutrient Management

Structure:

3.0 Integrated Nutrient Management (INM)
3.1 Definition
3.2 Objectives
3.3 Integrated Plant Nutrient Supply System (IPNSS)
3.4 Issues for effective adoption of INM
3.5 Different Sources of INM
3.6 Cropping systems

3.0 Integrated Nutrient Management (INM)

3.1 Definition

Integrated nutrient management (INM) is the maintenance or adjustment of soil fertility and plant nutrient supply at an optimum level to sustain the desired crop productivity. Integrated nutrient management system is nothing but judicious use of both chemical fertilizers and organic manures during crop growth period. Integrated nutrient management (INM) also include the use of bio-fertilizers and legumes in crop production.

3.2 Objectives of Integrated Nutrient Management

- Increasing crop yield
- Increasing crop quality
- Increasing farm income
- Correction of inherent soil nutrient deficiencies
- Sustaining soil fertility
- Avoiding damage to the environment
- Restoring fertility and productivity of the land that has been degraded by exploitative practices of farming for food, feed, fiber, fuel and fodder production.

3.3 Concept of Integrated Plant Nutrient Supply System (IPNSS) or Integrated Nutrient Management (INM)

Crops remove nutrients from soil. However, the soil is not an eternal supplier of nutrients required for crops growing on it. There is always a need to supplement the nutrient supply to crops through external sources like fertilizers and manures. Continuous use of inorganic fertilizers might harm the soil though the nutrients are supplied in adequate amounts. Several types of organic manures are available, but they are not capable of supplying needed amounts of N, P and K and other nutrients to facilitate their application alone to meet the crop need. Application of organic manures has long term beneficial effects leading to improvement in soil conditions and making them favorable for sustainable agriculture. Excess usage of fertilizers also lead to loss of energy spent on their manufacture, besides leading to increase chemical loads in soil and water resources both surface and ground water,

Keeping in view the above-mentioned aspects, the integrated nutrient management has been put forward as a concept which aims at the maintenance and possibly increase the soil fertility for sustaining increased crop productivity through optimizing all possible sources (organic and inorganic) of plant nutrients required for crop growth and quality in an integrated manner appropriate to each cropping system and farming situation.

3.4 Issues for effective adoption of Integrated Nutrient Management

1. Composting of agricultural and industrial wastes should become part of agricultural activity. Steps have to be taken for mass production of composts with
available wastes in the area, train farm women on compost technologies of farm wastes including vermin-composting; arrange demonstration of IPNS technologies; preparation of neem coated urea; arrange for green manure seed production and supply; preparation of enriched farm yard manure; composting of coir pith, sugarcane trash, bio-composting industrial waste like press mud, municipal and village wastes both solid and liquid.

2. Green manure seed availability is the major problem in practicing green manuring. Establishment of green manure seed farms/seed villages and setting up minimum seed certification standards for green manure seed quality are recommended for improving and sustaining the soil health. Popularization of green manuring with Dhiancha, cowpea, kolonji, pillipesara etc., is recommended. However, rainfed farming situations are not suitable for practicing green manuring.

3. Use of bio-fertilizers is becoming an integral part of crop production. The increasing use of rhizobial cultures for legumes, algae and azolla for rice is well established. However, the extent of adoption is found to be less. There is need to increase the quality standards.

4. In Andhra Pradesh and Tamil Nadu different biofertilizer production centers are functioning with an annual production of each about 1200 metric tons in the Department of Agriculture. Tamil Nadu Agricultural University, ANGR Agricultural University and other private agencies are producing the bio-fertilizers which is not sufficient to meet the requirement.

5. The role of soil survey and land use organization of the department of agriculture would become very important and their services can be utilized for the effective manner. The activities of soil testing laboratories and soil survey and land use organization are to be linked to agricultural universities with a working monitoring system in meeting the requirements of sustainable crop production and land use in every state of the country.

6. Development of better extension linkages for educating the farmers for using integrated nutrient management technologies and encouragement for cattle
sheep penning especially in dry land tracts. Financial support may be given to raise herds during fallow season.

### 3.5 Sources of Integrated Nutrient Management

#### 3.5.1 Chemical fertilizers

Among the sources available, chemical fertilizers are favoured by many farmers as their effects on crop production are visible and spectacular. Before the commercial production of fertilizers was started, farmers were traditionally applying organic manures. Chemical fertilizers have taken their dominant position very quickly and the use of organic manures in crop production, at present is very much ignored or neglected. Fertilizers contain the nutrients in higher concentration with high consumption of energy and because of this reason, they are costly. Majority of the resource poor small and marginal farmers can hardly afford to spend more on such inputs. Besides, non-availability of raw materials locally is forcing the country to import some of them from others to meet the local demand. Further, continuous uses of chemical fertilizers create ill effects to the soil.

**3.5.1.1 The Use efficiency of Chemical fertilizers**

The use efficiency of fertilizer nutrients shows variation with soils, crops and irrigation. If the use efficiency of added fertilizers for different crops are considered, it is found to be very low with N and P. The average use efficiency of added fertilizer N is 20-30, 30-35, 20-35, and 30-35 per cent in rice, wheat, cotton and sugarcane crops, respectively. The per cent utilization of added P ranges from 15-25 by a single crop in a season. These low efficiencies indicate that the added fertilizer nutrient is not fully utilized by the crops and a major portion of it is lost either through different ways or made unavailable for crop use. Increasing the use efficiency of fertilizer nutrients has thus, became obligatory and ways to increase the use efficiency of them for sustainability in integrated nutrient management has the following advantages:

- Generates more crop per unit fertilizer applied
- Increases net returns from fertilizer use
- Lowers the cost of production per unit crop yield
- Minimizes the chemical load on the environment
- Enables the country to strengthen the fertilizer supplies in the event of their shortages or price escalation
- Ensures a wiser and long lasting use of non renewable resources
- Increases returns from investments in fertilizer research
- Results in conserving the energy and
- Makes higher productivity systems sustainable

3.5.2 Organic resources

Organic resources are biological in origin and they have several nutrients in their composition, which on decomposition are released into the soil. The applied organic resources not only increase soil fertility but also improve soil physical conditions, which help in proper growth of plants. Increasing water holding capacity, aeration, permeability, soil aggregation and nutrient holding capacity and decreasing bulk density and soil crusting are attributed to the continuous use of organic manures. In this way productivity of soils is improved and serves over a long period to sustain the crop yields.

Organic manures are of different origin and hence, exhibit wide variability in their nature and chemical composition. Apart from higher quantities of N, P and K, they also contain secondary and micro nutrients. All these nutrients are released into soil system when organic manures are applied to fields. The available estimates show that about 875 million tonnes of organic wastes are generated annually in our country. Out of which only 60 percent is actually available for agricultural purpose. Their usage for fuel purposes, thus, does not permit the full potential to be harnessed for crop production.

Several organic wastes are recycled through rural and urban composting. Crop wastes and residues are renewable and readily available but are usually applied to the field since composting can be done. Vermi-composting is gaining popularity during
recent years because it is environmental friendly and economic. Biogas plant spent slurry has 1.4 to 1.8%, N, 0.4-0.9% P and 0.6-1.0% K and it can be used effectively for crop production. The high moisture content (92-96 percent) make handling difficult.

3.5.3 Green Manures

Green manures are applied to the field without composting. The legume crop grown in situ is turned down into the soil when it is 40-60 days old, while green leaf manuring through application of lopping of trees and shrubs also serve the same purpose.

3.5.3.1 Benefits of Green Manuring

1. supplies organic matter, nitrogen and other nutrients to soil
2. enhances soil microbial activity
3. helps in weed suppression, soil and water conservation and management of pests as trap crops under some specific situations

3.5.4 Bio-fertilizers

The preparation containing specialized live microorganisms for seed treatment or soil application with objective of increasing the number of such microorganisms and accelerates the microbial process of converting unavailable form of plant nutrients to available form.

3.5.4.1 Classification of Bio-fertilizers

- Symbiotic Nitrogen Fixer
  Ex: Rhizobium; Azolla
- Asymbiotic nitrogen fixer
  Ex: Azotobacter; Blue Green Algae
- Associative nitrogen fixer
  Ex: Azospirillum
- Phosphorus mobilizers
  1. Phosphorus solubelizers
     Ex: Bacillus, Pseudomonas; Aspergillus
2. Phosphorus absorber
   Ex: VAM

- Organic matter decomposer
  Ex: Arthrobacter; Cellulomonas; Trichoderma

3.5.4.2 Benefits of bio-fertilizers

- Bio-fertilizers help in eco-friendly use of microorganisms and their sustenance
- Help in biological nitrogen fixation
- Can meet part of nitrogen demand needed by the plants in certain cropping situations,
- Increase the efficiency of chemical/mineral fertilizers and bring the nutrients to available form.
- Help in reducing environmental pollution
- Biofertilizers suppress incidence of pathogens in soil (biological control)
- Synthesize and release growth promoting substances
- Increase crop yield
- Biofertilizers are cheaper, eco-friendly, renewable source of plant nutrient supply system
- Biofertilizers form an important component of integrated nutrient management.

They contain actively living cells of bacteria, fungi and algae and serve as microbial inoculants which would participate in nitrogen fixation either by symbiotic or non symbiotic means and also helps in bringing the phosphate in soil from difficultly insoluble compounds to soluble form, besides mobilizing other nutrients like sulfur.

Among the bio fertilizers available, rhizobium inoculants are noteworthy. Leguminous crops fix atmospheric nitrogen through symbiotic association with rhizobium, which harbours in either root or stem nodules. The quantity of nitrogen fixed by these legumes due to inoculation with rhizobium varies with the host species. Rhizobium inoculants are host specific, maximum benefit can be derived only when the respective cross inoculation groups are considered. Azospirillum and Azotobacter are useful for improving production of crops other than legumes. These bio-fertilizers fix
nitrogen by non symbiotic means. In rice fields, use of Blue- Green Algae (BGA) is proving beneficial. Azolla, a water fern, which harbours Anabaena, appears to be promising in submerged soils as well as for crops when applied under dry conditions. The quantities of nitrogen made available by these microbial inoculants, on an average, ranges from 20 to 30 Kg N per hectare per year.

Other biofertilizers such as phosphobacteria and mycorrhizae (VAM) are useful for mobilizing P in soils for use by annual and perennial crops respectively. Certain crops like rice, maize, cotton, and legumes showed considerable influence with microbial fertilizers.

3.5.4.3 Crops showing responses to use of bio fertilizers

<table>
<thead>
<tr>
<th>Name of micro organism/biofertilizer</th>
<th>Crop plant which received benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Rhizobium</em> sp (living symbiotically in root nodules)</td>
<td>All grain legumes (pulses ) and some oil yielding legumes (groundnut, soybean) and fodder legumes (clovers)</td>
</tr>
<tr>
<td><em>Ostoc, anabaena, aulosira</em> and other (free living Blue Green Algae)</td>
<td>Rice</td>
</tr>
<tr>
<td><em>Anabaena-azolla</em> (living symbiotically in the water)</td>
<td>Rice</td>
</tr>
<tr>
<td><em>Azotobacter chroococcum</em> (free living bacterium)</td>
<td>Rice, maize, cotton</td>
</tr>
<tr>
<td><em>Frankia</em> spp. (actinomyctes) (Living symbiotically) in non legume root nodules)</td>
<td>Alnus, Casurina</td>
</tr>
<tr>
<td><em>Azospirillum</em> spp (associate symbiont) <em>Bacillus polymyz</em>, <em>Clostredium</em> spp, and <em>Rhodopsirillum</em> spp</td>
<td>Maize, sorghum pearl millet, figure millet</td>
</tr>
</tbody>
</table>

3.6 Cropping Systems

Integrated use of chemical fertilizers, organic manures and bio-fertilizers have shown definite increase in yield of crops, besides reducing the cost of production.
Available information also lay emphasis on certain practices for achieving higher fertilizer use efficiency, besides sustaining the yield of agricultural crops in different cropping and farming systems. The following practices need attention:

### 3.6.1 Multiple Cropping Systems

1. In soils having low fertility and in cropping systems having crops with high nutrient uptake, the recommended dose of fertilizers need to be applied to each crop.
2. When residual effects of applied fertilizers are not expected, the individual crops in the system must receive optimum doses of fertilizer nitrogen.
3. When legumes are grown, proper inoculation and application of phosphorus fertilizers makes them require low N and leave behind 20 to 50 kg N/ha for use by succeeding crop.
4. Organic manures should be applied during wet season for easy decomposition and release of nutrient elements contained in them.
5. The potassium loving crops grown in the sequence must receive adequate potassium dressing, while the legumes need adequate phosphorus dressing too.
6. In medium soil fertility conditions, phosphorus to be applied in dry season, while potassium application appears profitable to wet season crops.

### 3.6.2 Intercropping systems

1. When two or more crops are grown in the system, balance application of fertilizers is suggested. The intercrop does not need to be fertilized when water use efficiency is only aimed at.
2. If a crop is grown for green manuring purpose, small quantity of N may be applied to it. If maximum production from the crop is expected, all the crops must receive optimum of fertilizers.
3. In cereal-legume combination, N has to be applied to cereal crop only, while application of N to legume has to be 10-20 days in advance and earlier than the beginning of symbiotic nitrogen fixation.
4. Nitrogen application should be in higher quantities to the cereals than for cereal-legume combination.
Unit- 4

Integrated Pest Management

Structure:

4.0 Integrated Pest Management (IPM)
4.1 Definition of Integrated Pest Management (IPM)
4.2 Components of Organic Pest Management
4.3 Biotechnological Approaches

4.0 Integrated Pest Management (IPM)

4.1 Definition

Integrated Pest Management (IPM) is a system that, in the context of prevailing environment and population dynamics of the pest species, utilizes all appropriate techniques and methods in as compatible a manner as possible, and maintains pest populations at levels below those causing economic injury. FAO (1967).
4.2 Components of organic pest management

The following are the components of organic method of pest management.

1. Ecology based pest management and habitat diversification
2. Use of resistant varieties
3. Wide hybridization.
4. Physical methods of pest management.
5. Mechanical methods of pest management.
6. Use of plant products/botanicals
7. Use of insect pheromones (sex attractants as traps)
8. Biological control of pests
4.2.1 Ecology based pest management

Various eco-friendly methods of pest management can be integrated so as to avoid or reduce the use of chemical pesticides. The knowledge of interaction among plant, pest, natural enemies and environment is essential for effective pest management. When the balance of nature is disturbed by man made interventions, nature strikes back in the form of pest outbreaks. Some cases of severe pest outbreaks are as follows

a. Whiteflies in cotton
b. *Helicoverpa armigera* in cotton
c. Slug caterpillar in coconut
d. Eriophyid mite in coconut
e. In several crops, pest considered as minor became serious like gall midge, leaf folder in rice.

Moreover the pest status changes over years due to interaction of various biotic and abiotic factors. One has to thoroughly understand the reasons for outbreak of pests and their changing status and plan the management practices accordingly so as to prevent further outbreaks.

4.2.2 Habitat diversification

Habitat diversification makes the agricultural environment unfavourable for growth, multiplication and establishment of insect pest populations. The following are some approaches by which the pest population can be brought down.

4.2.2.1 Intercropping system

Intercropping system has been found favourable in reducing the pest population and damage caused by many insect pests due to one or more of the following reasons.

- Pest outbreak less in mixed stands due to crop diversity than in sole crop stands
- Availability of alternate prey
- Decreased colonization and reproduction in pests
- Chemical repellency, masking, feeding inhibition by odours from non-host plants.
The following table gives a few examples of intercropping system where reduction in damage level was noticed

**Effect of intercropping system on pest levels**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Crop</th>
<th>Pest reduced</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sole crop</td>
<td>Intercrop</td>
</tr>
<tr>
<td>1.</td>
<td>sorghum</td>
<td>red gram</td>
</tr>
<tr>
<td>2.</td>
<td>sorghum</td>
<td>cowpea</td>
</tr>
<tr>
<td>3.</td>
<td>pigeon pea</td>
<td>sorghum</td>
</tr>
<tr>
<td>4.</td>
<td>green gram</td>
<td>sorghum</td>
</tr>
<tr>
<td>5.</td>
<td>ground nut</td>
<td>sorghum</td>
</tr>
<tr>
<td>6.</td>
<td>pigeon pea</td>
<td>sorghum</td>
</tr>
<tr>
<td>7.</td>
<td>chickpea</td>
<td>wheat, mustard or safflower</td>
</tr>
<tr>
<td>8.</td>
<td>sugarcane</td>
<td>greengram, balckgram</td>
</tr>
</tbody>
</table>

**4.2.2.2 Trap cropping**

Crops that are grown to attract insects or other organisms like nematodes to protect target crops from pest attack. This is achieved by

- Either preventing the pests from reaching the crop or
- Concentrating them in a certain part of the field where they can be effectively destroyed/controlled.

**List of successful examples of trap crop**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Main Crop</th>
<th>Trap crop</th>
<th>Pests controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>tobacco/ cotton/ groundnut</td>
<td>castor</td>
<td>tobacco caterpillar</td>
</tr>
<tr>
<td>2.</td>
<td>maize</td>
<td>sorghum</td>
<td>Shootfly, Stem borer</td>
</tr>
<tr>
<td>3.</td>
<td>cotton</td>
<td>onion / garlic</td>
<td>Thrips in cotton</td>
</tr>
</tbody>
</table>
4.2.2.3 Fertilizer management

Plant growth is dependent on the nutritional status of the soil which in turn has indirect effect on pests. High levels of N fertilizer always favour insects and makes plants more susceptible to insect infestation (Rathore and Lal, 1994). On the other hand lower potassium supply favours the development of insect while optimum and high K has depressant effects (Dale, 1988).

Effect of host plant nutrition on insect pests

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Plant</th>
<th>Insect</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>rice</td>
<td>Thrips, green leaf hopper, Whorl maggot, Leaf folder</td>
<td>High K application reduces pest incidence</td>
</tr>
<tr>
<td>2</td>
<td>rice</td>
<td>Leaf folder, gall midge, BPH, Yellow stem borer, Whit Backed plant hopper</td>
<td>High N levels increases pest population and damage</td>
</tr>
<tr>
<td>3</td>
<td>wheat</td>
<td>Cutworm ((\text{Mythimna separata}))</td>
<td>Increased N increases incidence</td>
</tr>
<tr>
<td>4</td>
<td>sorghum</td>
<td>Shootfly</td>
<td>High P reduced incidence</td>
</tr>
<tr>
<td>5</td>
<td>cotton</td>
<td>Pink boll worm, leafhopper</td>
<td>High N increased incidence</td>
</tr>
<tr>
<td>6</td>
<td>chickpea</td>
<td>(\text{gram caterpillar})</td>
<td>N increased infestation while P and K reduced</td>
</tr>
</tbody>
</table>

4.2.2.4 Planting dates and crop duration

Planting dates should be so adjusted that the susceptible stage of crop synchronizes with the most inactive period or lowest pest population. The plantings should also be based on information about pest monitoring, as the data varies with location. Crop maturity also plays an important role in pest avoidance.

Role of planting dates on pest population and damage

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Host Plant</th>
<th>Insect</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>rice</td>
<td>leaf folder</td>
<td>Early planted rice (upto 3\textsuperscript{rd} week of June) suppressed population</td>
</tr>
<tr>
<td>2</td>
<td>rice</td>
<td>BPH (Brown Plant Hopper)</td>
<td>Planting in end of July in Kharif and Early in Rabi escapes attack in AP</td>
</tr>
</tbody>
</table>
3. rice  Gall midge  Lowest incidence if planted in August or October months
4. rice  Shootfly  Advancing sowing date (Sept - Oct) reduces the incidence
5. sorghum  Leaf hopper  Delayed sowing increases the incidence
6. cotton chickpea  Gram caterpillar/ American bollworm  For every 10 days delay in sowing, 4.02% increase in pod damage was observed
7. cotton  Whitefly  Incidence less if planted within July- Nov
8. tomato chillies  Thrips  Late planted crop severely affected by thrips and leaf curl virus

BPH: Brown Plant Hopper

4.2.2.5 Planting density

Plant nutrient status, interplant spacing, canopy structure etc., affect insect behavior in searching for food, shelter and oviposition site. It also affects population of natural enemies.

Effect of plant density on pest population

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Crop</th>
<th>Spacing/ density</th>
<th>Insect</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>rice</td>
<td>Dense planting</td>
<td>Leaf folder, BPH</td>
<td>High incidence</td>
</tr>
<tr>
<td>2.</td>
<td>chickpea</td>
<td>Dense plant population</td>
<td>-H .armigera</td>
<td>High incidence</td>
</tr>
<tr>
<td>3.</td>
<td>chickpea</td>
<td>Less plant population</td>
<td>Aphid</td>
<td>High incidence</td>
</tr>
<tr>
<td>4.</td>
<td>sugarcane</td>
<td>Higher seed rate</td>
<td>Top shoot borer</td>
<td>Low incidence</td>
</tr>
</tbody>
</table>

4.2.2.6 Destruction of alternate host plants

Many insects use a wide range of cultivated plants especially weeds as alternate hosts for off season carry-over of population. The density of weeds around the crop can alter the proportion of harmful and beneficial insects that are present, and increase or decrease crop damage.
Alternate hosts to be removed to reduce damage by pests

<table>
<thead>
<tr>
<th>S. No</th>
<th>Crop</th>
<th>Pest</th>
<th>Alternate host to be removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>groundnut</td>
<td>Thrips</td>
<td>Achyranthus aspera</td>
</tr>
<tr>
<td>2.</td>
<td>rice</td>
<td>Gallmidge</td>
<td>Wild rice (O.nivara)</td>
</tr>
<tr>
<td>3.</td>
<td>rice</td>
<td>GLH (Green leaf hopper)</td>
<td>Leersia hexandra</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Echinochloa colonum</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E.crusgalli</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C.dactylon</td>
</tr>
<tr>
<td>4.</td>
<td>rice</td>
<td>WBPH (White Backed Plant Hopper)</td>
<td>Chleres barbata</td>
</tr>
<tr>
<td>5.</td>
<td>sorghum</td>
<td>Earhead midge</td>
<td>Grassy weeds</td>
</tr>
</tbody>
</table>

Destruction of off types and volunteer plants, thinning and topping, pruning and defoliation and summer ploughing are other cultural methods to reduce pest load in field.

4.2.2.7 Water management

Availability of water in requisite amount at the appropriate time is crucial for proper growth of crop. Hence, water affects the associated insects by many ways such as nutritional quality and quantity, partitioning of nutrients between vegetative growth and reproduction etc.

Effect of irrigation on pest population / damage

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Crop</th>
<th>Insect</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>rice</td>
<td>Mealy bug</td>
<td>Continuous impounding of 5cm water reduced incidence</td>
</tr>
<tr>
<td>2.</td>
<td>rice</td>
<td>Caseworm and BPH</td>
<td>Draining of water to field capacity reduces incidence</td>
</tr>
<tr>
<td>3.</td>
<td>fruit tree nursery</td>
<td>Termite</td>
<td>Copious irrigation reduces incidence</td>
</tr>
<tr>
<td>4.</td>
<td>groundnut</td>
<td>Aphids</td>
<td>Copious irrigation increased incidence</td>
</tr>
</tbody>
</table>
4.2.2.8 Crop rotation

Sustainable systems of agricultural production are seen in areas where proper mixtures of crops and varieties. Crop rotations are adopted in a given agro-ecosystem. Monocultures and overlapping crop seasons are more prone to severe outbreak of pests and diseases. Growing rice after groundnut in garden land in puddled condition eliminates white grub.

4.2.2.9 Organic manure

Application of press mud in groundnut @ 12.5 t/ha had a better influence on leaf miner with a lower leaflet damage. It is reported that farm yard manure, azospirillum and phosphobacteria have no significant influence on the control of leaf hopper and fruit borer in bhendi. The incidence of leaf hopper in rice was low in azospirillum combined with farmyard manure. Application of organic manure lowered the rice gall midge incidence.

4.2.3 Use of pest resistant or tolerant varieties

Host plant resistance forms are an important component of non-chemical method of pest management. Several resistant varieties of crops have been evolved against major pests, through intensive breeding programmes. Development of varieties with multiple resistances is essential.

4.2.4 Wide hybridization

Wide hybridization refers to crossing a wild species with a cultivated species which helps in enriching the gene pool of domesticated crops and raising agricultural productivity. It also helps crops in adapting to stress environments, protects crop plants from pests and improves quality of food, feed and fibre. Wide hybrids of rice Oryza sativa with wild species viz., O.latifolia, O. offidnalis, O eichengeri and O. ridileyi have been produced to widen the gene pool of rice. Further research in this line in rice and other crops to transfer insect resistance genes to cultivated varieties is warranted.
In recent years with the application of biotechnological tools it is possible to transfer genes from species to another and even microbes to plants. Bt cotton involving transfer of genes from Bacillus thuringiensis to cotton and other crops is a classical example of wide hybridization to control pests.

4.2.5 Physical method of pest control

The following are some examples of the use of physical methods of insect control

- Use of activated clay at one per cent or vegetable oil at one per cent has been found to effectively control damage by *Callosobruchus chinensis* in stored pulses.
- Solar heat treatment of sorghum seeds for 60 seconds using solar drier kills rice weevil and red flour beetle without affecting germination of seeds.
- Biogas fumigation for 5 days period caused mortality of eggs, grubs, adults of pulse beetle *C.chinensis*
- Drying seeds (below 10% moisture level) prevents insect development.
- Cold storage of fruits and vegetables to kill fruit flies (1-2° C for 1 2-20 days)

4.2.6 Mechanical method of control

4.2.6.1 Mechanical destruction

- Hand picking of caterpillars
- Hooking of rhinoceros beetle adult with iron hook
- Sieving and winnowing for stored product insect control
- Shaking plants to dislodge caseworm in rice.

4.2.6.2 Mechanical exclusion

- Wrapping of fruits against pomegranate fruit borer
- Banding with grease - against mango mealy bug
- Trenching - for larvae of red hairy caterpillar
- Tin barrier - around coconut tree trunk to prevent rat damage
- Rat proof structure in storage godowns
4.2.6.3 Appliances based on mechanical control method

- **a)** Light trap - stem borer of rice
- **b)** Yellow sticky traps - for attracting aphids and jassids
- **c)** Bait trap - fish meal trap for sorghum shootfly
- **d)** methyl eugenol trap - for fruit flies
- **e)** Probe trap - for stored product insects
- **f)** Pheromone trap - for various adult insects
- **g)** TNAU automatic insect removal bin - for stored product insects

4.2.7 Use of botanicals in pest management

Grainge and Ahmed (1988) listed about 2400 plant species with pesticidal properties (insecticide, acaricide, nematicide, fungicide etc. which are distributed in 189 plant families). Neem oil at 2% and neem seed kernel extract (NSKE) at 5% with liquid soap 0.05% have been proven effective against major pests of rice, sucking pests of cotton and vegetables. Neem cake applied at 250 kg/ha at last ploughing before sowing has been found effective against cotton stem weevil and soil insects of many other crops.

Neem seeds contain more than 100 compounds among which azadirachtin has been found to be biologically most active. The biological effects of neem products are insect growth regulation, feeding deterrent and oviposition deterrent effect.

Commercial Neem formulations are available in market which contain varying levels of azadirachtin (from 0.03% to a maximum of 5%). In India more than 50 firms are manufacturing neem formulations which are available in different brand names. A few examples are given below

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Brand Name</th>
<th>Azadirachtin content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Nimbecidine</td>
<td>0.03%</td>
</tr>
<tr>
<td>2.</td>
<td>Neem guard</td>
<td>0.03%</td>
</tr>
<tr>
<td>3.</td>
<td>Bioneem</td>
<td>0.03%</td>
</tr>
<tr>
<td>4.</td>
<td>Jaineem</td>
<td>0.03%</td>
</tr>
<tr>
<td>5.</td>
<td>Neem gold</td>
<td>0.15%</td>
</tr>
</tbody>
</table>
In addition to Neem which belongs to Meliaceae, plants belonging to Annonaceae, Asteraceae, Fabaceae, Labiatae, Rutaceae and many other families have been found to possess insecticidal activity. Research in this field will provide valuable information that will help in managing insect pests with plant products.

### 4.2.8 Pheromones in Pest Management

Pheromones are chemical substances released by insects which attract other individuals of the same species. Sex pheromones have been used in pest management in the following ways:

- Monitoring
- Mating disruption
- Mass trapping

These methods can be successfully included in organic method of pest management.

**Commercially available sex pheromones for insects**

<table>
<thead>
<tr>
<th>SI. No.</th>
<th>Common Name</th>
<th>Scientific name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>American bollworm</td>
<td><em>Helicoverpa armigera</em></td>
</tr>
<tr>
<td>2</td>
<td>Pink bollworm</td>
<td><em>Pectinophora gossypiella</em></td>
</tr>
<tr>
<td>3</td>
<td>Spotted bollworm</td>
<td><em>Earias vitella</em></td>
</tr>
<tr>
<td>4</td>
<td>Spiny bollworm</td>
<td><em>Earias insulana</em></td>
</tr>
<tr>
<td>5</td>
<td>Tobacco cutworm</td>
<td><em>Spodoptera litura</em></td>
</tr>
<tr>
<td>6</td>
<td>Early shoot borer of sugarcane</td>
<td><em>Chilo infuscatus</em></td>
</tr>
<tr>
<td>7</td>
<td>Yellow stem borer of rice</td>
<td><em>Scirpophaga incertulas</em></td>
</tr>
<tr>
<td>8</td>
<td>Diamond back moth</td>
<td><em>Plutella xylostella</em></td>
</tr>
<tr>
<td>9</td>
<td>Mango fruit fly</td>
<td><em>Bactrocera dorsalis</em></td>
</tr>
<tr>
<td>10</td>
<td>Melon fruitfly</td>
<td><em>Bactrocera cucurbitae</em></td>
</tr>
</tbody>
</table>
Aggregation pheromones of red palm weevil and rhinocerous beetle of coconut are also available in market. Different types of pheromone traps such as sleeve type trap, delta and sticky traps are also manufactured and sold by different firms. In addition to the above, many new pheromones of field and storage pests are being manufactured by commercial firms.

4.2.9 Biological control

Management of pests and disease causing agents utilizing parasitoids, predators and microbial agents like viruses, bacteria and fungi is termed as biological control. It is an important component of IPM.

The three important approaches in biological control are

a. Importation: Importation is also called classical method of biological control where bio-control agents are imported to control a pest of exotic origin.

b. Conservation: This is a method of manipulating the environment to protect the bio-control agents.

c. Augmentation: Augmentation aims at mass production of natural enemies / microbial agents and field release. Genetic improvement of bio-control agents to have superior traits also comes under this category.

The ICAR and State Agricultural Universities play an important role in identifying potential bio-control agents. The commercial bio-control laboratories mass produce the agents and distribute among the farmers.

Bio-control agents commercially produced

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Bio control agents</th>
<th>Pests managed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Egg parasitoids</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td><em>Trichogramma</em> sp.</td>
<td>Borers, bollworms</td>
</tr>
<tr>
<td>2.</td>
<td><em>Telenomus remus</em></td>
<td><em>Spodoptera litura</em></td>
</tr>
<tr>
<td></td>
<td><strong>Egg larval parasitoid</strong></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td><em>Chelonis blackburnii</em></td>
<td>Cotton bollworms</td>
</tr>
<tr>
<td></td>
<td><strong>Larval parasitoids</strong></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td><em>Bracon brevicornis</em></td>
<td>Coconut black headed caterpillar</td>
</tr>
<tr>
<td>5.</td>
<td><em>Gonozus nepanthidis</em></td>
<td>Coconut black headed caterpillar</td>
</tr>
<tr>
<td>Sl.No.</td>
<td>Bio control agents</td>
<td>Pests managed</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>6.</td>
<td>Elamus nephanthidis</td>
<td>Coconut black headed caterpillar</td>
</tr>
<tr>
<td>7.</td>
<td>Bracon kirkpatriki</td>
<td>Cotton bollworms</td>
</tr>
<tr>
<td>8.</td>
<td>B.hebetor</td>
<td>Cotton bollworms</td>
</tr>
<tr>
<td></td>
<td><strong>Pupal parasitoids</strong></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Brachymeria sp.</td>
<td>Coconut black headed caterpillar</td>
</tr>
<tr>
<td>10.</td>
<td>Tetrastychus Israeli</td>
<td>Coconut black headed caterpillar</td>
</tr>
<tr>
<td>11.</td>
<td>Trichospilus pupivora</td>
<td>Coconut black headed caterpillar</td>
</tr>
<tr>
<td></td>
<td><strong>II. Predators</strong></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Chrysoperla cornea (Green lacewing)</td>
<td>Soft bodied homopteran insects</td>
</tr>
<tr>
<td></td>
<td>Chrptolemus montrouzieri (Australian lady bird beetle)</td>
<td>Mealy bugs</td>
</tr>
<tr>
<td></td>
<td><strong>III Insect Pathogens</strong></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>NPV of Helicoverpa armigera (Virus)</td>
<td>H. armigera (gram caterpillar/American bollom</td>
</tr>
<tr>
<td>14.</td>
<td>NPV of S.litura (Virus)</td>
<td>S.litura</td>
</tr>
<tr>
<td>15.</td>
<td>Bacillus thuringiensis (Bacteria)</td>
<td>Lepidopteran insects</td>
</tr>
<tr>
<td>16.</td>
<td>Beauveria bassiana (Fungus)</td>
<td>Many insect pests</td>
</tr>
<tr>
<td></td>
<td><strong>IV. Fungal Antagonists</strong></td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td>Trichoderma viride</td>
<td>Root rot and wilt causing fungi</td>
</tr>
<tr>
<td>18.</td>
<td>Trichoderma harzianum</td>
<td>Rhizoctonia solani, Macrophomina phaseolina, Fusarium sp.) in pulses, cotton, oilseeds, vegetables</td>
</tr>
<tr>
<td>19.</td>
<td>Pseudomonas fluorescencs V. Weed killers</td>
<td>Root rot causing fungi in various crops</td>
</tr>
<tr>
<td>20.</td>
<td>Neochetina bruchi and Neochetina eichhornae (beetles)</td>
<td>Water hyacinth (Aquatic weed)</td>
</tr>
<tr>
<td>21.</td>
<td>Zygogramma bicolorata (beetle)</td>
<td>Parthenium weed</td>
</tr>
</tbody>
</table>

Even though many commercial bio-control laboratories are involved in production of these agents, they are hardly sufficient to cover less than one percent of the total cultivated area. Hence there is a vast scope for improvement.

Crop-wise pest management practices using bio-agents/ botanicals
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Crop</th>
<th>Pest</th>
<th>Bio-agent &amp; Bio-pesticides</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>rice</td>
<td>Stem borer</td>
<td>Trichogramma <em>japonicum</em> 5 cc/ha/release on 30 and 37 DAT</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Leaf folder</td>
<td><em>T. chilonis</em> 5 cc/ha/release on 58, 65 and 72 DAT, Neem seed kernel extract 5% spray</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Gall midge</td>
<td><em>Platygaster oryzae</em> 1 parasitised gall/ 10 m²</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Earhead bug</td>
<td>Neem seed kernel powder, Notchi leaf powder, Prosofis leaf powder</td>
</tr>
<tr>
<td>5</td>
<td>sorghum</td>
<td><em>H. armigera</em></td>
<td>HNPV spray at 1.5 x 10¹² POB/ha</td>
</tr>
<tr>
<td>6</td>
<td>pulses</td>
<td><em>H. armigera</em></td>
<td>HNPV spray at 1.5 x 10¹² POB/ha, NSKE 5% spray <em>Bacillus thurengiensis</em> @ 2.0 g/L of water</td>
</tr>
<tr>
<td>7</td>
<td>groundnut</td>
<td><em>S. litura</em></td>
<td>SNPV spray at 1.5 x 10¹² POB/ha</td>
</tr>
<tr>
<td>8</td>
<td>gingelly</td>
<td>Shoot webber</td>
<td>NSKE 5% spray</td>
</tr>
<tr>
<td>9</td>
<td>coconut</td>
<td>Rhinoceros beetle</td>
<td><em>Metarhizium anisopliae</em> fungus incorporated in manure pits, <em>Oryctes baculovirus</em> infected adults may be released, Neem seed kernel powder + sand (1:1) in whoral</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Black headed caterpillar</td>
<td>Release of <em>Goniozus nephanfidis</em> 3000 adults/ ha under the coconut tree Release braconid, betylid, eulophid and ichneumonid parasitoids from January.</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>Termites</td>
<td>Neem oil 5% spray upto 2m height of trunk</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>Mealybugs</td>
<td>Neem oil 3% spray on leaves</td>
</tr>
<tr>
<td>13</td>
<td>cotton</td>
<td><em>S. litura</em></td>
<td>SNPV spray at 1.5 x 10¹² POB/ha</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td><em>H. armigera</em></td>
<td>H. NPV spray at 3.0 x 10¹² POB/ha at 7 and 12th week after sowing <em>Trichogramma</em> spp. egg parasitoid @ 6.25cc chelonus thrice at 15 days interval from 45 DAS <em>Chelonis blackbuni</em> (egg larval parasitoid) and <em>Chrysoperla</em> (predator) @ 1 ,00,000 /ha at 6, 13 and 14th week after sowing</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Crop</td>
<td>Pest</td>
<td>Bio-agent &amp; Bio-pesticides</td>
</tr>
<tr>
<td>--------</td>
<td>---------------</td>
<td>-----------------------</td>
<td>------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>15</td>
<td>Sugar cane</td>
<td>Early shoot borer</td>
<td>Release 1, 25 gravid female of <em>Sturmiopsis inferens</em>, Granulosis virus on 25 and 50 DAP @1x10^8 OB/ml in 0.01% Teepal solution</td>
</tr>
<tr>
<td>16</td>
<td>Sugarcane</td>
<td>Internode borer</td>
<td><em>T. chilonis</em> egg parasitoid 2.5 cc/release, 6 releases at fortnightly interval from 4th month</td>
</tr>
<tr>
<td>17</td>
<td>Tobacco</td>
<td>S. litura</td>
<td>SNPV spray at 1.5 x 10^{12} POB/ha NSKE 5% spray</td>
</tr>
<tr>
<td>18</td>
<td>Citrus</td>
<td>Leafminer</td>
<td>NSKE 5% spray</td>
</tr>
<tr>
<td>19</td>
<td>Grapes</td>
<td>Mealybug</td>
<td><em>Cryptolaemus monfrouzieri</em> (beetles) 1 per vine Fish oil rosine soap 25g/lit</td>
</tr>
<tr>
<td>20</td>
<td>Sapota</td>
<td>Budworm</td>
<td>NSKE 5% spray</td>
</tr>
<tr>
<td>21</td>
<td>Tomato</td>
<td><em>S. litura</em> and <em>H. armigera</em> (Fruit borers)</td>
<td>SNPV and HNPV at 1.5 x 10^{12} POB/ha B.t. 2 g/lit <em>T. chilonis</em> 50000/ha/release</td>
</tr>
<tr>
<td>22</td>
<td>Brinjal</td>
<td>Shoot and fruit borer</td>
<td>NSKE 5% spray</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Chrysoperla</em> cornea 1st instar larva 10,000 /ha</td>
</tr>
<tr>
<td>23</td>
<td>Bhendi</td>
<td>Fruit borer</td>
<td><em>Trichogramma</em> 1,00,000 /ha <em>Chrysoperla</em> cornea 1st instar larva 10,000 /ha B.t. 2 g/lit</td>
</tr>
<tr>
<td>24</td>
<td>Chillies</td>
<td><em>S. litura</em> and <em>H. armigera</em> (Fruit borers)</td>
<td>SNPV and HNPV at 1.5 x 10^{12} POB/ha B.t. 2 g/lit <em>chilonis</em> 50000/ha/release</td>
</tr>
<tr>
<td>25</td>
<td>Cabbage, Cauliflower</td>
<td>Diamond back moth</td>
<td>B.t. 2 g/lit, NSKE 5%, <em>Diadegma semiclausum</em> (parasitoid) 50,000/ha</td>
</tr>
</tbody>
</table>
4.3 Biotechnological Approaches

Biotechnology has provided new avenues for management of insect pests and it holds great potential to be included in IPM system.

- The low toxicity of proteinase inhibitors and Bt d-endotoxin as compared to conventional insecticides would reduce the selection pressure and may slow down the development of resistance.
- Since all plant parts including growing points would remain covered with toxins, dependence on weather for efficacy of the sprays would be eliminated.
- Since toxins will always be there, so there will be no need of continuous monitoring of pests.
- Transgenic plant would also provide protection to "those plant parts which are difficult to be treated with pesticides. Thus, transgenics may prove useful for controlling bollworms and borers which are difficult to control by means of insecticides. The cost of application in the form of equipment and labour will be nil or negative.
- The development cost is only fraction of the cost of development of a conventional pesticides.
- There would be no problem of contamination in the form of drift and groundwater contamination.
- Insecticidal activity would be restricted to those insects which actually attack the plants. Transgenic plants would be safe to non-target species and human beings.

Transgenic plants will have inbuilt resistance to various insects replacing some of the current pesticide usage with protection which is intrinsically biodegradable, thus reducing the use of chemical insecticides and minimizing the problem of environmental pollution.
Unit 5

Irrigation and Rain Water Management

Structure:

5.0 Irrigation and Rain water Management
5.1 Definition of Irrigation and Irrigation water management
5.2 Objectives
5.3 Scheduling of Irrigation
5.4 Quality of irrigation Water
5.5 Practices for Crop Production under conditions of soil or water salinity
5.6 Water Logging
5.7 Water harvesting and different techniques

5.0 Irrigation Water Management

5.1 Definition

Irrigation is defined as artificial application of water for the purpose of supplying moisture essential to plant growth

Irrigation can also be defined as the supply of water to crops by artificial means, designed to permit farming in arid regions and to offset drought in semiarid and semi humid regions.

Irrigation water management can be defined as the integrated process of intake, conveyance, regulation, measurement, distribution, application and use of irrigation water to farms and drainage of excess water, with proper amounts and at right time for
the purpose of increasing crop production and water economy in conjunction with improved agricultural practices.

### 5.2 Objectives

- To add water to the soil for supplying the moisture essential for plant growth
- To provide protection to crops against short duration droughts
- To cool the soil and atmosphere, thereby making more favourable environment for plant growth
- To wash out or dilute salts in the soil, and
- To soften tillage pans

### 5.3 Scheduling of Irrigation

Irrigation scheduling is the process of determining 1). When to irrigate and 2). How much water to apply. Time of irrigation is usually governed by two major conditions, namely, water need of crops and availability of irrigation water. Water need of crops is, however the prime consideration to decide the time of irrigation.

#### 5.3.1 Water Needs of Crop

Crop plants require water to meet the transpiration loss, build up body tissue and to carry on biochemical and physiological activities within the body. Transpiration, which is considered as a vital physiological activity of plants, occurs continuously as long as the water supply is maintained. Also, a continuous evaporation occurs from the moist soil surface in crop field. After irrigation, the evapotranspiration begins to peak drawing water from the moist soil below and continues till there is available water in soil. This causes a continuous decline in soil water content. Rate of evapotranspiration decreases continuously sometime after completion of irrigation, with reduction in available soil water below the field capacity. A stage is reached within a few days after irrigation when the rate at which soil water is available for extraction by crop plants becomes equal to the normal consumptive use rate. This stage of soil water is considered as the lowest point of the optimum soil water regime. The optimum soil water regime
means the range of available soil water in which plants do not suffer from water stress and all the plant activities occur at an optimal rate. Field capacity is the uppermost limit of optimum soil water regime of crops other than rice.

A soil water deficit below optimum soil water regime causes water stress in plants causing decline in growth and yield, as the rate of availability of soil water falls short of the normal crop consumptive use rate. Irrigation is, therefore, needed when this lowest limit optimum water regime is reached and it is considered as the most opportune time for irrigation.

The stage of available soil water below which water stress begins to cause a serious fall in crop growth and subsequently the yield is termed as the critical level of soil water for crop plants. This level of available soil water coincides with the lowest level of optimum available soil water regime.

5.3.2 Critical Stages of Water Need of Crops

During the life cycle of a crop plant, there are some crucial stages in the life cycle of a crop plant when the plant is badly in need of water. Denial of water or allowing water stress beyond a certain limit during these stages causes a definite set back to growth processes and the yield is adversely affected. These stages are referred to as the critical stages of water requirement. These stages do not usually coincide with the periods of peak consumptive use by crops. It will not be correct to consider that crops at these critical stages require more water. Critical stages of water requirement are usually the turning points in plant life cycle. Crop demands adequate water at these stages and cannot afford to withstand water stress without serious reduction in growth and yield.

When crop plants are young and delicate, they are not able to withstand water stress and demand a proper supply of water. Again, with the start of grand growth period, crop puts up a faster rate of vegetative growth and transpiration and biochemical activities in plants occur at a higher rate. This leads to tremendous increase in water need of the crop and the supply of water should be adequate to maintain the normal rate of active growth and evapotranspiration. Water stress at the sensitive stages
causes a serious retardation in crop growth process that ultimately depresses the yield. The sensitive stages differ from one crop to the other. Water stress at these stages causes lower tillering, branching, pegging, tuber bulking, inadequate flowering and in extreme case, flower drops, poor setting of grains or fruits, bad filling of grains or serious fruit drops depending on the type of crops.

In areas where water is scarce, farmers are not able to apply normal irrigation to crops and are forced to skip some irrigation. It is therefore necessary that one decides a priority of stages of crops when irrigations are to be given and the stages when one can afford to miss irrigation. The critical stages of water need of crops receive the foremost attention. A preferential status of crop stages according to their relative importance to yield should be considered for irrigation in areas of water scarcity.

**Critical stages of crop growth for irrigation**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Critical Stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>rice</td>
<td>Panicle initiation, flowering.</td>
</tr>
<tr>
<td>wheat</td>
<td>Crown root initiation, shooting, earing.</td>
</tr>
<tr>
<td>sorghum</td>
<td>Booting, flowering, milky and dough stage.</td>
</tr>
<tr>
<td>maize</td>
<td>Tasseling, silking stages to early grain formation.</td>
</tr>
<tr>
<td>pearl millet</td>
<td>Heading and flowering.</td>
</tr>
<tr>
<td>finger millet</td>
<td>Panicle initiation, flowering.</td>
</tr>
<tr>
<td>groundnut</td>
<td>Flowering, Peg penetration, Seed development.</td>
</tr>
<tr>
<td>sunflower</td>
<td>Two weeks before flowering to two weeks after flowering.</td>
</tr>
<tr>
<td>cotton</td>
<td>Flowering and boll development.</td>
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<tr>
<td>chillies</td>
<td>Flowering.</td>
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<tr>
<td>sugarcane</td>
<td>Formative stage</td>
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<tr>
<td>pulses</td>
<td>Flowering and pod formation.</td>
</tr>
<tr>
<td>soybean</td>
<td>Blooming and seed formation</td>
</tr>
<tr>
<td>tobacco</td>
<td>Immediately after transplanting and knee stage.</td>
</tr>
<tr>
<td>citrus</td>
<td>Fruit setting and enlargement stage.</td>
</tr>
<tr>
<td>banana</td>
<td>Early vegetative period, flowering and yield formation.</td>
</tr>
<tr>
<td>tomato</td>
<td>From the commencement of fruit set.</td>
</tr>
<tr>
<td>potato</td>
<td>Tuber initiation to tuber maturity.</td>
</tr>
<tr>
<td>cabbage</td>
<td>Head formation until become firm.</td>
</tr>
<tr>
<td>carrot</td>
<td>Root enlargement.</td>
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</tbody>
</table>
5.3.3 Plant Criteria for Scheduling Irrigation

Plants show up certain characteristic changes in their constitution, appearance and growth behaviour with changes in available soil water and atmospheric conditions. These changes in plants are often valuable pointers to the time of irrigation. The different plant criteria considered to schedule irrigation are

- Plant appearance
- Plant water potential and water content
- Plant growth
- Critical crop stages of water need
- Indicator plant
- Stomatal aperture

5.3.3.1 Plant appearance

With water stress, some characteristic changes usually occur in the general appearance of plants. There may be changes in the normal colour of plant or distortions of plants such as wilting or drooping of plants and curling or rolling of leaves. Some crops are very sensitive to soil-water changes and develop water deficit symptoms easily, while others do not.

5.3.3.2 Plant water potential and water content

Some crops such as sugarcane show strong correlation between the water content of leaf or leaf sheath and the available soil water. Water content of sugarcane leaf sheaths decreases with decrease in available soil water and this has been taken advantage in determining the time of irrigation in sugarcane in Hawaii. The Relative Leaf Water Content (RLWC) and leaf water potential change with variations in soil water availability or owing to lag between water absorption by plants and evaporative demand of the atmosphere.
5.3.3.3 Plant growth

Cell elongation is considered as the growth process that suffers first with water stress in plant. Subsequently, retardation in growth of height or internodes length occurs. Timing of irrigation can be set as and when the normal growth rate is observed to decline. This is, however, possible in places where continuous measurement of plant growth is maintained as is done in sugarcane in Hawaii.

5.3.3.4 Critical crop stages of water need

Irrigation scheduling may be decided based on stages of growth more conveniently in crops in which the physiological stages are distinct to locate the critical periods of water need. The crown root initiation, tillering, flowering, milk and dough stages in wheat; branching, flowering and pod development stages in mustard; pegging, pod setting and pod development stages in groundnut; and tasselling, silking and grain filling stages in maize are very specific and can be easily identified by a farmer for scheduling irrigation. However, it may be a little difficult in crops where critical stages are not so well defined.

5.3.3.5 Indicator plant

There are some plants sensitive to soil water variations. They may be used for detecting the water stress in crops that do not show symptoms of water stress easily or exhibit the same when they have already suffered seriously. Sunflower plants are often used as in indicator plants in onion crop. An indicator plant for irrigation should be such that it shows the water stress before the crop has suffered from it. When an indicator plant is grown in a crop field, care should be taken not to shade the plant by crop plants.

5.3.3.6 Stomatal aperture

Opening of stomata in plants is regulated by soil water availability. Stomata remain fully open when the supply of water is adequate, whereas they start closing with scarcity of soil water to restrict the transpiration. The stomatal aperture is an indicator of
water deficit in plants because it influences both photosynthesis and transpiration by its effect on carbon dioxide and water vapour transport. Water deficit in plants is directly related to availability of soil water and that may be used for scheduling irrigation in crops.

5.4 Quality of Irrigation Water

5.4.1 Criteria and their Limits

In irrigated agriculture, the quality of water used for irrigation should receive adequate attention. Irrigation water, regardless of its source, always contains some soluble salts in it. Apart from the total concentration of the dissolved salts, the concentration of some of the individual salts, and especially of those which are most harmful to crops, is important in determining the suitability of water for irrigation. The constituents usually determined by analyzing irrigation water are the electrical conductivity for the total dissolved salts, soluble sodium percentage, sodium absorption ratio, the boron content, pH, cations such as calcium, magnesium, sodium, potassium, and anions, such as carbonates, bicarbonates, sulfates, chlorides and nitrates.

5.4.2 Quality of Water from Different Sources

Water from the rivers which flows over salt-affected areas or in the deltaic regions has a greater concentration of salts, sometimes as high as 7,500 ppm or even more. The quality of tank or lake water depends mainly on the soil salinity in the watershed areas and the aridity of the place. The quality of water from ground-water resources, i.e. from shallow or deep wells, is generally poor under the situation of

(i) High aridity - arid and semi-arid regions, with less than 45 cm of rainfall; high water-table and water-logged condition; and

(ii) The vicinity of sea-water, as in the coastal region.

Ground water in other areas is generally good. In saline regions, where the water from shallow aquifers is poor, the water from deeper strata may be good. Such water may be tapped by digging deep tube wells.
5.4.3 Salinity and sodium-hazard classes of irrigation water

<table>
<thead>
<tr>
<th>Salinity class</th>
<th>Electrical conductivity micro mhos/cm at 25°C</th>
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<tbody>
<tr>
<td>C1, Low</td>
<td>Less than 250</td>
</tr>
<tr>
<td>C2 Moderate</td>
<td>250 to 750</td>
</tr>
<tr>
<td>C3 Medium to high</td>
<td>750 to 2,250</td>
</tr>
<tr>
<td>C4 High</td>
<td>2,250</td>
</tr>
<tr>
<td>C5 Very high</td>
<td>5,000 to 20,000</td>
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</table>

<table>
<thead>
<tr>
<th>Sodium class</th>
<th>SAR</th>
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<tbody>
<tr>
<td>S1, Low</td>
<td>Less than 10</td>
</tr>
<tr>
<td>S2 Moderate</td>
<td>10 to 15</td>
</tr>
<tr>
<td>S3 High</td>
<td>15 to 26</td>
</tr>
<tr>
<td>S4 Very high</td>
<td>More than 26</td>
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</tbody>
</table>

Gypsum, which is available commercially, can be applied to the soil or mixed with water where poor-quality water, containing high concentration of sodium salts, is used for irrigation. The permeability of soils can be improved by incorporating organic matter into them to facilitate the leaching down of the salts beyond the root zone.

5.5 Practices for Crop Production under Conditions of Soil or Water Salinity

5.5.1 Choice of Crops and Varieties

A crop or a variety which is more tolerant to salt should be selected for growing under the cropping pattern adopted. Crops have been broadly grouped according to their salt-tolerance limits as follows. Tolerant species (over 5,000 ppm salts): Barley, Sugar-beet, date-palm, grape, cotton, rhodes grass, sesbania. semi-tolerant species (2,500 to 5,000 ppm salts): rice, sorghum, maize, barley, sunflower, lucerne, berseem, guar, safflower, onion, spinach, lettuce, carrot, cluster-been, wheat, pearl-millet or bajra, grasses. Sensitive species (below 2,500 ppm salts): Peas, cabbage, beans, gram, peaches, grapes, orange, grapefruit, potato, tomato.
The limits of relative tolerance of crops to boron are as under:

Tolerant species (2 to 4 ppm): Date-palm, cotton, lucerne, onion, turnip, cabbage, carrot and lettuce. Semi-tolerant species (1 to 2 ppm): Wheat, maize, barley, cotton, sunflower, potato, tomato, peas, beans and sweet potato. Sensitive species (0.3 to 1.0 ppm): Apple, apricot, grape, orange, grapefruit, plum, pear, cherry and walnut.

5.5.2 Other Cultural Practices to Ameliorate the Poor Quality of Water

Seed emergence from the soil, the seedling phase and flowering are three very critical stages in the growth of most of the field crops in the presence of salinity. Frequent irrigations are essential for maintaining low moisture stress and to leach down the salts.

Row crops should be grown near the furrow bottom where salt concentration is low. The plant population should also be enhanced by increasing the seed-rate and by reducing the spacing to compensate for the poor performance of individual plants.

Water, if only saline can be used by diluting it with good quality water. If it is a sodic soil, there will be a permeability problem. It is necessary to replace the sodium with calcium by applying suitable amendments and organic matter for allowing more water to penetrate the soil, so that salts can be easily leached down beyond the root-zone. Adequate arrangements for drainage should be made to lower the water-table and to maintain a satisfactory salt balance in the root-zone. Fertilizer releasing nitrogen slowly with a calcium base may be preferred and applied in split doses by placement.

5.6 Water Logging

5.6.1 Causes of water logging and development of high water table

Water logging is caused in a location when the inflow of water into it exceeds the outflow resulting in progressive rise of water table. The inflow may be due to excessive and high intensity rainfall, seepage from canals, reservoirs, and flood and over-irrigation. The outflow declines with impaired drainage, lack of adequate drainage, rise of water owing to construction of reservoirs, rise in water level in rivers.
5.6.2 Signs of Bad Drainage

There may be a number of indications by which a land can be identified as badly drained land. They are:

• Soil is very soft and wet. It sticks to farm implements and tools and feet of animals and farm labourers.
• Occurrence of spots or pools of free water. These may be few or many, big or small.
• Presence of good growth of bright green grasses or weeds in some places.
• Animals avoid resting on the ground where they are grazing, because of land being cold, particularly in winter. Free water may be flowing out of the field from sides of ditches or over the soil surface.
• Aquatic and water loving plants are seen growing
• Plants look usually yellowish or pale colour and unhealthy and are stunted in growth.
• When crops are sown, seedlings grow slowly. Many seeds may not germinate as there is excess water in the soil.

5.6.3 Harmful Effects

Water logging condition and presence of excess water in soil have various harmful effects on crops, soils and farm animals. There will be impaired soil aeration, imbalance in nutrient uptake, physiological imbalance in plants, restricted root system, toxicity of nutrients, loss of soil fertility, soil erosion, destruction of beneficial soil structure and soil aggregates, production of harmful gases, and activities of micro-organisms.

5.6.4 Benefits of Drainage

Drainage provides favorable soil and land conditions for optimum plant growth and productivity. The first and foremost benefit is the aeration of soil, which is essential for plants to carry on various vital activities. Root growth, availability of nutrients and their uptake, escape of carbon dioxide and other harmful gases produced in the soil, optimal activity of useful bacteria takes place properly.
5.7 Water Harvesting and different techniques

5.7.1 Definition and benefits

"Water harvesting" is the general name used for all the different techniques to collect runoff or flood water for storage in the soil profile or in tanks so that it can be used for the production of crops, trees or fodder. "Water harvesting" also can be the collection of runoff water for human or livestock consumption. The benefit of water harvesting is not only to secure and increase crop production in semi-arid regions where rainfall is normally high enough for crop production or to make crop production possible in regions were rainfall is normally not sufficient, but also to stop soil erosion and to recharge aquifers tapped for irrigation. An underestimated benefit of water harvesting is also the improvement of soil fertility. Silt, manure and other organic matter is "harvested" together with the water.

5.7.2 Classification of water harvesting Systems

The different water harvesting systems can be classified in the following ways. A Systems with an external catchment area for collection of runoff water or flood water from small watersheds:

A1 - agricultural use, without any special arrangements, of natural depressions where runoff or flood water is concentrated temporary and water infiltration is relative high

A2 - simple techniques for water spreading and infiltration by means of low, permeable bunds (ridges) which follow the contour lines. These bunds are made of stones, bundled sticks, crop residues or fences of living plants

A3 - "water pockets" - holes for seeding, runoff collection and management of organic matter

A4 - half circular or "V" shaped ridges mainly used for tree planting and rangeland improvement,
A5 - "Water collection", graded bunds or furrows are used for diverting runoff from agricultural fields, village and waste lands to tanks situated at a lower level. This water is used for supplementary irrigation in dry periods or as full irrigation

A6 - "Runoff farming", runoff water from a treated (e.g. by a chemical spray or the clearing of gravel-stones to improve the formation of a surface crust to increase the runoff) or untreated catchment area is diverted to lower situated agricultural fields

A7 - "Runoff farming", runoff water and silt from small watersheds is captured by dams in seasonal stream beds or is diverted to agricultural fields. In front of these dams the silt builds terraces which are used for agriculture. The infiltrated water makes crop production possible

- B - Systems for storage and agricultural use of flood waters
- B 1 - "Flood water farming": these traditional systems make use of the runoff concentrated by natural watersheds in seasonal or permanent river systems. The flood water is diverted from its natural channel by dams or barrages and led to the agricultural fields where the water is kept impounded by earthen dams around the fields. The infiltrated water is used for agriculture
- C - Systems with a -within-field- catchment area called -in-situ- water harvesting or -micro catchments-:
  - C 1 - runoff from a small plot (micro- or within catchment) is captured at one side where it infiltrates the soil and directly contributes to the available moisture in the rooted profile of an individual productive tree or shrub
  - C2 - "contour ridges or bunds", the same system as C1 but instead of small plots, strips are used. Crops can be seeded in front of the bunds were water infiltration is concentrated
  - C3 - "contour beds", the same system as C2, but the beds are " W"-shaped, with alternating wide and narrow ridges. The wide ridges serve as catchment zone, the narrow ridges as planting zone and the furrows can serve as drainage or irrigation channels/ mechanisation can be used.
Unit- 6

Bio Diversity and Environment

Structure

6.0 Biodiversity and Environment
6.1 Biodiversity for sustainable agriculture
6.2 Environmental pollution

6.0 Biodiversity and Environment

6.1 Biodiversity for sustainable Agriculture

6.1.1 Definition of Bio-diversity

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

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

6.1.2 Biodiversity is considered at three levels:

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

a) Genetic diversity refers to the variation of genes between different populations of a species as well as between species.
b) Species/organismal diversity refer to the variety of living species.
c) Ecosystem biodiversity relates to the variety of habitats, biotic communities
and ecological processes and the enormous diversity present within
ecosystems in terms of habitat differences and the variety of ecological
processes.

6.1.3 Importance of biodiversity

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

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

6.1.4 Human Impact on Biodiversity

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

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

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

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

6.1.6 Importance of Agricultural Biodiversity

- Recycling of nutrients
- Control of microclimate
- Regulation of local hydrological processes
- Detoxification of waste and toxic chemicals
- Regulation of the abundance of desirable and undesirable organisms.
- Soil structure
- Infiltration and run off Soil erosion
- Natural pest and disease control
- Pollination and
- Genetic introgression and hybridization

6.1.7 Agricultural Intensification on Biodiversity

Agricultural activities have three types of impacts on biodiversity.

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

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

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

6.1.8 Impact of biodiversity reduction on modern agricultural systems

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

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

6.1.9 Genetic erosion

Genetic erosion consists of the loss of genes, gene complexes and unique combinations of genes that occur in different land. The primary cause of the loss of genetic diversity of the widely used plant crops and vegetables is the wide spread adoption of a limited number of modern varieties that are generally bred for higher yield, resistance to insect pests and diseases, and high performance over a range of biophysical environment, thus reducing the need for specific local adaptations.
Further, advanced methods of cultivation using fertilizers, irrigation, and pest control chemicals have lowered the demand for land races, which have evolved largely through careful selection and area adapted to marginal growing conditions.

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

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

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

Thus the immense potential of soil biodiversity for agricultural productivity and sustainability is still undervalued and needs to be understood and harnessed.

6.2 Environmental Pollution

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

6.2.1 Greenhouse effect

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

This gas blanket has been in place ever since the creation of the earth. Since the industrial revolution, human activities have been releasing more and more of these greenhouse gases into the atmosphere. This leads to the blanket becoming thicker and upsets the "natural greenhouse effect". Activities that generate greenhouse gases are called 'source' and those that remove them are known as 'sinks'. A balance between 'sources' and 'sinks' maintains the levels of these. Humankind upsets this balance when new sources that interfere with the natural sinks are introduced. Carbon dioxide is released when we burn such fuels as coal, oil, and natural gas. In addition, when we destroy forests, the carbon stored in the tree escapes as carbon dioxide into the atmosphere. Increasing agriculture activities, changes in land-use patterns, and other sources lead to rising levels of carbon dioxide, methane and nitrous oxide . Industrial processes also release artificial and new greenhouse gases like CFCs (chlorofluorocarbons). The resulting enhanced greenhouse effect is more commonly referred to as global warming or climate change.
6.2.2 Potential Effects of Greenhouse effect or Global Warming

Some potential effects on agriculture and others associated with climate change are listed in the following (From U.S. Climate Action report).

- Biomass production- decrease in productivity of crops and grazing lands directly through changes in temperature and precipitation, frequency of droughts/floods and indirectly through changes in soil quality, pests, and diseases, shifts in agro ecological zones. Alteration in the species diversity and die-back of tropical forests and grasslands due to change in the pattern of rainfall etc.

- Decline in soil quality- It is due to decline in soil structure, increased soil crusting and compaction, accelerated soil erosion, leaching & acidification, salinization, and organic carbon decline and nutrient depletion.

- Water resources & quality- warmer climate will change rainfall & snowfall patterns leading to increased droughts & floods, melting of glaciers and polar ice sheets resulting in accelerated sea- level rise affecting freshwater resources, coastal agriculture, fisheries & aquaculture, forests, natural ecological systems, human settlements, loss of land due to inundation & erosion, salt-water intrusion, increased sediment load, eutrophication etc.

- Air quality- increase dust concentrations, greenhouse gases, industrial pollution etc affects the quality of air

- General - warmer and wetter climate will favour the growth and spread of vector borne diseases like malaria & dengue affecting human health, increased frequency of storm, and other extreme events cause decrease in hydro-power generation, loss of infrastructure, tourism, disruption in transport routes, human settlements, and industries.

6.2.3 Depletion of Ozone layer

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

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

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

6.2.4 Methane Emission from Rice Fields

Wetland rice fields have recently been identified as a major source of atmospheric methane. Methane is produced as the terminal step of the anaerobic breakdown of organic matter in wetland rice soils. In a natural wetland, flooding a rice field cuts off the oxygen supply from the atmosphere to the soil, which results in anaerobic fermentation of soil organic matter. Methane is a major end product of anaerobic fermentation. It is released from submerged soils to the atmosphere by diffusion and ebullition and through roots and stems of rice plants. Recent global estimates of
emission rates from wetland rice field's range from 20 to 100 Tg/year (IPCC 1992). The current burden of methane in the atmosphere is approximately 4700 Tg/year (1 Tg = million tons), and the global annual emission is estimated to be 500 Tg/year with an apparent net flux of 40 Tg/year. In tropical flooded rice soils, where soil temperatures are 25-30°C, methane production is rapid in alkaline and calcareous soils (may start hours after flooding) and slow in acid soils (formed five or more weeks after flooding). Easily degradable crop residues, fallow weeds, and soil organic matter are the major source for initial methane production. At later growth stages of rice, root exudates, decaying roots, and aquatic biomass seem to be more important.

6.2.4.1 Conditions favouring methane production and emission in rice fields

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

6.2.4.2 Mitigation options

- Prevention of submergence of rice fields where ever feasible without affecting the rice productivity
- Increased adoption of direct seeding (wet and dry seeding) instead of transplanting
- Crop diversification in rice based cropping systems
- Water management- intermittent drying and mid-season drainage in controlled water situations
- Growing rice cultivars having traits with low methane emission potential
- Use of sulfate-containing fertilizer reduces methane emission
- Minimization of soil disturbance during growing season to reduce escape of entrapped methane
- Use of properly composted organic amendments
AEM-205
Sustainable Livelihood in Agriculture
(3 Credits)

Block-II
Livestock Development

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Unit- 1

Livestock for Sustainable Rural Livelihood Security

Structure

1.0 Objectives
1.1 Introduction
1.2 Livestock ownership
1.3 Functions of livestock in the sustainable rural livelihood security
1.4 Livestock production systems
1.5 Classification of livestock production systems
1.6 Factors influencing production systems
1.7 Impact of livestock development programmes
1.8 Let us sum up

1.0 Objectives

After completing this unit, you should be able to:

➢ Understand the importance of livestock in sustainable rural development
➢ Knowing various livestock production systems and factors influencing the same

1.1 Introduction

India has a large livestock population, regarded by some as an asset provided in plenty by nature, and by others as a burden. Since 1971, when ‘poverty eradication’ became the main theme of development planning, Indian Government recognized the livestock development program as an important tool for poverty alleviation. The focus of the programme has been on improving production of livestock commodities for
income generation. In India, underprivileged families contribute 70 to 80% of the total livestock produce and livestock are central to their livelihoods and culture. Hence, to improve the livelihoods of the underprivileged families we need to understand their way of life, livestock production systems and their perceptions and about the role of livestock in their livelihood. The livestock species considered for discussion here are cattle, buffaloes, goats, sheep and pigs.

For sustainable rural livelihood, resource poor farmers have to overcome technical, economic and social constraints to take benefit of increasing demand of livestock products and compete with commercial producers. There are indications that this can be done in developing countries by complete understanding of the different production systems evolved over a period of time and introduction of improved and appropriate technologies eliminating the constraints faced by the farmers.

**Livestock resources**

India has vast resource of livestock and poultry (Table 1). It ranks first in respect of buffaloes, second in cattle & goats, third in sheep, fifth in ducks & chickens and tenth in camel population in the world. Substantial positive growth was observed in pigs, sheep and goat when compared to cattle and buffaloes.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Species</th>
<th>Livestock Census</th>
<th>Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2003</td>
<td>2007</td>
</tr>
<tr>
<td>1</td>
<td>Cattle</td>
<td>185.2</td>
<td>199.1</td>
</tr>
<tr>
<td>2</td>
<td>Buffalo</td>
<td>97.9</td>
<td>105.3</td>
</tr>
<tr>
<td>3</td>
<td>Total Bovines</td>
<td>283.4</td>
<td>304.8</td>
</tr>
<tr>
<td>4</td>
<td>Sheep</td>
<td>61.5</td>
<td>71.6</td>
</tr>
<tr>
<td>5</td>
<td>Goat</td>
<td>124.4</td>
<td>140.5</td>
</tr>
<tr>
<td>6</td>
<td>Pigs</td>
<td>13.1</td>
<td>11.1</td>
</tr>
<tr>
<td>7</td>
<td>Other animals</td>
<td>2.2</td>
<td>1.7</td>
</tr>
<tr>
<td>8</td>
<td>Total Livestock</td>
<td>485.0</td>
<td>529.7</td>
</tr>
<tr>
<td>9</td>
<td>Poultry</td>
<td>489.0</td>
<td>648.9</td>
</tr>
</tbody>
</table>

Source: Annual Report of Dept of AH, GOI 2011-12
Animal Husbandry, Dairy Development and Fisheries sectors play an important role in the national economy and in the socioeconomic development of the country. These sectors also play a significant role in supplementing family incomes and generating gainful employment in the rural sector, particularly among the landless labourers, small and marginal farmers and women, besides providing cheap nutritional food to millions of people.

**Employment Generation**

Animal Husbandry sector provides large self-employment opportunities. According to National Sample Survey Office’s latest quinquennial survey (NSS 66th round), total number of workers in usual status, engaged in farming of animals were 13.6 million in rural areas and 1.39 millions in urban areas. Total number of workers engaged in farming of animals and fishing were 14.9 million in rural area and 1.6 million in urban areas.

**Value of Output**

According to estimates of the Central Statistics Office (CSO), the value of output from livestock and fisheries sector together at current prices was about Rs 4,61,434 crore during 2010-11 (Rs 3,88,370 for livestock sector and Rs 73,064 crore for fisheries) which is about 28.4% of the value of output of Rs 16,23,968 crore from total agricultural and allied sector. The contribution of milk alone (Rs 2, 62,214.51 crore) was higher than paddy (Rs 1,51,634 crore), wheat (Rs 99,667 crore) and sugarcane (Rs 58, 470 crore) during 2010-11. The value of output from meat group as per estimates of Central Statistics Office (CSO) at current prices in 2010-11 was Rs 72,444.22 crore.

**Other Contributions**

Livestock Sector not only provides essential proteins and nutritious human diet through milk, meat, eggs etc., but also plays an important role in utilization of nonedible agricultural by-products. Livestock also provides raw material/by products such as hides and skins, blood, bone, fat etc.
Dairy sector

The Indian Dairy sector registered substantial growth achieving an annual output of 121.8 (estimated) million tonnes of milk over a period of time. This has not only placed the country on top in the world, but also sustained growth in the availability of milk and milk products for the growing population.

Dairying has become an important secondary source of income for millions of rural families and has assumed the most important role in providing employment and income generating opportunities. The per capita availability of the milk reached at a level of 269 (anticipated) grams per day in the year 2010-11, but it is still lower than the world average of 286 grams per day (2010-11 forecast). Government of India is making efforts to increase the productivity of milch animals and thus increase the per capita availability of milk. Milk production and marketing system in India is unique. Small, marginal farmers and landless labourers produce most of the milk. About 14.46 million farmers have been brought under the ambit of 1,44,168 village level dairy corporative societies.

1.2 Livestock Ownership

The possession of livestock is influenced by several factors viz. socio economic status, passion of farmers, resources availability, cultural compatibility, environmental conditions etc.

Majority of cattle were possessed by marginal farmers followed by small, medium and large farmers in that order. Further it is noticed that during last three decades the number of animals possessed by marginal farmers is increasing indicating its role in providing supplementary income.
Profile of livestock keepers:

Typical animal possession by a rural women

The species and the size of animals owned seem to be positively related to the socio-economic status and land holding of the families, viz. most of the underprivileged families own small ruminants, while large animals are commonly owned by better-off families. However, this picture changes when agricultural and infrastructural development as well as institutional support is available to the underprivileged families.

Preferred animals of the resource poor are buffaloes and goats. Over the last decade, the populations of buffaloes and goats in most states are increasing more rapidly than other species and they are considered the ‘animals of the future for the country’. Until recently, the buffalo was described as an animal of irrigated and assured rainfall areas where good quality fodder is available, while semi-arid and arid areas were considered cattle tracts (of breeds like Tharparkar, Rathi, Kankrej and Haryana). Yet even in these areas buffaloes are preferred over cattle. Goats seem to be preferred by the resource poor

Livestock biodiversity

India has vast livestock biodiversity with 18 recognized cattle breeds, 6 buffalo breeds, 14 sheep breeds, 17 goat breeds. These breeds evolved over a period in commensuration of the needs of the society. Various breeds and distinct animals’ types developed through selection and breeding practices. The quest for development of need based animal types in different agro climatic zones have required specific morphological
Livestock for Sustainable Rural Livelihood Security

and physiological characteristics grouped as adaptation. That led into development of different kind of breeds suitable in different parts of country. Presently, the very survival of these breeds is posing a threat to the rich biodiversity of the country. Several reasons viz. fast changing socio-economic condition of the farmers, mechanization, change in the nature of farming, shrinkage of grazing area, emphasis on crossbreeding as a tool to increase milk production, non-implementation of breeding policy, farmers preference, difficulty in the management of animals by poor people, scarce resources contributed to the down fall in the number of animals.

This table may be replaced with livestock breeds of India information available in NBAGR site

Punganoor Cow

<table>
<thead>
<tr>
<th>Livestock</th>
<th>Breed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffaloes</td>
<td>Important breeds are Murrah, Bhadawari, Jaffarabadi, Surti, Mehsana, Nagpuri and Nili-Ravi.</td>
</tr>
<tr>
<td>Sheep</td>
<td>Predominant breeds are Gurez, Bhakarwal, Gaddi, Bikaneri, Jalauni, Kathiawari, Deccani, Nellore, Bellari, Mandya etc</td>
</tr>
<tr>
<td>Goats</td>
<td>Pashmina, Kashmiri, Osmanabadi, Barbari, Jamunapari, Nimari, Malabari, Gnajam, Black Bengal, Assam Hill Goat etc are prominent</td>
</tr>
<tr>
<td></td>
<td>Indian Goat Breeds</td>
</tr>
</tbody>
</table>

1.3 Functions of Livestock in the Sustainable Rural Livelihood Security

The functions of livestock can be classified broadly into four major categories viz

- Output function: related to producing food and non-food products.
- Input function: related to providing inputs for crop production, transport etc.
- Risk coverage or asset function: related to raising money at times of need.
- Socio-cultural functions: related to social status, culture etc.
Output function:

This is the most commonly studied and reported function of livestock. It relates to the production of food (milk, meat, eggs) and non-food products (wool, hair etc). The food products are used for home consumption as well as for sale which result in generation of employment and income for the family. Home consumption of food products is affected by factors like food habits, economic status of the family, market conditions, crop performance, drought, socio cultural context and certain prejudices.

Animal products are primarily a source of proteins and essential amino acids, but when they are a major constituent of the human diet they also contribute a significant proportion of total calories. About 60 percent of the dietary protein supply in developed countries, 22 percent in developing countries is derived from animal products. In these countries, where diets are composed of only a small number of staple foods, animal products are of great importance in preventing malnutrition as they are concentrated sources of the limited essential amino acids available in vegetable proteins of staple foods.

Excessive consumption of calories, particularly fat from animal products, is often the cause of human health problems, especially in wealthy societies and not a problem for people in developing countries like India (Sansoucy, 1995)

The income and employment generated from the production of food and non-food products are well studied for large dairy animals and to some extent for small ruminants (in a few states); however, there are very few reports on pigs and backyard poultry. At farm level, cash can be generated regularly from direct sales of livestock products, such as milk, eggs and manure, occasionally from the sale of live animals, wool, meat and hides and from fees for draught power or transport services(Sansoucy, 1995).

In mixed crop–livestock farming systems, dairy production contributes 20 to 50% of family income. The share of income from milk in the total income of underprivileged family is as high as 75 to 80% during drought. Dairy production is labour intensive and
the employment generated is relatively high. Family members with low opportunity cost invariably provide labour. Small ruminants (sheep and goat) are a major source of income for the underprivileged families and their contribution ranges between 17 to 24% of family income.

**Input function:**

Livestock provide inputs for crop production by way of draft power, manure, transportation of produce & people and fuel needs (through dung cakes) of the families. Large ruminants (cattle and buffaloes) provide two major inputs for crop production, viz. draft power and organic manure. In many countries, the provision of animal draught power services for cultivation, transportation and the pumping of irrigation water is an important source of income that is particularly beneficial to landless owners of cattle or buffalo Draught animals remain the most cost-effective power source for small and medium-scale farmers. The share of animal power in farming is decreasing and hence the demand for bullocks / male buffaloes and their population has now gone down substantially, which is largely due to mechanization and changes in the farming systems.

Estimates indicate that 40 to 60% of dung is used as manure and the rest as fuel. The extent of use of dung for different purposes depends on land holding, herd size, economic status of the family and alternate material available as fuel and fertilizer. In many countries, cow dung is highly valued as fuel for cooking and heating, reducing expenditures for fuel wood or fossil fuels. It represents the major fuel supply for household use by millions of farmers. In India alone, 300 million tonnes of dung cakes are used for fuel every year. The collection and drying of dung for cooking generates income for women. Valuing cattle and buffalo dung as manure is done only on the basis of its NPK value and the beneficial effect on properties of soils is ignored. Using dung as fuel is criticized by many, but has some positive aspects such as saving fuel wood and oil, low cost, traditional preference for cooking, convenience and low dependency on fuel suppliers. Surplus dung cakes are sold and are a good source of income for women from underprivileged families.
The excreta from small ruminants are widely recognized as good quality manure and are used through an innovative and well-knit system of penning animals in harvested fields during seasonal migration by pastoralists/nomads. Biogas system is an efficient alternative for use of dung as manure and fuel; however, its adoption is limited due to initial capital cost and lack of awareness.

**Risk coverage or asset function**

Livestock is considered as an asset value to rural families, as it provides a means of security at times of crises. It also helps when the rural families are affected with natural calamities like floods, drought, cyclones, earthquakes etc., where in the livestock enterprises comes as a rescue to the rural farmers and sustain them in the above crises. In the rural areas of many developing countries financial services such as credit, banking and insurance are virtually non-existent. In these areas, livestock play an important role as a means of saving and capital investment, and they often provide a substantially higher return than alternative investments. A combination of small and large livestock that can be sold to meet petty-cash requirements to cover seasonal consumption deficits or to finance larger expenditures represents a valuable asset for the farmer (Sansoucy, 1995).

For resource poor families, any kind of animal is an asset since it can be easily encashed in times of need. There are several examples of resource poor farmers using income, from sale of animals, for improving their farms, irrigation facility, houses, as well as for meeting marriage expenses, health needs or paying school fees of the children etc. Livestock is considered as building asset and thus included in many of the rural development programmes.

**Social function**

This is an aspect usually ignored or undervalued even though it is now well known that livestock have strong socio-cultural linkage. For most rural families and particularly for women, livestock are a part of the family. Their importance in Indian rural society is evident from the fact that livestock are still indicators of social status and
provides a prestige value to the rural families because of the possession of very valuable and high yielding livestock. Many festivals and fairs are based on livestock. Possessing an animal of their choice gives women considerable satisfaction. The choice of an animal, kept by a family, and management practices are influenced by socio-cultural factors. These factors have to be borne in mind while studying production systems and suggesting interventions for increasing productivity and profitability with underprivileged families.

1.4 Livestock Production Systems

There are very few studies planned exclusively to understand livestock production systems (even farming systems in general) of the underprivileged rural families. The livestock production systems of the underprivileged families are different from those of resource-rich farmers since they aim at optimizing use of the limited available resources (material and labour) and minimizing external inputs and avert risks, as against maximizing profit by the resource rich. Thus ‘diversification and internalization’ are the main features of their production systems. Some shared characteristics of the livestock production systems of the rural underprivileged families are presented in Box.
Features of livestock production systems

- Livestock farming is secondary, albeit important, adjunct to crop farming
- Livestock are meant to avail primarily the crop byproducts and surplus family labour, which may not have immediate opportunity cost in the village
- Mixed farming system and diversified crop & livestock activities are common and symbiotic
- Low external input–low output and highly internalized system, making maximum use of available resources like crop residues, feed, labour, animal waste etc.
- Extensive grazing with limited supplementary feeding in semi-arid/arid areas and limited grazing/semi-stall feeding in other areas.
- Local breeds of livestock/poultry preferred over ‘improved’ stock as part of risk management, except in areas where there is organizational support.
- Traditional systems of livestock management and feeding are preferred and adoption of scientific recommendations or technologies is very low.
- Women play a major role in livestock production and sale of produce.
- It is subjected to taboos and prejudices with apathy / inability to change to improved husbandry.

1.5 Classification of Livestock Production Systems

The classification of livestock production systems (Steinfeld and Hokkonen, 1995) is as follows.

I. **Solely livestock production systems** (L): Livestock systems in which more than 90 percent of dry matter fed to animals comes from rangelands, pastures, annual
forages and purchased feeds and less than 10 percent of the total value of production comes from non-livestock farming activities.

**Landless livestock production systems (LL):** Subset of the solely livestock production systems in which less than 10 percent of the dry matter fed to animals is farm-produced and in which annual average stocking rates are above ten livestock units (LU) per hectare of agricultural land.

**Grassland-based systems (LG):** Subset of solely livestock production systems in which more than 10 percent of the dry matter fed to animals is farm-produced and in which annual average stocking rates are less than ten LU per hectare of agricultural land.

**II. Mixed-farming systems (M):** Livestock systems in which more than 10 percent of the dry matter fed to animals comes from crop by-products or stubble or more than 10 percent of the total value of production comes from non-livestock farming activities.

**Rain-fed mixed-farming systems (MR):** A subset of the mixed systems in which more than 90 percent of the value of non-livestock farm production comes from rain-fed land use.

**Irrigated mixed-farming systems (MI):** A subset of the mixed systems in which more than 10 percent of the value of non-livestock farm production comes from irrigated land use.

**1.6 Factors Influencing Production Systems**

Production systems are a result of the interplay between agro-ecology, stage of overall development of the area, farming situation, market demand, organizational
support, resources of the farmers and social factors and thus systems appropriate for specific situations are adopted by farmers in general.

Some of the factors influencing livestock production systems adopted by the underprivileged families are discussed next to elucidate the points mentioned above.

1. **Agricultural and overall development of the area:** In developed areas the livestock production systems of the underprivileged families are more productive than in other areas. For example, in tribal belt of Rajasthan, Gujarat and Maharashtra, the efforts of the district co-operative milk union and Bharatiya Agro Industries Foundation (BAIF, a major livestock NGO) have considerably improved dairy and crop production systems of thousands of tribal families, while tribal families from other parts of the country continue subsistence farming. Landless livestock owners have developed innovative systems to secure green fodder for their animals from farmers’ fields as part of labour wages or in exchange for dung. Most animals (including goats) are stall-fed or grazed in a limited area or in harvested fields. Animal owners get organizational support and services, well established in these areas, (livestock services, processing and marketing of produce, credit etc.). Access to reliable input and output markets aided by the motivation from observing the results achieved by progressive farmers in these productive areas are the key to success.

2. **Agro-ecology and farming systems:** There is large variation amongst livestock production systems between various regions of the country; which are influenced by climate, availability of resources (feed, fodder), breeds, cropping pattern etc.

3. **Women in livestock production:** Women play a major role in livestock production and management as well as in the marketing of produce. Involvement of women in livestock production activities varies among rural, tribal communities - rearing of animals, feeding, health care, management sale of produce etc.
4. **Veterinary Service Delivery System:** Accessibility and availability of Veterinary and Animal Husbandry services is also a significant factor influencing the production system.

1.7 **Impact of Livestock Development Programmes**

The experiences from livestock development programmes suggest that:

1. Livestock development is most likely to be effective as ‘a pathway out of poverty for underprivileged rural families’ and enable them to compete with commercial producers, provided:
   a. Organizations planning and implementing livestock development programmes are sensitive towards the needs, resources, production systems and perceptions of the families;
   b. Livestock development is a part of ‘integrated development programme’ that incorporates natural resource management and development of producers organizations to provide credit and services (backward and forward linkages) and help to improve efficiency and quality of livestock produce;
   c. Technologies, recommendations and services are developed on the basis of ‘needs assessment’ and are pre-tested for being beneficial to the resource poor farmer;
   d. Livestock extension is strengthened and targeted to the underprivileged families particularly the women.

2. Livestock production by resource-poor farmers can be more economic provided they have access to adequate techno-economic support; and

3. Integrated livestock development can improve all five ‘capital assets’ within the sustainable livelihoods framework.
1.8 Let us Sum Up

In India underprivileged families contribute a major part of livestock production. Livestock sector contribution to national is enormous. The rich livestock wealth is facing extinction due to various reasons. Livestock are central to their livelihood and culture. The major livestock species are cattle, buffalo, goat, sheep and pig. The output, input, risk, asset and social functions are hall marks of India’s underprivileged families who are maintaining livestock under differ production systems. There are several factors affecting where and how the livestock were managed.
Unit- 2

**Crop – Livestock Interactions - Mixed Farming Systems**

**Structure**

2.0 Objectives
2.1 Importance of Livestock in Indian Agriculture
2.2 Genesis of Crop Animal Systems
2.3 Crop – Livestock Interactions in Mixed Farming Systems
2.4 Availability and Use of feed resources in Crop -Livestock systems
2.5 Use of draught animal power
2.6 Nutrient recycling in Crop -Livestock systems
2.7 Mixed Farming
2.8 Different modes of mixed farming
2.9 Diversified versus integrated farming systems
2.10 Let us sum up

2.0 Objectives

After completing this unit, you should be able to:

- Understand the crop – livestock interactions and need for mixed farming systems in sustainable livestock development
- Distinguish the different models of mixed farming
- Comprehend the merits and limitations of various mixed farming systems
2.1 Importance of Livestock In Indian Agriculture

Crop-animal systems constitute the backbone of Indian agriculture. The synergistic interactions of the components of these systems have a significant and positive total effect that is greater than the sum of their individual effects. Animal production is a major component of the Indian agricultural economy, but, often official statistics underestimate the overall contribution of animals, as they ignore the multi-purpose role that livestock play in agricultural production (Sansoucy et al., 1995), infact leading to sustainability of the farming community.

In the context of crop livestock interactions, the latter play an important role as it convert plant resources of low nutritive value to high quality products such as meat and milk, and can be used to control weeds in perennial tree crop-systems. Livestock provide entry points in cropping systems for practices that promote sustainability, such as the introduction of forage legumes. Further, livestock are linked closely to the social, cultural and religious lives of millions of resource-poor farmers, for whom ownership ensures varying degrees of economic stability and agricultural sustainability. In this section let us understand the genesis of crop livestock interaction.

2.2 Genesis of Crop-Animal Systems

The type of crop and animal system that has developed at any particular location is a function of the agro-ecological conditions. Climatic and biotic factors decide whether cropping is feasible and, if so, the type of crops. This, in turn, determines the quantity, quality and distribution of animal feed resources available throughout the year. Feed resources provide a direct link between crops and animals and the interactions between the two dictate to a large extent, the development of the systems. Combining crops and livestock also has many environmental benefits, including the maintenance of soil fertility by recycling of nutrients.

In India, around 52% of farms are less than one hectare. The traditional small farm scenario is characterized by low capital input; limited access to resources; low levels of
economic efficiency; diversified agriculture and resource use; and conservative farmers who are illiterate, living on the threshold between subsistence and poverty, and suffer from an inability to use new technology.

Different integrated systems evolved from Agro-eco system environments exist in the country. The problems and prospects, the approaches and strategies to be adopted, the policies and programs to be implemented in different zones are further influenced not only by the natural resource base in the region but also by the distribution of livestock and its productivity, human population and their social and economical status.

2.3 Crop-Livestock Interactions in Mixed Farming Systems

The integration of crop and animal production is well developed in the small holder farming systems. Around 70% of ruminant livestock are found on mixed farms in rain fed areas. There is marked complementarities in resource use in these systems, with inputs from one sector being supplied to others. The crop and animal interactions are presented in Table1.

<table>
<thead>
<tr>
<th>Crop production</th>
<th>Animal production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crops provide a range of residues and by-products that can be utilized by ruminants. Native pastures, improved pastures and cover crops growing under perennial tree crops can provide grazing for ruminants.</td>
<td>Large ruminants provide power for a range of agricultural operations such as land preparation and for soil conservation practices. Both ruminants and non-ruminants provide manure for the maintenance and improvement of soil fertility. In many farming systems, it is the only source of nutrients for cropping.</td>
</tr>
<tr>
<td>Cropping systems such as alley cropping can provide tree forage for ruminants.</td>
<td>The sale of animal products and the hiring out of draught animals can provide cash for the purchase of inputs in crop production. Animal grazing vegetation under tree crops can control weeds and reduce the use of herbicides in farming systems.</td>
</tr>
</tbody>
</table>
2.4 Availability and use of Feed Resources In Crop-Livestock Systems

Feed resources and nutrition constitute the principal technical constraints to ruminant production. Four main categories of feed resources are potentially available for use in small-holder crop-animal systems. These are pastures, crop-residues, agro-industrial by-products and non-conventional feed resources (Refer Unit 4 for more details). There is significant potential for the more effective use of locally produced agro-industrial by-products and non-conventional feed resources, all of which are under utilized currently.

The production of fodder from food crop systems and the establishment of multi-purpose trees and shrubs are potentially important for ensuring adequate feed supplies for ruminants and improving soil fertility, but there has been limited adoption on small farms to date. Of the available feed and fodder resources, there exist regional and seasonal surpluses and shortages, leading to inefficient use of scarce resources of nutrients across the country.

2.5 Use of Draught Animal Power

Draught animal numbers have increased only slightly over the last 30 years despite proportionally much larger increases in the human population and agricultural production. Nevertheless, they still play a vital role in many farming systems especially on smaller and poorer farms. It is noted that very little quantitative information is available for assessing the impact of draught animals in many farming systems.

With the modernization of agriculture, the use of mechanical power in agriculture has increased but draught animal power (DAP) continues to be used on Indian farms due to small holdings and hill agriculture. More than 55% of the total cultivated area is still being managed by using draught animals as against about 20% by tractors (Singh, 2000). Better update statistics if possible.
2.6 Nutrient Cycling In Crop-Livestock Systems

In taking an overview of the impacts of livestock of nutrient dynamics in mixed farming systems, in the broadest sense there are two main direct interactions and one indirect “managerial” influence.

**Organic resources-livestock interface:** The interface between organic resources, from both on and off the farm, and livestock is associated essentially with the provision of nutrients and energy from ingested feed. Some organic matter may also be used as bedding material for animals. Feed inputs across the organic resources-livestock interface may take two forms:

1. Indirect management in a grazing or browsing situation
2. Direct management of feed offers to stall-fed livestock

**Livestock-land interface:** The livestock-land interface includes two quite distinct forms of interaction:

1. The production of manure and compost
2. The provision of draught animal power

Close integration of animals with cropping provides the means to sustainable intensification of agricultural production. The management systems have evolved over centuries for the purposeful and efficient interlocking of different farming enterprises that serve to support high rural human population densities.

According to Devendra (2002), crop animal systems will see continued intensification and important growth in the future, and that small holder mixed farms will remain predominant in Asia and particularly in India for some time to come. Important productivity gains can be achieved by further enhancing nutrient and energy flows between the crop and livestock components. Animals, in addition to production, will continue to enhance the natural resource base. The environmental and economic stability of the mixed farming system will make it the prime focus for continuing transfer of technology and development. Important interactions between cropping the livestock production are currently under-exploited, but provide exciting possibilities for
technological change in the future. However, the development of sustainable and productive crop-animal systems in the future will require an increased commitment to interdisciplinary research with a farming systems perspective that can focus on whole farm situations.

2.7 Mixed Farming

Mixed farming is however, the most relevant system of farming to Indian conditions, because of small size of holdings and unsound economic status of the average Indian farmer. In mixed farming crop production is combined with livestock, raising the livestock enterprise as complementary to crop production, vice versa, depending on the relative emphasis given to one other. If a farm is to be categorised as mixed type at least 10% of its gross income must be contributed by the livestock. This contribution in no case should exceed 49%.

Mixed farms are systems that consist of different parts, which together should act as a whole. They thus need to be studied in its entirety and not in separate parts if one wants to understand the system and the things that drive farmers and that influence farmer's decisions.

Many farmers in tropical and temperate countries survive by managing a mix of different crops and/or animals. The best-known form of mixing occurs probably where crop by products such as straws, cereal and gram husks are used to feed the animals and where the excreta from the animals are used as nutrients for the crops. Milch buffaloes, cattle, sheep are the most extensively reared species on mixed farming. Other forms of mixing take place where grazing under fruit trees keeps the grass short, or where manure from pigs is used to feed the fishpond. All over the world and throughout history there are a wide variety of mixed farming systems. They are essential for the livelihood of farmers and for the production of food and other commodities for the cities and export markets. Even many highly specialized crop and livestock systems in developed and developing countries start to rediscover the
advantages of mixing as it gives balanced labour load for the farmer and his family throughout the year.

2.8 Different Forms of Mixed Farming

The different forms of mixed farming systems can be classified in several ways based on land size, type of crops and animals, geographical distribution, market orientation, etc. The three major categories of farming are:

1. On-farm versus between farm mixing
2. Mixing within crops or animals
3. Diversification versus integration

On-farm versus between-farm mixing:

*On farm mixing* refers to mixing on the same farm, and *between-farm mixing* refers to exchanging resources between different farms. On farm mixing occurs particularly in low external input agriculture (LEIA) where individual farmers will be keen to recycle the resources they have on their own farm. *Between farm mixing* occurs increasingly in high external input systems (HEIA) systems; e.g. in tropical countries manure is transported from livestock farms to cropping areas where manure is in short supply.

Pastoralists also exchange cattle and crop products with crop farmers. Cultivators receive manure, labour, and less importantly milk in return for cash, grain and water rights traded to pastoralists. Entrustment of livestock from crop farmers to pastoralists follows more or less the same rules. In return for taking care of the herd, herders receive either cash, or cropland, or labor for the cropland or a share of the milk and the offspring.

Mixing within crop and/or animal systems:

Mixing within crop and/or within animal systems refers to conditions where multiple cropping is practiced, or where different types of animals are kept together, mostly on farm and both these systems occur frequently. Within crop mixing takes place where crop rotations are practiced over and within years. For example, a farmer has a
grain-legume rotation to provide the grain with nitrogen or a potato/beet-grain rotation to avoid disease in the potatoes. Plants can also be intercropped to take maximum advantage of light and moisture, to suppress weeds or prevent leaching of nutrients through the use of catch crops.

Mixing between animals are found in chicken-fish-pond systems where chicken dung fertilizes the fish pond, in beef-pork systems where pigs eat the undigested grains from the beef cattle dung or in mixed grazing such as cow-sheep mixes to maximize biomass utilization or to suppress disease occurrence. By keeping several species, farmers can exploit a wider range of feed resources than if only one species is kept.

2.9 Diversified Versus Integrated Farming Systems

Diversified systems consist of components such as crops and livestock that coexist independently from each other. Particularly HEIA farmers can have pigs, dairy and crops as quite independent units. In this case the mixing of crops and livestock primarily serves to minimize risk and not to recycle resources.

Integration is done to efficiently recycle resources. Integration occurs mostly in LEIA farming systems that exist in many tropical countries where (by) products of one component serve as a resource for the other; dung goes to the crops and straw to the animals. In that case the integration serves to make maximum use of the resources. Unfortunately, these systems tend to become more vulnerable to disturbance because mixing of resource flows makes the system internally more complex and interdependent.

2.10 Let us Sum Up

Historically, crop and livestock operations have been compatible with environmental security by recycling wastes from one system as cheap inputs for the other. The livestock revolution will require rapid intensification of agriculture in many regions. This can upset the delicate balance provided by the earlier low intensity crop-livestock systems. It will stretch the capacity of existing natural resource base – crops,
animals, land and water in given agro climatic conditions - leading ultimately to its degradation to put the long-term livelihoods security of the rural poor at risk.

Mixed systems occur in several forms and shapes. Diversified systems are a combination of specialized sub-systems that aim to reduce risk in conditions of variable but relatively abundant resources. Information on interrelationships of different enterprises in the farming system in different agro climatic zones is lacking and it needs further development of various suitable models on integrated crop-livestock farming systems. An important aspect in promoting mixed farming is that the yield of the total enterprise is more important than the yield and/or efficiency of the parts. The policies can be effective only if they are based on a holistic approach that focuses on understanding and integrating the nature of the interactions between crop and livestock based farming systems, the natural resource base and the impact on the rural livelihoods systems.
Unit- 3

Best Management Practices for Sustainable Livestock Production

Structure

3.0 Objectives
3.1 Introduction
3.2 Importance of best management practices
3.3 Nutrition management and health
3.4 Health management
3.5 Housing management
3.6 Livestock waste management
3.7 Building good neighbour relationships
3.8 Environmental issues in sustainable livestock development
3.9 Let us sum up

3.0 Objectives

After completing this unit, you should be able to:

- Understand the concept and importance of best management practices in livestock production
- Know the role of livestock waste management and methods
- Understand the environmental issues in SLD
3.1 Introduction

Livestock management strategies with concern for environment play an important role in sustainable livestock development. On the other hand intensive production practices are in demand to meet the growing needs of population. Understanding Best Management Practices helps the reader to realize the importance of the same so as to minimize the effects of intensive production.

3.2 Importance of Best Management Practices

Management and nutrition are central to the prevention and control of many infectious and noninfectious diseases besides high-level production performances. Although infectious diseases require the presence of a specific infectious organism(s) (eg, a bacterium, virus, and parasite), the mere presence of the causal organism is not usually sufficient to assure that disease will develop. Other environmental and host factors influence whether the infected animal develops clinical disease or has reduced productivity as a result of the infection.

The most effective method of preventing infectious disease is to eradicate and exclude the organism(s) causing the disease. Often, this is impossible or impractical. It becomes necessary to control the infectious disease by minimizing circumstances that favor the spread of the infectious agent, mitigating the environmental circumstances that contribute to development of the disease in the presence of the infectious agent, and minimizing circumstances that increase the host’s susceptibility. These circumstances that contribute to the development of a disease are termed risk factors for the disease. They can be grouped into several categories: microbe risk factors, environmental risk factors, and host risk factors etc. Identifying and mitigating the impact of these risk factors is the goal of a management strategy to prevent specific diseases and maintain productivity.

Effective multifaceted management to control and prevent disease is particularly important in dealing with many of the diseases that are commonly seen in food animal
production. These diseases have either a complex etiology involving the interaction of several microbes or are caused by pathogens for which there are no reliable treatments (e.g., viruses, some parasites).

Animal-agriculture is under pressure from consumers and public interest groups to address concerns arising from current industry practices; need to change current management practices while developing and adopting new approaches to deal with health and production problems.

### 3.3 Nutrition Management

Proper nutritional management is essential to animal health and productivity. Rations/diets (providing energy, protein, fats, carbohydrates, vitamins, minerals) must be formulated to meet for the basic physiological needs of the animal and to ensure optimal growth and productivity. Nutrition also play a significant role in influencing the animal's immune compatibility and metabolism as well as in managing certain diseases.

In animal agriculture, feeding management heavily influences health. Nutritionally related diseases may result from excess of nutrition, nutritional deficiency, or nutritional imbalance. Inadequacies in nutritional delivery can directly cause disease (e.g., ruminal acidosis, laminitis) or increase susceptibility to disease. Feeds and feeding management also influence animal health if feeding results in exposure to food borne physical hazards (e.g., sharp objects), chemicals (e.g., mycotoxins, toxic plants and pesticides) or microbes.
3.4 Health Management

Livestock diseases cost farmers million of rupees. In addition to deaths, they cause loss of production and loss of body conditions. Unthrifty animals require more food and take longer time for growth than the healthy stock. They become susceptible to all types of infection. A good animal health programme calls for full cooperation between herdsman and the veterinarian. Farmers should also know that many livestock diseases are transmissible between classes of animals and from animals to men.

Generally, animals are born free of diseases or parasites except those, which are transmitted intrauterine. But they usually acquire these maladies either through contact with diseased animals or improper sanitation, feeding, care and management. Keeping animals healthy by confining purchases from healthy herds, by proper quarantine at the time of bringing in new animals, by employing sound principles of sanitation, management and feeding and by judicial use of appropriate and dependable vaccines are the practical and economical ways to avoid loss from disease. Prevention of diseases is better and economical than hurrying around to control actual outbreak of disease. Disease surveillance and forecasting along with other disease prevention measures (mass vaccination, deworming etc) will keep the flock healthy.
3.5 Housing Management

Intensification of animal farming has taken place and large number of animals is confined to small lots. However, we still find large number of small farms too, sometimes a farmer keeping only a few animals. Housing many animals in small areas is both challenge and risk. Suitable is essential if good productivity is expected from them In India, not much attention is paid so far to this important aspect - animal housing. Different types of animal houses are constructed without careful planning and designing. Farm building should be properly located, constructed, spaced out and grouped. Economy in their initial cost and maintenance and the health and comfort of animals should receive special attention while constructing animal houses. They should lead to efficient management so as to reduce labour to the minimum. It is impossible to design an ideal set of buildings, which would be equally suitable for livestock farming all over the country, owing to different methods of animal husbandry and / or farming priorities, which in turn are governed by climatic, geographic, economic and other conditions.

The general lay-out of dairy farms should be planned depending on the number of animals to be housed, facilities to be provided for feeding the animals economically, collection of manure and cleaning and washing. The principles of animal management, general hygiene and sanitation and disinfection should be kept in view. Two types of dairy houses are presently in general use - i) Conventional barns and ii) Loose housing

Conventional barns are also called as stanchion barns. These refer to housing cows in which the cows are confined together on platform and secured at neck by stanchions or neck chains. The cows are fed as well as milked in this bran. The barns are completely roofed and the walls are complete with windows and / or ventilators located at suitable places.

Loose Housing comprises keeping cows loose in an open paddock or pasture throughout the day and night except at milking time. The open paddock is provided with shelter along one side under which the animals can retire when it is hot or cold or during rains. The floor space requirement are provided in following Table
### Floor space requirements for different livestock

<table>
<thead>
<tr>
<th>Type of animal</th>
<th>Covered area</th>
<th>Open paddock</th>
<th>Height of shed (cm) at caves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cows</td>
<td>3.5</td>
<td>7.0</td>
<td>175 in medium and heavy rainfall areas and 220 in semi arid and arid areas</td>
</tr>
<tr>
<td>Buffaloes</td>
<td>4.0</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>Young calves</td>
<td>1.0</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Ewe/ Nanny</td>
<td>1.0</td>
<td>--</td>
<td>300 in dry areas and 220 in heavy rainfall areas</td>
</tr>
<tr>
<td>Ram / Buck</td>
<td>3.4</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Lamb/ Kid</td>
<td>0.4</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Boar</td>
<td>6.0 – 7.0</td>
<td>8.8-120.</td>
<td>200 to 250</td>
</tr>
<tr>
<td>Sow</td>
<td>7.0-90.</td>
<td>8.8-120.</td>
<td></td>
</tr>
</tbody>
</table>

Source: N S R Sastry and C K Thomas – Livestock production and Management

#### 3.6 Livestock Waste Management

Livestock waste contains many microorganisms such as bacteria, viruses, and protozoa. However, some others are pathogens, meaning they are capable of causing disease in animals and/or humans. Some of these microorganisms do not cause sickness in animals or humans. Not all pathogens are the same. Some are able to survive for long periods in manure. Others are susceptible to temperature extremes and manure processing. Irrespective of the size of their farms, all livestock producers have an important role in limiting pathogen movement from their operational area to the environment. Waste management helps livestock producers to control pathogens in their production system. The number and types of pathogens present in livestock waste varies with animal species, feedstuff sources, health status of the animals, and characteristics of the manure and manure storage facilities. Adequate control of pathogens may require multiple management interventions to achieve significant reduction of pathogens in a manure management system. The best management practices (BMPs) pertain to animal management and housing, dietary modifications, production management, land application of manure, and the chemical and biological treatment of stored manure.

**Pathogens and human health:** Pathogens can be transmitted to humans directly through contact with animals and animal waste or indirectly through contaminated
water or food. Water can become contaminated by runoff either from livestock farms or from excessive land application of manure. Pathogens can contaminate food products during meat and milk processing. Simply coming into contact with a pathogenic organism does not necessary mean that an individual will become sick. Some pathogens are highly virulent; meaning that exposure to even a few microorganisms can result in sickness. Others are less virulent. Healthy people exposed to low doses of less virulent pathogens likely will not become ill. However, elderly, young, or other susceptible individuals may become sick when exposed to even low levels of less virulent pathogens. Because it is impossible to know who will come into contact with pathogens from a livestock production area, it is a good management practice to reduce all potential exposures by controlling pathogens in livestock systems.

What can producers do to reduce potential contamination of surrounding surface and ground water from their livestock or poultry operations? There are three basic points in the manure management cycle where producers can implement best practices to reduce pathogens: (1) in the animal, (2) during manure collection and storage, and (3) during land application of manure. A good pathogen reduction program will include BMPs at each of these three points.

1. **Pathogen reduction in animal:** There are 2 aspects a) animal management and housing and b) Diet modifications

a) **Animal management and housing:** The more pathogens present in the animal, the greater the risk the manure from the infected animal will contaminate water or the food. Sick or stressed animals are more likely to shed pathogens in their manure than healthy, comfortable animals. Some animals appear healthy but are “carriers,” meaning they have previously been exposed to disease-causing microorganisms and can shed pathogens in their manure. In addition, some animals shed pathogens even when they appear perfectly healthy. Therefore, simple management practices such as vaccinations, adequate access to feed and water, appropriate space
allowance, temperature and ventilation control, on-farm sanitation and bio-security measures and good animal husbandry practices can be an easy first step for producers to reduce pathogens in their manure management system.

Cattle are often raised in pasture systems instead of confinement facilities. How does this influence the prevalence of pathogens in livestock waste? Raising cattle on pasture does not appear to affect the strains of pathogenic E. coli, which is most commonly associated with severe food borne illness in humans. Fly and vermin control in livestock facilities may also reduce the spread and subsequent infection of other animals with pathogenic bacteria.

Cattle shed with concrete flooring

The type of animal housing facility can also influence presence of pathogens. Producers may or may not have a choice in the type of housing facility that is available for their operation. However, implementation of BMPs that are consistent with good animal husbandry to reduce animal stress is an easy first step for reducing pathogens in any livestock operation. It is likely that the small economic expense of implementing these BMPs will be recovered with increased animal performance.
2. **Pathogen reduction in manure collection and storage:** Three aspects viz. production management, biological treatment of manure and chemical treatment of manure are discussed under this head.

a) **Production management:** The following management methods are to be adopted.

- **Use of vegetative filter strips:** Runoff and erosion from open feedlots and manured fields can be routed through grass filter strips to remove sediment, nutrients, and bacteria.

- **Control runoff and leaching from stockpiled manure:** Some livestock operations need to stockpile manure before land application. Permanent stockpiles must be placed on a concrete pad or clay base and have at least two feet of separation distance between the base of the stockpile and the seasonal high-water table. Catch basins can be used to prevent runoff from permanently stockpiled manure from reaching surface water.

- **Control runoff and leaching from open lots:** Catch basins can be used to contain manure-contaminated water from an open lot. The water collected in catch basins can be land-applied or further treated by running through vegetative filter strips.

- **Install clean-water diversion:** Ditches can be used to divert up-slope runoff and rain water from buildings away from open lots or other areas where manure may accumulate. Preventing this excess water from entering the lot or manure stockpile area will not only reduce pollution potential, but will also help keep these areas drier. Drier facilities can improve animal health, which in turn lowers pathogen levels in manure.

- **Eliminate or reduce livestock access to streams, rivers, lakes, or ponds:** Fencing livestock away from open water is an effective method of improving water quality.
Keeping animals away from open water will prevent urination and defecation in the stream, which can lead to bacterial pollution. Animal health may also be improved through reduced exposure to water-transmitted diseases. Alternative livestock water systems can replace direct, uncontrolled livestock access to streams, ponds, and lakes. Best management practices to control runoff from livestock operations will not eliminate or reduce pathogens on a livestock operation. However, implementation of these BMPs will prevent pathogens from leaving the livestock operation and potentially contaminating food or water supplies.

b) **Biological Treatment of Manure:** It consists of mainly four methods viz. anaerobic storage, composting, aeration and anaerobic digesters.

- **Anaerobic storage:** Anaerobic lagoons or deep pits are anaerobic storage systems, located beneath animal housing facilities. In an anaerobic system, bacteria are not exposed to oxygen. Although bacteria can survive anaerobic conditions for long periods of time, most pathogens are reduced within 30 days.

- **Composting:** Compost is an organically rich soil amendment produced by the decomposition of organic materials. During the composting process, microorganisms break down organic materials such as animal manure and livestock carcasses.

- **Aeration:** Aeration involves exposing manure to oxygen and air. *Natural* aeration involves storing manure in large, shallow (less than 5 ft. depth), storage structures so enough oxygen can naturally reach the bacteria. *Anaerobic digesters:* Anaerobic digesters have been primarily used for manure stabilization and odor control.

Many livestock producers, particularly those raising piggery and dairy, may already be utilizing anaerobic manure treatments such as deep pits in their operation.
Farms that generate solid waste can modify their operation to incorporate composting. There is growing interest in the use of anaerobic methane digesters for manure treatment.

c. **Chemical Treatment of Manure:** consists of following five methods

- **Chlorine:** Chlorine is a method of disinfections commonly used for drinking water. Chlorine is very effective against bacteria but less effective against viruses and protozoa. Unfortunately, the high organic matter found in manure substantially inhibits the effectiveness of chlorine. The chemical reactions that occur when chlorine and organic matter are exposed to each other also produce toxic and carcinogenic by-products.

- **Lime stabilization:** Lime stabilization of animal slurry has been used to reduce odor and pathogens before land application. The advantages include low cost of lime, easy disposal of treated slurry, and reduction in soil acidification. However, there may be some additional costs to consider such as labor to mix and haul the lime.

- **Ozone:** Ozone is a powerful oxidizing agent and very effective at killing bacteria. However, organic materials found in animal waste interfere with ozonation and therefore a pretreatment such as solids separation would be needed for an effective ozonation process.

- **Ultraviolet light (UV) irradiation:** Ultraviolet light irradiation destroys the DNA and RNA of pathogens. There are no residual compounds present after UV disinfection and the nutrient content of manure is not affected by UV exposure. Viruses are more resistant to UV treatment than bacteria and protozoa.

- **Pasteurization:** It is effective at reducing all pathogens but would be cost-prohibitive on most livestock operations unless it occurs as part of a composting or digesting system.
3. Pathogen reduction in land application

Land application is a critical period in manure management. Pathogens from animal waste can threaten humans who are exposed to runoff, have direct contact with manure, or consume food or water contaminated with infectious manure. Application rate and seasonal conditions are important factors contributing to the transfer of pathogens from lands where manure has recently been applied to nearby surface water.

There is a higher risk of pathogen transfer to the food chain when fresh manure is land-applied than when stored manure is land-applied because there is no storage or treatment period to decrease pathogen numbers. Typically, bacteria are highly susceptible to UV light and drying that naturally occurs following surface application of manure to cropland.

The greatest risk of pathogen transfer from manured land to surface waters is through runoff. Production practices that reduce or eliminate runoff of manure-contaminated water will ultimately reduce pathogen transfer.

3.7 Building Good Neighbour Relationships

Developing and maintaining good neighbour relations is important for all livestock and poultry producers. There are certain attributes of animal farming that come up again and again as being objectionable to neighbors. The top two are odor and flies. Let us take a look at these concerns and how farmers can minimize their annoyance to neighbors.

Tips to Minimize Odor

- Inject or immediately incorporate land-applied manure.
- Cover stored manure in storage with a roof, a fibrous mat, or a flexible membrane.
- Composting or methane digesters are sometimes feasible in large operations to treat manure and reduce odors.
• Don’t spread manure on weekends or holidays.
• Don’t spread manure if there is an air inversion or stable conditions with a light wind blowing toward nearby homes.
• Avoid spills on roadways by not overfilling spreaders and checking for leaks before leaving the fill site.
• Shovel or scrape roadways promptly if mud or manure gets on them. Maintain the required amount of freeboard in manure storages. If you wait until it is brim full, leaks are more apt to happen.
• Be prepared to contain larger spills by constructing dams across ditches or small watercourses. This will reduce the damage and decrease the size of the area you have to clean up should a spill occur. Be sure to promptly notify the appropriate environmental regulatory agency in the event of a spill.

Tips to Control Fly Populations

Good manure management plans and structures should minimize fly production. Organic material that is very wet or very dry will not support fly production. Use flytraps to catch adult flies moving to your farm. Use pesticide sprays sparingly. An outbreak of adults should be treated with a non-residual knock down spray. Avoid residual surface sprays. If they seem to be needed, focus on the location of egg laying with maggot development. Cleanliness is a key to controlling fly population.

3.8 Environmental Issues in Sustainable Livestock Development

Intensification of agriculture and animal husbandry is associated with environmental pollution problems. Increased emissions of methane (CH₄), nitrous oxide (N₂O) and ammonia (NH₃) can influence both the global climate and regional soil quality. Industrialization leads to increase in the concentration of atmospheric Carbon dioxide (CO₂) worldwide because of combustion of fossil fuels. Carbon dioxide is a gas, which contributes substantially to the greenhouse effect and therefore, has the potential the influence the global climate. Climate change is particularly threatening to
agriculture in developing countries because adaptation measures are expensive and frequently not possible there.

**Green House Gases**

In rice growing areas, the methane produced from paddy fields may make a much higher contribution to total green house gases than burning fossil fuels (Paul Brown, 1998). It is estimated that paddy fields contribute to the extent of 11.65 per cent of the total world methane emission of 515 million tonnes per year. Nitrous oxide released from chemical fertilizer is associated with higher damage potential than any of the animal wastes/manures. High levels of Nitrous oxide contributed to acid rain and global warming (Kushwaha et al. 1999). The two major green house gases produced by animal husbandry are methane and nitrous oxide. Their concentrations have increased considerably over the past 120 years. In this period the atmospheric CH$_4$ concentration has more than doubled and the N$_2$O concentration has risen by more than 30 per cent. One source of CH$_4$ in animal husbandry is the fermentation of feed in the stomach of ruminants and non-ruminants. Due to their ability to digest cellulose, ruminants account for the greater share in the production of CH$_4$. Another source of CH$_4$ associated with animal husbandry is the decomposition of animal wastes. These mainly consist of organic material, which produces CH$_4$ when decomposed under anaerobic conditions. Any further intensification of animal husbandry will increase the amount of animal waste, making a further increase in N$_2$O emissions likely.

Ammonia (NH$_3$) is emitted through animal husbandry in large quantities. While it is not a green house gas itself, due to interactions with anthropogenically emitted trace gases and the microbial reactions it undergoes in the soil, it has the potential to influence the green house effect and to affect the soil quality. Due to its high water solubility, ammonia only resides in the atmosphere for a short time compared with CH$_4$ and N$_2$O, so its effects on the environment are more on a regional scale where intensive animal husbandry is practiced.
Many different management practices can improve livestock production efficiency and reduce greenhouse gas emissions. Improved livestock management reduces atmospheric concentrations of carbon dioxide through the mechanism of soil carbon sequestration on grazing lands. As plants grow, they remove carbon dioxide from the atmosphere. Even though grazing cattle harvest a large portion of the plant material, through good management residues accumulate and increase the amount of organic matter in the soil. Some of this organic matter will remain in the soil or plant root system for long periods of time instead of being released back into the atmosphere as carbon dioxide.

**Loss of Biodiversity**

Ironically using superior genes on a massive scale to increase food production as exemplified by the green revolution in cereal crops, blue revolution in fish production, white revolution in milk, has posed one of the biggest threats to the genetic diversity of crops, fish and livestock. In each of these areas, we have promoted a narrow genetic base - a few genes with highly desirable characteristics to increase production. In this process, we have lost thousands of wild varieties and primitive cultivated varieties, which are resistant to harsh climatic conditions, pests and diseases. If the displaced varieties are not collected and properly stored, they could be lost forever. India has already lost thousands of traditional varieties of wheat since the beginning of Green Revolution (Chaatwal, 1998). It has been reported that at least one species is disappearing each day in the tropical forests alone and in few more years there may well be a species lost each hour. The seriousness of the situation can be gauged from the fact that a disappearing plant can take with it 10-30 dependant species such as insects, higher animals and even other plants.

**Causes affecting Cattle biodiversity are**

1. Lack of awareness  
2. Economic benefits  
3. Overall policy of breed improvement
4. Shrinkage of grazing land
5. Over population of livestock-high density)
6. Aiming only for yield improvement and economic benefits
7. Replacement of local/non-descript breeds with exotic breeds/breed crosses
8. Mechanization of agriculture & transport
9. Inadequate attention on identification of germplasm and performance recording
10. Indiscriminate cross breeding with exotics for other purposes

Consequences of loss of cattle genetic biodiversity are
1. Stagnation and even deterioration of production performance of indigenous breeds
2. Loss of indigenous genetic resources
3. Disappearance of native varieties and breeds
4. Threat to native draught breeds
5. Loss of indigenous biodiversity
6. Shrinkage and even disappearance of grass-lands leading to loss of biodiversity
7. Grassland ecosystem is disturbed

Issues that need to be addressed

a. All efforts must be made to retain biodiversity of unique climatic regions of India.
b. Increase productivity through better management. Better awareness and management of livestock would increase productivity without harming ecology.
c. Optimum population, which the limited grazing land and fodder can support, needs a reappraisal. Policy needs to be adopted to maintain that population for sustainability as also to regenerate available pastures.
d. Slaughter of animals for meat/leather to be made humane and scientific. Export of meat not to be at the cost of natural capital.
e. Caring for non-productive and abandoned cattle needs education, public awareness, transparency and ethics.
f. Emission of methane by cattle should not make us apologetic in climate negotiations, as these are livelihood supporting.
The conservation of domestic livestock biodiversity is a complex and multi-dimensional activity in which number of agencies can play significant role. Different measures of conservation should be implemented through national and state-level strategies, plans and programme developed, keeping in view the social and cultural diversity, ecology, farming practices, present level use, sustainability and economic use. Thus all these issues should be carefully harmonized.

Agricultural Pollutants

The risks of nitrate contamination of water appear greatest in regions where inorganic nitrogen fertilizers are used intensively particularly in seasonal climates where high yielding cereal varieties are cultivated with irrigation. Nitrates are flushed into surface and ground water at the onset of the rainy season and irrigation water provides a direct conduit for nitrate to surface and ground water. Moreover during reuse, nitrate levels may become progressively concentrated (IIED, 1988). Nitrate in drinking water has also been reported to cause methemoglobinemia (blue baby syndrome), which may be fatal in infants (IIED, 1988). Furthermore, nitrosamines derived from nitrogen fertilizers have been implicated in the causation of cancers.

Biological Effects of Air Pollution

The most dreaded effect of air pollution is acid rain. It refers to the precipitation of carbonic, sulphuric, sulphurous and nitric acids during rainfall. It causes fertile lands to grow barren since excessive acidity is deterrent to plant growth. Air pollution effects may be divided into acute effects of exposures to high concentrations over short periods and chronic effects of exposure to low concentrations over long periods. The pollutants induce changes in physiological process of plants such as chlorosis and necrosis of leaf tissue, leaf, flower or fruit abscission and epinastic curvatures of leaves and leaf stems.

Soil Salinity And Water Logging

Indiscriminate use of irrigation facilities resulted in soil salinity and water logging rendering lands unsuitable for farming activities. It is estimated that in developing
countries, every year, more than 2.5 lakh hectares of fertile land under irrigation becomes unfit for crop production. India possesses largest area of irrigated land but unfortunately 36 per cent of its irrigated land got damaged due to salinisation. Faulty irrigation management and inadequate drainage led to serious rise of water table. In Punjab where canal/river irrigation is practiced, since 1985, water table is raising by one meter annually (Singh, 1995). A high water table also causes floods even during slight rains because of the reduced moisture storage capacity. In Hisar (Haryana), the bearing strength of the soil has declined to less than 50 percent in the last 50 years.

3.9 Let us sum up

The Best Environmental Livestock Production Practices consist of best management practices (BMPs) that are commonly applied throughout confined livestock production operations. These practices apply to all types of concentrated livestock operations, including dairy cattle, goats, sheep, broilers and layers. These BMPs address each of the five fundamental concentrated livestock production risk areas: 1) General Site Conditions, 2) Production Areas, 3) Outdoor Manure and Storm Water Storage, 4) Manure Utilization, and 5) Mortality Management. The BMPs are considered to be the fundamental environmental management practices that are necessary for a livestock production operation to function in an environmentally sound and protective manner. These BMPs are based on academic research, professional society publications, guidance from governmental agencies, and the findings from nearly 2,000 on-farm assessments conducted on concentrated livestock production operations across the world.

Suitable strategies are to be advocated to reduce the emission of greenhouse gases from livestock such as adjustment of livestock numbers to the carrying capacity of the land and efficient handling of animal waste through sound agricultural management practices.
Unit- 4

Nutrient Management for Sustainable Livestock Production

Structure

4.0 Objectives
4.1 Introduction
4.2 Importance of nutrition management
4.3 Nutrient requirement of calves
4.4 Nutrient requirement of growing and other cattle
4.5 Nutrient requirements of lactating cattle
4.6 Water requirement of dairy cattle
4.7 Feed resources
4.8 Importance of Agro Industrial By products and Non Conventional Feed Resources (NCFR)
4.9 Characteristics of NCFR
4.10 Status of crop residues and AIBP
4.11 Current constraints to utilization
4.12 Let us sum up

4.0 Objectives

After completing this unit, you should be able to understand:

• Role of nutrition in livestock management and nutritive requirements of different classes of livestock
• Understand the importance of Agricultural Industrial By Products and Non-Conventional Feed Resources in Sustainable Livestock Development (SLD)
• Know the various sources of non-conventional feed resources
4.1 Introduction

Nutrition management is the most important issue, which requires immediate attention in Sustainable Livestock Development. The problem is simply how to expand and increase the efficiency with the available feeds.

Animals should be fed to meet their nutrient requirements. Feeding diets that are deficient in any nutrient will decrease production. On the other hand, feeding excessive amounts of a nutrient will decrease the efficiency of nutrient utilization, which results in increased nutrient excretion into the environment, increased cost of production, decreased profits for producers, and increased costs for the consumers. Hence, it is very essential to understand the nutrient management of animal for better production efficiency.

4.2 Importance of Nutrition Management

There are many factors that affect nutritional requirements of animals under various conditions. Mainly the breed, physiological status, production levels, environment etc. determine the nutrient requirements of animals. Milk production mainly depends on two important aspects – potential of cow / buffalo and feeding. About 60 to 70% of cost of production is related to feeding alone. Hence feeding of animals is very important. Farmers should always aim to provide low cost balanced feed as grazing alone can’t satisfy all nutrient requirements.

In India, animals are given dry fodder liberally and green fodder sparingly. Even though milk producing animals require lot of nutrients than dry (non-producing) animals, farmers provide same quality and quantity of feed to both superior and inferior animals. Severe shortage of green fodder is also coming in the way of increasing the milk production. Some farmers provide little concentrate mixture to milk producing animals only.

Knowledge on scientific feeding will improve the production and productivity of the animals. Let’s understand certain basic principles of feeding dairy animals.
Animals require different nutrients (food constituents) which are essential for the preservation of life. They are water, proteins, carbohydrates, fats, minerals and vitamins.

These substances serve as raw material for the production of milk, meat, egg or wool.

Livestock derive their nutrients from a variety of feedstuffs – pasture/ grazing lands/ grasslands, roughages, concentrates and supplements and additives.

Grass lands are the major source of feeding in India. Animals graze in these lands from morning to evening.

Commonly used roughages for feeding cattle include - leguminous fodder crops viz. Berseem, Lucern, Cowpea etc. Non leguminous fodder varieties – Maize, Sorghum, Bajra, Oats (cereal crops), and perennial verities viz., Paragrass, Guinea grass, Napier Grass, Hybrid napier, Rhodes grass, Sudan grass etc.

Concentrates include all the grains and their by products. Grains of Maize, Oats, Jowar, Barley are important. Plant by products of Cowpea, Blackgram, Horse gram, Bengal gram, oilcakes like Groundnut cake, Linseed cake, Coconut cake, Cotton seed cake are used in preparation of cattle feeds.

Locally available agricultural waste products are used to prepare complete feeds

Important animal proteins used in feed formulation are fish meal, meat meal, dried skim milk etc.

<table>
<thead>
<tr>
<th>Maize Grains</th>
<th>Groundnut Cake</th>
<th>Rice Bran</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deoiled Rice Bran</td>
<td>Mineral Mixture</td>
<td>Salt</td>
</tr>
</tbody>
</table>

Different Feed Ingredients
Let’s understand the nutrient requirements of different classes of animals – calves, growing cattle, lactating cows.

4.3 Nutrient Requirement of Calves

Calf management is very much essential in dairy farming. Proper management and feeding of calves eliminate many problems. The care of a calf starts from its birth itself.

The calves at birth, should be fed colostrum within 2 hours and its feeding should be continued unto 4 days. It is essential to provide antibodies through colostrum, which are absorbed intact in first few days of calf’s life. It has high nutritive value and laxative action to remove first faeces. In case the mother does not give colostrum, a substitute of equal nutritive value of two eggs with an ounce of castor oil and antibiotics may be fed.

Hygienic practices have to be maintained when calves are fed with milk. Milk is a good source of bacterial infection in weaned calves. Because of lower disease resistance of calves, in spite of feeding colostrum, it is better to prevent diarrhoea or dysentery to occur in the calves rather then offer treatment. The feeding schedule of calves is presented below in Table 1.
Table 1: Feeding schedule of calves up to three months of age

<table>
<thead>
<tr>
<th>Age of the calf</th>
<th>Whole milk</th>
<th>Calf starter</th>
<th>Good quality hay</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3 days</td>
<td>Colostrum @ 1/10th Body weight (BW)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4-7 days</td>
<td>Whole milk @ 1/10th Body weight (BW)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8-14 days</td>
<td>Whole milk @ 1/10th Body weight (BW)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15-21 days</td>
<td>Whole milk @ 1/10th Body weight (BW)</td>
<td>A little</td>
<td>A little</td>
</tr>
<tr>
<td>22-35 days</td>
<td>Whole milk @ 1/10th Body weight (BW)</td>
<td>100g</td>
<td>Ad lib</td>
</tr>
<tr>
<td>Upt 2 months</td>
<td>Whole milk @ 1/10th Body weight (BW)</td>
<td>250g</td>
<td>Ad lib</td>
</tr>
<tr>
<td>2-3 months</td>
<td>Milk is gradually reduced and tapered</td>
<td>500g</td>
<td>Ad lib</td>
</tr>
</tbody>
</table>

Source: Applied Animal Nutrition by Dr D V Reddy

4.4 Nutrient Requirements of Growing and Other Cattle

Poor growth rate and late maturity are general problems observed in heifers and young bulls. This is partly due to the hampering of growth due to high parasitic load and also due to underfeeding and general neglect till the heifers are calved. Appropriate feeding schedule has been found to result in adequate growth and thereby overall economy in productivity. Various feeding schedules for the growing animals beyond the age of 6 months are given in Table 2.

Table 2: Nutrient requirements of growing cattle

<table>
<thead>
<tr>
<th>Animal</th>
<th>Body weight in Kg</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Dry Matter (DM) in Kg</td>
</tr>
<tr>
<td>Calves 6-12 months</td>
<td>150</td>
<td>3.7</td>
</tr>
<tr>
<td>Young stock 1-2 years</td>
<td>300</td>
<td>7.5</td>
</tr>
<tr>
<td>Young stock over 2 years</td>
<td>400</td>
<td>10.0</td>
</tr>
</tbody>
</table>
4.5 Nutrient Requirement of Lactating Cows

Milch animals require additional attention as they are the producing animals. Definite feeding strategies based on milk production are to be evolved. The feed management should be such that it provides at least part of the feed in succulent form in summer months in order to help reduce the heat load and to make the feed palatable. In order not to augment the heat load of the animal, one of the useful practices has been to provide feeds during cooler hours of the day and at more frequent intervals especially during summer months. It has been recommended that conserved fodder like silage in the absence of cultivated green fodder is very advantageous and helps to maintain the level of production in lactating cows. In winter, when legume green fodder such as Berseem is available for feeding in large quantities, this should be preferably mixed with dry fodder or fed in installments to avoid bloat. Feeding schedule of lactating cows is presented in the Table 3.

Table 3: Feeding Schedule of Lactating Cows according to Milk Yield

<table>
<thead>
<tr>
<th>Milk Yield in Kg</th>
<th>Requirements</th>
<th>Source of Feed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry Matter  (DM) in Kg</td>
<td>Digestible Crude Protein (DCP) in Kg</td>
</tr>
<tr>
<td>Upto 10</td>
<td>12.0</td>
<td>0.8</td>
</tr>
<tr>
<td>10.1 to 13.0</td>
<td>13.0</td>
<td>0.9</td>
</tr>
<tr>
<td>13.1 to 16.0</td>
<td>14.5</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Source: NDRI handbook on Dairy production
Feeding of a milch animal

**Thumb rules:**

Although the conventional method of ration formulation is based on scientific experimentation, the common farmer finds difficult to follow the computation on body weight basis. The following thumb rule may guide them to feed their livestock satisfactorily. This is based on practical experiences rather than scientific basis.

1. **Maintenance ration**

<table>
<thead>
<tr>
<th>Feed stuff</th>
<th>For desi cattle</th>
<th>For cross bred cows and buffaloes</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Straw</td>
<td>4kg</td>
<td>4-6 kgs</td>
</tr>
<tr>
<td>b. Concentrates</td>
<td>1- 1.25 kgs</td>
<td>2.0 kgs</td>
</tr>
</tbody>
</table>

14-16% DCP  
68-72 TDN

2. **Extra allowance during pregnancy:** During the last trimester of pregnancy, a further quantity of 1.25 and 1.75 kg concentrate is recommended for desi cattle and cross bred cow / buffalo respectively.

**Extra ration for milk production** : Additional amount of 1 kg concentrate mixture is required for every 2.5 kgs of milk over and above the maintenance requirement for cattle and 2.0 kg of milk in case of buffaloes.

**Characteristics of a ration**

1. Ration should have highly digestible feed ingredients
2. Palatable. Evil smelling, musty and mouldy feed should not be given. If unpalatable, improve the palatability by the addition of salt and molasses.

3. Inclusion of variety of feeds in the ration makes it more palatable.

4. Should contain enough minerals.

5. Should be laxative, include succulent fodders in the ration.

6. Green succulent fodders have cooling effect and aid the appetite and keep the animal in good condition.

7. Ration should be bulky to satisfy the hunger.

8. Avoid sudden change in the diet.


10. Prepare feed properly to make it more digestible and palatable.

11. Minimize the cost of feed to make it more profitable.

### 4.6 Water Requirements of Dairy Cattle

Provision of adequate water and free access to it throughout the day is very important especially in summer months. Lowering of temperature of drinking water has proved effective on experimental basis, but it is not practical in field conditions. In the organized dairy farming, care may be taken to bring the temperature of drinking water to the body temperature of cattle. As an alternative, shading of water troughs is helpful.

Water consumption depends on the ambient temperature. The requirements of different categories of animals at different temperatures of 20\(^\circ\)C and 30\(^\circ\)C are given in the table 4. Water consumption can be increased by as much as 40 percent when atmospheric temperature rises to about 35-37\(^\circ\)C. For each Liter of milk produced, a cow may need as much 4 liters of water for drinking.
Table 4: Estimated daily water intake of various groups of cattle

<table>
<thead>
<tr>
<th>Body weight In Kg</th>
<th>Water requirements in litres at different temperatures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20°C</td>
</tr>
<tr>
<td>DAIRY HEIFERS</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>3.6</td>
</tr>
<tr>
<td>100</td>
<td>11.0</td>
</tr>
<tr>
<td>200</td>
<td>20.0</td>
</tr>
<tr>
<td>300</td>
<td>27.3</td>
</tr>
<tr>
<td>400</td>
<td>35.2</td>
</tr>
<tr>
<td>LACTATING DAIRY COWS</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>26.5</td>
</tr>
<tr>
<td>500</td>
<td>31.0</td>
</tr>
</tbody>
</table>

4.7 Feed Resources

Livestock derive feed from different sources. They are pastures, crop residues, agro-industrial by-products (AIBP) and non-conventional feed resources (NCFR). It is appropriate to discuss briefly about each of these categories.

**Pasture:** It is the oldest form of livestock feed. The word pasture refers to land on which different types of edible grasses and other plants grow or grown for grazing livestock. Permanent pastures are those covered with perennial or self-seeding annual species of plants. In India, more than 80% of the livestock population thrive on pastures. The grasslands vary considerably with respect to their ecology. Except in and around forests, most of the so-called pastures in India are denuded by overgrazing and are not worth that name. A major thrust in the direction of grassland management is necessary to
improve them so that the productivity of livestock dependent on them improves. The main objective in grassland management is to provide maximum feed nutrients to the livestock from the pasture without any detriment to the health and productivity of the pasture. Measures like soil and water conservation, improvement of drainage, weed control, burning, closure of grasslands and reseeding in association with proper grazing management can improve pastures considerably.

**Crop Residues:** The term generally refers to various by-products from crop cultivation and each residue, is different in terms of its availability, its nutritive value and its potential impact in relation to the overall feeding system. The crop residues may be of two types - fibrous crop residues (FCRs) which have high biomass and low crude protein 3-4% and high crude fibre 35-48%. These FCRs form the base of feeding systems for ruminants throughout the developing countries, and include all cereal straws, sugarcane tops, bagasse, cocoa pod husks, pineapple waste and coffee seed pulp. Complementary to FCRs are those crop by products that are more nutritious and can therefore be used judiciously to improve the overall diet. This category includes a variety of oilseed cakes and meals, such as coconut cake, palm kernel cake, cottonseed cake and sweet potato vines, which are often used as dietary supplements.

**Agro-Industrial By-Products:** Agro-industrial by-products refer more to by-products derived in the industry due to processing of the main products. They are (in comparison to crop residues), less fibrous, more concentrated and have a higher nutrient content. Good examples of AIBP are molasses, rice bran, pineapple waste and palm oil mill effluent (POME) produced from refining the palm oil.

**Non-conventional Feed Resources:** Non-Conventionel Feed Resources (NCFR) have been identified separately from crop residues and AIBP although they can be components of both these feed categories. The main reason for this is to give them a separate identity, and especially in the context of their vast potential in the developing countries. NCFR refers to all those feeds that have not been traditionally used in animal feeding and are not normally used in commercially produced rations for livestock.
Thus, the term NCFR has been frequently used to describe such new sources of feedstuffs as palm press fiber (oil palm by-products), single cell proteins, and feed material derived from agro-industrial by-products of plant and animal origin, poor-quality cellulosic roughages from farm residues such as stubbles, haulms and vines. Other agro-industrial by-products also exist such as slaughterhouse by-products and those from the processing of sugar, cereal grains, citrus fruits and vegetables from the processing of food for human consumption. This list can be extended to derivatives from chemical or microbial processes, as in the production of single cell proteins.

It is not easy, however, to draw a distinct demarcation between traditional feeds and NCFR. This is because in some countries, such as India and Pakistan, what may now be classified NCFR may, in fact, be traditional to the extent that it may have been fed for a long time. Additionally, the availability of NCFR, especially of plant origin, is dependent to a large extent on type of crops being cultivated, and the prevalent degree of application of the crop technology.

4.8 Importance of Agro-Industrial And Non - Conventional Feed Resources

Expanding the use of agro-industrial by-products and non-conventional feed resources represents, possibly, the most challenging task concerning components of the animal husbandry. The situation is extremely compelling for at least three reasons. Firstly, there continues to exist serious feed deficits that do not appear to be contained in
the face of increasing human and animal population growth. Secondly, inadequacies in dietary nutrient supply penalize animal performance and do not maximize the production of animal products (meat, milk, eggs, skin and fiber). Thirdly, inability to meet national target, especially of edible animal products, has raised doubts about the efficiency of existing animal production systems and the utilization of resources used by animals.

It has been estimated that there was a shortage of 8.5 MTs of concentrates (44 percent), 38.4 MTs of dry fodder (11 percent) and 129.4 million MTs of green fodder (38.4 percent) for dairy animals. The National Commission on Agriculture (1976) report also indicated that only 70 percent of digestible crude protein (DCP) requirement of dairy animals, 50 percent of the requirement of dry animals, 40 percent of the requirement of adult cattle and about 20 percent of the requirement of young cattle were being met from the available feeds (National Commission on Agriculture, 1976). This situation calls for focus on alternate sources of feed to meet the growing demand.

4.9 Characteristics of NCFR

The NCFR has a number of characteristics worth noting and to keep in perspective:

1. They are the by products of food production that have not been used, recycled or salvaged.
2. They are mainly organic in nature and can be in a solid, slurry or liquid form.
3. Their economic value is often less than the cost of their collection and transformation for use, and consequently, they are discharged as wastes. E.g.- fallen tree leaves.
4. The field crops, which generate valuable NCFR, are excellent sources of fermentable carbohydrates, e.g., cassava, sweet potato, tapioca, sugarcane etc
5. Fruit wastes such as banana rejects and pineapple pulp by comparison have augers which are energetically very beneficial.
6. Concerning the feeds of crop origin, the majority are bulky, poor-quality cellulosic roughages with a high crude fiber.

7. Some of the feeds contain toxic factors which have deleterious effects on animals. For eg castor bean meal, neem seed cake

8. They have considerable potential as feed materials, and for some, their value can be increased if there were economically justifiable technological means for converting them into some usable products.

Many of the NCFR are currently designated as wastes, and this is an inaccurate description.

Non conventional feeds fall largely into one of the four areas – food processing residues, crop residues, forest product residues and animal wastes.

- **Sugar factory byproducts**: Sugarcane trash, sugarcane tops, bagasse, molasses
- **Starch Industry waste**: Maize germ, maize barn, maize gluten and maize oil meal
- **Brewery waste**: Brewers waste, left after the extraction of malt required for the beer production.
- **Fruit and Vegetable factory byproducts**: Mango peels and kennels, pineapple wastes, banana wastes, citrus peels, dried cocoa pod husks, oil palm byproducts (palm press fibre), palm kernel cake, palm oil sludge, palm oil mill effluents, tomato processing wastes, potato processing wastes, vegetable wastes.
- **High moisture agro-industrial byproducts**: Apple pomace, tomato pomace, pineapple waste, citrus waste, diary whey, pulp and paper mill residues, distillers grain, condensed molasses soluble, yeast sludge, single cell protein.
- **Marine and aquatic waste**: Fish waste, seaweed meal, prawn waste
- **Slaughter wastes**: Blood meal, meat meal, meat and bone meal, rumen waste
- **Poultry industry waste**: feather meal, offal meal/ poultry waste meal, hatchery waste
- **Animal waste**: Blood meal, meat scrape, feather meal, horn and hoof meal, dried poultry waste, cow manure, pig excreta etc
4.10 Status of Crop Residues and Agro-Industrial By-Products Utilization

1) There now exists substantial and adequate information on quantitative and, to a lesser extent, qualitative data on individual feeds.

2) Research programmes in most countries tend to focus mainly on the utilization of fibrous materials, especially cereal straws.

3) The present position is that urea-ammonia treatment is the most promising chemical treatment technique. A parallel innovation is the use of urea-molasses block licks.

4) Very few studies have attempted to utilize fibrous feeds in the untreated form in combination with other ingredients. There is evidence in this context that supplementation with leguminous forages may be just as effective and more cost-effective than chemical pre-treatments.

5) The bulk of work done hitherto has been at the laboratory or station level. Only limited effort has been made to extend these to site-specific and real farm situations. These extensions are in any case small scale and not altogether convincing.

6) The opportunities for much wider application of nutritional principles that can ensure more efficient utilization of crop residues, AIBP and NCFR especially in real farm situations are enormous, and need to be substantially expanded if ruminants are expected to make a bigger impact on current production.

It is of interest to note that that approximately 80 percent of the NCFR in field crops and 93 percent of the feeds in tree crops cultivation are principally suited for feeding ruminants. The utilization of these feeds by ruminants thus represents a most important function.

4.11 Current Constraints to Utilization

The NCFR are presently underutilized due to several reasons:

1) Production is scattered and in some cases, the quality produced is low, especially for processing.

2) High cost of collection of some of the NCFR, e.g. rubber seeds.

3) Non-competitive costs and unremunerative prices.
4) Tendency to think of some NCFR, e.g., palm oil mill effluent in terms of disposal, not utilization.
5) Processing is difficult and in any case problematical.
6) Lack of managerial and technical skills to utilize the feeds in situ.
7) Limitations in the end uses of the produced products.
8) Uncertainty about the marketability of the end products.
9) Associated with lack of managerial skills and capital resources for the purchase and operation of suitable technology, or for the study of new appropriate technology.
10) Small farmers who form the backbone of traditional agriculture have neither the resources and know-how nor the quantities of residue to take individual action.

In addition to these and with specific reference to NCFR utilization, there are additional major constraints that merit attention:

1) Availability in terms of time, location, seasonality, and storage facilities.
2) Convertibility with respect to handling, separation, transportation and physical processing of the residues.
3) Limited knowledge on the composition of the residues, such as proximate components (e.g., crude protein, crude fibre and minerals) intake and nutritive value (e.g., digestible energy and proteins) which are pertinent to the development of utilization technology.
4) Use of the end product in relation to demand, rate of growth of demand, storage and markets.
5) Inadequate demonstration of potential value in feeding systems both nationally and regionally due to low priority research.
6) Economic viability of residue utilization programmes involving NCFR also needs to be demonstrated.
7) Care is needed to detoxify the deleterious substances such as HCN (cassava leaves/stem, rubber seeds), tannins (salseed cake, tamarind seed hulls, sorghum), theobromine (in fermented cocoa pods husks) and trypsin inhibitor (in guar meal).
An effective feeding system allows maximum intake of a nutritionally balanced ration. As herd production levels continue to improve along with herd size, meeting the nutritional needs of the lactating dairy cow is an increasing challenge for modern dairy producers. In addition to milk production, it is also important to supply nutrients needed for reproductive purposes - most notably conception and pregnancy. A cow nourished properly will be in better physical condition and best suited to handle the stresses of high milk production. Therefore, the feeding system must undergo examination as production levels increase, not only for maximum milk production but also for the physical well being of the animal.

The most commonly recommended strategy is grouping by level of production. If employed, rations can be formulated and delivered to the group animals currently producing the specified level of milk production. The practice may allow efficient use of the feed inventory since top quality higher-priced feeds may be targeted for the top producing cows whereas poorer quality lower-priced feeds may be fed to lower producing cows.

Expanding the use of agro-industrial by-products and non-conventional feed resources is one of urgency. The urgency relates to continuing low animal performance, inadequate utilization of the available feed ingredients and poor efficiency of existing animal production systems. The strategy to correct this situation calls for more innovative technical application of the information on hand, backed by strong institutional support that can focus more particularly on the primary AIBP and NCFR
Health and Disease Management

Structure

5.0 Objectives
5.1 Introduction
5.2 Importance of prevention and control of diseases
5.3 Biosecurity management
5.4 Health and disease management
5.5 Strategies for the control of infectious diseases
5.6 Economic aspects of disease control
5.7 Let us sum up

5.0 Objectives

After completing this unit, you should be able to:

- Understand the economic importance of disease management
- Understand the importance of bio security management
- Appreciate strategies to be adopted for control of infectious diseases

5.1 Introduction

One of the most critical parameters in livestock husbandry and production is animal health. The livestock that forms the core of the food chain can be severely affected by outbreaks of highly infectious diseases, causing devastating effect on cash flow, equity and International trade besides ruining the individual farmer. In the livestock production, it is too late to undertake actions when clinical signs of diseases
have developed. The intelligent use of the wide options of available disease preventive measures easily contribute to a good health situation, improved economy of animal production and help in preventing suffering and death. Therefore, a sound health plan should be established that continuously focuses on disease prevention. The implementation of strategic plan for control of infectious diseases at both herd and national levels needs close cooperation between producers, stakeholders, veterinarians, authorities and also consumers. The prevention of diseases essentially relies on the use of therapeutic and prophylactic drugs although effective vaccines and eradication can play a significant role.

5.2 Importance of Prevention and Control of Diseases

With the intensification in the production system and importation of exotic breeds of food animals in developing countries, the economic impact of animal diseases has become increasingly important. Infectious diseases cause an enormous economic loss to the country by reducing the production and productive potential of the livestock. Rough estimate put the annual loss on account of endemic and epidemic outbreaks at Rs.7000 crores, a significant loss to growing industry. The annual loss incurred on Foot and mouth disease alone in India exceeds Rs.500 crores. In addition, disease prevalence is also a serious constraint to the expansion of international trade in animal and animal products. Therefore, controlling both endemic and epidemic diseases is very important requirement for augmenting animal production. Public health implications of disease may be another factor in determining the need for disease control.

5.3 Biosecurity Management

Biosecurity literally means the safety of living things or the freedom of concern for sickness or disease. Another definition of biosecurity is "security from transmission of infectious diseases, parasites and pests". Biosecurity threats come from the possible introduction of a disease into a herd or flock, which is not known to have the disease. Biosecurity protocols on the farm and during transport are now more important than ever.
Biosecurity Protocols: All livestock can be affected by a loss of biosecurity. Effective biosecurity protocols allow large-scale intensive production to occur on a single site. The poultry industries have had biosecurity protocols in place for many years and with good effect. The cattle and dairy industries have shown less interest in biosecurity but every year there are instances of diseases that could have been prevented with effective biosecurity protocols.

What to Do?

It is an approach to animal husbandry that has a focus on maintaining or improving the health status of their animals and preventing the introduction of new disease pathogens by assessing all possible risks to animal health. The biosecurity mindset must ultimately maintain itself as tangible measures. Always consider the question, "What would I do if something goes wrong?"

Disease Transmission in Livestock: The most common method of disease transmission is by contact of a susceptible animal with an infected animal. This can occur within the herd or from herd to herd by the introduction of new livestock.

Implementing Biosecurity:

- Know where new and replacement animals are coming from and if in doubt quarantine them before introduction into the herd. Make sure they will be compatible with the existing herd.
- Follow a protocol for the introduction of new animals into the herd as recommended by your veterinarian.
- Follow programs of rodent control and other wild animals on your premises.
- Control insects to the extent possible within the herd.
- Evaluate all feed inputs, vehicles and visitors for biosecurity. Consider the front gate of the farm as your control point for the entry of disease.
- Develop protocols for all visitors such as providing boots, clothing, showers and disinfectant footbaths for them.
Disposal of carcasses: Proper disposal of carcasses of animals died of infectious diseases is utmost important in preventing the spread of diseases. Carcasses should never be disposed off by depositing them in or near a stream of flowing water, because this will carry infection to downstream. An animal died of a infectious disease should not be allowed to remain longer in shed as biting insects, rodents etc can reach it. Unless approved by a Veterinarian, it is not safe to open carcasses of animals that have died of a disease. All carcasses should be disposed properly either by burial or burning.

Proper disposal of dead animals

5.4 Health And Disease Management

Cattle health management is a disease prevention strategy that includes:

- fostering natural immunity in animals by increasing animal and plant biodiversity on the farm
- balancing nutrition through pasture grazing management and mineral supplementation
- reducing animal stress through appropriate facility design and pasture exposure
- providing high quality forage in the dormant season

The natural living conditions of pastures decrease animal stress and remove unnecessary burdens on the immune system. Other practices such as sanitation, quarantine of new animals, and the use of probiotics in young animals can also foster a healthier environment for livestock. Disease prevention is the best health plan for herd, and a well-planned pasture-based system effectively eliminates many disease vectors and alleviates many nutritional disorders.
Disease

Disease has been broadly defined as any condition in which there is a deviation from health or normal functioning of any or all the tissues and organs of animal body. Disease is a condition that usually occurs when an infectious agent comes in contact with an immuno-compromised host. Stress factors usually underlie compromised immune systems. Stress factors in beef cattle production include hunger, heat, cold, dampness, wind, injury, fatigue, and rough handling. Infectious agents include viruses and bacteria, which cause many of the following disease conditions.

Table 1: Common Livestock Diseases

<table>
<thead>
<tr>
<th>Cattle</th>
<th>Sheep and Goat</th>
<th>Pigs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Viral Diseases</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foot and Mouth Disease</td>
<td>PPR (Peste des Petits Ruminants)</td>
<td>Hog cholera</td>
</tr>
<tr>
<td>Infectious Bovine Rhinotracheitis</td>
<td>Blue Tongue</td>
<td>Vesicular Stomatitis</td>
</tr>
<tr>
<td>Para Influenza</td>
<td>Capri Pox (Goat Pox)</td>
<td>Pig Pox</td>
</tr>
<tr>
<td>Bovine leukemia</td>
<td>Dermatitis</td>
<td>Auzesky’s Disease</td>
</tr>
<tr>
<td>Bovine Viral Diarrhoea</td>
<td>Contagious Erythema</td>
<td>Swine Influenza</td>
</tr>
<tr>
<td>Cow and Buffalo Pox</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malignant Catarrhal Fever</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ephemeral fever</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bacterial</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wooden Tongue</td>
<td>Wooden Tongue</td>
<td>Anthrax</td>
</tr>
<tr>
<td>Anthrax</td>
<td>Anthrax</td>
<td>Tuberculosis</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>Johne’s Disease</td>
<td>Johne’s Disease</td>
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<td>Johne’s Disease</td>
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5.5 Strategies for the control of Infectious Diseases

Control is the reduction of morbidity and mortality from the disease. The approach to control a specific disease is dependent upon understanding of its etiology. In most instances, the etiological agents are single or a few related species of pathogenic organisms, which are relatively genetically stable and which have a narrow host range. In addition, diagnostic tests which can be applied to screen affected animal populations are available for majority of these infections. Such diseases therefore can be effectively controlled following standard control measures. The methods applied for the prevention and control of infectious diseases are briefly dealt here.

Quarantine:

Quarantine is the detention of animals that are either infected or suspected of being infected or non-infected animals that are at risk, for a time equivalent to incubation period of the disease in question. Animals being imported undergo quarantine for a period till it's being cleared or confirmed free from the disease. Countries that are free from the disease impose strict quarantine for importing animals from such regions where the disease is endemic. A breach in quarantine procedure during import of animals from certain countries where such disease prevail can pose significant public health hazard. Apart from this, government should impose quantitative restrictions on import of meat products in the wake of liberalized international marketing, which might otherwise pave way for emergence of exotic diseases.

Slaughter:

This is selective elimination of the infected animals. Test and slaughter policy has been highly successful in most developed countries where the disease has already been eradicated or where it was not reported earlier. For instance Mad Cow disease was responsible for slaughter of large population of cattle in UK in the late nineties. Of late, Britain had to slaughter one million cattle and other cloven hoofed animals following fresh outbreaks of FMD.
Slaughter also applies to culling chronically infected or diseased (such as tuberculosis or chronic mastitis) animals which might otherwise act as reservoir of infection to susceptible livestock. Selective slaughter is not feasible when prevalence of infection is very high or when socio-economic conditions abstain from such practices.

**Vaccination:**

Mass immunization though vaccines is the best way of controlling epidemic and particularly endemic diseases in developing countries. Vaccines can also be used in the wake of epidemics to check the number of susceptible population. Despite the availability of both inactivated and live vaccines against a number of infections of livestock, the disease outbreak is not a uncommon phenomenon. Some vaccines based on inactivated antigens may afford only partial or no protection. For example, Hemorrhagic septicemia vaccine has not been very efficient requiring 2-4 doses annually. H.S.oil adjuvant vaccine developed at Indian Veterinary Research Institute also requires a booster dosage. Therefore, developing an improved or more efficient vaccine is an important research area. An inactivated vaccine employing potent adjuvant to enable induction of early protection is of great value in the spate of any outbreak. In contrast to killed vaccines, live vaccines may have disadvantage of causing spread of infectious agent. In some cases, they may have public health significance (*Brucella abortus* vaccine strain 19). Mass immunization is also used to reduce very high prevalence to a level whereby selective slaughter can be introduced as control measure.
Mass treatment:

Antibiotics, anthelmintics and hyper immune sera (HIS) are used either therapeutically or as a prophylactic measure of controlling disease in a flock or herd. It can be used as blanket control measure either in emergency situations, as with sudden rise in incidence or when disease prevalence is high. The method is useful in controlling especially gastrointestinal infections of bacterial or protozoal or helminths in origin.

Vector and reservoir control:

Removing the vectors can control certain infections transmitted by either biological or mechanical vectors. Insecticides and acaricides have had a significant impact in controlling several diseases such as Viral Encephalitis, Yellow Fever and African Horse Sickness. Reservoir host (wild/domestic) can also propagate the infectious agent through susceptible livestock. For example, prevalence of TB in wild reservoirs in UK, New Zealand, South Africa and North America have posed serious threat to disease control programs in these countries. Elimination or vaccination of such hosts is very important for effectively combating the disease incidence. Veterinary personnel must follow proper personal hygiene and use appropriate vaccine handling and administration techniques to prevent spread of diseases.

Disinfection:

Sometimes fomites, which include surgical instruments, farm equipments; vessels and utensils may also transmit the infection. Such infected or suspected fomites may be disinfected or burnt or boiled to free from the infectious agent. Proper disposal of the infected wastes from animals or infected carcass is equally important.

Husbandry practices:

Inadequate hygiene is the important environmental cause for increased incidence of mastitis, neonatal mortality and other such diseases. The animal house should have well designed ventilation. Removal of faeces and litter twice daily and use of disinfectant can help improve the health status of farm animals.
Nutritional status of the domestic animals raised for food production plays an important role in resistance mechanisms against disease causing agents. Nutritional stress through deficiency of energy, protein, vitamins and minerals may influence the outcome of disease in infected animals. It is pointed out that any future evaluations of the requirements of particular nutrients should include not only growth and production criteria but also immunological criteria.

**Movement of hosts:**

Infectious diseases may be transmitted over long distances as a result of mobility of infected animals, vectors and also fomites. For example, the movement of horses in connection with their sale, racing and breeding can spread a variety of equine infections. Therefore there should be restriction on the movement of animals from the endemic zones or from an area where outbreak is reported. An area falling within 10-15 km of radius from infected zone has to be demarcated from which the trans boundary transmission should be avoided. This shall also be followed by ring vaccination to bring spread of disease under control.

Man is also a most likely source of spread of infection. Therefore, it is important to restrict such human carriers at the farm level as visitors, servicemen from one farm to another, visiting veterinarian from one to another farm and workers.
Education:

Improving the level of awareness in the society is essential for success of disease control programs, especially where the social attitude of the public has to be influenced. The educational programs should be aimed at gaining the confidence of livestock owners by public demonstrations of the importance for control of the disease through immunization or slaughter.

Slaughter campaigns against the diseases such as rabies in dogs, tuberculosis in cattle can be implemented unless socially or economically, or religiously acceptable. For example slaughter of dogs in western countries or cows in India is unacceptable on religious grounds. The educative programs should be designed to influence their attitude and motivate them to contribute towards controlling a disease.

5.6 Economic aspects of Disease Control

Economic aspects of various disease control programs need to be studied before implementing them. An optimal control program for a given disease can be determined based on the cost and benefit analysis of alternative control strategies. Cost analysis includes the actual expenditure on control, preventive and curative measures. Benefits in terms of both financial and social ways have to be taken into account to assess the impact of particular program. Monetary benefits can be through saving on treatment of sick animals and loss due to reduced production, abortion, animal mortality and slaughter of infected animals. Social benefits are difficult to assess. They include easy
management, better quality produce for human consumption, and lack of suffering, avoidance of inconveniences arising from disease status in animals. In general, benefits to the producers/farmers must be ensured within short period of time to encourage them participate for success of programs.

Need for animal disease control centre?

Food and agriculture organization (FAO) recommends that countries shall set up National Animal Disease control Centre (NADC) for designing, implementing and monitoring various disease control programs and policies decided by a much higher central body. There should be Local Animal Disease control Centre (LADC) to operate at the regional level. However, in a bigger country like India, a further hierarchy in the system may be needed to diversify the activities for effective management and coordinating of the system at all levels. Disease forecasting mechanism need to be evaluated.

5.7 Let us sum up

Prevention is better than cure. Disease control programs help in sustaining production performance of farm animals and prevent massive suffering and death. It significantly contributes towards public health also, as 80% of diseases are zoonotic in nature.

No single or foolproof method of control is available for a particular disease but combination of such methods is necessary in most instances. Nevertheless, some of the diseases have not been controlled successfully in developing countries because of inadequate veterinary services, political will, lack of support from local population and inefficient financial and technological assistance.

In addition to these approaches, proper legislation for disease notification and control of diseases is necessary towards controlling and final eradication of livestock diseases. Although government funds livestock disease programs, community support is the bottom line for their success.
Unit- 6

Technologies for Sustainable Livestock Development

Structure

6.0 Objectives
6.1 Introduction
6.2 Importance of Biotechnology in Sustainable Livestock Development
6.3 Importance of ITK
6.4 Concept of Indigenous Technical Knowledge (ITK)
6.5 Importance of ITKs
6.6 Scouting and Documenting ITKs
6.7 Blending ITKs with Modern Technology
6.8 Establishing Scientific Rationale / Validity Of Documented ITKs
6.9 Documented ITKs for promoting Sustainable Livestock Development
6.10 Merits and Limitations of ITKs
6.11 Let us sum up

6.0 Objectives

After completing this unit, you should be able to:

- Understand the applications of biotechnology in Animal Sciences
- Understand the concept and importance of ITK in sustainable livestock development
- Scout, assess and document ITKs in Sustainable Livestock Development
- Use ITKs for promoting sustainable livestock development
6.1 Introduction

Human beings have been practicing biotechnology – the application of technology to living things – from the earliest times. Biotechnology in animal sciences began when man started artificially selecting and breeding animals to enhance their desirable characteristics, particularly to improve food production. Subsequently, biotechnological exploitation of microorganisms resulted in processes to produce bread, beer, antibiotics and many other fermentation products that are used by people around the world.

In the recent past, the term ‘indigenous technology’ has also gained momentum in every field of development including agriculture. Literature suggests that, from the very beginning, farmers have been developing their own techniques of farming as solutions to their problems of pests, diseases, drought, cyclone, rain and other unfavourable weather conditions. The farmers have learned these methods by experience, trial and error techniques. On the other hand, there is also another school of thought that there is a farmer-based method of research, which is more or less identical to scientific method adopted by scientists. Experts have claimed that farmers follow more or less the same steps of research as the scientist does. The product of farmers continued experimentation is the Indigenous Technical Knowledge (ITK).

6.2 Importance of Biotechnology in Sustainable Livestock Development

Biotechnology procedures increasingly dominate breeding and veterinary practices in animal keeping and open up new areas of production. Thereby biotechnology reproduction techniques are most important in conventional animal keeping. Various techniques are already broadly applied techniques in livestock husbandry practices.

Acceptance of biotechnology in livestock production is difficult, and depends heavily on the perception of risks and benefits by general public. The acceptance of biotechnology applied to animal production will depend on social and cultural aspects, and on the perceived benefits for consumers and society in general.
6.3 Application of biotechnology in Animal Production

Biotechnology is already widely in use in animal production and there are numerous other potential applications – livestock breeding, nutrition, health, disease diagnostics, animal waste treatment etc. Let's understand the specific role of biotechnology in animal production.

6.3.1 Biotechnology And Livestock Breeding: Biotechnology has been utilized different livestock breeding arenas- artificial insemination, embryo transfer technology, genetic markers, cloning etc. A striking example for using biotechnological tools for selective breeding is application of semen collection, cryopreservation, etc in the past few decades.

Embryo transfer technology, in fact, revolutionized the field of reproductive biology. It involves placing of an embryo into the lumen of the oviduct or uterus. An animal with superior genetic characteristics is superovulated to produce maximum number of eggs, which are then fertilized by semen from a genetically superior bull. Fertilized embryos are flushed and then transplanted into surrogate mothers, which had been synchronized into heat. Higher selection intensity on the bull dam path, shortened generation intervals and increased number of offspring from excellent parent stock have become possible through this technique. This technology can also be efficiently used for conserving animal species, which are on the verge of extinction.

Biotechnology offers tools that allow us to achieve rapid increase in productivity. Genetic markers help breeders identify those animals that carry desirable genes without having to wait and test them. It helps breeds to keep fewer animals and apply a much greater selection pressure, weeding out less promising animals. The end result is smaller, cheaper breeding programmes and faster progress.

Cloning, Embryo sexing, another cutting edge technology, allows producers to concentrate their genetic improvement on their superior male or female lines And reduce that cost
6.3.2 Biotechnology in Animal Nutrition: Use of biotechnology derivates like probiotics pre-biotic enzymes, organic acids help in better nutrients utilization by livestock.

6.3.3 Biotechnology and Vaccines: One of the greatest biotechnological interventions of all time is vaccination. One of the major problems in livestock production services is the availability of effective vaccines in remote rural areas. Traditional vaccines, be they attenuated or inactivated have often proved to be very efficient in controlling animal diseases. However, they have a number of limitations. The goal of scientists working to overcome disease problems is a vaccine that is to develop cheap to generate, easy to deliver and gives widespread protection against disease.

New generation vaccines are commonly lyophilized - freeze dried - to form a powder that can be stored at room temperature and hence no more cold chains. The vaccine is reconstituted by adding water to the powder, as the vaccine is needed. It is simple, cheap, safe to use and highly effective. This was possible because of biotechnological tools.

Protection of sheep against PPR through vaccination
6.3.4 Biotechnology and Animal Disease Diagnostics: Most current methods of diagnosing livestock diseases are labor intensive and require good equipment and facilities and well-trained, experienced people to identify the pathogenic organisms concerned. Biotechnology offers prospects of better, more accurate diagnostic tests that are cheap and simple to use and better suited to the situation of national programmes than older testing systems. PCR-based diagnostic systems are more specific and sensitive. Improvements in control procedures, reductions in the cost of equipment (thermocyclers) and reagents (polymerase) are making this technology particularly attractive. The ability to get primers made on demand is making this approach even more viable in the developing country situation.

![Disease Diagnosis](image)

6.3.5 Biotechnology in Treatment and Disease Control: The use of antibiotics extracted from various bacteria and fungi is one of the most important applications of biotechnology for animal health. Monoclonal antibodies can also be potentially used for treatment of diseased animals. Numerous antibodies are now semi-synthesized or totally synthesized. Other molecules from the vector family, have been extracted from
microorganisms and hence been proved to be efficient in parasite control. Monoclonal antibodies can also potentially be used for treatment of diseased animals.

6.4 Concept of Indigenous Technical Knowledge (ITK)

Rural people have an intimate knowledge of many aspects of their surroundings and their daily lives. Over centuries, people have learned how to grow food and overcome difficult environments. They know what varieties of crops to grow, when to sow and weed, which plants are poisonous and which can be used for medicine, how to cure diseases, and how to maintain their environment in a state of equilibrium.

This "Indigenous Technical Knowledge" or ITK covers a wide range of subjects such as agriculture, animal husbandry, food preparation, education, institutional management, natural resource management, health care and many other topics.

The Indigenous Technical Knowledge (ITK) is regarded as the information gained over a period of time and passed on from generation to generation by the word of mouth. ITK is stored in people's memories and activities, and is expressed in the form of stories, songs, folklore, proverbs, dances, myths, cultural values, beliefs, rituals, community laws, local language and taxonomy, agricultural practices, equipment, materials, plant species and animal breeds. ITK is shared and communicated orally, by specific examples and through culture. An African proverb says "When an old knowledgeable person dies, a whole library dies" indicating the importance of ITKs.

Of late, the policy makers, the scientific community and the extension workers started recognizing the value and importance of ITKs in agriculture. The inherent nature of ITKs in to prevent over-exploit of natural resources, thus paving the way for sustainable agriculture.

ITK is a valuable resource for development. Under certain circumstances it can be equal to or even superior to the know-how introduced by modern research. Development efforts should, therefore, consider ITK and use it to best advantage. Although more and more development professionals have come to realize the potential
of ITK, it remains a neglected field. A key reason for this is the lack of guidelines for recording and applying ITK. Without such guidelines, there is a danger that ITK will get eroded.

The development of ITK systems, covering all aspects of life, including management of natural resources has been a matter of survival to the people who generated these systems. It is based on experience, often tested over centuries of use, adapted to local culture and environment and dynamic and changing. Indigenous forms of communication and organization are vital to local level decision making process and to the preservation, development and spread of ITK. ITK is not confined to tribal groups or the original inhabitants of an area. It is not even confined to rural people. Rather any community possesses Indigenous Technical Knowledge - rural and urban, settled and nomadic, original inhabitants and migrants. Other names for indigenous technical knowledge (or closely related concepts) are ‘Local Knowledge (LK)’, ‘Traditional Knowledge (TK), Native Wisdom (NW)’ and ‘Traditional Ecological Knowledge’ (TEK).

**Definitions of ITK:**

- Wang (1988) defined ITK as the sum total knowledge and practices which are based on people’s accumulated experiences in dealing with situations and problems in various aspects of life and such knowledge and practices are special to a particular culture.

- Indigenous technical knowledge (ITK) refers to the unique, traditional, local knowledge existing within and developed around the specific conditions of women and men indigenous to a particular geographic area (Grenier, 1998).

- *Indigenous technical knowledge (ITK) can be defined as any information originated out of farmers experience which has practical utility in solving farmers problems which is feasible, profitable, and socially acceptable and adopted to farmers own conditions which moves from one generation to another by word of mouth (Sabarahnam, 1996).*
6.5 Importance of ITKs

Indigenous technical knowledge has two powerful advantages over outside knowledge - it has little or no cost and is readily available (Kothari, 1995). ITK is found to be socially desirable, economically affordable, sustainable, and involve minimum risk to research users and widely believed to conserve resources. Thus, ITK provides basis for problem solving strategies for local communities. In addition, the use of ITK assures that the end user of specific development projects are involved in developing technologies appropriate to their needs (Warren, 1993). Learning from ITK can improve understanding of local conditions and provide a productive context for activities designed to help the communities.

Identifying, documenting and incorporating ITK in Animal Husbandry extension organization is essential to achieve sustainable development. ITK systems provide a frame of reference for strengthening extension programmes.

Scattered Indigenous Technical Knowledge: Compared to modern scientific knowledge, is scattered and in-built in the life of the rural people. The farmers have discovered, selected and domesticated the major crops and animals. With the result, a number of farming systems have emerged. Even today, farmers play an important role in developing technology, however, this has not been well acknowledged by scientists.

Scientists and ITK: Scientists find it difficult to swallow the fact that they have also something to learn from the farmers and the rural people. They do not think that there is a parallel system of knowledge to their own which is complimentary in nature, usually valid and sometimes superior in some respects. It is very difficult for the scientists to believe that the farmers also have their own professionalism.

When scientists make attempts to know something from the farmers they try to rationalize in their own categorization, meaning and prioritization rather than learning from the farmers, their meaning and priorities. In fact, they don’t treat them as professional colleagues and collaborates nor as teachers. It is often taken as granted that farmers are passive listeners, and receivers of modern technology accepting whatever
the scientists say, extension workers persuade and input dealers indicate. However, unfortunately, this assumption is not correct most of the times. Farmers have invented or re-invented many technologies, indigenous technical knowledge, indigenous technology, local technology, farmers technology are all fashion of the day among scientists, administrators and extensionists.

6.6 Scouting and Documenting ITKs

There is no dearth of ITKs and native wisdom. The problem lies in accessing it. For this the starting point is to accept the very fact that there is a treasure of ITKs in our countryside. It only needs to be scouted and documented. Now, with IPR regime in place, it is high time that all concerned agencies devote concerted and conscious efforts to identify, document and thereby protect out ITKs. The important steps in this regard are listed below.

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<th>S.No.</th>
<th>Steps</th>
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<td>Document the ITKs</td>
<td>Surveys / RRA / PRA / Observations / Documentary evidences</td>
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<td>2.</td>
<td>Validate the ITKs / Assess the ITKs for Scientific Logic</td>
<td>Survey / Laboratory Analysis / On-farm testing</td>
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<td>3.</td>
<td>Refine the ITKs for increasing its applicability on wider scale</td>
<td>Input to Research / On Farm Research / Farmer Participatory Research / Laboratory Studies</td>
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<td>4.</td>
<td>Patent the Valid and Refined ITKs</td>
<td>Guard and legalize the ITKs, ensure ownership to local communities</td>
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<td>5.</td>
<td>Promote the Use of validated and refined ITKs</td>
<td>Involve local communities, use media mix, integrate indigenous networks, publicize &amp; reward</td>
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6.7 Blending ITKs with Modern Technology

Of late, scientists and the technology developers have realized that there is a need for blending the modern technology with a local technology to increase the adoption rate for local technologies. Thus, in the process of technology development, knowledge of indigenous technology is an indispensable source that can be possessed and managed by a local community.
Today it is widely accepted among agricultural scientists throughout the world that the re-assessment of indigenous technical knowledge is an indispensable part of the introduction of new agricultural technology. It is recognized that the knowledge of farmers must be taken into account before any new technology is developed and disseminated.

6.8 Establishing Scientific Rationale / Validity Of Documented ITKs

All the ITKs may not be scientifically valid. In fact, much of the ITKs may just be based on beliefs, taboos, cultural ethos etc. Therefore, it is essential to first filter out the ITKs by establishing their rationale or scientific validity. The following criteria are to be considered while validating the ITK:

Criteria for Validating ITK:

- Efficacy
- Cost-effectiveness
- Availability
- Complexity
- Cultural appropriateness
- Effect on different groups in communities, and
- Environmental soundness
- Constraints

6.9 Documented ITKs for promoting Sustainable Livestock Development

The intensive livestock farming resulted in depletion of nutritional status of soils, erosion of bio-diversity, natural habitats, forests and water resources. Indiscriminate use of chemical pesticides and fertilizers affected the agro-ecosystems, caused pollution of soil and water resulting in human and animal health hazards and contributed significantly to destabilize the traditional systems of agriculture. The traditional livestock and fisheries management practices have been classical examples of non-
exploitative and non-polluting methods of farming leading to sustainable development. A select list of such documented practices given below.

- Spices of mango pickles (afara) and neem leaves are fed to animals to cure bloat
- A bandage with jowar, kerosene and yellow soil is applied for lesions of Foot and Mouth disease in cattle
- Leaves of ‘Dikkamani’ (*Gardenia resinifera*) and seeds of ‘Bendval’ (*Dendrophthoe falcata*) plant are pounded and the mixture is fed to animal to cure the constipation within a day.
- To cure swelling of udder caused due to Mastitis, bites of poisonous insects or mechanical injury or improper milking, 200 grams of soil from the termite mounds is collected and boiled in water, and the boiled suspension is applied to the affected part to give relief to the animal within a day. This is very effective in summer, not so effective in monsoon season.
- Flatulence caused due to excessive grazing or feeding of green fodder which is common during the monsoon, can be cured by giving whey milk, onion and leaves of custard apple to the animal.
- For the animal suffering from gastric trouble, 10 grams of Hing (asaphoetida) is dissolved in 500 grams of edible oil and given to have a carminative and soothing action.
- For de-worming the young calves, a small quantity of curd or buttermilk is kept in a copper container overnight to get a blue-green colour, diluted and given. The effect is seen from the next day.
- To treat FMD affected animals, the hooves and mouth are washed with warm salt solution, and the mixture of leather ash and Sesame oil or groundnut oil is applied to affected area.
- Neem leaves and turmeric powder is used as a paste on external injuries to cure the wounds and other skin disorders.
- Hot fomentation with bags containing salt and boiled Tamarind leaves is used to relieve sprains and inflammation in cattle.
Oral administration of castor oil mixed with neem leaf or bark extract is used to cure constipation in cattle.

Salting followed by sun drying is an effective method of fish preservation.

Immediately after dressing and cutting fish into pieces, mustard oil, salt and turmeric powder are rubbed to prevent spoilage.

Banana stems are put in the ponds after harvest, to make water alkaline, to increase fish growth.

To catch more fish, thorny bushes are used as aggregating devices – especially in summer to enable fish to take shelter and then catch with net.

Glue made from tamarind bark is used for strengthening fishing nets.

Cow dung slurry is used to control the ‘Euglena’ bloom.

Supernatant of the cow dung slurry is used as disinfectant for the preparation of dry fish.

Ray fish’ oil is used for painting boats for leak proofing.

Cashew shell oil, coal tar and sardine oil are used for preservation of boats and nets.

Saw dust and ice are used for fish preservation and live transport.

Boiled extract of Tamarind seed powder and the bark of “Kalasha’ are used to treat fishing nets for improving their strength.

Lime spray is used to rectify water pollution signified by green water coloration.

6.10 Merits and Limitations of ITKs

By now you might have realized the significant role ITKs play in promoting sustainable livestock development. While, ITKs definitely have lot of potential in this regard, we must understand and appreciate their specific merits and limitations. This should guide us in selection of proper ITKs for blending with modern technology in the overall interest of sustainable livestock development.

**Merits of ITKs:** ITKs are location specific and hence readily fit in to the scheme of sustainable development. They use the creative wisdom and intelligence of local rural
masses. Hence, by fostering ITKs, we can enhance innovation ability of rural people. It also encourages judicious use of locally available inputs or resources. Thus, by promoting ITKs, we can reduce the pressure on use of external and costly resources and inputs. This will also help in protecting the environment from degradation and pollution.

**Limitations of ITKs:** While ITK provides for initial self-belief and confidence needed to counter the fatalism of the poverty and leads to some form of self-development, it has its own limitations. ITK is from uniform distribution either within or across communities as distribution depends upon the capacity of the individuals to manage the knowledge, monopolization of knowledge and specific groups of economic stratification. Therefore, indigenous technology cannot be manipulated independently of social, political, economic structures, it occurs.

**6.11 Let us sum up**

Biotechnology is not a new science and has been known to us for several ages. However with the emergence of genetic engineering, it has assumed tremendous importance in the field of animal sciences. Biotechnology helps animal scientists understand how biological processes normally occur, as well as what happens to these processes in disease conditions. Through better understanding, we can work to maximize animal well-being, production, and efficiency, as well as develop new treatments for diseases in animals.

The Indigenous Technical Knowledge (ITK) is socially desirable, economically affordable, sustainable, involves minimum risk and focus on efficient utilization of eco-friendly resources. The context of local knowledge systems combining traditional skills, culture and artifacts with modern skills, perspectives and tools is not something that has happened only in the recent past.

The need of the day is to establish a foundation at the national level that helps in building national register of innovations, file applications for patents, provides micro-venture capital support for enterprises based on indigenous knowledge and non-
material incentives such as recognizing or honoring innovators and community holding indigenous knowledge. Policy reforms need to be aimed at building local ecological knowledge in educational curriculum, development of markets for the indigenous and organic products and supporting collective resource management institution reinforcing conservation ethics.
AEM-205

Sustainable Livelihood in Agriculture

(3 Credits)

Block-III
Fisheries Development

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Unit- 1

**Culture and seed production of Freshwater Fin fishes and Shell fishes**

**Structure**

1.1 Introduction
1.2 Design and Construction of Fish Farm
1.3 Culture Carp in Static Ponds
1.4 Culture of Freshwater Prawn
1.5 Integrated Fish Farming
1.6 Breeding and Seed Production of Cultivable Freshwater Fin fishes and Shell fishes

**1.1 Introduction**

Aquaculture in India has shown a phenomenal growth during the last two decades. Further, the freshwater aquaculture has been the major contributor of the country’s aquaculture production with a share of over 95% in terms of quantity. Carps form the mainstay of culture practice in the country. While the three Indian major carps viz., catla (Catla catla), rohu (Labeo rohita) and mrigal (Cirrhinus mrigala) form the most important group and contribute a lions share of the aquaculture production, the three other domesticated exotic carps viz., silver carp (Hypophthalmichthys molitrix), grass carp (Ctenopharyngodon idella) and common carp (Cyprinus carpio) are the second important group. With technological inputs, entrepreneurial initiatives and financial investments, the pond productivity on a national basis has gone up from 600 kg / ha /yr in seventies to over 2800 kg/ha/yr at present. Higher production levels of 6-8 t/ha/yr has been a common feature for several farmers and entrepreneurs in the states like Andhra Pradesh, Punjab, Haryana, Maharashtra, etc. In an attempt towards diversification and
enhancing farm income, subsequently high valued catfish and freshwater prawn species were also brought into the culture systems. In addition, a range of other non-conventional culture systems, *viz.*, sewage-fed fish culture, integrated farming systems, cage and pen culture, etc has made freshwater aquaculture an increasingly growing and economic farming enterprise across the country.

**Criteria for Selection of Candidate Species for Culture**

Selection of species for stocking is one of the prime factors which determine the success of any culture operation. There can not be a universal fish which will follow or which can satisfy all the desirable qualities for maximizing the production. However, the species selected for culture should satisfy the maximum criteria for increasing the production rate. The following are the few criteria considered for selection of the candidate species

**i) Rate of growth and size attained**

Fishes which grow to a larger size in short period are suitable for culture. Indian major carps *viz.*, catla, rohu and mrigal and exotic carps *viz.*, silver carp, grass carp and common carp are preferred because of their higher growth rate and larger size compared to other species.

**ii) Fishes with shorter food chain**

Fishes which utilize the base of the trophic level i.e. phytoplankton or which can live and grow well on detritus/decaying matter are preferred over the other groups. It is because only 10% of the energy is transferred or converted from one trophic level to the other.

**iii) Adaptation to climatic condition**

Fishes adapted to the various climatic conditions are preferred over the species which grows well in a particular environmental condition. For example, common carp is cultured throughout the world because of its adaptability to various climatic conditions.
iv) **Hardiness of the animals**

The species selected should tolerate to wide fluctuation of physico-chemical conditions of water like temperature, dissolved oxygen, salinity, pH, etc.

v) **Availability in space and time**

The species should be available in the locality or at transportable distance in adequate quantities at appropriate time.

vi) **Reproductive behaviour and fecundity**

The species should have high fecundity and capacity to breed under controlled condition. Besides this, it should have the capacity to breed many times during its life span.

vii) **Larval development**

The length of larval phase and the number of larval stages are also very much important. Species with least larval stages and shorter larval phase are preferred to minimize the risk and achieving higher survival.

viii) **Compatibility**

The different species selected should be compatible with each other for effective utilization of food and space. In polyculture or composite fish culture, fishes which thrive on different feeding niches and utilize different layers of the water column are selected.

ix) **Feeding habits and food conversion efficiencies**

Species feeding with wide range of items and ability to grow well with natural feed are important. The acceptance towards artificial feeds is an equally important factor to be considered.
x) Market demand and economic factors

Consumer preference is one of the important factors to be considered for maximizing the profit, which varies with the locality. The demand in external market too is an important factor to be considered for higher profit margin and foreign exchange earnings besides the demand of the species for internal market.

1.2 Design and Construction of Fish Farm

Suitable ponds are one of the most important pre-requisite for the success of fish culture. Enough water of desirable quality, impervious soil of suitable type and land of satisfactory characteristics are the important aspects which ultimately decide fish farm design and construction. Apart from this, other desirable aspects are design and layout, construction of dykes and drainage arrangements, etc. For the preparation of a good fish farm, it is required to know the type of soil, bearing capacity and permeability of soil, topographical features of the land, climatological data, ground information, etc. Soil texture depends on the presence of sand, silt and clay contents.

Important hydrological data like discharge, yield and floods, the existing water sources like rivers, canals, reservoirs, lakes, springs, etc. can be obtained from the irrigation department or other water authorities for planning, designing and construction of fish farm.

Design and construction

The design of a farm depends on the information received during survey, with respect to topography and soil type in particular. The size and shape of different ponds for nursery, rearing and grow-out systems and their number are decided based on the requirements and contour levels. The preferable sizes for nursery, rearing and stocking ponds are 0.02-0.1 ha, 0.05-0.20 ha and 0.2-2 ha, respectively. Ponds of rectangular shape are usually preferred for facilitating netting operations and easy management. While designing the farm, water supply and drainage facilities should be provided.
The dyke must be strong and water tight. The recommended slope of the dyke in different soil such as for good clay and silty clay should 1:1.5 (vertical: horizontal), for sandy clay should be 1:2, for sandy loam should be 1:2.5, and loose and wet earth should be 1:3.

1.3 Culture Carp in Static Ponds

The technologies of scientific composite carp culture or polyculture as practiced at present are of recent concepts. In this fish farming system, three exotic species viz., silver carp, grass carp and common carp are incorporated along with the three Indian major carp species viz., catla, rohu and mrigal for effective utilization of ecological niches in ponds. To illustrate, the indigenous catla inhabits the surface layer and is predominantly a zooplankton feeder sparing considerable amount of phytoplankton for exotic surface dwelling silver carp. Rohu remaining at middle or column layer feeds largely on periphyton and decaying material. Grass carp is a voracious feeder of weeds, both aquatic and terrestrial. Finally the mrigal and common carp being bottom dwelling species feed largely on bottom detritus and other decaying matter present on the pond bottom.

Depending on the provided input levels, carp culture can be categorized under low-input, medium input or high input based systems. Fertilizer-based culture, sewage-fed culture, biogas-- slurry-based culture systems, etc. are categorized under low input culture system. Feed constituting a larger share of the input cost are avoided in these types of culture systems. The production is mainly contributed through the natural fish food organisms produced by intermittent fertilization/ biogas-- slurry /sewage addition. Production levels of 2-3 tonnes/ha/yr are achieved under these culture systems. This can also be called as extensive culture systems. Production of fish can be enhanced from a unit area considerably with the provision of supplementary feeding. A production level of 3-8 tonnes are obtained using judicious combination of feeds and fertilizers, know as medium-input system or semi-intensive culture system. The third type of culture systems are known as intensive culture or high-input culture system. In
this case the targeted production is kept at high levels. The management measures taken in intensive culture systems include high stocking density, aeration, water exchange/circulation, bio-fertilisation, bio-filtration, etc. besides intensive feeding with balanced formulated feeds. Under intensive carp culture system production levels of 10-15 tonnes/ha/yr has been achieved in static earthen ponds in the country.

The technology of scientific carp culture involve two main components, viz., seed rearing and grow-out culture, which have undergone several modifications and refinements over the years. The technology of seed rearing further comprises rearing spawn to fry in nursery and rearing of fry to fingerlings. While seasonal ponds, those dry up during summer months, can be used effectively with minimum pre-stocking pond preparation, perennial ponds require specific steps for preparation prior to seed stocking. Removal of aquatic vegetation and control of predatory and weed-fishes are the two important pre-stocking activities in case of perennial ponds. The details of the above processes are discussed as follows.

1.3.1 Aquatic weeds and their control

The macro-vegetation that grows and reproduces in water is termed as aquatic weed. The excessive growth of these weeds in water bodies cause serious problem for development of fish culture in many ways viz.

i) It restricts the movement of fish
ii) Limits the living space for fish
iii) Provides shelter to predatory and weed fishes as also the aquatic insects
iv) Interfere in netting operation
v) Prevents penetration of solar light, thus restricts plankton production
vi) Absorbs the inorganic nutrients present in water body
vii) Leads to heavy accumulation of organic material due to gradual decomposition of vegetation.
1.3.2 Control of predatory and weed fishes

Control of predatory and weed fishes is one of the primary activity of fish culture operation. The predatory fishes are harmful to the cultured species as they not only compete for food and space but also directly prey on them. They also greatly affect the dissolved oxygen levels of the pond.

1.3.3 Nursery pond management

The nursery rearing involves nurturing of spawn of 3 days old for a period of 15-20 days. During this period, they grow to a size of about 20-30 mm and known as fry. Spawn are delicate and require special attention while nursing. Small water bodies of 0.02-0.1 ha with a water depth of about 1.0-1.5 m are preferred for nurseries. Concrete nurseries of 50-100 m² with 1.0-1.2 m water depth are also used as nurseries for high density rearing. The preparation of seasonal ponds which dry up during summer include removal of terrestrial grasses, if any, followed by ploughing, liming, filling of water, fertilization and control of aquatic insects in that order. Perennial ponds on the other hand involve removal of aquatic vegetation and control of predatory and weed-fishes prior to liming, fertilization and aquatic insect control. In case of concrete tanks (filling of water, liming, fertilization and aquatic insect control???) all these steps, however, are avoided due to filling of filtered water just 2-3 days before seed stocking.

Preparation of nursery ponds before releasing the spawn is an important step for successful rearing of carp spawn to fry. The occurrence of large scale mortality of spawn stocked in unprepared nurseries is a common problem experienced by most of the fish culturists in the country. Seasonal ponds are preferred over perennial ponds for effective management of nursery ponds. The drying up of such water bodies in summer months helps in organic mineralization, killing of predatory and weed fishes, and desilting of ponds wherever necessary. The methods followed for control of aquatic weeds and predatory and weed fishes are similar to as discussed earlier.
Liming and fertilization

The ponds are first limed after removal of unwanted predatory and weed fishes depending on the pH of soil. However, the dosage of lime application is reduced when either bleaching powder or combination of bleaching powder and urea is used as piscicide. Further, the ponds are enriched either with organic manures such as cow-dung/poultry droppings or inorganic fertilizers or both, one following the other. The dosage of fertilizers to be applied also depends on the type of materials used as piscicide.

Phased manuring with mixture of groundnut oil cake at 750 kg, cow-dung 200 kg and single super phosphate 50 kg/ha have also shown to be effective in production of desired plankton. In such cases half of the above amount is applied in ponds 2-3 day prior to stocking after making thick paste by addition of sufficient water. The remaining amount is applied in 2-3 split doses depending on the plankton level of the ponds.

Stocking of spawn

After three days of hatching when the yolk is completely absorbed and mouth is developed, spawn are ready for stocking in nurseries. Stocking densities of 5.0-10.0 million/ha is a common practice with survival levels of 30-50%. For higher growth and survival of both Indian major carps and exotic carps spawn rearing in earthen ponds at a stocking density of 3-5 million/ha and in concrete tanks @10-20 million/ha. is suggested and in concrete tanks the density can be 10-20 million/ha.

The quantities of spawn to be stocked are carefully measured with the help of metal cups of predetermined capacity having perforated bottom. If the spawn are transported to the nursery site with open containers, conditioning may be done with the gradual addition of pond water into the container before release. When they are transported through closed oxygenated polythene packs, the packs are kept over the pond water for few minutes before release to acclimatize with the environmental temperature. Stocking is preferably done in the morning hours when the temperature of water remains low.
Supplementary feeding

Mixtures of rice/wheat bran and groundnut/mustard oil cake at 1:1 ratio are commonly used as supplementary feed for raising fry in nurseries. The feed ingredients are powdered, sieved to obtain uniform and smaller particle sizes and mixed thoroughly before use. Incorporation of other supplements like fish meal (10-20%), roasted soybean flour (10-20%), vitamin-mineral mixture (1-2%), probiotics (< 1%), etc. are also suggested to improve the feed quality and in turn the growth and survival of fry. The quantity of feed provided is four times of the initial biomass of spawn stocked per day for first five days followed by eight times the weight for the next ten days. The individual weight of major carp spawns generally range 1.4-1.5 mg, and hence an amount of 600 g feed per day may be provided for one lakh spawn initially which is doubled after 5 days. Feeding is done twice a day. In case of nurseries the feeding method followed is usually the broadcasting to ensure that feed are available all over the water surface.

Water management and harvesting

The physico-chemical conditions of pond water need close monitoring to prevent losses due to sudden fluctuation in pH, poor oxygen condition, higher ammonia concentrations, increased levels of toxic gases, parasitic and microbial infections, etc.

The fry are harvested generally after 15 days of rearing, during which time they attain a size of 20-25 mm. But sometimes they are harvested after 10 days of rearing, especially when smaller sizes of fry are necessary to be transported. The day preceding the date of harvesting is not provided with supplementary feed. This not only reduces the feed requirement but essentially facilitates conditioning by minimizing faecal metabolites during transport.

1.3.4 Rearing pond management for fingerlings production

Raising fingerlings in rearing pond is the second stage of rearing seed. Ponds of 0.05 - 0.2 ha size with an average water depth of about 1.5-2.0 m are generally used as
rearing ponds. Seasonal ponds can also be used as rearing ponds. Fry of 20-25 mm in size are grown in these ponds for a period of 2-3 months to obtain fingerlings of 80-100 mm in size.

Similar to the nursery ponds, preparation of rearing ponds includes removal of aquatic vegetation, eradication of predatory and weedfishes, liming and fertilization. Pond fertilization includes application of cowdung @ 3-4 tonnes/ha as the basal dose one week prior to stocking followed by fortnightly application of equal doses @ 0.5 tonne/ha after stocking. If mahua oil cake is used during pond preparation, the basal dose of cowdung application is avoided. Further, urea and single super phosphate (SSP) are applied at fortnightly doses @ 10 and 15 kg/ha, respectively for sustaining the growth of plankton.

**Stocking of fry**

Fry of 15 days old obtained from nursery ponds are stocked in rearing ponds.

Unlike nursery ponds mixed species culture of carps is taken up in rearing ponds. The fry are stocked at the rate of 1-3 lakh per ha in earthen ponds. Various combinations of Indian major carps and exotic carps separately or in combinations have been experimented depending on the ponds condition and requirements, as follows:

- Catla: Rohu: Mrigal - 1: 1: 1: or 2: 4: 4 or 3: 4: 3
- Silver carp: Grass carp: Common carp - 4: 3: 3 or 6: 5: 5 or 1: 1: 1

**Supplementary feeding**

Mixture of groundnut/mustard oil cake and rice /wheat bran at 1: 1 ratio are commonly used as supplementary feed for rearing fry. Other ingredients such as fish meal, soybean flour, vitamin-mineral mixture, etc. are also suggested to be incorporated for improving the feed quality. Feeds are provided at the rates of 8-10% of the initial body weight of fry stocked per day during the culture period. Periodic samplings are
done at least at monthly interval to assess the growth and biomass. Feeds are provided in moist dough form. Crumbled pellets may be used for reducing the feed wastage.

**Water management and harvesting**

The reduction of water level in ponds through evaporation and seepage are required to be compensated to keep the level of 1.5-2.0 m. Care must be taken to keep the water quality parameters and natural plankton concentration within the desirable levels through periodic liming and fertilization. In case of intensive rearing system where fry are stocked at higher density, aeration or water exchange are necessary to keep the water quality parameters and dissolved oxygen content in particular within the optimum range. The fishes are evaluated periodically especially during sampling with respect to any parasitic or microbial infections and suitable preventive or curative measures are taken, if required.

Harvesting is done after 2-3 months of rearing period during which the fingerlings attain a size of 80-100 mm. Rearing period is extended when the desired size are bigger. But it is observed that prolonged rearing affects the survival considerably.

**1.3.5 Grow-out pond management**

The objective of grow-out pond management is to obtain higher production of fish in shortest possible time with reasonably low capital investment. Carps are cultured traditionally in many Asian countries including India under polyculture system. Ponds of any shape and size can be used for growing fishes. However, ponds of rectangular in shape with size ranging 0.2-2.0 ha are usually preferred for better management. The desirable water depth maintained in stocking ponds ranges between 2.0-3.0 m. The different steps followed for management of stocking ponds remain almost similar as that of nursery and rearing systems irrespective of intensity of culture. The practices of pond preparation such as eradication of predatory and weed fishes, and weed clearance are similar to what has been discussed earlier.
Stocking of seed

Fingerlings of 100-150 mm in size form the best stocking material for grow-out ponds. Normally fingerlings of such sizes are not available in adequate quantity and hence seed of 60-100 mm are generally stocked. Before the ponds are stocked, it must be ensured that the toxicity of pesticides/piscicides is completely eliminated. A short bath of potassium permanganate is usually given to the seed as a prophylactic measure. The ponds are stocked at a density of 5,000-10,000 fingerlings/ha for production target of 3-5 tonnes/ha/yr. However, the stocking density is enhanced to 15,000-25,000/ha in case of intensive culture.

Though culture of six species combination has been suggested through composite carp culture system, availability of seed of desired species and consumers' demand largely decide the species to be cultured in a particular locality.

The proportions of different species stocked are based largely on biological productivity of the pond and depth. Several combinations of Indian major carps and exotic carps alone and in combinations have been experimented with different stocking densities keeping growth as the index of performances. The species combination suggested for stocking with six species is catla 15-30%, rohu 15-30%, mrigal 15-30%, silver carp 10-25%, grass carp 5-10% and common carp 15-25%. In case of culture systems with the Indian major carps alone, the ratios advocated for catla, rohu and mrigal are 4 : 3 : 3 or 3 : 4 : 3 or 3 : 3 : 4 depending on the pond productivity. In Godavari and Krishna delta of Andhra Pradesh, which is a hub for commercial carp farming, stocking ratio of 80% rohu and 20% catla are commonly followed due to high market demand of these two species.

Besides six carp species as mentioned above, several other indigenous medium and minor carps such *Labeo calbasu, L. bata, L. fimbriatus, L. kontius, Cirrhina cirrhosa, Puntius sarana* and *P. jerdoni* are also considered as potential candidate species for inclusion in polyculture system.
Supplementary feeding

In India, mixture of rice/wheat bran and groundnut/mustard oil cakes at 1:1 ratio are generally used as supplementary feed by most of the fish culturists. Though several other non-conventional feed ingredients of plant and animal origin have been identified as potential substitute for conventional ingredients, their commercial exploitations are yet to be achieved.

Feeds are provided in the form of dough mostly in trays hung at different depths in the pond. The feeding trays are suspended with the help of bamboo or wooden poles at four sides of the dykes. Further, feed filled in HDP bags with holes at the bottom and sides for feed release are hung from the bamboo or wooden poles fixed at regular intervals are also effectively used by the fish farmers in Andhra Pradesh. However, in case of intensive culture the feeds provided are in the form of dry pellets of different diameters. Though sinking types of pellets is usually used, extruded floating pellets shown to be advantageous for its effective utilization, minimization of wastage and maintenance of water quality.

The amount of feed provided are 3-4\% of the biomass per day during the initial months, which is reduced to 1-2\% of biomass towards the later part of culture period. The standing fish biomass in the pond is assessed through periodic sampling, at least at monthly interval and feed quantity is adjusted. Feeding is usually done in two equal rations i.e. during morning (7-8 am) and evening before dawn (4-5 pm). Grass carps are fed with desired aquatic vegetation, kept in enclosure in selected corners of the pond. Aquatic weeds like *Hydrilla, Najas, Ceratophyllum* and duck weeds (*Spirodela, Wolffia, Lemna*, etc.) are considered to be most suitable for grass carp.

Water management and aeration

Day to day management of pond is very much important, especially towards the later part of the culture period. The gradual increase in biomass over the period of culture results in increasing stress often associated with adverse water quality. Low
oxygen levels and high ammonia contents often encountered at higher biomass make the fish susceptible to disease outbreaks. Thus, maintenance of water quality is of utmost importance, particularly in case of intensive culture systems. Regular monitoring of hydro-biological parameters help in both deciding the fertilization schedule and also taking corrective measures, if required. The optimal ranges of different parameters for culture are as follows:

<table>
<thead>
<tr>
<th>Water</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparency (light penetration)</td>
<td>20-40 cm</td>
</tr>
<tr>
<td>pH</td>
<td>7.</td>
</tr>
<tr>
<td>Free carbon dioxide</td>
<td>&lt; 20 mg/l</td>
</tr>
<tr>
<td>Dissolved oxygen</td>
<td>&gt;4 mg/l</td>
</tr>
<tr>
<td>Nitrogen (ammonia and nitrate)</td>
<td>0.5 - 0.6 mg/l</td>
</tr>
<tr>
<td>Phosphorus (PO₄-P)</td>
<td>0.1 - 0.2 mg/l</td>
</tr>
<tr>
<td>Total alkalinity</td>
<td>CaCO₃/l</td>
</tr>
<tr>
<td>BOD₅</td>
<td>&lt; 25 mg/l</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sediment</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>5 - 8.0</td>
</tr>
<tr>
<td>Organic carbon</td>
<td>5 - 2.5%</td>
</tr>
<tr>
<td>Available nitrogen</td>
<td>50-75 mg/100 g</td>
</tr>
<tr>
<td>Available phosphorus</td>
<td>3-6 mg/100 g</td>
</tr>
</tbody>
</table>

In case of intensive culture systems with production targets of beyond 10 tonnes/ha/yr water exchange is necessary at least towards the end of the culture period. In such cases aerators are also used to keep the dissolved oxygen levels within desirable limit. Aerators used in fish culture systems are either paddle wheel aerators or aspirator aerators. About 4-6 numbers of aerators operated for 6-8 hours during night hours are sufficient to keep the desired dissolved oxygen levels even at stocking density of 20-000-25,000/ha.
**Disease management**

Proper health management is the prime prerequisite for success of any culture operation. The fish can be kept healthy through three sequential steps *viz.*, prophylactic measures, fish health monitoring and treatment. Prophylactic measures include sanitation of ponds using disinfectants like bleaching powder or quicklime prior to the stocking. Prophylactic therapeutic treatments against the pathogens are done to the seed material preferably prior to the stocking as also during sampling. Periodical health monitoring, at least during the time of fish sampling helps in timely detection and diagnosis so that immediate treatment measures are adopted depending on the nature of disease.

**Harvesting**

Harvesting of fish is done effectively with the help of drag nets of suitable mesh size. Though maximum amount of fishes are usually caught through repeated netting, the complete harvesting is possible only through total draining of the pond. Fishes are usually harvested at the end of culture period of 10-11 months. It may however, be advised that fishes of larger size groups are harvested when it attain marketable size. Partial harvesting not only reduces the pressure of higher biomass but also provide sufficient space for growth of remaining fishes.

**1.4 Culture of Freshwater Prawn**

Among all the freshwater prawn species that are available in the country as also in other parts of the world, two species *viz.*, *Macrobrachium rosenbergii* and *M. malcolmsonii* are considered to be commercially important for aquaculture because of their high growth rate and larger size. Most important among the two is *M. rosenbergii* which grows both in freshwater and low saline water. Thailand is the major producers of *M. rosenbergii* through farming. The other countries involved in farming are Taiwan, Equador, Brazil, France, Mexico, USA, Malaysia, India, etc.
Freshwater prawn farming in India is practiced traditionally by collecting juveniles and stocking them in rice fields. With the advent of indoor hatchery breeding and development of farming technologies commercial production is gaining popularity in many States. Rearing of prawns is usually carried out in earthen ponds of 0.1 to 2 ha in size with water depth of about 1 m. The ponds are limed and fertilized as in case of carp culture ponds. Higher dissolved oxygen content in ponds is always necessary and hence, fertilization should be done in low dosages. Though these species grow well in fresh waters, salinity levels up to 6‰ may be used for culture.

The post-larvae obtained from hatchery are usually reared in nursery for about 1-2 months before they are stocked in grow-out ponds. The stocking density followed in grow-out ponds is usually limited to 50,000/ha. Compared to penaeid prawns, the freshwater prawns require only a lower protein level of 25-30% in the diet. Provision of supplementary feed in the form of dry pellet will reduce the wastage significantly. However, in most of the farm the feed used are in the form of dough only. Harvesting is done usually after 6-7 months of culture period. The production level obtained under monoculture usually ranges 1.0-1.5 t/ha/yr.

1.5 Integrated Fish Farming

Integrated farming systems have been one of the important means of increasing food production and improving the economic condition of farmers in developing and underdeveloped countries. Integrated fish farming is the link of two or more normally separate farming systems where byproduct i.e., waste from one sub-system is utilized for sustenance of other e.g., fish-pig/poultry/duck farming. It generally consists of three systems *viz.*, fish-livestock/poultry integrated farming, fish-agriculture integrated farming and fish-livestock/poultry-agriculture integrated farming systems. Some of the important model of integration of live stock and agriculture along with fish culture are discussed here.
1.5.1 Fish-cum- Cattle integration

Use of cow manure in fish farming is one of the prevailing practices all over the world. Among the different livestock excreta, cowdung is the most abundant one in terms of availability. Cattle are preferably raised on pond banks and the washings drained directly into the pond. Fertilization of carp nurseries, rearing or stocking ponds with cowdung is a widespread practice in India. Cowdung has a slow rate of inorganic transformation. Therefore, it is desirable to apply cowdung in split doses at periodical interval to avoid the ecological balance. It has been estimated that the daily output of dung and urine from 2-4 cows is enough to maintain the fertility status of one ha pond.

1.5.2 Fish-cum- Pig integration

The integration of pig with fish culture in India appears to be less obvious than that of the other livestock integration, as pig keeping in the country is associated with only the weaker sections of the society. Raising of pigs is rather easier than other farming animals, as they feed largely on kitchen wastes, aquatic plants and crop wastes. At present fish-pig integration is practiced in countries like China, Taiwan, Vietnam, Thailand, Hong Kong, Malaysia, Hungary and other European countries. In India, north-eastern states have very high potential for fish-pig integrated farming due guided by any principles of sustainability.

1.5.3 Mussel/oyster farming

Culture of the filter feeding bivalves which are low in the food chain can be successfully undertaken by small scale coastal fisher-folk in nearby water bodies. This is already evident in many maritime states of India like Kerala, Karnataka and Goa. Mussel (Perna viridis) is cultured by raft method (in bays, inshore waters), rack method (in estuaries and backwaters) and long-line method (in open sea). Mussel seed (15-25 mm size) collected from natural beds are attached to coir/nylon ropes of 1-6 m length and enveloped by a mosquito net. These ropes are hung from rafts, racks or long-lines depending on the technology adopted. After a few days, seeds get attached to the rope while the netting disintegrates.
1.5.4 Pearl oyster farming and Pearl Production

Success in production of cultured pearls was achieved for the first time in 1973 by CMFRI using the pearl oyster Pinctada fucata. Raft culture and rack culture in inshore areas are two methods commonly adopted for rearing pearl oysters and recently onshore technology has also been developed. Shell bead nucleus (3-8 mm) implantation is done in the gonads of the oyster through surgical incision while graft tissues are prepared from the donor oysters of the same size and age group.

1.5.5 Seaweed farming

The seaweed industry in India until recently was mainly a cottage industry based on the natural stock of agar yielding red seaweeds (Gracilaria edulis, gelidiella acerosa) and algin yielding brown seaweeds (Sargassum spp.). In recent years the farming of the carrageenan yielding Kappaphycus spp. Has picked up on a large scale along the Tamil Nadu Coast. Seaweed mariculture is essential for a continuous supply of raw material for the industry with improved yield and quality which can also ease the exploitation pressure on natural beds. Culture methods involve either vegetative propagation using fragments from mother plants or using spores. Fragments of adult/juvenile plants, spores are seeded on to polypropylene ropes of 10 mm diameter and hung from floating rafts at depths upto 3-4m. Considering the immense market for seaweed products, it shall play a key role in development of coastal fishing communities and a valuable foreign exchange earner.

1.5.6 Marine ornamental fish breeding

Marine ornamental fish breeding technologies have the scope to reduce the fishing pressure on the various ornamental resources which are mostly found in sensitive ecosystems such as coral reefs and sea grass bed. They are also likely to be more economically feasible than that of marine food fish culture due to high unit price per number of ornamental fish. In addition these can be taken up by coastal fisher-folk, especially women as a means to supplement their income.
1.5.7 Lobster fattening

There is huge demand for lobsters in the international seafood market and the price difference between a small (<100g) and larger (>100g) lobster is three fold. At the same time a large number of undersized lobsters are caught and these have been successfully grown to larger sizes in small inter-tidal ponds, feeding them with cheap molluscan meat and trash fish until they reach 125g weight.

1.5.8 Open Sea Cage Culture / Capture based aquaculture (CBA)

Open sea cage culture is fast developing as the most efficient and economical way of raising fish. It has several advantages over land based aquaculture systems in that it can achieve optimum carrying capacity as current flow brings in fresh water and removes metabolic wastes and excess feed. Simple cage designs for inshore waters are relatively easy to construct with minimal skilled labour. The ideal locations for cage farming along the Indian coast include the bays in Ratnagiri, Goa, Karwar, Palk Bay, Gulf of Mannar, Lawson’s Bay, Lakshadweep islands and Andaman and Nicobar islands. Capture based Aquaculture (CBA) is defined as the practice of collecting “seed” material (from early life stages to adults) from the wild and its subsequent rearing in captivity using aquaculture techniques to a marketable size. It is an intermediate between capture fisheries and true mariculture and can provide alternate livelihood or an additional source of income for local coastal communities. In India since the seed production technologies of many species are either not standardized or commercially viable, CBA can be developed with proper management. Many fin-fish seed of commercially important species are netted along with other fish during operation of shore seines and other artisanal gears by coastal fishermen. These can be used to stock in cages in the near-shore areas to grow them to marketable sizes and thus help the fishermen make an additional income.
1.6 Breeding and Seed Production of Cultivable Freshwater Fin fishes and Shell fishes

1.6.1 Breeding and Seed Production of Carps

1.6.1.1 Natural breeding of carps

Indian major carps do not breed naturally in small confined waters. They breed in rivers, reservoirs or bundh-type tanks in presence of flowing condition. The spawning season of Indian major carps generally coincides with the south-west monsoon. However, it varies from region to region in the country. The shallow areas of the rivers inundated by heavy monsoon flood form the breeding grounds of the fish. Flooding in the early phase of the South-west monsoon is found to be very much effective. The Indian major carp species spawn only once in a year i.e. during monsoon months.

1.6.1.2 Factors responsible for breeding of carps

Among the environmental factors light, temperature, water condition, meteorological conditions, etc. are known to play important roles in stimulating the release of pituitary gonadotropins and thereby controlling reproduction of fish. Indian major carps are observed to breed within a wide range of temperature varying 24-31°C. Besides having direct effect, the temperature also has indirect effect on gonads, regulating their ability to respond to pituitary stimulation. Further, it also affects the pituitary synthesis and release of gonadotropin. Apart from light and temperature, rain water and weather conditions are the other factors that decide the success of spawning. Successful spawning of majority of fishes has been induced especially on cloudy and rainy days. In rivers generally flood and rain, current of water, increased dissolved oxygen content of water; optimum water temperature, shallow inundated areas (spawning grounds) and spawning congregations are considered as important ecological inducement for natural spawning of these carps. The Chinese carps having more or less similar breeding requirements can also be induced bred at similar conditions as those of Indian major carps.
1.6.1.3 Natural seed collection

Consequent to the breeding during monsoon months the fertilized eggs, hatchling and post-larvae drift down the river along with the water current. These fish seed thus collected were used as sole source of stocking material for culture in freshwater ponds and tanks up to seventies in the country. With the success of induced breeding in 1957 and the implementation of the technology thereafter by the farmers all over the country, the dependence on natural seed collection has been reduced significantly.

1.6.1.4 Bundh breeding

Bundhs are special type of perennial and seasonal tanks or impoundments where riverine conditions are simulated during monsoon months for breeding of Indian major carps. They are located in some parts of West Bengal as also in Bihar and Madhya Pradesh. They are either perennial bundhs commonly known as 'wet bundhs' or seasonal ones called 'dry bundhs.' These bundhs receive considerable quantities of rain water from washings after a heavy shower from the extensive catchment areas.

1.6.2 Induced breeding

Hypophysation

The concept of induced breeding by administration of pituitary extract was first successfully attempted in Brazil in 1934. In India the success was achieved only in 1955, when the carp minnow.

*Esomus danricus* and the catfish *Psodeutropius atherinoides* were induced bred by pituitary hormone injection. Further, the Indian major carps were bred in 1957. After this major breakthrough, the breeding technique was extended to even Chinese carps. With the development of the technique in India, the induced breeding method has spread allover the world replacing the age-old practice of collection of seed from natural waters.
The pituitary glands are collected from gravid fishes of both sexes either belonging to the same species as the recipient or closely related ones. Extracts are made by homogenizing the pituitary gland which is injected to the breeder at predetermined dose. Female alone is injected with a stimulating dose of 2-3 mg/kg fish followed by a second dose of 5-8 mg/kg fish after 6 hours. Two males per female are given a single dose, each of 2-3 mg/kg weight at the time of second injection to the female. Both the injected males and females are kept together in a breeding hapa or breeding pool for spawning. Generally the Indian major carps spawn within 6-8 hours after final injection to the breeder. Fertilization of eggs takes place externally and the fertilized eggs soon start swelling up, look like small pearl like bodies and gradually get water hardened. The fertilized eggs are then transferred to the hatching hapa or the hatchery system for hatching.

**Induced breeding of major Indian and Chinese carps**

In early days of induced breeding in India, the breeding and hatching were carried out in outdoor stagnant ponds and tanks and at times in canals with mild flow of water by using hapas. The modern hatchery, however, consist of breeding pools besides the separate pools for hatching. Induced breeding is generally taken up at the onset of monsoon, with the accumulation of fresh rain water, when the temperature goes down. The spawners are netted out and selected carefully and are weighed individually. As discussed earlier, selection of proper brood decides the rate of success of breeding performance. Usually a breeding set consists of one female and two males. The dosage of the pituitary extract to be administered is decided depending on the fish body weight, ripeness of gonad and prevailing climatic condition. Determination of proper dosage is very much important. Standardization of dosage of pituitary extract depends on several factors like, size and stages of sexual maturity of the recipient fish; potency of the gland according to the time of collection; freshness and stages of maturity of the donor fish as also species from which the gland collected; preservation methods of the gland and the extract, and also the ecological factors or the breeding environment at the time of taking up of induced breeding operation.
The females are given pituitary extract at the dosage of 2-4 mg/kg fish in the first injection and 5-10 mg/kg body weight for the second injection. However, males are administered only one dose of 2-4 mg/kg during the time of 2nd injection to female. With the use of Ovaprim at present, both males and females are given one dose of injection only. The dosage given for female catla is 0.4-0.5, rohu 0.3-0.4, mrigal 0.25-0.3, silver carp 0.4-0.7 and grass carp 0.4-0.8 ml/kg fish body weight, where as for male it is restricted to 0.1-0.2 ml/kg only. The fishes usually lay eggs in about 4-6 hours after the 2nd injection depending on the maturity of the fish and prevailing environmental conditions. The eggs are collected from the breeding hapas after they are water hardened and transferred to the hatchery for incubation.

The fishes are injected either by intra-peritonial or intramuscular injection. The intra-peritonial injections are usually given at the base of pelvic fin, where the injection needle is inserted quite easily. The tip of the needle is inserted under a scale and is pushed through the abdominal wall into the body cavity and then directed parallel to the ventral surface. In this method, there is the danger of damaging the internal organs. On the other hand, the intramuscular injection is very effective and convenient. The injection is given on the back muscles, caudal peduncle or the muscles in the humeral region. While injecting, the needle is first inserted under a scale parallel to the body of the fish and then the muscle is pierced through quickly at an angle of 45°. Hypodermic syringe of 2 ml capacity with 0.1 ml graduations and a locking arrangement is preferred. Normally no. 22 needle is used for fish of 1-3 kg, no. 19 for larger ones and no. 24 for fishes below 1 kg. The brood fishes selected for injection are kept either in breeding hapas or in breeding pools as practiced at present. The recipient fish are taken out one by one with the help of hand nets and are gently put on a foam-rubber cushion of suitable size. While injecting, one person places his hands on the head and other person holds the caudal peduncle with one hand, gently but firmly, and with the other hand hormone is injected at the predetermined location of the fish. The injected fishes are soon put back to the breeding hapas or breeding pool. In the event of two injections, the first injection could be given around 4 pm and the 2nd injection at 10 pm so that the spawning is over by early morning. With the use of Ovaprim, the breeding has become
rather easy and it is becoming possible to inject the brood during morning hours and complete the process by evening, thereby avoiding the presence in the night hours.

In case of grass carp and silver carp, natural spawning in hapas after 2nd injection is often not successful and the quantity of eggs laid is poor, hence stripping method is followed for fertilization. In this case, the female is examined at regular intervals of three to four hours after the final injection. When the female releases eggs very freely with mild pressure on abdomen it is ready for stripping. The eggs are stripped on an enamel tray or basin (indicate size), about 500 ml in each container and sufficient milt is added over it. The eggs and milt are thoroughly mixed with a feather and by rotating the contents for ensuring better fertilization of eggs. It is known as artificial fertilization. After 5 minutes of thorough mixing some amount of water is gradually poured into it and the mixing of the contents is continued. The excess amounts of sperm, blood clots, etc. are subsequently removed by repeated washing. By this time swelling of eggs commences and eggs gradually get water hardened. There are two methods of stripping, dry method and wet method. In case of dry method the eggs are stripped into a dry enamel tray over which the milt is poured. Care is taken in such a way that no extra water falls into the basin. In case of wet method physiological salt solution is used to receive the milt first and later the eggs are stripped into the basin. The sperms of Chinese carps remain active for 2-3 minutes at 0.3% saline solution. The dry method of stripping is much more convenient and effective than wet method. The method practiced in India is mostly the dry method. In cases where spawning behaviour of males and females are not synchronized in natural spawning, the stripping method is found to be effective. However, in many cases the fertilization rates remain at low level may be due to the inadequate quantity/quality of the milt, forced release of unripe or over-ripe eggs, advanced weather conditions, etc.

Breeding of common carp on the other hand is relatively simple. Common carp can be bred throughout the year. In this case, both matured males and females are collected and kept in the breeding hapa. They are not required to be given any injection. Certain quantity of aquatic weeds like *Hydrilla, Najas, Ceratophyllum*, etc. are to be
provided in the breeding hapa for the attachment of sticky eggs. Breeding takes place in the night. The spent fishes are removed on next day morning and the fertilized eggs are allowed to develop.
Unit - 2

Culture of Shrimp and Brackishwater Fin fishes and Management practices

Structure
2.0 Objectives
   2.1 Introduction
   2.2 Types of Farming Systems
   2.3 Site Selection
   2.4 Culture pond
   2.5 Pond Preparation
   2.6 Stocking
   2.7 Feeds and Feed Management
   2.8 Soil and Water Quality Management
   2.9 Economics of Shrimp Culture Operation
   2.10 Culture of Brackishwater Fin fishes
   2.11 Cultivable Brackishwater Fin fishes
   2.12 Culture Systems and Utilization of Brackishwater Bodies
   2.13 Pond Culture
   2.14 Culture of Fin fishes in Cages
   2.15 Integrated Fish Farming
   2.16 Tools and Approaches for Managing Sustainable Brackishwater Aquaculture
   2.17 Better management practices
2.18 Aquaculture Extension Approaches

2.0 Objectives

After completing this unit you will understand

- Techniques of shrimp culture production
- Cost and returns of adopting shrimp culture

2.1 Introduction

Shrimps are aquatic organisms inhabiting the seas, estuaries and brackishwaters. In the seas around India, 90 species of penaeid shrimps are known to occur of which 10 species are considered for culture. Among them, the highly promising species for aqua farming are the black tiger shrimp *Penaeus monodon*, Indian white shrimp *Fenneropenaeus indicus*, banana shrimp *F. merguiensis*, green shrimp *P. semisulcatus* and white leg shrimp, *Litopenaeus vannamei*. Shrimp farming can be defined as the process of growing shrimp in different intensities for a varied period in specially designed ponds adjacent to selected brackishwater and coastal sites by proper irrigation, fertilization, feeding and management.

2.2 Types of Farming Systems

Based on the level of scientific management measures and use of inputs, shrimp culture can be broadly classified as traditional, extensive, semi-intensive and intensive. Based on water exchange adopted during farming certain of the farming systems are referred as Zero water exchange system.

2.2.1 Traditional Shrimp Farming Systems

In traditional shrimp farming seed shrimp and fish are trapped during high tides in the coastal low lying areas or fields/ponds. In this process, many predators and competitors are also get free entry and they all co-exist in the same pond. Escape of these trapped organisms is prevented by fixing suitable screen(s) in the sluice
and the crop is harvested at regular intervals. Shrimp are often harvested before they grow to optimum size.

Production under this system is normally unpredictable and often very low in quantity because of predation by fishes, low stocking density and frequent harvest. The average production from traditional system is below 500 kg/ha/annum.

2.2.2 Extensive Shrimp Farming Systems

This is a little improved method of traditional farming, wherein shrimp is stocked in ponds at a comparatively lower density with supplementary feeding. The water quality is maintained either through the natural fall and rise of tides or exchange through minimal pumping (up to 10%). The average production normally ranges from 1.0 to 1.5 t/ha/crop.

2.2.3 Semi-intensive Shrimp Farming Systems

In semi-intensive farming, 0.2 to 1.0 ha size ponds are constructed and selectively stocked with hatchery shrimp seed. The stocking density ranges from 1 to 3 lakh per ha and the water quality was maintained by exchanging 10-20% daily. Ponds are aerated with air blowers/paddle wheels and the shrimp are fed with high protein nutritious feed. The average production varies from 4 to 5 t/ha/crop.

2.2.4 Intensive culture system

The intensive system of shrimp culture is done in ponds of 0.03 to 0.1 ha in size stocked with quality shrimp seed exclusively procured from hatcheries @ 5 to 10 lakh / ha. Water quality is maintained by exchanging over 30% a day and aerating the ponds with mechanical aerators and feeding the shrimps with nutritionally well balanced high energy feed. The production from this system ranges from 10-20 t/ha/crop.
2.2.5 Zero water exchange system

In this system of farming, shrimp seeds are stocked @ 1 lakh to 3 lakh/ha in well prepared ponds with absence of water exchange, but water may be recirculated or topping is done to maintain the water depth. Probiotics and sanitzers are used in this system.

2.3 Site Selection

Selection of a proper site suitable in all aspects is important for construction of ponds for the sustainable shrimp farming. Issues to be considered are:

- Mangrove areas, marine parks, sanctuaries etc. should be avoided for constructing shrimp farms.
- Shrimp farms should not be constructed in agricultural lands and saltpans.
- Areas with sandy and/or porous soils are prone to water seepage and should be avoided to overcome salinisation impacts.
- Shrimp farms should not be located on natural flood drains to avoid flooding human habitations.
- As far as possible, the intake and outflow should not be in the same creek and over crowding of the farms should be avoided.
- Carrying capacity of the source water bodies should be assessed to determine the total area that can be developed for aquaculture.

2.3.1 Soil quality

The natural productivity of a farm is dependent on the soil quality of the culture system.

The optimal soil parameters suitable for shrimp culture are as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7-8</td>
</tr>
<tr>
<td>Organic carbon</td>
<td>1.5 - 2.5%</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>&gt;5%</td>
</tr>
<tr>
<td>Available nitrogen</td>
<td>50-75 mg/100 g soil</td>
</tr>
<tr>
<td>Available phosphorus</td>
<td>4 - 6 mg/100 g soil and</td>
</tr>
<tr>
<td>Electrical conductivity</td>
<td>&gt; 4 mmhos/cm</td>
</tr>
</tbody>
</table>
2. 3.2 Water quality

Availability of good quality water in sufficient quantities is an important prerequisite for sustainable aquaculture. Before pond construction, studies have to be made on the water source, quality of water and its quantity available during the different seasons and also the possible sources of pollutants.

2.4 Culture pond

The layout of the culture ponds has to be designed properly with the help of a qualified aquaculture engineer to decide the relative position of nursery and grow out ponds, main and secondary drainage canals, main and secondary sluice gates, pump houses etc. for effective water management and control of predators and harvesting. Culture ponds should be either rectangular or square in shape. By designing the longest axis of the pond parallel to the wind direction, natural aeration could be maximized through wind action. The rearing pond must have a minimum depth of 1.0 m and a maximum of 1.5 m with bottom slope of 1:2000 towards the outlet with an overall drop of 20 to 30 cm for a 1.0 ha pond. This will facilitate easy draining and drying of the pond.

2.5 Pond Preparation

To get a healthy shrimp crop, the culture pond has to be prepared in scientific ways and the pre-stocking management ensures the pond water suitable for the growth of the post larvae. By proper pond preparation the ‘stress’ causing factors are either removed or minimized and the pathogens, pests and predators are also eliminated. Cleaning of the pond bottom Before starting a new crop, if the pond was used for farming, it has to be drained and dried so that the bottom soil cracks and this will ensure elimination of pests and predators, mineralization of the residual organic matter and release of nutrients and oxidation of hydrogen sulphide and other obnoxious gases. Tilling/ploughing/furrowing/raking, drying of pod bottom etc. is not needed for
the newly constructed ponds. But the ponds should be ploughed from the second crop onwards. Tilling or ploughing or raking the pond bottom and exposing the sub-soil of previously used culture ponds speeds up the oxidation process and release of nutrients. The raked pond bottom is allowed to dry for 5 – 7 days. In acidic soil ponds, tilling and ploughing should not be done as it will increase the acidity problem. The black soil in the pond bottom caused by the accumulation of sulphides over a period of culture can not be eliminated completely by tilling and drying.

2.6 Stocking

A number of pre-stocking measures are to be followed before stocking the post larvae produced under controlled hatchery conditions to the fluctuating pond conditions. Stocking of shrimp seed of differential size will lead to cannibalism in the culture system. Therefore, hatchery produced seed with uniform size are preferable. Normally, the PL 20s are grown to 40-50 mm size groups in separate nursery ponds/ small velon screen enclosures in a portion of grow out ponds, to ensure effective feeding and survival rate and then released into grow out ponds. The pond water quality parameters should be within tolerable limits to the post larvae, otherwise heavy mortality might occur. Even within tolerable limits, if there is a wide variation between the hatchery and pond conditions, the post larvae will be under severe stress and are liable to become weak, affected by diseases and sometimes result in mortality. Proper acclimatization of seeds to pond salinity and temperature is essential to avoid mortality during stocking.

2.6.1 Seed quality

The post larvae should be free from any lesions, black colouration and deformities or loss of appendages. They should be uniform in size and colouration, active swimming and react swiftly to any external stimuli. Stress test by 50% reduction in salinity and 100 ppm formalin treatment should be performed to ascertain the seed quality.
2.6.2 Stocking density

Densities higher than the prescribed limit is not advisable under extensive system which may lead to poor growth and production. The type of management, culture duration, expected size at harvest and complying policy guidelines are the guiding principles for fixing the optimal stocking density. High density culture requires intensive water quality management and any failure will lead to deterioration in pond soil conditions resulting in mortality of shrimps and other associated problems.

2.6.3 Packing and transportation

The post larvae are packed under oxygen in polythene bags filled to 1/3 level with filtered seawater and stocked @ 500-1000 no./lit. The duration of transport may be kept within six hours and it is advisable to transport seed in the evening or night or early morning hours when the atmosphere is relatively cool. For long distance transportation that involves more than six hours, the seed bags should be placed in thermocole boxes. Ice packets are placed outside the bags to avoid wide fluctuations in temperature within seed bags and thereby to a large extent the transportation stress can be prevented.

2.6.4 Acclimatization

The shrimp post larvae, on arrival at the farm site should be acclimated to the pond water conditions before releasing them into the pond. Salinity acclimation is generally done in the hatchery itself. By floating the seed bags for about 30 minutes in the pond temperature acclimation can be achieved and that of pH is done by mixing equal volume of pond water into the seed bags and maintaining for 30 minutes before releasing into the pond/nursery area.

2.7 Feeds and Feed Management

Feed management is a very important aspect in the overall pond management. Feeds constitute about 40-60% of the recurring cost in running a farm or
could be even more depending on the farming intensity. Feed management is essentially for avoiding overfeeding or under feeding, while the former causes pollution and the latter results in reduced growth. Feeds of superior and consistent quality are used to obtain more shrimp production through lesser feed input (excellent FCR).

The moisture content in feed should be less than 10%. It should be water stable for at least 4 hours in pond conditions. Feed should be stored in a dry and cool place. Otherwise PUFA gets oxidized and deterioration of nutritional quality occurs. Excess moisture during storage may lead to mould growth and results in aflatoxin contamination. The total quantity of feed required for one month may be procured at a time and feeds stored for more than three months should not be fed to shrimps.

2.8 Soil and Water Quality Management

It is very important to maintain good soil and water quality in *P. monodon* culture ponds to avoid environmental and disease problems. Maintenance of soil and water quality parameters in optimal levels and the pollutants below their ‘safe levels’ are cardinal principles in pond management. Organic carbon, pH and nutrients in soil need to be analysed on fortnightly or monthly basis depending upon the system of culture. Temperature, salinity, pH, dissolved oxygen and transparency of water should be monitored daily to get an idea of the existing water quality, apart from the general management measures including water exchange, aeration, liming, fertilization and application of chemicals.

2.8.1 Salinity

Cultivable Shrimps are normally eury-haline species and can tolerate wide ranges of salinity. It is cultured near freshwater conditions (with traces of salinity) to seawater salinity (35 ppt). However the growth rate of the species varies according to the salinity of the rearing waters. Since pond salinity is greatly influenced by source
waters, care should be taken to keep the fluctuation to the minimum during the culture period. Salinity of 15-25 ppt is ideal for culture.

2.8.2 pH

The pH of brackishwater varies between 7 and 9. The acid sulphate soils when aerobic have pH even below 4.0. To treat acid sulphate soils, brackishwater with high pH should be added, ploughed and drained repeatedly prior to application of high dose of lime (as high as 2 t/ha). pH of 8.0 to 8.5 is the ideal range for the culture of *P. monodon*.

2.8.3 Alkalinity and hardness

Alkalinity and hardness are usually high in brackishwater and if they are too low, lime should be applied to increase their concentrations. Suspended solids and organic matter The brackishwater, drawn from the estuary for growing shrimps contain heavy loads of suspended solids. Gradually this will accumulate in the pond bottom and reduces the depth of the pond. Organic matter in the sediment when subjected to degradation by bacteria may consume more oxygen.

2.8.4 Transparency/turbidity

Turbidity in the culture pond can either be due to phytoplankton blooms or caused by suspended soil particles. Turbidity inhibits the penetration of light into pond bottom and prevents the growth of unwanted filamentous algae and aquatic weeds. Turbidity due to phytoplankton up to a level is desirable since it results in the production of organic matter and the release of oxygen.

2.8.5 Water exchange

Water exchange is done at different rates and frequency depending on the management measures followed and to maintain the water quality parameters in optimal ranges for the betterment of the culture. Water exchange controls algal bloom, maintains pH, keeps required levels of DO, eliminates build up of obnoxious
gases, prevents organic matter accumulation and keeps the pond bottom in healthy condition.

1.8.6 Aeration

Aeration maintains the DO content of water in optimum levels, cleans pond bottom, prevents accumulation of wastes and circulates pond water. The quantity of oxygen available from aeration depends upon the type and number of aerators in the pond and the concentration of dissolved oxygen in the water. Paddle wheel aerators, floating vertical spray aerators and submerged aspirating jets, and “pumped-air” system including diffusers and air-lift pumps are commonly used in culture ponds. Paddle wheel aerators @ 4 to 6 no/ha are generally used in shrimp ponds. Normally aeration will be required during the early morning hours when the DO level will be at its minimum and also during cloudy and rainy days, when DO drops below 4 ppm, during algal bloom crash in the pond and application of chemicals for treatment.

2.8.7 Liming and fertilization

Lime application to culture ponds is done whenever the water pH drops below 7.5 or the daily pH fluctuation is more than 0.5, after every water exchange and also after heavy rain to maintain the optimal pH. Fertilization is done in split doses during the culture to maintain algal bloom in the pond.

2.8.8 Application of chemicals and probiotics

During the culture, various chemicals like probiotics and water conditioners are generally used to maintain good water and soil quality conditions. Zeolite is used by some farmers to reduce ammonia concentration in the pond water. Generally it is applied @ 375 – 625 kg/ha.
2.9 Economics of Shrimp Culture Operation

Capital Investment for the construction of one ha farm will be to the tune of Rs. 3-4 lakhs depending on the soil characteristics, distance and elevation of the site with reference to the source water. Recurring Expenditure per ha farm will be Rs. 2 to 3 lakhs per annum with the cost of production at Rs. 150 and 180 per kg of shrimp. A total production of 2 tons of shrimp at a total farm gate price of Rs. 5-6 lakhs is the expected revenue from a hectare farm. The average profit will be Rs. 2 lakh/ ha.

Sum Up

Growing of shrimp in a controlled pond environment using supplementary external inputs for a determined production is known as shrimp aquaculture. Depending on the intensity of production and management, shrimp farming systems are classified as traditional, extensive, semi-intensive, intensive and zero water exchange systems. Appropriate site selection with suitable soil, water and infrastructure facilities is critical for the success of the shrimp aquaculture. Site-specific farm design and construction of culture pond and other structures are essential. Actual culture begins with preparation of pond for better pond condition and natural food. Stocking of healthy seeds procured from a reputed hatchery decides the culture. Optimum feeding and management and proper soil and water quality management ensure better growth and ideal pond conditions for the growing shrimp.

Drainage treatment needs to be done before letting them in to the open waters. Adoption of better farm management practices gives good harvest and better economic returns.

2.10 Culture of Brackishwater Fin fishes

2.10.1 Objectives

After going through this unit you will be in a position to
• Know about cultivable Brackishwater fin fishes
• Understand pond and pen culture
• Know integrated fish farming system

2.10.2 Introduction

Coastal fish farming is an age old practice in many countries carried out by the fishermen/coastal community with their indigenous traditional knowledge. However, in the recent years fish culture has become full time profession taken up on large scale basis by the farmers, self help groups, corporate, entrepreneurs etc., in a much more improved version. Diversification of farming practices to other species such as fin fishes is suggested one of the remedial measures. Culture of fish is mostly carried out in ponds, pens and cages with supplementary feeding, water quality and disease management. The fish culture is the rational cultivation of fish in confined water mass.

2.11 Cultivable Brackishwater Fin fishes

2.11.1 Species selection

The fish should have the following characteristics for the economical cultivation.

• rapid growth in a short period of culture
• ability to withstand wider ranges of salinity and temperature
• herbivore fish, feeding on plankton, benthic algae decaying plants
• carnivore fish preferred mono species culture
• good market value
• availability of adequate seed
• higher edible meat to spine ratio

Some of the important cultivable brackishwater fin fishes are
Grey mullet  *Mugil cephalus, Liza parsia, Liza tade*
Milk fish   *Chanos chanos*
Pearlspot  *Etroplus suratensis*

Seabass  *Lates calcarifer*

Chichilid  *Oreochromis*

Cobia  *Rachycentron canadum*

Grey mullet (*Mugil cephalus*)

*Mugil cephalus* inhabits estuarine, freshwater, coastal and marine water bodies. It occurs in lagoon, with juvenile fishes most common in impounded areas, around mangroves, in seagrass beds, and offshore. Mullets are herbivore fish and it consumes the decaying organic matter. It can withstand salinity from 0 to 35 ppt. The fish can grow to 500gm size in about six months period under pond conditions with low cost feed such as rice bran and ground nut oil cake.

**Milk fish (Chanos chanos)**

The milk fish *Chanos chanos* is an important food fish in South East Asia. Fish seed is collected from the backwater, low lying region areas and raised for grow out culture either in ponds or in cages. Milk fish is an ideal fish for pen culture and can be cultured even in fresh water. The fish can grow to 500 gm in 5-6 months. It is a plankton feeder and the diet of the milk fish is either supplied wholly by natural productivity or is fed with wet particulate diets.

**Pearl spot (Etroplus suratensis )**

Pearl spot can withstand the salinity from 0 to 30 ppt but can grow better in lower salinities up to 15 ppt. It is a detrivore fish but can accept the artificial diet. It can attain the growth of 150-200gm in 6-9 months depending upon the salinity. It is mostly preferred for polyculture.

**Sea bass (Lates calcarifer)**

Asian sea bass *Lates calcarifer* can withstand the salinity from 0-40 ppt. The fish can be cultured in freshwater, brackishwater and marine condition in earthen
ponds and cages. Under pond condition, the fish can attain the growth of 800-1000gm in 8-10 months period either with trash fishes or artificial diet. In India, the seed production technology of sea bass has been standardized by Central Institute of Brackishwater Aquaculture, Chennai.

Cichilid (*Oreochromis* spp)

*Oreochromis* spp is available in Andaman waters. It is considered as an alternate potential candidate brackishwater fish, suitable for farming in earthen ponds either as monoculture or polyculture mode. Seed production technology of this species in the hatchery is yet to be established for large scale production.

Cobia (*Rachycentron canadum*)

Cobia is the most preferred fish for farming in the recent years because of its fast growth rate under culture conditions. Cobia is a pelagic fish which occurs in most of the tropical and temperate seas. Cobia prefer water temperatures between 20°C - 30°C; they migrate south to warmer waters during autumn and winter then journey back north when temperatures rise again in the spring. Cobia a very tasty fish, it also grows very quickly: they reach 6-7kg one year after. These characteristics make cobia an appealing aquaculture species. Farmed cobia has a low feed conversion ratio.

2.11.2 Mono species culture

Mono species culture of fin fishes is generally practiced for the high valued species. However, other low value species also can be taken up by extensive culture method. Carnivore fish species such as seabass *Lates calcarifer*, grouper *Epinephelus* spp, Snapper *Lutjanus* spp and omnivore species like Cobia *Rachycentron canadum* can be taken up either in ponds or in cages. Since these fishes are highly carnivores, they can predate other species of smaller size fishes and hence they are suitable for monoculture practice.
2.11.3 Polyculture

Culture of many fish species in a single pond is called polyculture. Polyculture method is practiced by the farmers in order to utilise the available phytoplankton, zooplankton and benthic organisms in the pond as feed for the fishes. In this method, the production can be achieved by introducing fish species which can be the surface water feeders, column feeder and bottom feeder. Ponds that have been enriched through chemical fertilization or manuring contain abundant natural fish food organisms living at different depths and locations in the water column. Fish species for the polyculture have to be selected based on their feeding habits. Polyculture is being done since the fish farming was started by traditional way. In the brackishwater culture system, fish species such as Milk fish *Chanos chanos*, grey mullet *Mugil cephalus*, Pearl spot *Eтроplus suratensis* and Tilapia *Oreochromis* spp can be taken up together with the varying stocking densities. Along with the finfishes, shrimp species such as tiger shrimp, white shrimp, banana shrimp can also be cultured.

2.12 Culture Systems and Utilization of Brackishwater Bodies

2.12.1 Traditional culture systems

In India, fish culture in coastal waters is being practiced traditionally. In the traditional method, fish culture was done by extensive method without much of inputs like stocking of seed, feed and water exchange etc. Fish seeds are allowed to enter into pond through sluice gate (auto stocking) during high tide. Seed stocking is done by this method during the season when fish seeds are available from the wild. With low stocking density and no supplementary feeding fish production of 500 to 700 kg/ha in a season (maximum of six months) is being achieved.

2.12.2 Improved culture systems

In the improved culture systems, selective stocking of seed is done either from wild collection or from hatchery production. After pond preparation seed stocking
is done @ 6000-8000nos/ha., feeding is done with the artificial diet and proper water quality management is carried out. Sampling is done at regular intervals to assess the growth and enhancement feeding or health assessments are done. Water exchange is also carried out according to the requirement. Aerators are provided in the fish pond in order to improve the dissolved oxygen levels. All the activities are conducted based on the schedules to achieve the maximum production. In the improved pond culture method, fish production can be achieved from 4000 to 6000 tonnes / ha.

2.13 Pond Culture

2.13.1 Site selection

The brackishwater fish farm can be constructed near mangrove areas, mud flats, and low lying areas and also in inter tidal areas of the coast. The information on assured source of water supply, geographical and climatic conditions, tidal amplitude in relation to the elevation of site, nature of soil and waters, approachability of site, legal and social problems are essential in deciding the merit and demerits of particular site. Criteria for site selection are as follows:

2.13.2 Tidal amplitude

An ideal site, would be one which gets required water level of about 1 to 1.5 meter on the sites for 7-8 days in a fortnight by gravity.

2.13.3 Water supply

The availability of good quality brackishwater is the most important factor in the selection site. The source should be free from agricultural and industrial pollution. It should be clean, clear and relatively free from silt. The quality should be good with minimal fluctuation in salinity all year round.
2.13.4 Availability of power supply

Electricity should be readily available to provide power to run the equipment and other life supporting systems such as pumps and aerators. A standby generator should be available in case of power failure.

2.13.5 Accessibility

The site must be accessible to transport of supplies and materials and for marketing the produce.

2.13.6 Soil type

Sandy loam to heavy clay soil is good for the brackishwater farming due to its good water retention capacity. Soil properties, particularly their fertility, structure and texture, directly affect the growth of different groups of algae. In general, soil with heavy textures and rich in organic matter are favourable for the production of filamentous blue green algae, which is one of the most important fish foods.

2.13.7 Pond preparation

For the better growth and survival of fish the pond has to be prepared and soil has to be conditioned as per the need. The best way to improve the soil condition is to dry the pond bottom, plough the surface layer and add lime and other soil enrichment products for conditioning. This process enhances mineralization of organic load at the bottom.

2.13.8 Liming

Lime application is essential for soil pH correction, pond bottom disinfection and nutrient mineralization. In acidic soils, where pH is low, quantity of lime to be applied should be calculated based on the soil pH.
2.13.9 Fertilization

The growth of fish larvae depends on the natural food available in the pond and to achieve a sustained production of the plankton, it is essential that inorganic fertilizers are applied at 200 kg/ hectare. Organic manures such as cow dung are also applied to enhance the plankton growth in the pond.

2.13.10 Fish seed acclimatization and stocking

Disease free healthy fish seed are prime important for initiating a sustained fish culture. Seeds can be brought from both hatchery and wild for stocking. Before stocking the fish seed, the seeds can be subjected for stress test to assess the quality of the seed. The quality seed is characterized by active movement against water current in the water filled container. Stocking density of 8000 to 12000 fingerlings / ha is advisable brackishwater finfish farming.

2.13.11 Feeding and Feed management

Formulated feed (commercially available) or on-farm feed can be given to both nursery and grow out phase of finfish farming. The feed must have good water stability and required protein for better growth of the fish. The feeding rate must be decided depending on the fish and season of fish farming. The feeding schedule should be regulated based on the feeding check trays placed in ponds. Excess feeding can be avoided by proper monitoring of check tray and by increasing the feeding frequency. The daily ration can be split into 3 to 4 times a day.

2.13.12 Water quality management

Depending upon the water quality of grow out system water exchange may be carried out. Mostly, periodical water exchange after 50 to 60 days of culture will maintain a good water quality condition. While exchanging water, care should be taken to avoid wide fluctuations in water quality. Development, maintenance and control of algal bloom are essential requirements in fish culture ponds.
2.14 Culture of Fin fishes in Cages

Cage culture of fish is a method of raising fish in containers enclosed on all sides and bottom by materials that hold the fish inside while permitting water exchange and waste removal into the surrounding water. The advantages and disadvantages of cage culture are,

- Water bodies can be potentially used
- Can be set up in better aquatic environmental condition
- Can be stocked with more fish on per square meter basis
- Requires moderate investment for construction and operation
- Easily manageable in terms of feeding, sampling, observation and harvesting
- The pond or water resources can still be used for sport fishing, recreation and farming

The disadvantages are as follows:

- Vulnerability of crowded and confined fish to incidence of diseases and parasites
- Rapid spread of diseases
- Localized poor water quality, e.g., dissolved oxygen in and around cages
- Caged fishes need a nutritionally complete, fresh feed
- Cage area attract predators, vandals and poachers

2.14.1 Site selection

Net cages should be set up in calm water e.g., sheltered lagoons, bay behind an island or a river mouth. This is to avoid damage due to strong waves and current. The criteria for selecting a suitable site for cage culture are:

- Water depth should be more than 2-3 meters
- An ideal area would be a protected bay, sheltered cover or island sea
- Water quality without pollution
- Water circulation to improve the poor water quality
- Accessible and preferably secured from vandals and poachers
2.14.2 Design of cages

Cages are designed usually rectangular, square or circular in shapes. Size of the cages varies according to the depth of water bodies in which cage has to be fixed. The size can be 5×3×1m, 5×3×2m, 5×5×1m and 5×5×2m. The cages have to be designed in such a way so that a series of cages can be fixed as row in one place and platform has to be fixed to connect from the road or main land or to get down from the boat. All the cages have to be connected together. Materials required for fabricating the cages are Nylon net materials with the mesh size of 1-2 inches, Wooden or galvanized iron or PVC pipes frame, Plastic drums for floating and Anchor & wooden platform/walkways.

2.14.3 Types of cages

Cages can be set up according to the water depth and two types of cages can be used for the culture purpose. They are floating cages and stationary cage.

2.14.3.1 Floating cage

Floating cages are set up usually in the deeper water bodies having water depth of more than four meters. In this cage, floats can be fixed at the bottom of the frames, which enables the cage to float. In the top, four corners of the net are tied to all the four corners of the cage frames. In the bottom, four corners of net have to be tied separately with the separate anchor and allowed to hang so that the cage is positioned stiff. In the frame top, wooden planks can be fixed tightly and can be used as walkway.

2.14.3.2 Stationary cage

Stationary cages can be fixed in shallow water bodies having water depth of 1.5-2.5 meters. Wooden poles have to be used for fixing the cage. Bottom of the net has to be tied with the poles. All the four sides of the cage have to be tied with series of poles at one meter intervals.
2.14.4 Stocking

Size of juvenile fish to be stocked in cages can vary from 5 to 10 cm and smaller than the mesh size of the net. The stocking density up to marketable size varies from 10 to 100 fish per m³. Salinity of the cage rearing water has to be checked before stocking and accordingly the seed has to be acclimatized.

2.14.5 Feeding in cages

Seabass, grouper, and snapper are highly carnivorous and voracious, predominantly dependent on live fish and crustaceans as food. It is advisable that these finfishes must be trained first to feed on trash fish. Similarly, fish has to be trained for artificial diet if farming is on feed based. In the initial period of culture, feeding rate can be fixed at 7-5% body weight and later it can be fixed at 5% body weight.

2.15 Integrated Fish Farming

Integrated fish farming means integration of culture of fish in association with livestock and agriculture. In other words, integrated fish farming systems refer to the production, management and comprehensive use of aquaculture, agriculture and livestock, with a focus on aquaculture. The production of other cultures in association to fish farming relies mainly on each crop’s traditional technologies, but some factors, in particular the variety, may be adopted.

2.15.1 Species suitable for integrated fish farming

Fish species are selected based on their feeding habits (herbivore, benthivore, planktivore) in order to exploit all available trophic level resources. Milk fish, _Chanos chanos_, grey mullet _Mugil cephalus_, Pearl spot _Etroplus suratensis_, Tilapia spp and shrimps can be selected for integrated fish farming.
2.15.2 Poultry –cum-fish culture

Poultry-cum-fish farming can be taken up in brackishwater ponds with low external inputs such as feed etc. Mixed fish species can be stocked in the ponds and over that a poultry shed can be set up. The poultry droppings serve as manure and thereby develop the algal production. The available phytoplankton and zooplankton in the pond can be enhanced which serve as food for the fishes. At the same time, poultry also grow and gain weight.

2.15.3 Paddy-cum fish culture

Integrating fish farming with agriculture guarantee the maximum productivity and continuous employment opportunities not only for the farmers but also other related upported workers. In Kerala, mostly shrimp species are cultured along with the fish species such as Mullets (Mugil parsa, Liza tade, M.cephalus) and Pearlspot (Etroplus suratensis). The catch varied from 785 to 2135kg/ha/year. In West Bengal, the fish production in the paddy fields vary from 100-200kg/ha/year. Fish species such as L parsia, L.tade, Lates calcarifer, Mystus spp and shrimps are dominantly cultured in West Bengal rice fields.

Sum Up

The annual contribution of finfish to total aquaculture production has been increasing in recent years. While the freshwater fish dominates the total finfish production, brackishwater and marine fishes make up an important component in terms of production and value. The diversity provides very promising development opportunities for the brackishwater fish culture. Unlike other aquatic organisms, finfish can be cultured in a number of culture systems like cages, pens and in ponds. Variety of fishes is available and suitable for different culture practices such as monoculture, polyculture and can be integrated with live stock and agriculture. Therefore, fish plays major role in aquaculture production and lot of scope to expand the farming activities in a diversified manner.
2.16 Tools and Approaches for Managing Sustainable Brackishwater Aquaculture

2.16.1 Objectives

After studying this unit, you will be in a position to

- Understand concepts and techniques of managing sustainable brackishwater aquaculture
- Plan for sustainable brackishwater aquaculture development
- Be able to apply the techniques learned in field situations

2.16.2 Selecting Areas for Aquaculture Development

Proper site selection and monitoring of aqua farms are important management practices in order to mitigate the negative environmental impacts attributed to aquaculture. The various tools for identifying the potential aquaculture areas are discussed as hereunder:

2.16.2.1 Potential sites suitable for expansion of aquaculture

The extent of utilization of resources like creeks, location of different resources such as mangroves, mud flats and other eco systems needs to be documented to provide the basic inputs for planners to formulate new policies and also to ensure proper use of the resources. Methodology has been developed by the Central Institute of Brackishwater Aquaculture (CIBA) to identify suitable areas for brackishwater aquaculture from satellite digital images incorporating land use pattern, guide lines, buffer zone, and soil and water quality in GIS platform.

2.16.2.2 Environmental impact of aquaculture on ecosystems

Major environmental issues such as the conversion of important coastal ecosystems like lakes, mangroves and agricultural lands to aquaculture farms and pollution of drinking water resources adjacent to aquaculture farms have been raised against the development of aquaculture. The timely, accurate information of
natural resources and the usage pattern derived from the images will help the planners for better management of our resources, aiming at sustainable aquaculture.

2.17 Better management practices

It is possible to solve most of the production constraints through well developed management practices. Hence, there is a strong need to facilitate the adoption of Better Management Practices (BMPs) to achieve the goal of sustainable shrimp farming. BMP includes eight basic principles starting from Farm siting, Farm designing, Water use, Brood-stock and post larvae, Feed Management, Health management, Food safety and Social responsibility.

BMPs are often voluntary practices, but can also be used as basis for local regulations, or even certification programmes. While extension messages are often focused on ways to increase production and quality of the product, BMPs can facilitate the farmer to farm shrimp in a more sustainable way taking into account also the environmental and socio-economical considerations.

BMPs must meet the needs of farmers and has to be modified and adapted to their conditions to make it more appropriate and relevant in each location. Farmers need to be relied upon as learning base for enhanced capacity building and their participation is a must in the development of strategies for the adoption of BMPs.

Self-Help Groups

In the Indian context, the concept of Self-Help Group (SHG) has caught up with the momentum of women development. Group approach is considered to be the most powerful means to strengthen the socio-economic bondage for development of different stakeholders. It could serve as a platform to provide opportunity to the members for overall development through group efforts. SHG approach is for self-determination, self-reliance and self-empowerment. The Self-Help Group effort was witnessed for the first time in Bangladesh during 1953 for which Mr. Mohammed Yunus was awarded Nobel Prize for peace in the year 2006.
Self-Help Group is a homogenous group of not more than 20 individuals who join on a voluntary basis in order to undertake some common activities through mutual trust and self-help. In recent years, SHGs have become important local institutions for rural development. This has been particularly so in the case of poor women. It is now being realised that instead of targeting the individuals in the process of development, it would be useful to facilitate the group approach through the process of social mobilisation. The poor people do not have enough capital to take up any business enterprises on an individual basis besides required confidence. The group approach makes available the collective wisdom and use of combined resources for any task.

In the field of coastal aquaculture, women as well as men SHGs could undertake several Income Generating Activities (IGA) viz., crab fattening, sea bass culture, grouper culture, seaweed culture, milk fish culture, ornamental fish culture and other suitable fish species etc. The banks are ready to provide financial assistance. Apart from culture of different fish species, SHGs can also undertake value addition activities like scientific fish drying, pickles, cutlets, wafers etc. They can do collective marketing of value added produce to serve the consumers according to their tastes and preferences.

**Farmer Interest Groups (FIG’s)**

The Farmer Interest Groups can be formed for achieving overall economic development of the members, their area and their environment through close interaction. The size of the group may vary from minimum of five to maximum of 15. The group may be purely men, purely women or purely women and men i.e. mixed group. The group should be homogenous. The group should have rules and regulations which is acceptable to all the members in the group. The extension functionaries may encourage formation of these interest groups to serve their customized needs and services.
Formation of clusters / Aqua clubs

The success of shrimp farming largely depends on sharing of information among stakeholders as it will try to reduce the uncertainties of the farming of shrimp. One of the major constraints inhibiting the sustainable development of shrimp farming is lack of sharing of information among the farmers particularly with regard to soil and water management and disease management etc. This often resulted in heavy economic losses to the farmers in addition to environmental damage.

The Collective Approach (CA) practiced both within the country and outside brought out enormous benefits in many farming enterprises benefiting the producers and consumers in a larger way. The testimony to this is group farming of rice in Kerala and cluster farming of shrimp in Thailand.

In order to promote responsible and sustainable shrimp farming, Marine Product Export Development Authority (MPEDA) - Network of Aquaculture Centers in Asia Pacific (NACA) project on cluster farming has been initiated in Andhra Pradesh in 2001 and gradually extended to other states. In cluster approach to shrimp farming, the major focus is diverted towards adoption of Better Management Practices (BMPs). There are 10 major areas in which 15 practices are being propagated under each major head as BMPs which are considered as essential for sustainability of coastal shrimp farming. Hence, there are about 150 BMPs. Farmers who experienced continuous loss of crops due to diseases are gradually changing their attitudes towards collective approach in managing shrimp farms.

2.18 Aquaculture Extension Approaches

There are so many stakeholders involved in aquaculture development. The farmers, hatchery operators, PCR lab owners, input dealers, private input manufacturers, processors, exporters, research organizations, extension functionaries, company technicians, consultants, tutorials, planners, NGO’s, civil societies, other local institutions etc. are all key stakeholders in the supply chain process of producing and trading the aqua products. The other stakeholders like labourers of aqua farms,
women involved in aquaculture operations, neighbouring farmers of aquaculture, fishermen who do sampling, transporters, ice factories etc though are less pronounced in research and extension circles are likely to play significant roles in helping the producers to produce quality produce and get fair price. A grass root level organisation should be enabled to train the stakeholders who are accessible at local level. These organisations may be KVKs, FIGs, department of fisheries or even NGOs. Farmers should be educated on cost competitiveness and added value, techniques of producing aqua products in accordance with requirements of buyers etc. Awareness campaigns should be regularly conducted to prohibit the use of antibiotics. Demonstrations of feasible and viable BMPs need to be ensured in farmers’ ponds. More number of mass media programs to be organized to create awareness on different aspects of aquaculture. Some of the extension approaches are discussed as under:

2.18.1 Institutional mechanism for aquaculture extension

Department of Fisheries at state level extends the technology transfer and various government schemes to different stakeholders of the sector. The fisheries department officials who are part of Agricultural Technology Management Agencies (ATMA) involve in preparation of Strategic Research and Extension Plan (SREP), mobilising community specific groups, self-help groups and farmer’s interest groups at micro level and promotion of rural entrepreneurship through training and financial assistance. The Krishi Vigyan Kendras (KVKs) situated in every district undertake technology validation and transfer through trials, demonstrations, fairs, exhibitions, vocational trainings and publications in vernacular language to serve the farmers on need assessment basis. Central government agencies like Coastal Aquaculture Authority and MPEDA serve the coastal farmers through licence issuance and aqua promotional activities respectively. CIBA conducts number of front line demonstrations on latest technological innovations at various locations of coastal states. The institution like NFDB provides financial assistance including
subsidy and equity contribution for promoting aquaculture through field level agencies.

2.18.2 Promotion of aqua-entrepreneurship

Unless the human resource is oriented to become enterprising, all the physical assets available cannot be of use and sustain for long time. The understanding by the rural youth of coastal areas adds to their confidence and risk taking ability. The vast employment potential for unskilled, semi-skilled and professional educated workers can be tapped by taking up of diversified aquaculture activities. The human resources should be the focus of the extension system and not just the technologies. There is need to give impetus on value addition to primary aqua produces. When individuals become achievement oriented, they bring all their potentials to innovate, take prompt decisions weighing the pros and cons of possible outcomes. They are dynamic agents of change who transform the physical, natural and human resources into corresponding production possibilities. With concerted effort, the natural changes that occur any way due to changing situation can also be harvested with well designed inputs in the form of entrepreneurship development programmes, vocational training, and modification in education system incorporating professional training component. The curricula of the fisheries undergraduate programme needs to be focused towards entrepreneurship development so that young pass outs from Universities are able to start new enterprises rather than seeking employment in an already volatile job market.

2.18.3 Establishment of aqua - clinics

Fisheries Colleges under the State Agricultural Universities and affiliated colleges outside the State Agriculture University System are annually producing significant number of graduates out of which only a few are able to avail of employment opportunities in various public & private sector agencies. The remaining manpower available is either underutilised or unutilised. This large reservoir of graduates can be tapped for providing support services to the farmers in
various areas through Agri-Clinic & Agri-business Centers, thereby supplementing Governmental efforts and public sector agencies and filling critical gaps therein.

The Government extension machinery as it exists at present is not equipped for lending location specific specialized aqua advice mainly because the field level staff of the government is neither exclusively available for extension work nor is adequately qualified and trained, and public sector input supply agencies are also not able to cope with the needs of fast transforming and accelerated pace of aquacultural production.

2.18.3.1 Village Knowledge Centres (VKCs)

Empowering the rural communities by making specific and need-based information accessible to them is the major goal of the Information Village Research Project of the M. S. Swaminathan Research Foundation (MSSRF). It was launched in 1998 in Puducherry, a Union Territory in South India. This project operates by setting up Village Resource Centre (VRC) and Village Knowledge Centres (VKCs) in the rural areas of Puducherry. The VKCs that currently have been set up in 13 villages; operate on a hub and spokes model. The hub Centre, Pillayarkuppam, is connected to 13 VKCs with high-end technologies. Out of these 13VKCs, five are in coastal areas viz.,

Veeranpattinam, Panithittu Periyakalapet, Ganapathychettikulam, and Moorthykuppam and their major livelihood is fisheries. Others are having agriculture and horticulture as their major livelihood. The Information Village Project in Puducherry has emphasised the use of multiple media. Knowledge centres in 13 villages are connected by a hybrid wired and wireless network consisting of PCs, telephones, Very High Frequency (VHF) duplex radio devices, as well as spread spectrum and e-mail connectivity through dial-up telephone lines. The centres are run and maintained by the local men and women. In this project, because of a deliberate decision to give priority to women, more than half of the volunteers operating the knowledge centres are women. The identified volunteers have been
trained in basic computer skills and in maintaining the centres. They have also been trained in hardware in order to solve the simple technical problem in the centres.

Relevant information or content is developed for every VKC through in-depth consultations with the community members. The hub centre has the necessary telephone equipment with which the staff works on the information that is uploaded in the network. The VKC is not only a knowledge centre but also a value addition centre, which generates a number of databases to provide information on government schemes on agriculture, livestock, health, educational opportunities, employment news, market rate for farm products, audio clips related to agriculture, education, market prices, rural technologies, weather including wave height alerts for fishermen, and other information that is useful for the rural communities.

**Sum Up**

Coastal aquaculture faces number of challenges including disease outbreaks, fluctuating market prices, rising input costs, etc. These challenges need to be tackled by appropriate management tools for sustainable development of aquaculture. These tools include social mobilisation of aqua producers, technology assessment and refinement, participatory planning and capacity building of key stakeholders. There are successful examples of farmer’s associations, aqua clubs, aqua-choupals and village knowledge centres which promoted the effective use of available resources and helped stakeholders. There is a need to create more awareness and knowledge among the stakeholders on various aspects of management tools for ensuring sustainable aquaculture development.
Unit- 3

Marine Fisheries Development in India

Structure

3.1 Introduction
3.2 Phases of Fisheries Development
3.3 Objectives of Fisheries Development
3.4 Fisheries Development under different Plan Periods
3.5 Status of Marine Fisheries of India
3.6 Sustainable Development of Indian Marine Fisheries
3.7 Future Strategies for Indian Marine Fisheries Development

3.1 Introduction

Fisheries development has progressed considerably since World War II and the estimates of world marine capture fisheries production was 84.2 million metric tons in the year 2005 (FAO, 2006). While in the past, fisheries resources far exceeded the human capacity to exploit them, since the last two decades, technological changes have paved the way for a situation where increasing annual catches of fish is no longer a simple matter of increasing fishing effort. The rate of increase in fish production is increasingly becoming difficult to maintain as a consequence of many of the stocks having reached or even exceeded their limits of sustainable exploitation. Fish is a significant contributor to the livelihood, nutritional, trade and economic security of countries and hence concerns are being voiced about the rational development and management of fisheries where new terminologies like “sustainable development” and “responsible fishing” are currently being widely used.
3.2 Phases of Fisheries Development

Fisheries Development is influenced by a variety of factors such as the economic status of the country and the relevance of fisheries to the people by way of availability of fish as well as socio-political reasons. Broadly speaking, the following four development phases have been recognized for the fisheries sector:

- An **initial phase** of slow development characterized by the absence of any major fisheries or only a traditional fishery
- A **steady phase** with significant increase in catch rate and production
- An **over-development phase** characterized by declining catches and catch rates
- **Management phase** arising out of the above developments and aimed at regulating fishing and arresting the decline.

3.3 Objectives of Fisheries Development

- Increase export of fish and fish products
- Increase supply of fish to domestic market
- Increase level of fishermen’s income
- Provide new employment opportunities in the fisheries sector
- Sustain the fishery

3.4. Fisheries Development under different Plan Periods

Fisheries development was realized through programmes for the development of marine fisheries under the different Five Year Plans such as

1) Intensive fisheries resource surveys in the Indian EEZ and resource assessment
2) Optimum exploitation of marine resources using a judicious mix of traditional country boats, mechanized boats and deep sea fishing vessels
3) Adequate landing /berthing facilities by construction of major and minor fishing harbours
3.5 Status of Marine Fisheries of India

Marine fisheries play a significant role in the socio-economic development of India, contributing to food/nutritional security and employment opportunities besides being a source of livelihood to many marginalized poor coastal folk. Prior to and immediately after independence, the marine fishing activity was mainly close to the shore and at subsistence levels only with indigenous crafts employing traditional gears such as cast nets, small seines and traps. During 2010-11, the number of people whose major occupation in marine fishing was 1.40 million, in fishery related activities 1.5 million and in the tertiary sector (marketing) about 0.1 million. Today, India is one among the top ten fish producing countries in the world and in 2010-11 contributing over 4% (8.2 million t) of the total world fish production (145 million t). The fisheries sector in India contributes 1.4% of the total national gross domestic product (GDP) and 4.5% of agricultural GDP besides providing employment and income to over 5 million fishers and fish farmers. The marine fisheries sector in the country contributes about 40% of the total fish production. The share of Indian sea foods in the world market has shown an increasing trend over the years since its inception in 1950s with a 21% increase during the 2000-2005 Seafood exports during 2011-12 were 8,60,000 metric t worth Rupees 16,500 crore.

3.5.1. Resources

The Indian EEZ (declared in 1976) with a 200 nautical mile boundary has a total area of 2.02 million square km. The availability and distribution pattern of marine fishery resources in the Indian EEZ are typical of tropical waters with a large variety of species (nearly 1570 species of Fin fishes and about 1000 species of shell fishes) coexisting in the same ground (Fig.1.1). Of this, over 200 are commercially important and include the pelagic groups such as sardines, anchovies, mackerel, carangids,
Bombay duck, ribbon fishes, seer fishes, tunas; demersal finfish groups like the sharks, rays, croakers (sciaenids), perches, silverbellies, lizardfishes, catfish; crustaceans including the penaeid and non-penaeid shrimps, crabs and lobsters; and cephalopods consisting of squids and cuttlefishes.

3.6 Sustainable Development of Indian Marine Fisheries

Sustainable development is the globally accepted goal for natural resource management, identified at United Nations Conference on Environment and Development (UNCED) in 1992. The basic principle that governs sustainable development of fisheries is that, it must be conducted in manner that does not lead to over-fishing, or for those stocks that are over-fished the fishery must be conducted such that there is a high degree of probability the stock(s) will recover and also fishing operations should be managed to minimize their impact on the structure, productivity, function, and biological diversity of the ecosystem. The marine fish production has reached a plateau since 1989, which is because the fishing effort (mainly trawl based) has increased considerably and is concentrated in the 0-100 m depth zone leading to excess pressure in the coastal waters.

Indian fisheries have recently been facing the serious crisis of unsustainable development. As in many developing countries there are problems of over fishing, inter/intra sectoral conflict, low incomes and high degrees of poverty which creates difficulties in shifting to a limited access system from the existing open access system. Sustainability concerns of Indian fisheries can be listed as follows,

- Multi-gear, multi-species, Open Access Fisheries
- Excess fishing effort /Over capitalization especially in the coastal areas upto about 50 m depth zone
- Decrease in area available in the sea per active fisherman and boat for conducting fishing operations
- Conflicts among different categories of fishermen particularly between the artisanal and mechanized groups of fishermen
- Limited scope for increase in fish production from the inshore fisheries as most have reached MSY levels
- Declining trend in catch and catch rates of commercially exploited stocks
- Discards/Indiscriminate exploitation of juveniles of many commercially important species due to use of small mesh nets
- Damage to the benthos and benthic ecosystem by continuous sweeping of the same ground by shrimp trawlers
- Ecosystem degradation (pollution, increased bottom trawling effort in coastal areas, mangrove destruction) affecting the productivity and the carrying capacity
- Conflicts between those engaged in coastal artisanal fishing and coastal aquaculture
- Absence of an informed management regime and a Limited Fishery Management system (Participatory Fisheries Management) due to resistance to imposition of fishery regulations and lack of political will
- Inefficient internal marketing system

- Impacts of climate change on fishery resources already under high fishing pressure

3.7 Future Strategies for Indian Marine Fisheries Development

Prospects for further development and expansion of fisheries include the unexploited component of exploited stocks (eg. offshore tuna fishing), unutilized resources which have not much market value at present but can be utilized after suitable conversion into value added products (eg. certain deep sea resources such as Black ruff Centrolophus spp., Bull’s eye Priacanthus spp., Drift fish Ariomma spp., Green eye Chloropthalmus spp.) and mariculture (mussels, oysters, fin-fish, seaweed). Along with this, development and/or improvements in the infrastructure facilities, operational efficiency and quality control at all stages (harvesting/mariculture, processing and marketing), reduction of wastage and value addition of fishery products are vital when planning the development of fisheries.
Presently, Indian seafood exports trade is mainly in the commodity (bulk) packing aimed at processors of the importing countries who reprocess it and sell it under their label. Today the demand is for hygienic, nutritious and attractively packed ready-to-eat or ready-to-cook convenience products. Hence there is tremendous scope for increasing export earnings through value addition to these bulk processed items as many other developing counties are doing. Some of these products include battered and breaded products, fish fingers, Individual Quick Frozen (IQF) products, *Sushi* (shrimp based) and *Sashimi* (tuna) products. For this serious thought to developing adequate technologies for value addition and marketing strategies (for new products, new markets) is required. There is also a good market for ornamental fish and live fish for which good harvesting practices and development of mariculture technologies are required. Proper quality assurance, suitable target markets for high end products and live seafood trade require focused attention which can contribute significantly to fisheries development.

The World Trade Organization (WTO) regime was supposed to facilitate a level playing field for increasing trade of both developing and developed countries. However it has often been observed that tariffs in advanced countries on imports from the developing countries are much higher than those from other advanced countries. The major trade barriers faced by the Indian seafood trade industry in the recent past are given below.

In the light of such experience, we should focus on diversification of mariculture from shrimp to other exportable items of fin-fish and shell-fish. In addition, introduction of a regulated oceanic tuna fishing fleet with focus on the high end products like *sashimi* tuna and tuna loins, quality assurance at landing, transporting and processing points through voluntary adoption of appropriate international standards by the industry, promotion of eco-labelling, organic farming and promoting a common trade brand for Indian seafood products through a logo will also go a long way in promoting marine fisheries development in India.
Although the Indian fish processing trade is mostly export oriented, prospects for domestic fish market is bright as recent economic growth of the country is reflecting in larger disposable incomes and purchasing capacity of the people for items such as high quality fresh/processed marine fish. A major concern is that appropriate quality standards for the fish and fishery products sold in the domestic market are generally lacking and there is an urgent need to set up standards for same.
Management of Marine Fisheries in India

Structure

4.1 Objectives
4.2 Introduction
4.3 Fisheries-Related Policies
4.4 Technical Controls in Marine Fisheries Management
4.5 Options for Sustainable Development of Marine Fisheries of India

4.0 Objectives

- Explain fisheries management plans
- Understand various legislations for fisheries management in India
- Know the various options for fisheries management in India

4.1 Introduction

Fisheries Management Plans (FMP) is all about determining a detailed plan of what is required to achieve the policy objectives for that fishery resource. Single species management practices prevalent in temperate waters will not be suitable to multi species-multi gear systems of tropical waters such as in India. In a multi-species system it is impossible to maximize returns from all the constituent stocks. Here the goal of management should be to promote sustainable fishing practices that do not decrease the stock levels, ensure livelihood security, resource sustainability, economic efficiency and ecosystem integrity. Besides, fish stocks live in a highly variable and complex ecosystem, affected by human intervention as well as the vagaries of nature resulting in
environmental variations. Recently many reports of climate change induced variations in fish abundance and distribution patterns have been widely reported in many fisheries of the world including India. Therefore this uncertainty factor also has to be incorporated in the management strategies. Fisheries resources must be managed to harvest stocks at sustainable levels for ensuring livelihood security for the benefit of the present and future generations. Hence management of fisheries is not managing the fish stocks alone but also has to take into account all the stakeholders who are directly or indirectly involved, such as the fisher folk, traders, fish processing sector and consumers. Thus management measures should involve action taken for improvement/addition to infra structure, performance of fishing operations, reduction of wastage (by-catch, discards); improvements in quality/value of fish caught and income from fisheries; protection of important coastal habitats such as mangroves and estuaries and resource enhancement programmes such as sea ranching, artificial reefs etc and efficient fish storage, distribution and marketing systems to ensure steady prices for the fishes caught and minimize wastage of valuable protein food.

To ensure that the management plan is put into operation and functions efficiently includes responsibilities such as:

- Collecting and analyzing the biological and fishery data necessary for assessment, monitoring, control and surveillance
- Adoption and promotion of appropriate and effective laws and regulations necessary to achieve objectives
- Ensuring that fisheries comply with them to achieve the objectives

4.2 Fisheries-Related Policies

Recognizing the importance of fisheries in the coastal ecosystems and national economy several regulations and notifications have been promulgated by the central and state governments. The important ones are

1. Indian Ports Act (1963)
2. Indian Wildlife (Protection) Act (1972)
4. Territorial Waters, Continental Shelf, Exclusive Economic Zone and other Maritime Zones Act (1976)
5. The Coast Guard Act (1978)
6. The maritime Zones of India (Regulation of Fishing by Foreign Vessels ) Act (1981)

4.3 Technical Controls in Marine Fisheries Management

In order to maintain the fish stocks at a target level, the management used is that of controlling fishing mortality, that is the amount and age of the fish removed and this is achieved through various technical measures such as restrictions or constraints that regulate the efficiency of fishing (mainly closed seasons, closed areas, gear restrictions such as type of gear, mesh size etc.)

4.3.1. Input controls

This is control of the effort put into the fishery. Effort can be measured in many ways e.g. number of vessels combined with size, horsepower, number of crew, number of fishing lines or gear; number of fishers combined with the gear they are using; or the number of days fished or other time measure. This includes,

- Limiting of Access to fisheries (e.g., through licenses)
- The size and power of boats (craft OAL, engine hp)
The amount of time (days/hours) a boat can fish each month

Size of the nets used

It is vital that if this type of control is being used that the increase in the technological ability of gears and fishers is taken into account. As this increases so does the effort and efficiency of the fishery.

4.3.2. Output controls

This is the direct regulation of the catch taken from the fishery, e.g. forms of quota management. This is a more total control of the primary factor ‘the catch’, but it can be both expensive and complex to enforce. Additional controls on the catch can also be made such as the size of fish or the maturity stage (juvenile/adult/spawner) of the fish.

- Total Allowable Catch (TAC) for a fishery
- Size limits (for capture and marketing)
- Closed areas for fishing
- Closed seasons for fishing

4.4 Options for Sustainable Development of Marine Fisheries of India

4.4.1 Shift from Open-access to user rights

As an input control measure, policy measures that abandons the present “open access” system to resource allocations and establishment of user rights is likely to be most effective for resources management and protection of critical fish habitats in the aquatic environment. If such measures are introduced they will, inter alia, provide greater incentives to reduce excess fishing capacity/pressure, which has been one of the major factors responsible for overfishing and unsustainable development. In addition, the establishment of user rights is particularly important in protecting the interest of artisanal fishers from unequal competition with industrial vessels.
The policy should aim to ensure socio-economic security for the artisanal fishermen whose livelihood depends solely on this avocation. Thus, the measures suggested are:

- Mandatory registration and licensing of all motorized and mechanized boats.
- Review of registration and licensing every five years.
- Upward revision of the registration, licensing fees and berthing charges to discourage new entrants.

4.4.2 Reduction of fishing effort

The fishery regulation through effort reduction that is in vogue in different maritime states is chiefly aimed at the trawl fishery. In recent years, there has been significant increase of the motorized sector, especially the ringseine fishery and the mini-trawl fishery. This trend is most evident along the Kerala coast, causing concern for sustenance of some of the exploited stocks. There have been huge increases in the dimensions of gears employed giving it wider coverage of the fishing areas and resulting in higher catchability. Similarly, the increase in the time spent for fishing in the mechanized sector by undertaking multi-day voyage and use of sophisticated electronic devices for fish finding and communications has resulted in increased fishing efficiency. Action points suggested are:

- Fixing and capping the size and power of the boats in each sector by imposing upper limits for the length and horsepower, especially the large ring seiners operating in Kerala.
- Restriction of multi-day fishing by fixing upper limit for absence from the shore in all the states.
- Discourage further entry into the fishery through refusal of licensing to new boats.

4.4.3 Closed season/closed area/Marine Protected Areas (MPAs)

Recognizing the necessity for ensuring sustainable yields from the exploited stocks, certain maritime states have enacted fishery regulation acts enabling effort
reduction, rebuilding of the stocks and ecosystem rejuvenation by closure of fishery for a specified period of time. Restriction of the number of days of fishing during monsoon is the most common method followed in India. The objectives being protection of the spawning stocks from capture by mechanized fishing vessels and also allow the natural replenishment of the fish stocks. Presently, there is consensus among the fishermen that the intensive exploitation of the coastal waters does adversely affect the ecosystem resulting in low productivity from different trophic levels. This has led to the acceptance of a uniform ban on mechanized (mainly trawl fishing) crafts during the monsoon months along the entire Indian coast.

Designating areas of fish spawning and feeding as Marine Protected Areas (MPAs) in which fishing is prohibited, allow rapid build-up of fish spawning stock biomass. The idea behind reserves is that if the fish are protected from fishing, they live longer, grow larger and produce an exponentially increasing number of eggs. It is observed that adult fishes tend to remain in the protected areas while their larvae help replenish adjacent fisheries. Marine reserves in the Gulf of Mannar, Gulf of Kutch and Andamans are a right step in this direction.

**The suggested measures are:**

- Mandatory closed fishing season from 15th June to 31st July for the west coast.
- Mandatory closed fishing season from 15th April to 30th May for the east coast.
- Only non-motorized and low horse powered motorized (up to 10 HP) OBM/IBM vessels to be allowed to operate during the closed season.

*Dol* net operations off Maharashtra and Gujarat to be controlled by closure of fishing area in specified fishing zones.

**4.4.4 Mesh-size regulations and curbs on destruction of fish juveniles**

The fine meshes of gears like trawls and bag nets cause large-scale destruction of juveniles of many important commercial fishes. The cod end mesh size (CEMS) of the trawls prevalent in India is uniformly very small (10-15 mm stretched knot to knot)
while the recommended minimum stretched mesh size is 35 mm. It may be recommended that a cod end mesh size of 35 mm may be enforced in Indian waters to ensure sustainable exploitation of the fish and shrimp stocks. As regards to lobster resource, Central Marine Fisheries Research Institute (CMFRI) has recommended the Minimum Legal Weight (MLW) for capture of four species of lobsters to ensure sustainable exploitation of the resource. Based on the recommendations of CMFRI, the Ministry of Commerce, Govt. of India has issued orders specifying the Minimum Legal Weight fixed for lobster exports as *Panulirus homarus* – 200 g, *P. polyphagus* – 300 g, *P. ornatus* – 500 g and *Thenus orientalis* – 150 g. Similarly, for silver pomfret (*Pampus argenteus*) the MLW suggested is 300g.

The fishing for shrimp seed along the coastal waters of the east coast is yet another example of the destruction of valuable ichthyo-plankton. For every shrimp seed collected, hundreds of other larvae and juveniles of commercially important species of fin-fishes and shell-fishes are destroyed. The juvenile fishing should be stopped forthwith and interventions required are:

- Complete ban on landing and marketing of juvenile fish.
- Minimum export size of high value resources should be fixed.
- Restrictions on collection of natural shrimp seeds.
- Awareness creation

### 4.4.5 Diversification of vessels and targeting specific resources

To ease out fishing pressure in the inshore waters, the existing vessels may be suitably upgraded/modified as multipurpose/combination vessels to harvest the under tapped resources like tunas, bill fishes, pelagic sharks and oceanic squids available in the oceanic and deeper waters. The suggested options are:

- Diversification of fishing to passive fishing by gill nets, squid jigging and hooks & lines
- Promote deep-sea fishing by resource specific craft and gear (long lining) to tap the oceanic/deepwater tuna resources.
4.4.6 Participatory fisheries management

Participatory fisheries management is an innovative approach to decentralize management authority and make fishermen as resource managers. Here, management of fisheries is made more effective by the active involvement of all principal stakeholders in the decision-making and implementation of resource management programmes.

4.4.7 Ecosystem based Fisheries Management (EBFM)

Traditionally fish population dynamics have been studied as a single species, for example as mackerel, shrimp or sardine and almost always in isolation from the system in which they exist. However, there is growing awareness that these kinds of assessments and management interventions based on these will be unrealistic which gave rise to the concept of EBFM. Fishing activities may have positive or negative effects on other components of the ecosystem through the food chain effect, by-catch or physical damage. It is therefore important to strive for the sustainable use of the entire ecosystem not just the species being targeted in any one management plan. With an ecosystem approach to fisheries management, EBFM is a geographically specified fisheries management that takes account of knowledge and uncertainties about, and among, biotic, abiotic and human components of ecosystems, and strives to balance diverse societal objectives. It takes into consideration trophic (predator-prey) interaction between various fish species in the fishing grounds as well as the environmental variability that affects the productivity of fisheries resources. In India EBFM is being attempted by CMFRI by developing models for the Karnataka coast of south west India, Gulf of Mannar and Northwest coast of India.

4.4.8 Code of Conduct for Responsible Fisheries (CCRF)

The CCRF was evolved by FAO aimed at long-term sustainable measures for optimal exploitation of fishery resources. It is voluntary in nature and defines the general principle that “The right to fish carries with it the obligation to do so in a responsible manner”. The code calls for effective legal and administrative framework for
the refusal, withdrawal or suspension of authorization to fish in the event of non-compliance with conservation and management measures. Also the member countries are required to implement effective fisheries Monitoring, Control and Surveillance (MCS) and law enforcement measures wherever appropriate. The CCRF has been endorsed by India also.

4.4.9 Strengthening of Management Information System

The basic requirement for knowledge based fisheries management is availability of reliable and adequate data on the resources and their dynamics including economics of fishing. For this, an effective data acquisition mechanism is needed. The maritime states must develop mechanisms to generate reliable data on marine fish landings and fishing effort, which can be used for understanding dynamics of the fisheries as well as for regulating their exploitation. For this, linked to the schemes for registration of crafts and availing of subsidies etc. by the fishermen, compulsory availability of fishing log books to identified national research institutes such as CMFRI, can be enforced.

4.4.10 Strengthening of Fisheries Extension Programmes:

Fisheries development is closely related with the improvement in the ability of the fisherman’s/fish farmer’s understanding and adoption of sustainable fishing practices and innovative mariculture technologies. Extension agencies facilitate transfer of useful and practical information emerging from research activities and inform the scientific community of the problems of fishermen/farmers for finding suitable solutions.

The extension system in Marine Fisheries in India is conspicuous by the absence of its formal institutionalization as in the case of Agriculture sector where the Transfer of Technology (ToT) approach (a three tier system comprising of technology generation, frontline extension and grassroots level extension) is followed. In this approach the technology generation and frontline extension activities come under the mandate of ICAR research institutes as well as State Agricultural Universities while grassroots level extension is carried out by State departments.
The Krishi Vigyan Kendras (KVK), Brackishwater Fish-Farmers Development Agencies (BFFDA); the Institute Village Linkage Programme (IVLP) and Agricultural Technological Information Centres (ATIC) of Indian Council of Agricultural Research (ICAR) are playing an important role in extension programmes of the marine fisheries sector. However, the State Fisheries Departments, the main agency concerned with extension, are doing little extension work, and are mainly concerned with implementation of regulatory measures and welfare programmes for fishermen. Hence, there is great need to develop a Research-Extension system oriented towards responsible and sustainable fisheries in the country. In marine fisheries sector extension efforts were fruitful in the introduction of mechanized trawler boats under the Indo-Norwegian Project (INP), fiberglass beach landing crafts by the Bay of Bengal Programme (BOBP), improved 45 feet OAL mechanized boats for deep sea trawling under Indo-Danish (DANIDA) Project and improved fish processing by sun drying and salt curing. Further scope for useful extension exists in creating awareness among fishermen of adverse consequences of destruction of fish eggs and juveniles and discarding fish at sea; conservation of endangered species and fragile marine ecosystems, improvement of hygiene and sanitation in landing/processing centres, production of value added products, ornamental fish culture and mariculture activities.
Unit- 5

Processing / Post Harvest Technologies

Structure

5.1 Objectives
5.2 Introduction
5.3 Icing, Handling and Transportation of Fish
5.4 Freezing of Fish
5.5 Salt Curing and Drying of Fish
5.5 Smoking of Fish and Prawns
5.6 Fish Canning
5.7 Value Addition in Fisheries
5.8 By-Products

5.0 Objectives

After going through this unit, you will be in a position to

- To make you understand the importance of fish in our nutrition and he
- To understand different techniques of processing applying low temper and high temperatures i.e., icing, freezing, drying, salting smoking, canning etc.

5.1 Introduction

This unit contains different Post -Harvest Processing / Preservation Techniques or technologies viz. icing, freezing, canning, curing drying and smoking etc. in utilization
of fish and fish products. Whole some fish is going to be the best food in future among the animal meat food.

Fish is highly nutritious food and are rich in proteins, fats, minerals and certain vitamins that are required for human body and growth. Fish is also one of the important ingredients in the formulated feeds for cattle and poultry and also in the aqua feeds used extensively for both fish and shellfish farming.

Biochemical composition of fish shows wide variations from one species to another, within the same species, in different portions of the body in the same fish, from different geographic regions, from season to season, according to age, size, sex and growth etc. The important constituents of the fish muscle are moisture, proteins, fats, minerals, vitamins and some non-protein nitrogenous compounds. From post-harvest technology point of view also, the biochemical composition of the fish and shell fishes becomes important prerequisite.

5.2 Icing, Handling and Transportation of Fish

The quality of fish or prawn reaching the consumer or the processing factories will greatly depend on how the fish is handled after the catch; how it is preserved and transported before it reaches the user. Fish is highly perishable material and it undergoes bacterial, enzymatic and biochemical decomposition after its death.

As 50-70% of total landing of fish is consumed as fresh, it is absolutely important that efficient and hygienic practices are employed, so as to ensure that the fish reaches the consumer in freshest and safest condition possible.

5.2.1 Icing

As fish become unfit for human consumption in about 8 to 12 hours after they are taken out of water, it is imperative to store them with crushed ice as early as possible after they are caught, in order to retain their freshness for the maximum length of time.

The rate of spoilage mainly depends on temperature condition under which the fish is stored. The fish pass into rigor mortis almost immediately after death and attain a
rigid structure. When once the rigor is resolved the fish become soft and bacterial proliferation starts. Icing has to be done before this stage sets in i.e., when the fish is still stiff.

Methods of icing play a very important role in bringing about cooling. The ice should come in close contact with the fish. The best method of doing this is by putting ice and fish in alternate layers in the container, so that both bottom and top layer of fish are covered by ice. Total height of the fish – ice mixture so stored should not exceed one metre, as otherwise the fish in the lower layers get crushed due to the weight from above. For rapid cooling, ice must be crushed well and layers of fish should be as thin as possible, so that intimate contact between ice and fish is ensured. Theoretically, for bringing down the temperature of 1 kg of fish from 30 to 0ºC about 1/3kg of ice is required. However in practice at least 50% of ice may have to be used for chilling the fish. Generally icing is done at 1:1 ratio and ice is replenished at interval to keep the temperature not rising.

Considering the efficiency of cooling, flake ice is preferred over crushed block ice, as it makes better contact with fish without bruising their bodies by the sharp corners of the broken lumps of the latter. An approximate period of shelf life of marine fish is 8 to 14 days. The shelf life of freshwater fish is generally more than marine fish.
5.2.2 Advantages of ice for cooling fish

1. It is non-toxic and non-injurious and hence can be brought into intimate contact with fish.
2. Cooling is rapid and the coldness is retained in direct contact.
3. When ice melts, the melt water washes away the slime and bacteria from the exterior of fish.
4. Ice has high relative humidity and hence retards desiccation of the fish.
5. It is cheap and efficient.
5.2.3 Problems of leaching in iced fish:

A very important event that takes place in iced fish is the leaching out of the water soluble constituents from the fish muscle, mainly it is soluble protein and free amino acids. The problem in tropical country is more due to high ambient temperature. In case of prawn, leaching losses are minimum when the prawns are stored in round condition, more in headless and most in peeled and deveined and increase with decreasing size of the prawns in all cases.

5.2.4 Preservation by Refrigerated Sea Water (R.S.W.):

In bigger vessels which are at sea for longer periods, preservation of fish by refrigerated sea water is adopted. Sea water contains 3-4% salt hence the freezing point of sea water is around -1.5º C. R.S.W. tank can chill the fish rapidly as the fish comes in contact with the liquid from all sides and heat transfer is accelerated.

The fish remains at temperature of -1º C to 2º C through out. This enhances the shelf life of the fish and is widely used in many advanced countries for preserving various species of fish. In India also some of the trawlers are installed with R.S.W. tanks. The tank contains either clean sea water or water fortified with sodium chloride. Depending upon the concentration of salt, the temperature of brine will vary. The brine is chilled by passing over chilling coils and chilled brine is re-circulated in the tank.

The fish is dumped into the tank. As the density of fish is less than that of brine, the fish will be just floating. R.S.W. preservation has been found quite satisfactory in non fatty fish and bigger size fish and can be stored for longer periods than in ice.

5.2.5 Avoiding or minimizing contamination, spoilage during handling of fish

1. Different days catch should be kept separately.
   Small fish, which tend to spoil more rapidly, must be separated from the larger fish.
2. Fish having soft bellies are to be kept separately.
3. If guts are removed or belly has burst, try to washout the body cavity to remove all traces of guts and also keep the guts away from other fish.
4. Any part of the boat which comes in contact with the fish should be thoroughly washed after each catch or also at the end of the fishing trip.
5. Fishing boat must carry insulated box and sufficient ice during trip.
7. The fish after catch should be washed immediately with sea water to free them of dirt, sand and extraneous matter.
8. The washing of fish to be done in sea water taken from the distant open sea and not from the sea water from near the shore, as it is highly contaminated by faecal organisms and chemical pollutants.
9. Fish should be protected on deck from sun and drying effects of wind and also from engine fumes.
10. It is essential to dispose off any ice contaminated with organisms or rotted fish.
11. Chlorinated water should be used, wherever possible, for every fish washing operations.
12. Removal of heads of shrimps at sea will reduce bacterial load and be more economical for icing and storage.
13. To avoid black spot, shrimp are dipped in 0.25% to 0.3% solution of sodium or potassium meta bisulphite solution for 30 seconds to 2 minutes and the treated shrimp are to be kept in finely crushed ice which control spoilage.
14. In case of big size fish it is preferable to eviscerate, remove gill and intestine which will enhance the keeping quality of the fish.
15. After each fishing trip, boat has to be scrubbed free from slime, dirt, blood or fish fragments with detergent like teepol, soap, washing soda and disinfected with germicide like chlorine, bleach liquor containing 100-200 ppm of available chlorine, after which any excess disinfectant remaining has to be flushed out with fresh potable water.
16. Wooden containers are not advisable for storing the fish either on board or in processing establishments as their surfaces are difficult to be disinfected properly. All containers used to store fish shall be constructed of non-corrodible material. The construction of the container shall be in such a way that it is easy clean and disinfect, that they can be stacked one above the other conveniently without ice melt water falling into the container below:

5.2.6 Transportation of iced fish in insulated vans by road

Presently freshwater fish are being transported from Krishna and West Godavari Districts of Andhra Pradesh to mainly West Bengal and Assam by packing in plastic
crates along with the crushed ice by insulated vans. Nearly 6 - 8 tons of fish is being transported in each van depending on the size of the van under iced condition and the quality of fish will be good even after about 36 to 40 hours of journey by road. Use of insulated vans for transportation of iced prawns and frozen prawns is practiced since long time.

Some times, dry ice (solid carbon dioxide) which has a sublimation temperature of \(-78^\circ\) C is used for cooling prawns in the insulated vans. Due to increase in cost, the use of dry ice has become negligible.
USE OF FISH IN DIFFERENT CONDITIONS

- Freshcuring
- Icing
- Freezing
- Product development (fish, prawns)
- Fish meal feed
- Prawns
- Squids for export

For transport to interior:
- Freezing - drying
- Accelerated fish drying
- Canned products (fish, prawns, very less)

I.Q.F

HANDLING OF PRAWNS - SPECIAL CARE

1. Speed is very important
2. Immediate washing with clean water and removal of heads to process head less (HL) material, meat should not be wasted while separating head and washed thoroughly.
3. Prevention of black spots: Immediate treatment of HL material with 0.25% - 0.3% of sodium (or) potassium Meta bisulphite solution – Dipping for 2 minutes. Packed with crushed ice in cleaned container.
Aquaculture Farms – Cultured Prawns

Fresh prawns after harvest are to be handled by-

1. Immediate keeping in shade with ice.
2. Removal of Heads (HL, washing the juices).
3. Dipping in Meta bisulphite solution for 2 minutes.
4. Packing in crushed ice in clean containers.
5. Quick transport to freezing factories

5.3 Freezing of Fish

It is not possible to keep the fish fresh for prolonged periods, but it is possible to produce a product which closely resembles to fresh fish by using freezing and cold storage. Freezing is a means of arresting either partially or completely the deteriorative actions of micro-organisms and enzymes, by lowering temperature to convert most of the fluid in the product into ice. The water in fish flesh begins to freeze at about –1°C. At –5°C it would appear that all the water is frozen, but, over 20% of the water in fish is still unfrozen. Approximately 10% of the water remains unfrozen even at –30°C.

5.3.1 Freezing rate

There are three stages in freezing fish. During stage I- the temperature of fish falls fairly rapidly to just below 0°C. During stage II – the temperature remains fairly constant at about –1°C and the bulk of the water in the fish freezes. This stage is known as the thermal arrest period. During the stage III- the temperature again drops. To produce a good frozen product, fish should pass through the thermal arrest period as quickly as possible.

Some freezing codes define freezing rate in terms of the thickness of fish frozen in a unit time.

<table>
<thead>
<tr>
<th>Term used</th>
<th>Rate of freezing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow freezing</td>
<td>2 mm / hour</td>
</tr>
<tr>
<td>Quick freezing</td>
<td>5 – 30 mm / hour</td>
</tr>
<tr>
<td>Rapid freezing</td>
<td>50 – 100 mm / hour</td>
</tr>
</tbody>
</table>
5.3.2 Types of freezer

There are three methods of freezing fish viz., a) air blast freezing b) contact or plate freezing and c) immersion or spray freezing. Freezer operating temperatures are given below:

- Batch air blast freezer: -30 to -37°C using cold air
- Continuous air blast freezer: -35 to -40°C using cold air
- Plate or contact freezer: -40°C
- Liquid nitrogen freezer: -196°C using N2 gas at -50 to -190°C
- NaCl brine freezer: -21°C using cold brine

5.3.3 Changes in fish during freezing

Slow freezing produces large ice crystals in the cells of the fish which can be larger than the cells themselves and thus break the cell walls. As the water begin to freeze in the flesh, the concentration of salts and chemicals in the unfrozen water will increase. This high concentration of salt and enzymes can cause accelerated autolysis. On thawing, the water, which was originally bound within the cells, is released as ‘Thaw drip’ and considerable loss of weight can occur. Thus, the structure is never completely restored in thawed fish. Quick freezing produces small crystals which are evenly distributed throughout the tissues resulting in minimum change in the initial properties of fish and allow maximum reversibility of the process.

5.3.4 Frozen Storage

Immediately after freezing the product should be glazed or wrapped. The frozen product should be immediately transferred to cold store.

5.3.5 Glazing

This is the process by which frozen fish are coated with a film of ice by spraying with water or by brushing or dipping in water. Glazing prevents both freezer burn and
oxidation. As long as the water glaze is maintained, loss of water from flesh will not occur during storage.

5.3.6 Storage life

Frozen fish can either be packed in boxes or cardboard cartons or stacked on wooden platform in cold stores. All products entering the store must be at or near the frozen storage temperature. The recommended storage temperature is – 30º C but not above – 20º C. The benefit of freezing at – 40º C will not remain, if the product is stored at higher temperature e.g. – 18º C. The exact shelf life of stored product depends on (a) fish species (b) quality of raw material (c) freezing temperature and time and (d) fluctuation of storage temperature. Very fresh quick frozen cod (non fatty fish) can be stored up to 4 years at – 30º C before it becomes inedible and Herring (fatty fish) upto a year under similar storage conditions.

5.3.7 Changes in fish during frozen storage:

If fish are properly frozen within a few hours of catching, glazed and subsequently stored properly at 30º C bacteria will remain dormant but slow autolytic changes and oxidation still takes place. Proteins are denatured very slowly even at low storage temperature. Water drip occurs after thawing and the flesh becomes spongy. Frozen fish may dry slowly in cold store even in good operating conditions. Dehydration causes undesirable change in fish i.e. oxidation of fat, denaturation of protein, discoulouration of flesh and loss of weight.

5.4 Salt Curing and Drying of Fish

Among the various preservation techniques viz., icing, freezing, canning etc., preservation of fish by the methods of curing is perhaps the oldest technique practiced since long by fishing trade. Simple drying of fish in sun was even practiced during prehistoric times. Preservation by salting is of a later origin and can be related to the period of bronze-age.
In India, the status of fish curing is still more significant. In 1958, about 50% of the total landing was processed by curing alone; by 1965 it came down to 25% and by 1970 onwards it has stabilized itself to around 20%. This decline is not actually due to challenge from other processing techniques which is almost insignificant compared to curing in terms of quantity of fish utilized. The fall in curing is mostly brought about by increase in fresh fish consumption rate. The development of better road communication system in coastal areas and transporting systems are the main reasons for this increased consumption of fresh fish.

5.4.1 Fish Curing and Rural Development

In spite of the sophisticated methods like freezing and canning, fish curing is still playing a very important role in the country in terms of both fishery economics and rural development. Freezing and canning are highly capital intensive, often needing import of costly equipment and machinery from abroad. These methods also need high technical expertise and their production is almost exclusively intended for export market. However the position of fish curing industry is entirely different. It is essentially a labour intensive industry needing very little technical expertise and financial outlay. As it is, fish curing is an extensive small scale industry among the innumerable fishing villages, scattered along the entire coast line of India.

5.4.2 Simple Sun - Drying

Generally, small and thin type of fishes like white baits, silver belly, small sardines and prawn etc., are directly dried in the sun. The idea is that the fish must get adequately dehydrated and dried in the shortest possible time before the tissue starts deteriorating. No salt is used. The fish is just washed and straight away spread out in the open sun, either on mats, hard ground or even on sandy beach. Sometimes the fishes are spread on the sides of the road thus getting exposed to contamination from several microbial organisms, dust and from dogs, and other animals. Sand and dust contamination is more in most of the traditionally dried fishes. Spreading the fish on coir of bamboo-mats, raised cement platforms or raised mat, surfaces etc., for drying
yields a hygienic product. Even though the method is very simple, in actual practice it is not followed.

Depending on the intensity of the sun, the fish is dried for 2-3 days. From the nutritional point of view, sun dried fish is superior and has an advantage in that at no stage nutrients are lost as in salt leaching and other curing methods. However, too much sand is undesirable. If properly dried and stored, the sun-dried product has a shelf-life of about 2-3 months and gives an approximate yield of 25%.

5.4.3 Salting

Sun-drying is not quite suitable for medium and large-size fishes like mackerel, sciaenids, seer, shark, rays, tuna, pomfret etc due to higher thickness of flesh. It takes comparatively longer time to get dried up to below the critical levels of moistures (10 to 15%) by which time the microbes and enzymes play havoc causing considerable spoilage of the muscle. In order to prevent this, the method of salt curing is employed.

5.4.4 Salting or curing methods

5.4.4.1 Dry salting or curing

This is the most widely employed method of curing fish in India and elsewhere and is applied to both medium and large sized fishes. In comparatively smaller sized fishes, the ventral side (both belly side) is split open, gills and intestines are removed and washed clean. Still larger fishes are split dorso-ventrally, gills and intestines are removed, washed, cleaned and spread out at the time of drying. This facilitates both absorption of salt while curing as well as drying after curing. The thick flesh portions are scored with a sharp knife and the number of scores depending upon the thickness and girth of the fish. After this, salt is applied in the ratios 1 : 3 to 1 : 10 (salt to fish) depending upon the size of fish. Weighed quantities of salt are scrubbed on the body/split/scored flesh surfaces and stacked in layers in curing tanks, wooden planks are placed over the fish and some heavy weight are also placed over them to keep down the fish. The salt draws water from the fish muscle and forms, what is called “self
Brine”. Usually sufficient self brine is formed in about 24 hours to immerse the fish in it. Big size salted fish are preferably restocked after 24 hours, so that the fish in top layer gets to the bottom and vice-versa and are allowed to remain for another 24 hours by which time the fish get “struck through” i.e. the flesh and residual fluids get saturated with salt. The fish also shrinks considerably at this stage itself. After this, the salted fish are given a light rinse in fresh potable water to remove the adhering salt crystals, drained well and dried on the mats under the sun for 2 – 3 days. Drying on raised platform will always gives a better hygienic product. Yield of the product by this method is around 48% and its shelf life if properly preserved is about three months. In rainy season, if the drying conditions are not favourable, the fishes may be allowed in the tank till the drying conditions are favourable.

5.4.4.2 Mona curing

It is essentially dry curing in principle and is applied to medium size fishes like mackerel, otoliths, lactarius etc. The main deviation in this case is that the fish are not split open; but the viscera and gills are pulled out through the mouth and cleared. The rest of the procedure is same as in dry salting. The advantage here is that the flesh does not get exposed during salting and drying and hence takes up comparatively less contamination with microbes and external materials. The final product also presents a better appeal and eye-appeal. The yield is about 70% and the shelf-life is approximately 50 days if preserved properly.

5.4.4.3 Wet curing

In this method salting is done as in the above cases, but the fish are allowed to remain under the self brine until they are removed to the market in the wet condition itself. This method is specially suited for fatty fishes like oil sardines, whose fats get easily rancid on drying or exposure to air. The advantage in this case is that as long as the fish are under the self brine atmospheric oxygen is excluded and consequent oxidation of the fats is prevented. When once the salted fish are taken out of the brine, the shelf life is very short, about a week or 10 days and may be prolonged to almost
double this period under optimum conditions, checking fungal and halophilic bacterial
attack and general putrefaction occurring in this interval. Moisture content is of the
order of 50%, salt content about 25% and the yield is approximately 70%.

In some areas of Andhra Pradesh the fishes like ribbon fish, sciaenids are the major
varieties used for curing and drying. After evisceration and washing, fish are stacked in
curing tanks in the brine solutions of about 20 – 25% strength.

After one batch of fish is cured (usually for about 18 hours for medium size fish)
they are drained, rinsed with water and left for drying under the sun. In the same tank,
another batch of freshly cleaned fish is dumped adding some more salt and stirred. In
this way about 4 – 5 batches of fishes are cured in the same tank. In case the brine
solution is not properly salted with additional salt and not hygienically maintained
(which is so in usual practice) maggots may develop in the tank. With the adoption of
better sanitary and hygienic practices and by discarding the brine after 2 or 3 batches
and proper cleaning of tanks, the maggot’s development in the tanks can be avoided.

5.4.4.4 Colombo curing or Malabar curing

This is perhaps the only type of commercial pickling in India carried out mostly in
South Canara and Malabar region. It is almost solely intended for Colombo market and
probably hence the name. Medium size fishes like mackerel, sardines and lactarius are
preserved with this method. The fish cleaned after removal of viscera and gills are salted
as in the case of dry salting. The salted fishes are taken out; pieces of dried pods of
Malabar tamarind (Garcinia qambogea) are placed in the body cavities of the fish and
stacked in wood drums. When the drums are full, they are filled with saturated brine,
closed water tight and exported to Ceylon. In this case also there is no drying at all. But
the fish is in a medium of concentrated brine fortified by a small quantity of tamarind
which gives a particular flavor and added protection. The fish is also out of contact with
air and spoilage and hence the rancidity is also appreciably reduced. Yield is about 75%
and the shelf life is more than six months.
5.4.4.5. Pit curing

This is a crude method of curing, which is slowly getting into obscurity due to poor quality of product turned out.

5.4.5 Insect infestation:

Insect infestation by flies and beetles usually occurs in poorly dried fish products where moisture is more and also in less-salted fish products not properly stored. If optimum moisture and salt contents are maintained and stored properly, the insect infestation can be prevented for a long time. In case of dried fishes, the insect infestation is more in the non salted fishes. During drying of fishes, flies and beetles perch on them, lay their eggs, which hatch out in due course when the dried fish is under storage. Their hatchlings pass through various stages and develop into full fledged insects and start feeding on the dry fish and depositing their excretions etc., on the product. The insect infestation can be controlled effectively by using some harmless natural chemicals / products like neem oil, citronella oil etc.

5.4.6 Artificial driers:

Different types of artificial driers have been experimented and developed in the country as well as in other countries. Mechanical tunnel driers (1.5 ton capacity) have been designed, developed and installed in Kerala by Scientists from C.I.F.T. Lot of experiments have been tried on use of solar tent driers, cabinet driers etc., but could not be successfully put into real commercial production due to several technical and extension problems. Simply by using raised and rack-type platforms for drying fishes and maintaining hygienic conditions in handling and curing, better quality cured and dried products can be prepared.

5.4.7 Basic Precautions to Improve Quality and Shelf Life of Cured Fish Product

1. Select good quality fish.
2. Clean fish in fresh water to avoid sea water spoilage bacteria carried on the skin of fish.
3. Degut the fish completely.
4. Select good quality salt. General tendency is to select salt which is having lot of contaminants besides bacteria. Salting of fish should be in accordance to the weight of fish and use of less or more than required concentration of salt can damage the product.

5. Dry the product completely. Incomplete drying especially when the fish is fat or big one and when the drying of inner parts of fish is improper the spoilage will occur during storage.

6. Promote drying of fish on elevated cemented platform with cleaned surface and such other practices to reduce the spoilage of fish.

7. Raining and drying: The usual practice is not to take the fish in doors to protect from rains. This shall be avoided.

Pack the dried products in good polythene covers and keep away from rats and high humid open places. This will facilitate long storage and enhanced shelf-life.

5.4.8 Improvements in Fish Drying Methods

OLD METHOD ON SAND

NEW METHOD USING DRYING RACKS

1. Wind is weak at ground level

1. Wind is stronger above the ground

2. Air can only pass one side of fish

2. Air can pass over both sides of fish and dry more
3. Fish on the sand attracts dirt, sand, insects and pests.

4. Hot sand it fragile.

5. During rain fish on sand even it covered gets wet from ground water

3. Fish above ground is cleaner and attracts

4. Fish dried on racks will not cook or burn and

5. During rain fish on racks can be covered and

Smoking is one of the traditional methods of processing fish. Smoked fish is a delicacy, ready to eat and as such have a great demand in sophisticated markets in the western countries.
5.5 Smoking of Fish and Prawns

5.5.1 Methods of smoking

**Hot smoking:** The flesh of hot smoked fish is delicious, succulent and tasty but the product has only limited storage life. Hence hot smoked fish products are manufactured at floats in big cities with sufficient demand to facilitate immediate marketing.

**Cold smoking:** Cold smoked fish is more stable and are noted for their pleasant odour.

5.5.2 Smoking process

The fish used for smoking must be of good quality. It can be fresh, chilled or frozen. The sequence of operation is as follows:

Washing -- -Dressing -- Washing --- Salting (brine solution) --- Rinsing (draining)--- Drying Binding ---

-- Cooking - Smoking - Quick cooling - Grading - Packing.

Small sized fish are smoked whole; large fish are grilled, headed and split or cut into fillets. In western countries smoking kilns of different type’s viz. chamber kilns, tunnel kilns are in use. The ‘Tory kiln’ developed by Tory Research Station, Aberdeen is widely used in the U.K. for the preparation of smoked fish.

5.5.3 Normal schedule of operation in kilns is as follows:

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Drying</th>
<th>Cooking</th>
<th>Smoking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>85 – 95</td>
<td>140 – 150</td>
<td>95 – 100</td>
</tr>
<tr>
<td>Time (minutes)</td>
<td>20</td>
<td>25</td>
<td>20</td>
</tr>
</tbody>
</table>
In cold smoking, the temperature usually employed is around 40°C and duration of smoking extends to several hours (36 – 72 hours).

**5.5.4 Preparation of smoked tuna fish product – Masmin:**

Masmin is a specially cooked, cured and smoked product prepared out of tuna fish. The method is widely employed in the Minicoy Island of Lakshadweep group. A similar product called Katsuobushi is produced in large quantities in Japan. The masmin produced in Lakshadweep is exported through the main land into Srilanka, Malaysia, Hong Kong etc. where it is a priced delicacy. The method of preparation is simple.

The fresh fish is beheaded, tails and fins removed, ventral wall split and viscera removed completely. The dressed fish are cleaned and the flesh removed in two pieces from both sides of the backbone. The fillets thus obtained are split longitudinally and pieces of 12 to 17 cm. in length and 4.5 cm thick are prepared. Each piece is then wrapped in green coconut leaves freed from splinters. This is meant to prevent any possible disintegration during subsequent cooking. The pieces wrapped in coconut leaves are cooked in 3 % brine or sea water for one hour and left over night for cooling. They are then spread out on frames and exposed to smoke generated by smoldering coconut husk and saw dust for three to four hours. The coconut leaves are then removed and the meat is dried in sun for one day. Alternate smoking and drying are repeated 3 to 4 times till a dark brown hard product is obtained. Since the moisture content of the product is around 10% it keeps well for more than a year. Sometimes a sort of fungus is also allowed to grow on the product. The fungus growth imparts to the product an ashy appearance and longer shelf life. With sufficient care in packing and storing, the product remains in sound edible condition for three to four years. Thin shavings or scaling are made from the product by a sharp knife, which are soaked in water and prepared as chutney or added to other culinary preparations.

**5.6 Fish Canning**

Canning technology is thermal (heat) processing using different machinery. Canning involves hermetically sealing the food in a container, sterilizing the sealed unit
by heating and then cooling the unit to ambient temperature prior to storage. Sterilizing is the basic method of preserving canned products. The hermetically sealed cans are heated in order to inactivate tissue enzymes, kill micro organisms and transform the raw fish or intermediate product into edible form. Sterilizing conditions (temperature and process time) are not only aimed to prolong shelf life but also to preserve the organoleptic and nutritive qualities of the product.

5.6.1 Types of canned fishery products

Cans made of tin plate or aluminum are popular for packing fish for many years. All canned fishery products are divided into the following groups

5.6.2 Natural products: Fish, crabs, shrimps etc., are individually packed into cans with only addition of a little salt.

5.6.3 Fish in oil: Fried or smoked or hot air dried fish in vegetable oil.

5.6.4 Fish in tomato sauce: Fried or hot air dried fish in tomato sauce.

5.6.5 Fish in brine: Cooked / blanched fish in brine.

5.6.6 Dietetic products: These products are prepared for patients requiring a strict diet. Apart from fish, other ingredients are vegetables, butter, vitamins etc.

5.6.7 Retortable pouch processing: A retortable pouch is a flexible laminated pack with sufficient strength and heat resistance to allow it to be used in place of a can for the heat processing and storage of food products.

5.6.7.1 Composition: The pouch has polyester film on the outside face, a core of aluminum foil and an inner layer of a polypropylene copolymer. The core of aluminum foil (12 micron) is used to give the laminate the necessary water, gas, odour and other barrier properties. The outer polyester film (normally 12 micron thick) protects the foil and provides the laminate with strength and abrasion resistance. The polypropylene inner ply (50 – 70 micron) is to give good heat seals and product resistance.
5.6.7.2 Advantages: Advantages of retortable pouch compared to metal cans are given below:

1. The retort pouches can be produced indigenously in any shape and size.
2. It has a high surface to volume ratio and a thin cross section.
3. Rapid heat penetration reduces 30 – 40% in processing time.
4. Retort pouches can be easily reheated (if necessary) and opened by consumers.

5.7 Value Addition in Fisheries

5.7.1 Objectives

After studying this unit, you should be in a position

- To learn and understand about value addition, adding value to fish and fish products
- How to prepare different value added products both for domestic and export markets

5.7.2 Introduction

The flesh from species which are unmarketable either whole or in conventional fish products can be used to make minces. Many of the underutilized species are not used because of consumer unfamiliarity; boniness; bad names and unpleasing looks as whole fish. As the process disguises the original nature of fish; the consumer may accept products made from mince even though the original fish would have been unacceptable whole. In the utilization of low-values fish considerable progress has been made through the development of minced meat technology. It is also important to transform the available fish catches into stable, acceptable products and to distribute them to people who need at a price they can afford. It has been observed the by-catch in shrimp trawl can be as high as 80% under normal operation. This by catch is often being discarded in sea. So world fish consumption can be substantially improved by proper
utilization of low priced fish as well as shrimp by catch by utilizing as minced fish products, thus adding value to the fish.

5.7.3 Minced Fish Products

The flesh of fishes which are unmarketable either whole or in conventional fish products can be used to make minces. Many of the underutilized species are not used because of consumer unfamiliarity, boniness, bad names and unpleasing looks as whole fish. As the process disguises the original nature of fish, the consumer may accept products made from mince. In the utilization of low-value fish, considerable progress has been made through the development of minced meat technology. It is also important to transform the available fish catches into stable, acceptable products and to distribute them to people who need at a price they can afford. It has been observed that the by-catch in shrimp trawl can be as high as 80% under normal operation and often being discarded in sea. Proper utilization of low priced fish as well as shrimp by catch as minced fish products has hence immense scope and opportunity.

5.7.4 Minced meat technology

Fish meat in comminuted form separated from skin and bones using mechanical meat-bone separator is known as minced fish. The flesh can be removed from the fish using filleting knives; it can then be passed through a conventional meat mincer (either hand operated or powered). On a small scale and if relatively large fish are used, this may be the most economical way of producing the mince. However, many of the fish used for mince are small and available in large quantities (e.g. shrimp by catch) in which case a mechanical device for removing the flesh from the fish is advisable. There are several machines generally known as meat/bone separators which can be used for this. These separate the soft parts of the fish from the harder parts (bones, skin, scales etc.). The minced fish preparation is based on physical squeezing out the flesh from bones, skin and scales through a perforated filter. A belt and a perforated drum system are generally used. The minced fish is unstable and gets contaminated during production if handling practices are not sound. Yield of minced fish varies from 40-50%.
5.7.5 Mince Yield of some commercially important fishes.

Fish

↓

Beheaded and gutted

↓

Washing

↓

Deboning and deskinning

↓

Fish mince

(Yield 40 – 50%)

5.7.6 Quality and shelf life

Freshness of raw material profoundly influences the quality of mince. The mince is highly susceptible to microbial, enzymatic and oxidative reaction. The intimate mixing with many organs and intestine (in case of small fish) can cause the release of many proteolytic enzymes. The mince also is an excellent substrate for these enzymes. Consequently minced fish is susceptible to rapid enzymatic spoilage. The lipid levels in the fish mince should be kept to minimum otherwise minced fish are susceptible to lipid oxidation causing rancidity. Mince can be packed in polythene bags and kept in ice for short term storage. Mince can be gently pressed and put in cartons and frozen at – 40° C in plate freezer. The frozen mince blocks can be stored at – 20° C or below. The frozen minced fish has a good shelf life up to one year at – 30° C.

5.7.7 Fish wafers

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Quantity required</th>
<th>Composition of Products (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish mince</td>
<td>2 kg.</td>
<td>Protein – 13.23</td>
</tr>
<tr>
<td>Tapioca starch</td>
<td>2 kg.</td>
<td>Moisture – 4.0</td>
</tr>
<tr>
<td>Corn starch</td>
<td>1 kg.</td>
<td>Minerals – 1.6</td>
</tr>
<tr>
<td>Refined common salt</td>
<td>50 gm.</td>
<td>Carbohydrates – 78.86</td>
</tr>
<tr>
<td>Water</td>
<td>3.5 Litre</td>
<td>Fat – 1.3</td>
</tr>
</tbody>
</table>
Fish mince, starch, salt and water are mixed in grinder to make smooth slurry. Slurry is spread on aluminum trays to a thickness of 3 – 4 mm and cooked in steam for 10 – 15 minutes. The gelatinized layer is cut into desired shape and dried in sun or in drier (at 45 to 50° C) to moisture content less than 6%.

### 5.7.7.1 Fish cutlets

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Quantity</th>
<th>Composition of Products (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooked fish mince</td>
<td>1000 gm.</td>
<td>Moisture – 61 – 63</td>
</tr>
<tr>
<td>Cooked potato</td>
<td>500 gm.</td>
<td>Fat 6 - 7.5</td>
</tr>
<tr>
<td>Peeled and chopped onion</td>
<td>250 gm.</td>
<td></td>
</tr>
<tr>
<td>Ginger (small pieces)</td>
<td>30 gm.</td>
<td></td>
</tr>
<tr>
<td>Green chilly</td>
<td>20 gm.</td>
<td></td>
</tr>
<tr>
<td>Pepper powder</td>
<td>3 gm.</td>
<td></td>
</tr>
<tr>
<td>Clove powder</td>
<td>3 gm.</td>
<td></td>
</tr>
<tr>
<td>Cinnamon powder</td>
<td>3 gm.</td>
<td></td>
</tr>
<tr>
<td>Turmeric powder</td>
<td>2 gm.</td>
<td></td>
</tr>
<tr>
<td>Salt</td>
<td>30 gm.</td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>125 ml.</td>
<td></td>
</tr>
</tbody>
</table>

**Cooking of minced fish meat**

1. Mixing with smashed boiled potato, salt and turmeric powder
2. Mixing with fried Onion, ginger and chilly etc.
3. The whole mass is cooked for 3 minutes while mixing continued
4. Powder spices are added and mixed thoroughly
5. Moulded in suitable shape
6. Dip in batter like egg white and roll in bread powder
7. Deep frying in oil
5.7.8 Fish Finger

Raw fish mince mixed with 0.1 - 0.3% Sodium tripolyphosphate

Frozen blocks are cut into small pieces 6 x 1.5cm, packed in polythene paper individually frozen and stored at – 20° C.

Frozen finger are battered, breaded and fried before use.

Frozen blocks are cut into small pieces, battered, breaded, frozen individually and packed in carton before storing at – 20° C.

Deep frying before use.

The composition of batters and bread mix can be formulated depending upon the taste of the consumer. The composition of a typical batter and bread mix used for preparation of fish finger is given below:
### Batter

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat flour</td>
<td>73%</td>
</tr>
<tr>
<td>Salt</td>
<td>1%</td>
</tr>
<tr>
<td>Dehydrated whole eggs</td>
<td>8%</td>
</tr>
<tr>
<td>Milk powder</td>
<td>6%</td>
</tr>
<tr>
<td>Hydrogenated vegetable fat</td>
<td>9%</td>
</tr>
<tr>
<td>Monosodium glutamate</td>
<td>1.5%</td>
</tr>
<tr>
<td>Baking powder</td>
<td>1.5%</td>
</tr>
</tbody>
</table>

All the solids are mixed to get a fine powder.

Mix all the ingredients in a blender, hydrogenated vegetable fat is added after melting. Prepare the batter by mixing the ingredients with 1 & ½ times its weight of water.

### Breading Mix

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat flour</td>
<td>40%</td>
</tr>
<tr>
<td>Dehydrated whole eggs</td>
<td>10%</td>
</tr>
<tr>
<td>Milk powder</td>
<td>3%</td>
</tr>
<tr>
<td>Salt</td>
<td>1%</td>
</tr>
<tr>
<td>Monosodium glutamate</td>
<td>1%</td>
</tr>
<tr>
<td>Fine bread crumbs</td>
<td>45%</td>
</tr>
</tbody>
</table>

5.7.9 Fish Sausage

Fish sausage is another product which can be prepared from minced fish. Most recipes are based on those used for meat sausages except replacing the meat component with fish. Fish sausage is very popular in Japan. The technology of sausage making is now known to India but is not yet commercialized.

Fish sausage is prepared by mixing minced fish with oil, seasoning materials (sugar, salt, and sodium glutamate), coloring material, preservatives and condiments and blended in silent cutter. The paste is then packed in a casing, sealed and steamed or boiled. Contents may be smoked before packing in casings.
5.7.10  Surimi and Surimi Based Products

WHAT IS SURIMI?

Surimi is a Japanese term for mechanically deboned fish flesh that has been washed with cold water and mixed with cryoprotectants for a good frozen shelf life. Washing not only removes fat and undesirable matters such as blood, pigments and odorous substance but also increases the concentration of myofibrillar protein, thereby improving gel strength and elasticity. Because of this unique property, surimi is extensively used in Japan since many centuries to develop a variety of fabricated products. The under utilized fish species will ensure a sufficient production of surimi at reasonable cost.

5.7.11 Types of Surimi

Two types of frozen surimi viz., salt free (muen surimi) and salted (Ka-en surimi) are being made. Beside frozen surimi, raw surimi (nama surimi) is produced in limited scale for local factories to make final products on the same day. Raw surimi has the advantage of high water holding capacity which enhances the yield compared to frozen surimi.

5.7.12 Preparation of Surimi

The prime requirement for making surimi is that the minced fish meat must be elastic. Croakers, lizard fish etc., have the desired elasticity. The steps for preparation of surimi are given below:

1. The head, scales and viscera are removed.
2. The flesh is cut into single fillets.
3. Washed dressed fish or fillet is fed to the meat separator. The bones and skin are removed. Care must be taken not to have dark meat mix with white meat.
4. The meat is mixed well with cold soft water 7 – 8 times of the volume of meat and is left to settle. The supernatant is removed. Washing machine with screen drum is also used to remove water. Washing of meat is repeated for 2 – 3 times.
5. Excess water is removed either in a basket centrifuge or by squeezing through a cloth.

6. Additives such as 4 – 5% sugar, up to 0.3% polyphosphate, 4 – 5% sorbitol and 2.5% salt (for ka-en surimi) are mixed with the washed meat/surimi using cooling type mixer or silent cutter. The amount of additives in surimi varies with manufacturers. The additives are blended with meat for 15 minutes at temperature below 13° C.

7. The prepared surimi is filled into polyethylene bags and packed in trays for freezing in plate freezer.

8. Freezing is done rapidly at – 40° C. The frozen bags/blocks are packed in carton boxes and stored in frozen storage at below – 20° C. The additives in surimi help to retain the quality during freezing and frozen storage, but loss of quality is reported on long storage.

The yield is around 40% of the whole fish.

5.7.13 Surimi based products

The surimi based Kamaboko is prepared by adding salt, potato, monosodium glutamate and sugar (if necessary) one by one to the surimi and kneaded for 15 minutes after each addition. The dough is moulded into half cylinders on wooden blocks, steamed for 80 – 90 minutes, cooled in air and then packed in cellophane. The product can be kept for a week in summer. Many allied products with different shapes eg. tubes, noodles etc., are prepared in similar way using extrusion/shaping machines.

5.7.14 Fish and Shell Fish Pickles

Pickles are prepared out of different fish and shell fish. Traditionally, vegetable pickles are used in India as a ready to serve item with Indian dishes. Fish and shell fish pickles are non-traditional items of preparation and are becoming popular. Pickle is a high acid food (pH 4 – 5). Salt and acetic acid are the main ingredients used in the pickle preparation as preservatives. Yeast and mould can easily survive in acid medium of pickle and hence preservatives are used in pickle for safe storage. In pickle the bacterial
Spoilage is not a serious problem, where as proteolytic enzymes in fish will still remain active. So fish is well cooked to take care of the enzymatic action of fish. As the pickle contain higher concentration of acid, disintegration of meat may take place due to acid hydrolysis. So salt is used in sufficient quantities in pickle to take care of the problem of hydrolysis of meat. In acid and salt solution the fish flesh becomes firm.

Pickle is a ready to eat product with long storage life at room temperature. Thus it should be prepared hygienically and stored carefully to avoid contamination. Pickle can be prepared with wide range of recipe to suit consumer’s choice.

### 5.7.14.1 General Composition of Pickle

| 1.     | Meat (dressed and cut into small pieces) | - | 1 Kg. |
| 2.     | Mustard seed                            | - | 10 gm |
| 3.     | Green chilly (cut into pieces)          | - | 50 gm |
| 4.     | Garlic (peeled)                         | - | 80 gm |
| 5.     | Ginger (peeled and chopped)             | - | 80 gm |
| 6.     | Chilly powder                           | - | 40 gm |
| 7.     | Turmeric powder                         | - | 2 gm  |
| 8.     | Oil                                     | - | 300 ml|
| 9.     | Vinegar                                 | - | 400 ml|
| 10.    | Salt                                    | - | 100 gm|
| 11.    | Sugar                                   | - | 10 gm |
| 12.    | Sodium Benzoate (as preservative)       | - | 0.025%|

### 5.7.15 Preparation

#### 5.7.15.1 Fish Pickle

Mix the fish thoroughly with salt (5% of fish weight) and keep for 2 hours. Light salted and partially dried fish also may be used. Fry the fish in minimum quantity of oil and set apart the fried fish. Fry the ingredients 2 - 5 in the remaining quantity of oil for 2 to 3 minutes and adding chilly powder and turmeric powder in low flame.

All the powdered spices are to be made into a thick paste by adding water and stored for 15 minutes before use. The required amount of salt is added and the mixture boiled. The fried meat is then added to this and stirred for some time. The pan is
removed from the flame and the ingredients are mixed thoroughly for 2 to 3 minutes and cooled. When sufficiently cooled, vinegar is added. Sodium benzoate is added and mixed thoroughly before packing into pasteurized glass screw-cap bottle and stored at room temperature.

5.7.15.2 Prawn Pickle

Procedure will be same as the preparation of fish pickle.

5.7.15.3 Clam Pickle

Live clams after collecting from landing centre are stored in clean sea water for 16 - 24 hours and allowed to depurate. The clam is later thoroughly washed with 10 ppm. available chlorine and shucked. The meat is thoroughly washed with potable water and then blanched in 6% boiling brine for 5 minutes. The blanched meat is drained well on perforated vessel and then fried in oil until brown in colour. The fried meats are kept apart and proceed as in other cases.

The following points are to be kept in mind for preparation of pickle

1. There should be a layer of oil over product; this will effectively prevent the contents from contact with air as seal against bacteria from external sources.
2. Use fresh raw material for pickles.
3. Powdered salt with low calcium content should be used in pickle. Otherwise higher calcium content will toughen the texture besides affecting flavour.
4. Powdered spices to be used to improve the flavour.
5. Sodium Benzoate to be used to check the growth of mould.

5.7.15.4 Machinery and utensils used for small scale production

1. Fish dressing table
2. Purification tank for clam, cockle, mussel
3. Weighing machine
4. Heating vessels
5. Heating source
6. Frying pan
7. Dry grinder
8. Table for cooling
   Bottle sealer
5.7.16 FLOW SHEET OF PICKLE PREPARATION

Clam/Mussel → Salt and Vinegar → Turmeric powder and Chilly powder mustard → Ginger, garlic Fresh fish → Green chilly & mustard

Depuration (Self cleaning in good water) → Steaming of dressed fish

Suckling of meat → Heat in low flame

Filing in oil → Filleting cutting pieces and into small

Blanching → Frying in oil

Mixing → Cooling

Add preservative → Bottling

Store at room temperature
5.7.17 Recent Trends in Diversification and Value Addition

There is a great demand for seafood and seafood based products in ready-to-eat convenience form. A number of such diverse products have already entered the western markets. The factors responsible for the popularity of value added products are, increasing trend in the employment of women in the context of shift towards small family norm, increased income and purchasing power, education, awareness and consciousness towards hygiene and health, and increased emphasis on leisure pursuits etc.

Marketing of value added products is completely different from the traditional seafood trade. It is dynamic, sensitive, complex and very expensive. Market surveys, packaging and advertising, along with other factors determine the consumer acceptance and successful movement of a new product. Most of the market channels currently used is not suitable to trade value added products. An emerging appropriate channel would be the super market chains which want to procure directly from the source of supply. Appearance, packaging and display are important factors leading to successful marketing of any new value added product. The retail pack must be clean, crisp and clear, and make the contents appear attractive to the consumer. The consumer must be given confidence to experiment with new products launched in the market. Packaging requirements change with product form, target group, market area, species used and so on. The packaging must also keep abreast with the latest technology developments.

A large number of value added and diversified marine products both for export and internal market based on shrimp, lobster, squid, cuttlefish, bivalves, certain species of fish and minced meat from low priced fish could be produced.

5.8 By-Products

5.8.1 Objectives

After studying this unit, you should be in a position
To completely utilize different waste parts from fish into economically useful products.

To know different by products from fish and shell fish.

5.8.2 Introduction

For any industry to establish on economically sound position, complete and profitable utilization of all the available by products is highly essential. Not only, should that, a complete package of technology of any product developed especially in food sector, involve maximum utilization of the waste substances that come out of the process. In the fish processing industry, a very important by product is the offal, which consists essentially of all the waste parts like heads, intestines, liver, tails, fins, scales, skin etc. Head and shell waste from prawns, crabs squilla and crustaceans also find good use in preparation of different by-products. Very small fishes caught as by catch from shrimp trawlers, which landed not only in fresh condition but are difficult to handle for processing can be used for production of fish meal which is an important nutritious supplement in cattle, pigs and poultry feeds. Now, growth of aquaculture in our country also has found use of these protein wastes in supplementing the fish and prawn feeds.

The major potential industrial by-products such as fish meal, shark liver oil, dried shark-fins, fish air bladders (maws) and isinglass, chitin and chitosan from prawn, squilla shell waste, surgical sutures from fish guts are described here with brief mention of other by-products viz., fish ensilage, fish oils fish skin-leather, pearl essence from fish scales, cuttlefish bones, shell of clams and mussels, ambergris (sperm-whales secretion) etc.

The by-products from fish and their multi-disciplinary uses are very interesting and those who have money and entrepreneurship can think of starting these industries.
5.8.3 Important Fishery by-Products

5.8.3.1 Fish meal

Fish meal is a highly concentrated nutritious feed supplement containing protein, minerals, vitamins and some unknown growth factors. Fish meal has been considered as an important product both for internal use and export. In India, commercial fish meal plants are mostly established on west-coast only. The production involves mainly cooking the waste / fish mass, pressing and separation of oil, drying the pressed cooked mass and pulverizing the dried substance.

5.8.3.1 Fish oils

Fish oils are mainly of two type’s viz., body oils and liver oils. The former is used as industrial oil, while the latter finds application in pharmaceutical preparations. In India, the main source of fish-body oil is the oil sardine. As there is good demand for fresh oil sardine for direct human consumption and for export, the production and export of fish oil had decreased considerably. Crude oils are used in painting of wooden country boats in India. Factice, an artificial rubber filling compound from sardine oil, paint base and printing ink materials can also be prepared from industrial fish oils. It is found that sardine oil has profound hypo-cholesterolemic effect.

5.8.4 By Products from shark fish

5.8.4.1 Shark liver oil

Shark liver oil is valued for its vitamins A and D contents. Indian shark liver oil contained 10,000 to two lakhs 1U/gm of vitamin A. Indian sharks contain 2 - 180 kg. of liver depending upon size, season etc. Many state fisheries departments had manufacturing units for the production of medicated shark liver oil and vitamin A and D concentrates. The fresh livers are chopped into small pieces, treated with 1.2% sodium hydroxide and digested in steel vessels by steaming. The oil is then easily separated from the aqueous layer by centrifugation, washed free of alkali, dried and
vitamin potencies are determined. It is then blended with refined vegetable oil to yield required vitamin level and marketed in bottles or in the form of capsules.

5.8.4.2 Squalene from shark liver oil

Squalene is a hydrocarbon extracted from the liver oil of shark by fractional distillation under vacuum. An improved method has been developed in C.I.F.T. to extract squalene from shark liver oil. Squalene is used in the preparation of steroid hormones, treatment of wounds and liver diseases and as anticancer agent and bactericide. Hydrogenated Squalene (Squalane) is used in the preparation of cosmetics, perfumes and aromatics and as anti-aging agent and lubricant in finishing silk and wool.

5.8.4.3 Dried shark – fins rays

Dried shark fin is one of the major by-products earning considerable foreign exchange for the country. The commercial value of the fins depends on their colour, size, variety and quality. Depending on the quality and quantity of rays present in the fins, they are broadly classified into two varieties, generally known as black and white. Also dorsal and pectoral fins, especially the former contain good quantity of rays than the caudal fins.

The preparation of shark fins does not require any elaborate treatment, but care is needed in cutting, trimming and drying operations.

5.8.4.5 Shark teeth

Shark teeth are used for making fancy ornaments and are imported by USA, UK, Canada and Australia. The price of teeth varies considerably depending on size and shape. The method of extracting teeth is simple.

5.8.4.6 Shark skin leather

Shark has thick skin and can be processed into leather just like from other animal hides, and the principal constituent of the skin is collagen. The shark skin has calcareous
coating known as ‘shagreen’ and is removed after peeling the skin, preserved in salt before taken for tanning, vegetables tannages are generally used on shark and other fish skins. It has been found suitable for the manufacture of suit cases, shoes, belts, variety bags etc. A good market has to be established.

5.8.5 Fish maws and Isinglass

Swim bladders in fish are also known as air bladders, sounds and fish maws. Like shark fins, dried fish maws also are one of the major by-products for export from India to many South Eastern countries. In 2005, the export figure is 420.3 tones worth of Rs.49.61 crore. Fish maws contain purest form of collagen, and is named as isinglass, which is used in confectionery products and food products (forming as gelatin) and used mainly as a clarification agent in beverage industry for clarifying wine, beers etc. In India, these bladders are collected from eel, cat fish, carps, thread fins and Jew fish. Isinglass from eel fish maws gives food quality “finings” with better clarifying capacity. The preparation of isinglass is very simple. Swim bladders are removed from the fish, washed to remove blood and pieces of flesh and the cleaned air bladders are dried by hanging in moderate sun. The dried bladders are soaked in water for several hours until they become soft and pliable. They are then cut into small pieces, rolled or compressed between cold steel rollers to form thin sheets or strips. These are dried in warm rooms, and the ribbon or leaf form isinglass is packed in polythene bags.

5.8.6 By products from prawn shell waste

Prawn shell waste is abundantly available in the country. The prawn head and shell waste comprises about 55 – 60% of weight of whole prawn depending upon size and species. However, the waste contains significant amounts of protein, chitin, calcium carbonate and minerals. The protein can be extracted from fresh prawn waste along with the flavouring compounds and converted into shrimp extract having potential use as a natural flavouring material.
5.8.6.1 Chitin

Chitin can be extracted from this waste. Chitin is a polysaccharide polymer of N-acetyl glucosamine. Chitin extraction involves crushing and washing the shells to remove the adhering meat. The material is then de-mineralized with diluted hydrochloric acid and hydrolyzed with diluted sodium hydroxide to yield chitin. Chitin as such can be used for supplementing poultry feeds at 0.5% level to yield more growth and meat in broilers. Chitin is converted into chitosan by treatment with concentrated caustic soda (40 – 50%) at high temperature. Chitosan, the de-acetylated chitin, has many potential uses in food, medical, pharmaceutical, cosmetic and personal care, agriculture, biotechnology and Paper, films and textile industries.

5.8.7 Collagen chitin film

The film is prepared from collagen and chitosan obtained from fishery wastes and can be used as artificial skin. It is used for covering wounds / burns to prevent moisture loss and microbial contaminations. Purified air bladder is partially solubulised in hydrophilic solvent, viscous suspension obtained is spread on clean glass surface and evaporated to give thin film of collagen. Reformed chitin matrix is deposited on this exposed surface to give strengthened collagen film.

5.8.8 Cuttlefish bones

Cuttlefish bones removed from the dorsal side during processing are soft bones which find use in polishing of glass etc. The item finds a good export market. About 296 tones were exported in 2005. It consists of essentially calcareous matter and is being collected from open beaches. A regular freezing industry is established based on cuttlefish, the collection of bones / pens has become easier.

5.8.9 Pearl essence

A lustrous substance ‘guanine’, is present in the epidermal layer and on the scales of most pelagic fishes, crystalline guanine can be extracted from the fish scales. The suspension of guanine crystals in suitable solvent is called ‘Pearl essence’. When the
particles are deposited on the inside of hollow beads or outside of solid ones, they produce an optical effect very similar to pearls. The principal source of pearl essence in the country appears to be ribbon fish. There is good demand for the product in countries like Japan.

5.8.10 Surgical sutures from fish guts

Fine surgical sutures could be prepared from the fresh guts of tuna and carp fishes. They have sufficiently long collagen filaments. The use of a collagen thread as surgical suture depends on its tenacity, durability, pliability, absorbability and certain chemical properties. These properties of fish gut collagen make them suitable for preparing extra fine absorbable surgical sutures. Technology of producing sutures has been worked out at CIFT, Cochin.

5.8.11 Ambergris

Ambergris is a metabolic product i.e. a product of the chemical routine of the living body of sperm whales. It is a secretion formed in the intestines of these animals. When once the substance is secreted by the animal, it acquires a grayish transparent color in contact with sea water and air. Its color is generally dirty white to blackish brown. The best quality of ambergris is called ‘grey amber’. It is highly soluble in rectified spirit. It is rare ingredient of perfumes, in some regions it is used in jewelry. One firm has also investigated that the ambergris has aphrodisiac property. Pure ambergris is highly expensive.

5.8.12 Other by-products

Fish hydrolysate and bacteriological peptone could be prepared from fish and prawn shell wastes. Insulin and bile salts extraction from pancreas and galls of fish and frog is also possible for commercial exploitation. Development of series of industries on the lines of above by products will surely boost our economy and provide lot of accessory employment potential.
Strategies for Development of Fisheries Sector

Structure

6.0 Objectives

6.1 Programmes and strategies:

6.2 Development of inland fisheries and aquaculture

6.3 National scheme for welfare of fishermen and fisherwomen

6.4 Central Sector Scheme on strengthening of database and Geographical Information System for fisheries sector

6.5 Institutional strengthening including capacity building, policy and legislative support

6.1 Objectives

It is now widely acknowledged that fisheries have a major role in supply of nutritious protein for the growing population and in accelerating the overall economy of the country. To achieve this, it is essential that both increase in production and resource sustainability would go hand-in-hand. In this regard, the following objectives are proposed for development and management of fisheries and aquaculture.

- Enhancing production of fish on an environmentally sustainable and socially equitable basis;

- Ensuring optimum exploitation of fisheries resources in the Indian Exclusive Economic Zone in a manner consistent with the principles of ecologically sustainable development;

- Conserving aquatic resources and genetic diversity and preservation of health of ecosystems while ensuring bio-security;
Maximizing net economic returns to the fishers and fish farmers through technological support and implementing efficient and cost-effective aquaculture and fisheries management practices;

- Strengthening infrastructure in harvest, post-harvest, value-addition and marketing;
- Increasing the per capita availability and consumption of fish to about 11 kg/capita/annum;
- Augmenting export of fish and fish products;
- Securing and increasing employment opportunities in the sector;
- Improving safety and labour conditions in fisheries and aquaculture;
- Uplifting the social and economic conditions of fishers and fish farmers and ensuring their welfare; and Improving overall governance and management of fisheries sector in the country through institutional strengthening and human resource development.

6.2 Programmes and strategies:

Development of marine fisheries, infrastructure and post-harvest operations

Development of marine fisheries, infrastructure and post-harvest operations would be taken up during the 12th Plan through a set of programmes aimed at both increasing production and optimum utilization of the resources. While most of the activities are carried forward from the 11th Plan with some changes in the unit cost and subsidy components, some new components/programmes have also been added to meet the growing requirements of the sector and removing institutional weaknesses.

Components under Development of Marine fisheries, Infrastructure and Domestic fish marketing:
<table>
<thead>
<tr>
<th>Development of marine fisheries</th>
<th>Development of infrastructure</th>
<th>Development of domestic fish marketing</th>
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</thead>
<tbody>
<tr>
<td>Motorization of traditional craft</td>
<td>Construction and expansion of Minor Fishing Harbours (FHs) and Fish Landing Centres (FLCs)</td>
<td>Modernization of wholesale fish markets</td>
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<tr>
<td>Fishermen development rebate on HSD oil</td>
<td>Modernization of FHs and FLCs</td>
<td>Modernization of retail markets</td>
</tr>
<tr>
<td>Use of sail in motorized boats</td>
<td>Strengthening of post-harvest infrastructure</td>
<td>Construction of new retail market with 10-20 stall capacity</td>
</tr>
<tr>
<td>Conversion of trawlers to resource specific fishing vessels</td>
<td>Developing fish preservation and storage infrastructure</td>
<td>Setting up of retail fish outlets /kiosks</td>
</tr>
<tr>
<td>Safety of fishermen at sea</td>
<td>Assistance for maintenance dredging of FHs and FLCs.</td>
<td>Cold chain development and preparation of value added products. Establishment of ice plant.</td>
</tr>
<tr>
<td>Development of Monitoring Control and Surveillance system for marine fisheries</td>
<td>--</td>
<td>Campaign for promotion of fish products and increased consumption of fish and fish products</td>
</tr>
<tr>
<td>Management of marine fisheries</td>
<td>--</td>
<td>Organization of fish festival/fish mela</td>
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<tr>
<td>Production enhancement through mariculture</td>
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<td>Setting up of model fish dressing units</td>
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<td>--</td>
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<td>Hygienic drying of fish</td>
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<td>--</td>
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<td>Fish transportation from FH/FLC to markets by women SHGs</td>
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</tbody>
</table>
6.3 Development of inland fisheries and aquaculture

Developmental programmes and strategies for inland fisheries and aquaculture during the 12th Plan aim at inclusion of all available resources for augmentation of fish production. The schemes include a judicious mix of production enhancement and resource conservation programmes for ensuring sustainability. In inland capture fisheries, the rivers and their tributaries, the floodplain wetlands, and the estuarine resources have been overlooked in the past Plans leading to resource deterioration and fall in production and productivity.

The reservoirs, with their large water-spread area and the fact that most of them are located in tropical to sub-tropical climate zones, are likely to be main fish production centers in the years to come. The input-output ratio in reservoir fisheries vis-a-vis other production sectors such as marine fisheries or aquaculture is the best. In reservoirs, with minimum capital inputs and with appropriate management norms, production levels can be highly remunerative. The proposed interventions for the reservoirs during the ensuing Plan period are aimed at supplementary stocking with quality seed of Indian Major Carps; creation of adequate rearing space for ex-situ/in-situ seed production; efficient fish harvesting gear and craft; support for creation of improved fish marketing paraphernalia; bringing more and more reservoirs under scientific fisheries management practices; ownership and leasing of reservoirs on long-term; and continuous programmes for HRD of reservoir fisheries managers and fishers.

Aquaculture, both in fresh and brackish waters would be another important area of increasing fish production during the 12th Plan. The schemes proposed for aquaculture aim at horizontal and vertical expansion of the farming area; optimizing productivity of existing waters including cold waters, water logged, saline and waste waters; canals; diversification of species and intensification of culture practices including integration of aquaculture with agriculture/livestock; fish health management and disease diagnostics and strengthening of field-level extension machinery.
Fish production and productivity from aquaculture would largely depend on availability of quality seed in sufficient quantities. Therefore, aquaculture programmes will also focus on achieving local-level fish seed self-sufficiency to cater to the needs of the sector in different parts of the country. Presently, seed production in the country is West Bengal-centric and seed supplies are made to many parts of the country. This results in considerable mortality of seed on account of long-distance transportation. Popularization of seed production in other States with potential for aquaculture will ease the situation, both in terms of quality as well as quantity.

Similarly, adequate thrust would also be given to quality feed production so that aquaculture practices are not hampered on account of non-availability of good feed. Presently, carp culture is largely dependent on a crude mix of oil cakes and rice bran, and this raw material is also in short supply in many parts of the country, especially in the North-Eastern States. Promotion of feed manufacturing units can ease this problem to a large extent. Poor health management and disease outbreaks take a sizeable toll of farmed fishes. This puts enormous burden on the farmers, who at times resort to quick remediation to save the stock. To reduce the incidence of disease outbreaks and also provide advance warnings to fish farmers, efforts will be made towards fish health management and a sound surveillance mechanism on disease outbreaks and their containment.

In the non-food sector, it is proposed to promote ornamental fisheries in both rural and urban areas. The focus in this area would be on development of entrepreneurial skills among women and unemployed youth to take up ornamental fish farming and other activities associated with it, such as manufacturing of aquaria, marketing of other aquaria accessories, etc. On the technical front, assistance is proposed to be provided for breeding of native varieties of ornamental species that have export market and can also reduce pressure on wild ornamental species.
Components under inland fisheries and aquaculture development

<table>
<thead>
<tr>
<th>Development of freshwater aquaculture</th>
<th>Development of brackish water aquaculture</th>
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<tbody>
<tr>
<td>Construction of new ponds in Plains</td>
<td>Construction of brackish water fish and shrimp farms</td>
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<tr>
<td>Construction of new ponds in Hill States/North-East Region</td>
<td>Renovation of brackish water fish and shrimp farms</td>
</tr>
<tr>
<td>Reclamation/ renovation of ponds/tanks in Plains</td>
<td>First year inputs for culture of <em>Penaeus monodon</em> and <em>Littopenaeus vannamei</em> and fin fish</td>
</tr>
<tr>
<td>Reclamation/ renovation of ponds/tanks in hilly areas</td>
<td>Aquatic Quarantine and Inspection Unit (AQIU)</td>
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<tr>
<td>Input cost for composite fish culture</td>
<td>Assistance to Specific Pathogen Free shrimp culture farms for additional infrastructure to cater to bio-security and waste management.</td>
</tr>
<tr>
<td>Input cost for integrated fish farming (with agriculture, horticulture)</td>
<td>Disease surveillance</td>
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<tr>
<td>Inputs for integrated fish farming-- Livestock (poultry, ducks, pigs)</td>
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<tr>
<td>Freshwater fish seed hatchery</td>
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<tr>
<td>Small-scale seed unit (spawn)</td>
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<tr>
<td>Fish seed rearing units (ponds with water supply)</td>
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<tr>
<td>Renovation/re-modeling of rearing space/nursery pond with brood stock maintenance and rearing in hatcheries of government/ private sector</td>
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<tr>
<td>Input cost for fish seed rearing (up to fingerling)</td>
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<tr>
<td>Fish feed units</td>
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<tr>
<td>Establishment of freshwater prawn seed hatchery</td>
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<tr>
<td>Development of coldwater fisheries/aquaculture</td>
<td>Development of saline waterlogged/saline land areas for aquaculture</td>
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<td>---------------------------------------------------------------</td>
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<tr>
<td>Preparation of resource survey report/feasibility report</td>
<td>Development of water logged areas</td>
</tr>
<tr>
<td>Construction of raceway</td>
<td>Inputs – seed, feed, etc.</td>
</tr>
<tr>
<td>Input cost</td>
<td>--</td>
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<tr>
<td>Running water fish culture in hilly areas including cost of inputs</td>
<td>--</td>
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<tr>
<td>Hatcheries</td>
<td>--</td>
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<tr>
<td>Capacity: 5.0 million eyed ova/year</td>
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<tr>
<td>Capacity: 0.4-0.5 million fry/year</td>
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<tr>
<td>Stocking of fingerlings in small, medium and large reservoirs.</td>
<td>Riverine fisheries conservation and awareness programme</td>
</tr>
<tr>
<td>Pen/cages/rearing ponds for fish seed raising</td>
<td>Stocking of floodplain wetlands (mauns/beels/chaurs)</td>
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<td>Craft and gear for reservoir fishers.</td>
<td>Restoration of floodplain wetlands (mauns/beels)</td>
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<tr>
<td>Construction of landing centre.</td>
<td>Restoration of river connecting channels and water regulatory structures (Mauns/beels)</td>
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<tr>
<td>Assistance for fish marketing</td>
<td>Development of seed rearing units</td>
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<td>Backyard hatchery</td>
<td>Small hatchery</td>
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<td></td>
<td>Commercial unit</td>
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<td>Aquarium fabrication, accessories and service Unit</td>
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</table>
6.4 National scheme for welfare of fishermen and fisherwomen

Being poorest of the poor, the welfare of fisher community in India is of utmost importance. Thus the welfare schemes implemented for the fisher community during the 11th Plan are also proposed to be continued during the ensuing Plan. However, changes have been proposed in some schemes to make them more useful and comprehensive. The components that are proposed to be continued are as follows:

- Development of Model Fishermen Villages
- Group Accident Insurance for Active Fishers
- Saving-cum-Relief

Since fisher women have been playing a pivotal role in the sector, it is proposed to extend the Group Accident Insurance and Saving-cum-Relief components to women also.

6.5 Central Sector Scheme on strengthening of database and Geographical Information System for fisheries sector

Reliable database is a pre-requisite for undertaking any developmental programme or for formulating policies and plans. This is all the more important for countries like India, which is not only of continental proportions but also has a huge diversity in terms of fisheries resources and their production and productivity levels. The situation is further compounded with pre-dominant small-scale fisheries, which is widely dispersed in both marine and inland sectors. To enable this diversity to be captured in both time and scale, the on-going Central Sector Scheme which covers inland and marine sectors is proposed to be continued with the following components:

- Strengthening of data-base and resource mapping of water bodies using GIS platform;
- Documentation of all water bodies through satellite imagery data and revalidation through manual survey;
- Socio-economic status of fishers covering parameters such as assessment of literacy, income and health status, etc.;
- Quinquennial census of marine and inland fisheries sectors. Special drive to be undertaken to map the cold water fisheries resources; and
- Vulnerability assessment of marine and inland fisheries and aquaculture resources for climate change.

6.6 Institutional strengthening including capacity building, policy and legislative support

Sound policies and comprehensive legislative framework form the backbone of good governance. In the fisheries sector, policies have been largely restricted to the Five-Year Plan documents or occasional stand-alone policies (e.g. the 2004 Comprehensive Policy on Marine Fisheries). The entire fisheries sector has so far not been covered with a sound policy framework, as was done for the agriculture sector in the past. In fact a comprehensive policy on fisheries sector can be a guiding factor for all the States/UTs and help them in shaping their policies and programmes from time to time. The following list details some of the important areas that would need policy-level interventions during the ensuing Plan:

- Treating fisheries and aquaculture at par with agriculture;
- Leasing of inland natural and manmade waters such as rivers, reservoirs, floodplain lakes, etc for fisheries and aquaculture purposes;
- Conservation and habitat restoration of inland water bodies, maintaining minimum flow levels in rivers and allocation of water for aquaculture purposes through cross-sectoral policy interventions;
- Introduction of exotic aquatic species;
- Insurance for aquaculture and capture fisheries’ assets such as boats, nets, etc;
- Reducing pollution load in inland water bodies;
- Deep sea fishing;
- Leasing of coastal waters for mariculture purpose;
Occupational safety and health aspects of fishers;

- Cross-sectoral issues in coastal and marine fisheries such as displacement of fishers due to setting up of national parks and marine sanctuaries, manmade disasters such as oil spills and due to other economic activities (oil exploration, commercial ports, etc.) and national security purposes;

- Habitat restoration by Installation of Artificial Reefs and FADs, bio-inventorying and biodiversity preservation in marine ecosystem;

- Vulnerability reduction of coastal fishers from natural disasters, including climate change and developing their adaptive capacities;

- Strengthening of fisheries cooperative societies;

- Human resource development in fisheries sector;

- Promotion of co-management regime for management of common pool public property fisheries resources;

- India’s accession to international binding instruments and implementation of their provisions;

- Safe and hygienic fish and fish products thorough zero use of banned drugs and chemicals in aquaculture, improved sanitation and hygienic conditions in all post-harvest operations, etc; and

- Encouraging public, private and community participation in fisheries sector for attracting investment and better use of available resources.

Fisheries and aquaculture is a State subject and the activities are primarily multi-stakeholder. Therefore, it would be essential that both policy formulation and legislative framework is carried out through extensive stakeholder consultations at each and every stage. This would ensure a stakeholder-based approach and the policies and legislations would be well-accepted by the stakeholders resulting in higher level of compliance.

* * *