INTEGRATED AQUACULTURE IN EASTERN INDIA
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CURRENT PRACTICES IN INTEGRATED AQUACULTURE FROM INDIA

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INTRODUCTION

The freshwater aquaculture resources in India comprises 2.25 million hectares of ponds and tanks, 1.3 m ha of beels and derelict waters, 2.09 m ha of lakes and reservoirs as also 0.12 m km of irrigation canals and channels and 2.3 m ha of paddy fields.

Fisheries are destined to play an important role in human nutrition but it is becoming a luxury food in some of the countries. Utilisation of grain and animal protein as feed for aquaculture may not be economical as it might reduce the food availability for human consumption. The world's energy and food crises are redirecting the attention to a wiser use of all resources and integrated fish farming offers a solution to the problem.

INTEGRATED FISH FARMING

It may be defined as the association of two or more normally separate farming systems which become part of the whole farming system. The major features of this system include:

- Recycling of waste or by-product in which the waste of one system becomes the input of other system.
- Efficient utilisation of farm space for multiple production.

Integrated livestock-fish, poultry-fish, and rice-fish farming and crop rotation in fish ponds have been well developed and practised in countries like China, Hungary, Germany and Malaysia. Indian freshwater aquaculture has been largely organic-based, with inputs derived from activities of agriculture and animal husbandry with plants and animal residues forming the major component of feeds and fertilizers in carp polyculture. For centuries, small-scale farmers have sustained themselves by practising different kinds of crop diversification. About 80% of India's population live in rural areas at subsistence or near subsistence level. These rural folk are greatly under-nourished and need not only a large supplement of animal protein in their diet but also new sources of gainful employment. India being an agrarian economy, produces large quantities of plant and animal residues, the former to the tune of 321.4 million metric tonnes and the latter amounting to about 1000 million metric tonnes of animal dung on annual basis. It is known that the country supports the largest bovine population of over 240 million cattle heads along with 108 million sheep and goats, 7 million pigs 140 million poultry and other live stock. Activities like mushroom cultivation and rabbitry, silviculture, apiculture, etc. apart from providing for diversification of farming systems, also provide huge quantities of organic material, that may become resources in the aquaculture system. The agro-based industries like distilleries and food processing pants also produce the effluent that could be recycled to aquaculture apart from the well known resource-domestic sewage to the extent of 4000 million litres per day.

ECOSYSTEM OF INTEGRATED FISH FARMING

Integrated fish farming system works in following way:

- Trapping of solar energy and production of organic matter by primary producers.
- Utilization of primary producers by phagotrophs or tertiary consumers.
- Decomposition of primary producers and phagotrophs by saprotrophs or osmotrophs.

- Release of nutrients for producers.

The animal waste in water body enter into the food chain in three different ways

- **Feed**

Certain bottom feeders like *Cyprinus carpio* and *Cirrhinus mrigala* directly utilized the organic particles which are generally coated with bacteria along with other material.

- **Autotrophic production**

Some of the decomposed portion of waste products provides nutrients for the micro-flora (autotrophs), while non-mineralised portion provides food base for bacteria and protozoa (heterotrophs). Temperature, light, micro and macroflora, inorganic nutrients, carbon, phosphorous and nitrogen are the basic inputs required for photosynthesis process.

- **Heterotrophic production**

Micro fauna (zooplankton) feed on small manure particles coated with bacteria. In the process, bacteria is digested while rest is excreted. In this heterotrophic production system micro fauna (protozoans and zooplanktons) are produced finally shortening food chain. This system of production is not linked with the process of photosynthesis.

Advantages of integrated fish farming systems

Integrated fish farming systems utilise the waste of live stock, poultry and agriculture by-products for fish production. **About 40-50 kg of organic manure can produce 1 kg of fish**. Fish farms having an integration with mulberry cultivation, sericulture and silk extraction from cocoons allow the pupae to be utilised fish feed and the worm faeces and wastewater from the processing factory to be used as pond fertilisers. Pond silt can be used as fertiliser for fodder crops which in turn can be used to raise live-stock and poultry or as fish feed. Thus a recycling of waste is done in integrated fish farming system.

The scope of integration in a fish farm is considerably wide. Ducks and geese may be raised on the pond, pond dykes may be used for fruit plants and mulberry cultivation or for raising pigs, cattle, and dyke slopes for fodder production. From integrated fish farming systems not only fish but meat, milk, eggs, fruits, vegetables, mushrooms etc. can be obtained. This system fully utilizes the water body, the water surface, the land, and the pond silt to increase food production for human consumption.

The integrated fish farming system holds great promise and potential for augmenting production, betterment or rural economy and generation of employment. In India this has a special significance, as it can play an important role in improving the socio-economic status of a sizeable section of weaker rural community, especially the tribals.

Integrated Aquaculture Systems include:

1. RICE-FISH SYSTEM

Rice is the dominant cereal crop in Asia. It is the staple food of over 1.6 billion people in the world, mostly in Asia where 90% of all rice is grown and eaten. For most rural farmers, this single crop is virtually their sole livelihood. The practice of collecting wild, naturally occurring fish for food from rice field is probably as old as rice cultivation itself. Fish culture in rice fields was introduced into southeast Asia from India about 1,500 years ago. The problems of food supplies during the second World War gave an impetus for extensive fish culture in rice fields. The reason for decline in rice-fish culture has been the introduction of various insecticides, which are harmful to fish. Rice-fish culture plays an important role in rural economy of Southeast Asia. This is because fish culture lends itself well to small labour intensive farming operations. It can be used in conjunction with rice cultivation to increase productivity. Rice fields form the natural habitat for a larger variety of indigenous species of fish which gain entry only from the nearby perennial water bodies. The fishes feed and grow on natural food available and the farmers usually collect the fish during rice growing season and/or when the water level subsides. In eastern India, rice cultivation varies due to impaired drainage.

Scientific rice-fish systems can ensure higher productivity, farm income and employment in these areas.

Field design of rice-fish plots

The rice fields which retain water for a fairly long duration and free from flooding are generally suitable for rice-fish integration. Some modification of rice-fish plot is required to make the system more profitable. Clay soil is suitable. A peripheral, trench is excavated around the rice growing area (width 3.5 - 4.0 m, depth 1.5 m) which is blocked at one place and connected to the main land for easy access for farmers and agricultural appliances to the rice plot. The rice plot may range from one acre to one hectare or more and preferably be rectangular or even square. A dyke is constructed all around. For a 1 ha plot area required for dykes, trenches, pond refuge and field will be:

Dykes 2000 sq. m. (20%)
Trenches and pond refuge 1300 sq. m. (13%)
Field 6700 sq. m. (67%)

Modifications in size may be made as per availability of available land.

Culture methods

Improved varieties of rice like Panidha, Tulasi, CR 260-77 are cultivated in season which have tolerance to submergence and pest attacks. Fertilization schedule includes 40 kg N. and 20 to 30 kg each of P_2O_5 and K_2O/ha at the time of seeding, besides FYM at 5 to 10 t/ha.

Fish and Prawn

Catla, rohu, mrigal and common carp in combination with freshwater giant prawn are stocked in equal proportions @ 10,000 individual/ha. These are fed with rice bran and mustard groundnut oil cake @ 2-3% of the total body weight. Manuring schedule includes application of cow manure at 10 t/ha/yr, while liming is done @ 200 to 500 kg/ha. These are harvested periodically along with receding water levels.

Horticulture on the dykes

After the harvest of rice certain crops which require lesser amount of water like water melon, groundnut, vegetables, cow pea, money etc. can be grown. Top of the bund which is 10% of the pond area is utilised for growing vegetables and fruit bearing plants.

Rice-fish system results in 168% intensity of cropping in field and 400% on bunds as compared to 52% in the case of traditional monocropping of rice. Rice-fish system provides a net annual income of around Rs. 30,000/ha in the first year which accounts for about twelve folds income over farmer's traditional practices and three folds over the improved monocropped rice.

This system encourages synergism between rice and fish leading to increase in grain yield by 5-15% and straw yield by 5-9%. It facilitates crop diversification, thereby reducing investment risk. It promotes gainful linkage between rice, fish, prawn, vegetables, fruit crops and other resulting in better resource utilization as well as conservation of the ecosystem. IT generates year-round employment in the farm.

2. MUSHROOM CULTIVATION IN CONJUNCTION WITH AQUACULTURE

Mushrooms are fleshy fungi and are the most preferred food item. References to their consumption as food and even medicine are recorded in the classical religious writings (Vedas, Bible, etc). The first record of mushroom cultivation was during 1638-1715. Most early advances on the extensive mushroom cultivation were made particularly in different parts of Europe.

Cultivation of edible mushrooms in India was initiated quite recently, although the methods of cultivation for some were known since long. A well organised attempt was made at Himachal Pradesh in collaboration with the ICAR during 1961 and a project on development of mushroom cultivation was started at Himachal Pradesh, prior to which the entire mushroom production was from natural sources. Even today, the morel (Gucchhi), a prized mushroom is not cultivated but routinely collected from natural sources.

In every country mushrooms grow wild from snowy mountains to sandy deserts on all types of soils, pastures, forest land or litter, cropped or fallow land. Edible mushrooms can grow in all seasons, particularly during rainy weather wherever organic matter or its decomposed products are available. In literature more than 1000 species of edible mushrooms are reported and in India about 200 species are on record.

Cultivation of edible mushrooms

In most parts of India, three types of mushrooms are being cultivated commercially for consumption purpose. They are, *Agaricus bisporus*, *Volvoriella* species and *Pleurotus* species. These are commonly known as, European button, paddy. straw and oyster mushrooms, respectively.

White button mushroom

Introduction of white button mushroom (*Agaricus bisporus*) in mid fifties in Taiwan as a cottage industry and its emergence as the largest exporter of this mushroom in the world within a decade initiated new efforts. Realizing its significance, the ICAR and Government of Himachal Pradesh initiated a project for experimental cultivation of this mushroom at Solan in 1961, that was further stengthened through F.A.O. Later, standard techniques were adopted by small growers in India, particularly in the states of Jammu and Kashmir and Himachal Pradesh.

Paddy straw (*Volvariella species*) mushroom

Successful cultivation of this mushroom was reported in 1943 and in various parts of the country it was gradually adopted. Large part of India have temperature conditions favourable for growing this mushroom either throughout the year or during a part of the year. Paddy straw, the basal substrate is also available in plenty.

Paddy straw mushroom is also called, Chinese mushroom which includes three edible species (*V. volvacea, V. diplasia and V. esculentsa*). Over a hundred species and varieties are known. About ten species have been reported from India. Most popular species are *V. diplasia and V. esculenta* for Indian conditions. These mushrooms require high temperature up to 45^{o}C or even more and do not grow below 25^{o}C. In general, the optimum season for growing paddy straw mushroom is from April to October in the states of Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, West Bengal, Orissa, Andhra Pradesh, Tamil Nadu and Maharashtra. A number of crops can be raised during the favourable season since one crop cycle takes about 30-45 days. It gives comparatively higher yield on handthreshed paddy straw. Unlike the button mushrooms, it can be cultivated in the open space, yet sheltering the beds against rain, direct sunlight and dessication assures better yield.

An average yield of 3 kg per bed (made from 32 kg paddy straw with 200 g of gram powder) is normally obtained within a period of 45 days. The cost of production is low, about RS 25/- per kg and the sale price fluctuates between Rs. 40 to 50 per kg.

Oyster (*Pleurotus* species) mushrooms
These mushrooms under natural conditions grow on trees or dead woody branches of trees. Different edible species are popularly known as, 'Dhingiri'. It is used popularly in the preparation of many delicious dishes. In India, successfully cultivated species of Pleurotus are, *P. ostreatus*, *P. flabellatus*, *P. sajor caju*, *P. ervngi*, *P. sapiduc* and *P. cornucopiae*. Most of these species grow wild in different regions of the country during the rainy weather on dead decaying tree stumps and other organic matter. Cultivation is done on different substrates viz paddy straw, saw dust, maize stalks etc. Best yields are obtained on synthetic compost, mixture of paddy and wheat straw, mixture of paddy and wheat straw, mixture of paddy straw and maize stalks (1:1) and paddy straw alone. Optimum temperature for growth of *Pleurotus* species us 25^{o}C and all species fail to grow at 35^{o}C or above. The vegetative mycelial growth is generally unaffected by light but fruiting is enhanced. The artificial cultivation of oyster mushroom is very popular now in most mushroom growing states on India. Among various species, *P. sajor caju* has shown consistent performance within a temperature range of 21-26^{o}C. The produce is consumed either fresh or it is sun dried for 2-3 days and it can be dehydrated at 48 - 50^{o}C.

The method of cultivation involves the use of dried paddy straw chopped into 1-2 cm long bits and soaked in water overnight. Excess water is drained off and horsegram powder (8G/kg) and spawn (30 g/kg) are added and mixed with wet straw in alternating layers. the polythene bags with perforations are filled with this substrate and kept in a room at 21-35^{o}C with sufficient light and ventilation. The mycelial growth takes about 11-14 days to penetrate the substances in the bags. After this period, the polythene bags are cut open on the sides without disturbing the bed which becomes quite compact during this period. Water is sprayed over it twice a day. In a few days, the crop is mature for harvest. For cultivation of oyster mushrooms some modified methods have also been tried by some growers. These can be sun dried or dehydrated at 50-55^{o}C for later use. Oyster mushrooms are also useful for preparing pickles. Since the oyster mushrooms can grow on a wide variety of agricultural wastes, which are easily available and cheap, the cost of production is lower than of others. The yields per unit area of the substrate are also good, the cost of production being about Rs 20/- per kg of mushrooms. The price for market ranges between Rs 40 to Rs 45/- in Orissa.

Mushroom cultivation adjacent to aquaculture units and utilization of used substrates.
During the recent years, much emphasis has been given to implement certain agriculture programmes which could be interdependent with the other allied disciplines viz., animal husbandry, dairy science, poultry science, agro-forestry and fishery. Since the mushroom cultivation requires high degree of humidity, it would be possible to extend its cultivation in the vicinity of fish ponds.

It has been observed that the paddy straw after growth of mushroom is mush enriched in proteins, inorganic nutrients and other organic matter. This supplemented nutritive value of used paddy straw after the harvest of mushrooms can be well utilised for cattle feed. Preliminary trails have shown the beneficial effects of such cattle feed on enhanced milk yield. In turn the excreta of cattle is fed to fish which is maintained in experimental and commercial ponds.

Being a source of most nutritious food, its alternative use in pickle preparation, medicines etc, also provides a good scope for possible job opportunities to many unemployed persons in the country.

3. HORTICULTURE-FISH SYSTEM

According to the available information, an average American consumes 250 g of fruits and 500 g of vegetables, whereas 150 g fruits and 350 g vegetables are required by an average Japanese. In India, per capita consumption of fruits and vegetables are 47 g and 142 g per day as against the recommendations of Indian Council of Medical Research which are 85 g and 300 g respectively. Floriculture trade is well established in USA and European countries. In India, it is a booming industry for lose and cut flowers, pot culture of roses, chrysanthemum, gladiolus, tuberose, marigold, jasmines etc.

Ponds are well situated for this purpose. The top, inner and outer dykes of ponds as well as adjoining areas can be best utilised for horticulture crops. These crops are fertilized by the pond silt and fertile pond water is used for watering. The success of the system depends on the selection of plants. They should be of :

1. Dwarf variety
2. Less shady
3. Evergreen
4. Seasonal
5. Highly remunerative

Dwarf variety of fruit bearing plants like mango, banana, papaya, coconut, lime can be grown around the pond. this will not obstruct the sunlight to the water bodies and also the pond will be free of dry leaves. Pineapple, ginger, turmeric, chilly can be grown as intercrops. Ponds dykes are used for growing vegetables solo as well as intercrops. During summer season, brinjal, tomato, chilli, gourds, cucumber, melons, ladies finger is cultivated while during winter peas, beans, cabbage, cauliflower, carrot, beet, radish, turnip, spinach, ethic etc. is raised. Pond silt and pond water is used for providing nutrient for these crops.

Flower bearing plants like tuberose, rose, jasmine, gladiolus, marigold, cassandea, chrysanthemum are grown on the pond dykes. These flowers have tremendous market potential in the cities which provides additional employment to the farmers.

Farming Practices

Farming practices are carried out on broad dykes which can stand ploughing and irrigation. Ideal management involves utilisation of the middle portion of the dyke covering about 2/3 of the total area for intensive vegetable cultivation and the rest on the area along the length of the periphery through papaya cultivation keeping sufficient space on either side or netting operation. Semi intensive farming is done where the dykes are not good. Crops of longer duration like beans, ridgegourd okra, papaya, tomato, brinjal, mustard and chilli are suitable for such dykes. Narrow dykes are suitable for cultivating sponage gourd, sweet gourd, bottle gourd citrus and papaya. Where the dykes are shaded ginger ad turmeric can be cultivated.

Fish culture practices

Large quantities of leaves of cauliflower, cabbage, turnip and radish are available at the farm site. These are fed to the fishes as feed. Grass carp is one of the ideal fish for this purpose. A monoculture of grass carp with a stocking density of 1000/ha will give a production to the tune of 2000 kg/ha/yr. During summer, amaranth and waterbind weeds through fortnightly cutting are fed to the grass carp. If possible, common carp can also be added Grass carp is a voracious feeder. Only part of the intake food is digested, while the rest released as faecal matter which serves as a good feed for the common carp. This results in additional production without involving any cost towards cort feed. In mixed culture of grass carp along with fohu, catla, mrigal in the ratio of 50:15:20:15 at a density of 5000 fish per hectare results in yield of 3000 kg/ha/yr.

Economic viability of the system

The system though labour intensive, generates 30% of returns over investments annually which is quite high. about 69% of the total operational cost goes for that purpose. Integrated agri-horti-aquaculture practice fetches about 15-20% higher returns compared to aquaculture alone besides generating employment opportunity round the year. Dilapidated or narrow dykes can be used for the cultivation of black gram. In addition to extra crops, it biologically controls the weeds which are heavily infested on dykes. The cultivation provides 0.80 t pulses, 1.8 t dry pod and 3.64 t straw per hectare in 100 days. Cultivation of black gram requires only broadcasting of seeds after cutting weeds during monsoon season. Irrigation, fertilization or post-sowing care is not required. An income of Rs 10,000 is achieved in 100 days of cultivation and saving of recurring cost towards periodical deweeding. The foliage of black gram is utilised by grass carp feed.

4. SERI-FISH SYSTEM

This is one of the most economically viable system which can be traced back to the 5th century BC. This includes mulberry cultivation, sericulture, silk extraction. Fish farming is done using silk worm faeces, silk worm pupae and waste water. In this system mulberry is the producer, silk worm is the first consumer and fish are the second consumers ingesting the silk worm faeces directly. In the fish ponds having this integration the energy flow in the following patterns:

- Silk worms faeces are directly consumed by the fishes and part of the detritus is filtered by the filter feeding fishes.
- Inorganic nutrients in the silk worm faeces are utilized by phytoplankton and heterotrophic bacteria and these phytoplankton and bacteria are, in turn, consumed by filter feeding fish, either directly or indirectly.
- Leftover feeds and fish faeces are decomposed by hydromicrobes, releasing inorganic nutrients and then, the same process occurs as above.
- At the same time pond silt which is composed of all kinds of sediments return to the pond dyke and a new cycle begins.

Energy passes through the complex food-web of the dyke-pond system and undergoes a series of exchanges as it flows among the sub-systems. It forms a complex food which is extended in various forms and via various pathways of the system. Some energy exports, such as those stored in silk worm cocoons or in the fish, are of economic value. Others, like losses in the form of radiation is the energy source that drives the dyke-pond system. This energy enters the system via three pathways: Absorption by the dyke crops which converts energy into chemical energy during photosynthesis. Absorption by phytoplankton in the pond and conversion to chemical energy via photosynthesis and direct input with the pond of chemical energy stores in plant material and waste production, used, respectively as fish feed and pond fertiliser. The silk worm sub-system provides the energy linkage between the mulberry and pond sub-system. It absorbs energy stored in harvested mulberry leaves and semi most outputs of silk worm-rearing enter the fish pond as a mixture of mulberry leaf waste and silkworm excrement transmit the energy to the pond.

In general 75 percent of the mulberry leaves supplied is consumed by the silk worms. Together with silk worm excrement, the remaining 25 percent of unconsumed leaf debris is dumped into the pond. Mulberry dykes yield leaves at the rate of 30 t/ha/yr, when fed to silk worms 16.2 t of waste is produced in which the energy store is 66% of that supplied to the silk worms. The energy intake by the fish accounts for only 32% of the total energy input to the pond. about 72% of this intake energy is absorbed and the remainder output with fish excrement and in the process of respiration. Based on these facts of energy exchange, a two way energy exchange system exists between the dyke and the pond. Energy enters the pond via materials grown on the dykes and then fed to the fish and in this mulberry-dike system via silkworm excrement. This is then returned to the dyke in the form of silt.

In this situation, a 1 ha mulberry dikes-ponds system is prepared in which 50% of the area is dike and 50% water body. Of the former, 0.45 ha is planted with mulberry and 0.05 ha is under crop. During winter season vegetables are inter-planted with the mulberry. A production of 30 t/ha mulberry leaves, 21 t/ha silk worm cocoons, 225 t/ha crop and 3.75 t/ha vegetables is achieved. Waste of the vegetables which account for 50% is fed to the fish while 50% is consumed by the human beings.

Approximately 16 t of waste is produced per ha mulberry which is put in the pond. Mulberry leaves are harvested for feeding silk worm 7-8 times a year. Mulberry grows best at a temperature of 25-30^{o}C whereas growth is retarded below 12^{o}C. It cannot tolerate higher regime of temperature. Inter cropping with vegetables etc. improved mulberry leaf yields.

Nursery bed preparation
3.5 months before transplanting usually on any small section of the dyke close to the transplanting location. The nursery area is thoroughly and the soil is reduced to a fine tilth. Beds are treated with a pesticides (BHC) @ 45 kg/ha) before broadcasting the mulberry seed @ 20 kg/ha. A week time is generally required for sprouting. Seedlings remain for 3 months in then beds. Periodically these are fertilised using urea @ 38 kg/ha. Any pest problem is controlled by the Roger or DDVP (Dichlorvos).

Transplantation of seedlings
Dykes are prepared before the transplantation of seedlings which include activities like tilling, sundrying, breaking-up of soil, making rows about 60 cm apart and separated by a shallow drainage ditch and application of manure. about 1.25 lakh plants/ha area planted. There are periodically watered, using pond water and salt.

Management practices
Deweeding, pest eradication and manuring are the main management practices. Urea and salt are main features. The use of slurry is also very common other management practices include the removal of buds which give birth to the new plants making the each plant bushy.

Leaf harvesting
Leaves are harvested several times a year as per the requirement. These provide good nutrition for silk worms. Generally the dykes are divided into several sections to ensure daily supply of fresh leaves for silk worm.

Replanting of mulberry plants
Generally the leaves production goes down after 5-6 years. At this juncture plants can be uprooted and new crop should be planted to maintain the productivity.

Silk worm culture
This system flourishes where the temperature and humidity ranges between 15-32^{o}C and 50-90% respectively. Silk worm rearing trays are cleaned and disinfected and sheds are prepared. The basic unit of calculation in silk worm rearing is the sheet of paper (16 x 21 cm) on which the moths are induced to lay eggs. Each sheet carries 18000/20000 eggs of which approximately 90% are viable. The worm produced by one sheep of eggs require the leaves from 0.067 ha of mulberry dike to produced cocoons. Eggs are hatched in the rearing shed and placed on a net spread over a 1.5 m diameter bamboo rearing tray; stacked on a wooden or bamboo scaffolding from the floor to a height of 2 m approximately with sufficient space for ventilation. Feeding rates increase sharply during the rearing period. Successful worm-rearing demands supply of fresh leaves. Waste material is removed

daily from the rearing trays. At the end of the rearing period of the worms (19 days for multivoltine worms and 24 days for the bivoltine - worms) area ready to spin cocoons. At this stage, they are removed from the rearing trays and placed in separate compartments on a bamboo cocoon spinning board process is completed within 48 hours. They are removed from the board and dried in the field. Several crops can be obtained every year depending on the weather and mulberry conditions.

5. DUCK-FISH INTEGRATION

Duck-fish integration is the most common integration, mainly practised in China, Hungary, East Germany, Poland, Russia and upto some extent in India. It utilises the mutually beneficial biological relationship between fish and duck. Asia is considered to be the holy land of the domesticated ducks, but the best breeds and strains currently available have been developed for their excellent egg/meat production in Europe and America through systematic breeding, feeding, management and disease control.

In the West and other affluent countries, duck meat is a delicacy, and ducks are mainly reared for table purposes. In some countries, duck eggs are not popular because of the fear of possible *Salmonella* infection.Duck eggs are an important source of food in India. These are very cheap to produce and can play an important role in balancing the diet of the Indian people. Consumption as well as production of duck eggs in India is mostly done by socially weaker sections of the community. According to the 1972 livestock census, the duck population in India is about 9 million which is 7% of the total poultry population. The production of duck eggs is about 400 million/year which is 5% of the total egg output in the country.

Importance of duck rearing

1. Rearing of ducks is limited to watershed regions. It is very popular among villagers as a profitable back-yard enterprise as average egg production from ducks is higher than local fowls.
2. They have great foraging capacity.
3. Maintain egg productivity almost at the same level up to the age of 2 to 3 years as compared to 1 to 1½ years in case of fowls.
4. Eggs are bigger and because of thicker and strong shell, transportation is easier and breakage during transit is lesser.
5. Energy level is higher in duck eggs than in hen egg.
6. Ducks feed on a large variety of organisms like snails, flies, earthworms, insects, etc, that area vector of diseases. Ducks may serve as effective biological control of a number of human and animal diseases.
7. Ducks keep the water clean by controlling potato beetles, grass hoppers and other aquatic fauna. They feed on green algae and weeds thereby helping in the control of unwanted plants.
8. Ducks are quite hardy, easily brooded and resistant to the common diseases. They need less attention and area easily manageable.
9. Cannibalism behaviour is not usually encountered in ducks.
10. Duck eggs are larger than the chicken.
11. Ducks do not require extensive housing.
12. Cholesterol level in duck egg is less as compared to the eggs.

Varieties of ducks

Ducks are of several kinds as the egg type, the meat type and the ornament type. In India, mainly ducks of egg-laying type are reared.

Ducks for eggs

The famous Indian duck breeds for eggs are:

(a) Sylhat mate

(b) Nageswari
(c) Indian Runner
(d) Khaki Campbell - Khaki campbell is recommended for integration duck-fish.

As they are prolific layers they can be reared economically. These ducks start laying eggs when they are 3 months old. The annual average egg production is about 300 eggs or more.

Ducks for meat

The ducks for meat include Pekin, Aylesbury, Muscovy, Rouen, Cayuga, Buff and Swedish breeds. Pekin is most popular taste bird. Its grows very fat. Weight ranges from 3.5-4 kg.

Housing and management

A comfortable house should provide adequate accommodation, be reasonably coll in summer and sufficiently warm during winter. It should be free from draughts and should at the same time provide adequate supply of fresh air and sunshine and always remain dry. The house should give adequate protection against sudden changes and extreme temperatures as these have an adverse effect on the health of birds. The house should also give protection to the birds from their natural enemies like jackals, foxes, dogs, cats, rats, snakes, kites and crows.

Centralised enclosure - In this method, a relatively large duck shed is constructed in the vicinity of the fish ponds with a cemented area of dry and wet runs outside. The average stocking rate is about 4 ducks/m^2. The dry and wet runs must be cleaned daily. During cleaning, the sluice of the wet run is opened to allow organic manure to be flushed into fish ponds through a manure ditch. After this, the sluice is closed and the wet run is filled with fresh water. This method is advantageous for its centralised management mechanisms, but it is unable to fully utilise the leftover and undigested duck feed. It is also unable to take advantage of the duck-fish symbiosis.

In the fish-pond - This is the most common method of integrated fish-duck farming. The dykes of grow-out ponds are partly fenced to form a dry run and part of the water area of a corner of the pond is fenced with used material to form a wet run. The net pen is installed 40-50 cm above and below the water surface to save net material. In this way, fish can enter the wet run for food but cannot escape. In a large pond, a small island is constructed at the centre of the pond with feeding facilities.

The number of ducks to be raised in fish ponds depends on the quantity of excreta per duck, which in turn depends on the species of duck, the quality of feed applied, and the method of raising.

Care of ducklings

The brooder house should be kept ready and be checked 24 hours before arrival of ducklings. Each duckling should be given a drink by dipping its beak in water. It should be provided dry litter. The birds need heat for first 8-11 days depending on the weather. It should be checked regularly to avoid any possible complications.

Feeding

First 3 weeks are vital for future growth and the ration should be high in protein. There should be balance between cereals and protein. The starter ration should also contain vitamins, mineral salts and trace elements. A feed containing 17% protein in a high energy ration will be enough for proper growth of ducklings. In layer ration 15% protein will serve the purpose. Ducks are voracious eaters and foragers. Apart from compound feeds snails, fingerlings, earthworms, insects and other vegetative forms are taken by them when reared in ponds. It reduces the feed cost. Ducks have difficulty in swallowing dry mash. Pellet feeding is popular which reduces wastage, feed cost and labour cost. Ducks are very much susceptible to aflatoxin produced by fungus, *Aspergillus flavus*, is groundnut oil cake. Duck can tolerate up to 0.03 ppm as against 0.2 ppm in chicken. The mouldy feed toxicosis is more harmful to the ducklings than adult ducks.

Annual consumption of feed is about 50-60 kg per duck. It requires about 3 kg of feed to produce a dozen eggs and 3.22 kg feed to produce 1 kg of broiler duck. The layer requires 200-210 grams of food per day.

Diseases

Ducks are more susceptible to aflatoxin and hence as far as possible feeding of groundnut cake, maize and rice polish should be restricted. Feed ingredients should therefore be stored properly to prevent aflatoxin contamination. Other diseases which affects the ducks are duck plague, duck virus hepatitis and duck chlorea. Timely vaccination can be helpful against viral diseases.

Benefits of duck-fish integration

A fish pond is a semi-closed biological system. In fish ponds, there are many aquatic animals and plants, most of which are natural food organisms of fish, some are detrimental to fish but can be utilized by ducks. Fish ponds provide ducks with an excellent, essentially disease free environment. Ducks consume juvenile frogs, tadpoles, and dragonfly larvae, thus eradicating many predators of fry and fingerlings. Furthermore, the protein content of these natural food organisms of duck is high. Therefore, duck raising in fish ponds reduces the demand for protein in duck feeds. For ducks raised in pens, the digestible protein content in the feed must be 16-20 percent; for ducks raised in fish ponds, the digestible protein content can reduce to 13-14 percent. This can save 200-300 g available protein for each duck, equivalent to 2-3 percent the duck feed. Duck droppings go directly into the pond, providing C, N, and P and stimulating the growth of natural food organisms. This direct fertilisation of the pond has two merits: 1, there is no loss in the availability of manure: 2, direct fertilization is more homogeneous and avoids any heaping of duck droppings. For these reasons, raising ducks on fish ponds promotes fish growth, increase fish yields and eliminates pollution problems that might be caused by excreta in duck pen.

The quality and quantity of duck excreta, however, are dependent on species, feeds applied, culturing management, and climatical conditions. The stocking rate of ducks is generally 300-500 ducks/ha and each duck produces about 7 kg of dropping during the 36 day fattening period. If 500 ducks are raised, 3500 kg of excreta would be produced in that t period. the moisture content of duck excreta is 56.6 percent; organic substance, 25.2 percent; C, 10 percent; P_2O_5, 1.4 percent; N, 1 percent; K_2O, 0.62 percent; Ca, 1.8 percent; and others. Each egg-laying duck annually produces 7.5-10 kg (dry weight) of excreta (equivalent to 70 kg wet weight).

Duck feeds are fully utilised in fish-duck integration. Ducks lose 10-20 percent 923-30 g/day) of their feed. This feed can directly be consumed by fish.

Fish-duck integration also promotes the recycling of nutrients in the pond ecosystem. In shallow areas, a duck dips its head to the pond bottom and turns the silt to search for benthos. By virtue of this digging action, nutritional elements locked in the pond humus will be released. Ducks also act as pond aerators. Their swimming, playing and chasing disturbs the surface of the pond and aerates the water.

Duck raising in fish ponds has three advantages over raising ducks in pens. The feed efficiency and body weight of each duck improved. The higher feed efficiency also implies than the waste feeds are utilised by the fish. The food conversion factor in fish-duck integration was reduced from 3.84 to 2.64. The survival rate is increased by 3.5 percent because fish ponds provide a clean environment for the ducks. It was believed that if fish and ducks were raised in the same pond, the ducks would eat the small fish. However, above 5 g the fish is able to escape from the duck.

Daily amount (g) of duck excreta and split input into fish ponds

Time	**Excreta**		**Feed**	
(days)	Wet wt.	Dry wt.	Applied	Split
21-30	127	68	194	29 (15)
31-40	248	74	227	34 (15)
41-50	420	73	248	37 (15)

(Values in parenthesis are the percentages of feed split)

An accurate economic analysis of fish-duck integration is impossible because of the variations in production costs, duck yields in different countries. even in the same district, fish and duck species, stocking densities, quality and efficiency of feeds, rearing management techniques and climatic conditions vary greatly.

From the viewpoint of input - output relationships fish-duck integration is the best model of integrating fish, livestock and poultry. From a micro-economic stand-point, the economic efficiency of fish-pig integration is not as good and profit is low. Fish-chicken integration lacks any symbiotic relationship. Protein input and output in integrated fish-duck and fish-cow farming are similar:

Integrated management of fish-duck farming can be further developed to achieve even economic efficiencies. High yield aquatic plants can be cultivated as duck feeds and wastes from integrated fish farming and the city proper can be used to raise earthworms, an additional feed for ducks, at the output end, products (fish, ducks and eggs) could be further processed before marketing. This could considerably increase economic efficiency and income.

6. FISH-LIVESTOCK SYSTEM

Fish farming using manure has long been practised all over the world. Integrating fish and livestock farming reduces the necessity too purchase fertilisers and fish feeds, and increases the income generated by the fish farm.

Management

Animal sheds can be built close to the fish ponds to simplify the handling of the manure. The faeces and urine may be collected separately. If the floor is higher than the pond dyke, a manuring ditch can be dug to collect the faeces and urine together and the mixture can be flushed directly into the fish ponds. This method saves time and labour. The area of the fish pond to be matched with the number livestock and waste food; the species ratio and target output of fish, etc. The frequency of manuring depends on the conversion of the manure, which changes seasonally, and the fluctuation of food organisms in the fish ponds. Cow faeces and urine are beneficial to filtering and omnivorous fishes. Therefore, silver carp and catla are usually the major species with assorted omnivorous fish (common carp) and herbivorous fish (15-20 percent). The optimal output of herbivorous in fish-cow integration should be around 12 percent of the total output of the pond. With more herbivores, supplement feeds must be applied.

India does not possess a suitable native breed of pig to develop pig industry. The common village pig in India is a scrub animal, with its growth being slow and poor. It produces small litters. The pork produced by this animal is of poor quality. Several exotic breeds of pig have been introduced in India to augment pork production. Amongst these breeds, the popular ones are the large white Yorkshire, middle white Yorkshire, Berkshire and Landrace.

Biological basis
Among all livestock excreta, cow excreta is the most abundant and, in terms of availability, the most reliable. A 450 kg cow annually produces 12000-13000 kg of faeces and 8500-9000 kg of urine. The nutritive content of cow dung, however, is a little less than of pig excreta. If 0.024 kg of fresh cow manure is applied to 1 m^3 of water every day, inorganic N and P will be 0.897 and 0.024 mg/l, respectively. These levels are close to the inorganic N (0.97-2.06 mg/l) levels in high-yield fish ponds. The N/P ratio will be 36.9.

The increase in natural food organisms, detritus, and bacteria in fish pond enables filter feeding and omnivorous fish to grow faster. The conversion factor of cow manure is 3.15 in dry weight or 21 in wet weight at an average weekly manuring rate of 0.17 kg/m^3 in filtering and omnivorous fish farming. In silver carp it is 3.3 in dry weight or 26 in wet weight at the same manure input. Further investigation has shown that **about 200 kg of cow urine can be converted into 1 kg of silver**. Cow manure particles sink at 4.3 cm.min. If the same amount of manure is applied, after 24 h, the density of suspended organic detrius below 0.65 µm in the cow-manured pond (40 mg/l), around 150 percent is higher than in pig-manured pond. This 40 mg/l of cow.

Composition of cow and pig excreta

	Moisture %	Organic material	N	P_2O_3	K_2O
Milk cow dung	85	11.4	0.36	0.32	0.20
Cow dung	80-85	14.6	0.30-0.45	0.15-0.25	0.05-0.15
Pig manure	85	15.0	0.50-0.60	0.45-0.60	0.35-0.50
Cow urine	92-95	2.3	0.60-1.20	trace	1.30-1.40
Pig urine	97	2.5	0.30-0.50	0.07-0.15	0.20-0.70

Source: FFRC Agricultural Handbook

Quantity of natural food organisms in cow-manured and fertile, high yield ponds

	Phytoplankton (mg/l)	Zooplankton (mg/l)	Bacteria (ind/mg)	Organic deteritus
Cow-manure pond	19.15-2650	5.61	5.18x104	64.44
High-yield	46.2-47.8	10.1-15.1	-a	67.9-111.2

a: not available in the original table

Deteritus accounts for 55 percent of the total suspended particles in the pond, which is the highest percentage when compared with pig, duck, or chicken-manured ponds. The susceptibility of cow manure not only enables the fish to obtain more feed but also reduces oxygen consumption caused by manure stacking and avoids the formation of harmful gases. The BOD of cow manure is lower than that of other livestock manures because the cow forage had already been decomposed by micro-organism in the rumina. The BOD of 1 kg of cow manure in 5 days in 20.6 g, 32 percent lower than the BOD of pig manure (30.0 g).

Oxygen demands of different animal manures

Oxygen consumption index	**Manure**		
	Cow	Pig	Chicken
BOD (mg/day)	3.66	5.48	6.27
COD (mg/day)	13.7	14.01	14.51

Cow feed mainly on grass and during the grass-growing season (about 7 months), an adult cow requires 9000-11000 kg grass. Around 3000 kg of this grass, however, is leftover. That period of time is the highest ingestion season of herbivorous fish: therefore, this waste fodder can be utilised as fish feed to the grass carp. The food conversion factor of terrestrial wild grass is 40-50. In addition, the matted grass in the cow shed can be used as compost for the pond. The leftover fine fodder for cows can also be used as fish feed.

Under favourable conditions of management, a good sow or gilt can produce two litters/year and raise about 7 piglets/litter. The piglets are weaned at the age of 8 weeks. The growing animals are ready for market at about 6 months of age. The gilts retained for breeding attain puberty at the age of about 8 months and farrow at about one year of age. The average duration of pregnancy in pigs is 114 days. The male piglets which are maintained for stud purpose become fit for service after the age of 7 months. The ration between the breeding boars and sows in a herd is usually 1:15.

The yield and consumption of pig dung

A pig weighing about 60 kg can approximately void 2 to 2.5 kg of fresh dung daily. The moisture content of the fresh dung is about 70%. An average chemical composition of the dung in pigs fed ration containing 18 to 20% protein may be as follows:

Component	Approx. % on DM basis
Crude protein	12
Expandable energy	5
Crude fat	8
Nitrogen free extract	65
Total ash	10

The average contents of phosphorus and potassium in pig dung are 0.2 and 0.4% respectively. The dung was found to contain 69% moisture when the pigs were fed concentrate containing 16% protein. the nitrogen and phosphate contents of the dung were observed to be 1.36 and 0.36% respectively on dry matter basis.

The excreta voided by 35-40 pigs in India and 36-60 pigs in Hungary was found to be adequate to fertilise one hectare of water. A dose of 5 t/ha is recommended for fish

ponds. The conversion ration between pig dung and fish biomass was studied to be 17:1.

8. RABBIT-FISH INTEGRATION

Rabbit can play an important role as a non-conventional meat animal for hilly, tropical rain forests, roughage, legumes and horticulturally rich areas. Until recently, rabbit was considered, at least in India, as a pet animal by the common citizens. For the professionals, it was an experimental animal. But currently rabbit has emerged as an alternate meat source for the future. Rabbit meat has been regarded as a dieticians choice for the health-conscious meat consumers. Rabbit meat is low in fat content in comparison to chicken, mutton, beef and pork. Among the food animals, rabbits has the highest reproduction rate and can attain the growth rate comparable to modern broiler chicken. Rabbit furskin which is an important bi-product supplements the farmers income. The following attributes makes rabbit a favourable animal for meat production.

Breed, varieties and strains

Approximately 60 individual breeds and varieties of rabbits are recognised world over today. this domestic rabbit which is available in so many sizes, colour and shapes is not a wild animal but a farm species. Some of the popular breeds are as follows:

Meat type Soviet Chinchilla Grey Giant White Giant New Zealand White

Wool type Russian Angora German Angora Russian fur Chinchilla

Technology of operation

Infrastructure (Housing etc): Rabbits may be reared in three ways

a. Cage system b. Hutch system c. Floor system

Cage system: This system is followed in semi-commercial and commercial system i.e., when the number of foundation stock (Parent stock) is 100 and above. This system is practised in combination with hitch system. Depending upon the number of rabbits, a simple shed should be made with either cemented or mud floor. A number of racks should then be made keeping a common passage between two rows. Over these racks, cages should be placed. Preferable cage size is 2 2ft x 2ft x 2 ½ft (height). Cages made of welded wire mesh (16 or 18 gauge) with a hole size of 3/4" have been found ideal and durable. Under each row there should be proper drainage system so that urine, dung etc. are easily drained out. The cages may also be kept in their system.

<u>Hutch system</u>: The hutch system is generally kept for breeding and maturity purposes. It is portable and can be fabricated locally either with wooden structure or with bamboo. Roofing can be made again either with (CGI sheet, polypropylene or with thatched grasses. For durability and managemental ease, flooring may be made with wire mesh. Fryer rabbit may be kept together is weaned pool made without partition walls. Each compartment of hutch (2-5 compartments in one hutch) may be of the size of 3 1/2 ft x 3ft x 3 1/2 ft (height). Provision should be made in each compartment for a delivery quarter. If separate delivery quarter are not made, separate kindling boxes may be put inside each compartment 3 or 4 days before delivery.

<u>Floor system</u>: This is like the rearing of poultry birds in deep litter system except that the flooring should be preferably made of cement concrete. Since rabbits have the burrowing habit, earthern floor may not be desirable. In such a system the space inside the house is divided by partition for keeping proper breeding and production records.

<u>Animal</u>: One should decide on the type of rabbits he wishes to start with i.e. whether it is to be reared for meat or for wool purpose.

Management

(a) Meat and fur type rabbit: after the basic requirement like housing and animal are met, day to day and periodic management schedules are to be followed for maximum production. The management is like that of other animals. So, regular attention is needed. Rabbit is scared of almost everything, so it is advisable to keep unfamiliar people and visitors during off periods and children away. A rabbit has to be lifted by the scruff of its neck and when carrying it needs to be supported from the bottom and it should never be lifted by holding its ears.

(b) Feeding: Rabbit is a monogastric animal but the presence of microflora in the hindgut (caecum) and the habit of coprophagy makes it capable of consuming a variety of feed. In backyard a few rabbits can be reared with the kitchen waste and other available forages but for large scale production, balanced pelleted rabbit ration is a must. So due emphasis is required to be given for availability of cheap and balanced rabbit ration wherever rabbit production is to be promoted. Pelleted feed should be given at a rate of 100 g/day/rabbit. Twice a day, feeding should be practised.

(c) Watering: Watering is provided once a day, but it should be available for both day and night particularly to a lactating mother. Rabbit is a prolific breeder and the non seasonal nature of their heat period is yet another important character which has made them to be recognised as one of the most promising animal for future generation. Both the male and female attain maturity at 6 to 7 months.

(d) Mating: Mating is to be done either in the morning or in the evening. The doe is introduced to the buck in his cage. The gestation period of rabbit is 30 days with 2 days difference either in the upper side or in the lower side. For taking adequate care just before and after delivery it is important to note the breeding date. Pregnancy can be diagnosed by palpation method by experienced hands. Quantity of feed should be increased gradually towards the last quarter of pregnancy and the doe should not be disturbed unnecessarily. Around 20 days after the breeding the doe should be given one individual compartment in a hutch/preganat cage and a nest box should be provided if the compartment does not have suitable arrangement.

(e) Kindling: This is the period when the act of delivery begins. Just before kindling, the doe will generally prepare a bed by plucking fur from her breast. However, it is necessary to put extra bedding like saw dust/paddy straw. Normally, no assistance is needed during kindling and it is better to leave the new borns undisturbed except for checking the dead ones. If any dead animal is found the same should be removed.

(f) Care of the new born: New born kits are helpless animals as they are blind and devoid of body hair. They lie quietly inside the bedding material and the doe feeds her young ones periodically.The kits start developing hair 4 days after birth and open their eyes after 10 days. After kindling the kit should be examined daily and dead ones should be removed. When the bedding becomes wet, it should be replaced by fresh and clean ones. The doe should be fed with *ad lib* nutrient rich ration. Some of the does crushs or eat kits. Adequate feeding and watering can prevent such incidents. In spite of proper feeding if the doe repeats the same for the second time, it should be culled .From the age of 10 days onward, the kits start coming out of their bed and from around 21 to 23 days they start nibbling at the feed given to the mother. From the 30th day of their age separate feeding through should be provided for the young ones.

(g) Slaughtering for meat and fur purpose: If the male population is more in the herd and all of them are not needed for breeding purpose, then the culled animals may be slaughtered at 90 days for meat purposes and fur may be kept for processing.

Rabbit excreta - A new potential aquaculture manurial input

The potential of rabbit excreta was evaluated through studies on its composition and effects on hydrobiological conditions, in comparison with the traditional organic manure, cow dung. The high nitrogenous rabbit excreta (10 times higher than that of cow dung) was found to be releasing nutrients gradually, sustaining high plankton production over a long period of time.

It is evident from the above facts that rabbit excreta, low in moisture and high in nitrogen content, is a quality manure for sustained plankton production and hence rabbitry can be efficiently integrated with fish farming.

9. INTEGRATION WITH GOATS

Goat farming is an age-old practice but its integration with fish culture has not been explored. Goats not only provide meat and milk but also a good amount of manure. Annual production of manure from a goat is around 1.5 - 2 tonnes per year. If animal manure is not properly used, it causes pollution of water and environment. It has been observed that 40-50 kg of animal manure produce 1 kg of fish. Animal manure and green fodder can totally replace the commercial feed for fish farming achieving a similar fish production.The goat is a versatile animal. It is known as the poor man's cow. Goats can be kept with little expense on undulating lands with an inexpensive shelter. India has 1/4th of the worlds total goat population. (FAO, 1990).

There are about 13 well known India breeds of goats apart from local non-descripts scattered throughout the country.The breeds are described in 5 regions.

1. Himalayan region: Chamba, Gaddi, Kashmiri, Pashmina, Chegu
2. Northern region: Jamnapari, Beetal, Barbari
3. Central Region: Marwari, Mehsana, Zelwadi, Berri, Kathiwari, Sirohi, Jhakrana
4. Southern region: Surti, Deccani, Osmanabadi, Malabari
5. Eastern region: Bengal, Assam hilly breed, Ganjam

Distribution of fibre, meat and milk type breed

Fibre type	Meat type	Milk type
Himalayan, Chegu	Bengal, Assam hill goat, Deccani, Osmanabadi, Jhakrana, Sirohi	Jamanapari, Beetal, Barbari, Marwari, Mehsana, Kutchi, Surti, Malbari

<u>Housing</u>: Housing of goats should be such that they are provided with a dry, comfortable, safe and secure place, free from worms and affording protection from excessive heat and inclement weather. Goats can be kept on elevated, plain pond dyke under wide spread shady trees, when the climate is dry, provided the goats are safe from thieves and predators. Kids are kept under large inverted bamboo baskets until they are old enough to run along with the mother. Male and female kids are kept together. It is worthwhile to design a cheap house for goats. Adequate space, proper ventilation, good drainage, plenty of lights should be taken care of while constructing a house. Goats do not thrive on marshy and swampy ground. Grazing area should be free from pits and shallow pots. Goats contract parasitic infections mainly from such places.

<u>Feeding</u>: Goats are selective with peculiar feeding habits. Some of the common green roughages preferred by Lucerne goats are: Berseem, Napier grass, Green arhar, Cowpea, Soybean, Cabbage, Cauliflower leaves, Mathi, Lettuce are liked by goats. Shrubs and weeds of different kinds, leaves of trees Babool (*Acacia arabica*), Neem (*Azadirachta Indica*), ber (*Ziziphus mauritiana*), tamarind (*Tamarindus indica*); Pipal (*Ficus religiosa*) and mulberry leaves in the form of green leaves and in dried form are relished by goats.

<u>Management</u>: Male goats are raised for meat. They are castrated at the age of 6 months. Castration improves the meat of adult buck. Bucks for breeding are maintained separately. Stall fed bucks are let looses on a large paddock. A well grown buck kid breeds at 6 months to 5-6 does. At 18-24 months breeds 25-30 does. Full mature bucks are bred to 50-60 does. Bucks are mostly sexual in winter and spring. Period between heat varies from 18-21 days. Average gestation period 151 ± 3 days. Goats reach their maximum efficiency at the age of 5-7 years.

<u>Manure</u>: Goat manure is good for soil. The solid excreta of goat is several times richer in nitrogen content and phosphoric acid than cow and buffaloes. Goat urine is equally rich in both nitrogen and potash. It is said that one hectare of land gets sufficient dressing of manure if 4800 goats are kept there

for a night. Goat fish farming has tremendous scope. It is good for the farmers who traditionally keep goats. Goat excreta is in pellet form. It takes sufficient time to decompose. this helps in maintaining the BOD at optimum level further the fishes get sufficient time to consume the edible part of it.

10. POULTRY-FISH SYSTEM

A simple and economically viable system of fish-cum-poultry farming has been developed. Under the system, the poultry droppings of fully built up poultry litter is recycled in the polyculture fish ponds which results in production of 4,500-5000 kg fish. Broiler production give good and immediate returns to the farmers.

The most important factor a farmer should consider before taking up broiler production is to investigate the market conditions, where the product will be sold. There should be steady demand for his chickens, so that all the stock could be disposed of immediately when they are ready for market. Success in broiler production depends mainly on the efficiency of the farmer, his experience, aptitude and ability in the management of the flock. Profitable production of broilers requires the following factors:

Procurement of well-bred stock
Broiler chicks should come from fast growing, well feathering, strain-bred and cross-bred parents to convert feed into meat efficiently in shorter time. They should also have resistance to disease and should have broiler qualities. These chicks are available mostly at commercial broiler hatcheries, and they have to be procured by placing orders with them.

Housing
Efficiency in broiler operation depends on several factors and facilities. The main is poultry housing. Prevention of diseases can be accomplished with good housing. Proper housing reduces mortality and morbidity losses. The broiler house should be built where there is goof ventilation and one should be able to maintain the temperature. Common type houses should be gable type with open sides. Width of the houses should not exceed 0.3 metres (30 feet) in order or effect proper ventilation. Length of the house is usually left to the convenience of the farmer depending on the number of broilers raised giving about 22 to 23 sq. cm. floor space per bird. Height of the house should be about 3 metres. One half to two thirds of the house is covered with wire mesh. Curtains for windows are necessary to combat extremely cold nights and winter months.

Equipment
Hovers made of G.I. metal sheet having 4 electric bulb holders or 3 infra-red bulbs may be used for brooding 250 to 300 chicks. about 30 cm high cardboard or G.I. sheet chick guard is required.

Feeders
G.I. sheet grill type feeders are durable for chicks which are easy to clean and reduces feed wastage. about 8 cm feeding space up to 8 weeks of age should be provided per bird. Two size of feeders are recommended chick size and broiler grower size.

Waterers
Aluminium 2 litre capacity up to 2 weeks of age for 100 chicks and plastic waterers 4 to 5 litres capacity up to 8 weeks of age should be provided. In the beginning a wooden board should be placed below the waterer to avoid spilling of water into the litter and litter falling into waterers.

Management practices
Brooder house should be thoroughly cleaned, and disinfected at least 15 days before chicks are brooded. About 6 to 8 cm dry absorbent litter (paddy husk or saw dust) be spread on the floor. The litter should be covered with 2 to 3 fold newspaper for the first 5 days to prevent chicks eating litter material when they are hungry. At least 12 hours before the chicks arrival, brooder lights should be put on and make sure they are in working condition and required heat is maintained.Use a chick guard to keep the chicks confined to the brooders at least 50 to 60 cm away from the brooders. This may be moved away from the brooder gradually and removed after 8 to 10 days. Few hours before chicks arrive, waterers and feeders should be filled and kept ready at equal distance around the brooder so that the chicks can start drinking and eating immediately. It is advisable to ensure about 18^{o}C temperature for drinking water. Feeders should be kept full for the first few days.

Care of chicks
1. Chicks should be taken to the brooder house immediately when they are received.
2. Chicks are let down under the hover, where there is ample heat and near the feeders and waterers.

3. Watch the chicks for a few minutes whether they find their way to the waterers and feeders.
4. During the first few weeks they should be watched carefully to enable them grow into vogorours, healthy and profitable broilers.

Brood House Management
Brooder temperature should be around 35°C at the edge of the hover i.e. 15 cm from the surface of the litter. This temperature is reduced about 2.5°C per week until the chicks do not require artificial heat i.e. up to 22°C too much heat in the room may result in poor feathering and cannibalisms. If the room is too cool chicks will huddle together under the brooder and will not eat and drink enough to put on weight. Important thing is to keep the brooder house temperature around 23°C to 25°C by covering windows with a plastic sheet during winter or gunny bags during summer months especially during night. The brooders have to be raised as the chicks grow and after 5th or 6th week or age they may gradually be removed.

Floor space
Crowding birds is expensive-death losses from piling up and disease rise. Enough floor space of about 22 to 25 sq cm. should be made good. In cooler season 20 to 22 sq cm. space/bird is ideal.

Feeder space
Birds should not fight to get to feeders. They will eat more when feed is easy to get to. Space the feeders evenly so that chicks do not walk more than 20 to 25 cms.

Water space
Broiler chicks need plenty of fresh water in order to make best use of their feed. Availability of drinking surface is more critical than amount of water in waterers. Hence, several small waterers are better than few large ones. Requirement of floor, watering and feeding space for different age groups on deep litter system.

Period	Floor space 100 birds (sq. Mtr)	No. of waterers/100 chicks	Feeding space/100 birds
0 - 2 weeks		2.50	two 2.50
3 - 6 weeks		5.00	four 4.50
7 - 10 weeks		10.00	six 6.50

Approximate growth rate and feed consumption of broilers

Age weeks	Average weight gm/bird	Daily feed consumption kg/100 birds	Cumulative feed consumption in kg/100 birds	Feed efficiency
1	90	1.2	8.4	0.93
2	200	2.5	25.9	1.30
3	350	4.3	56.0	1.60
4	550	5.6	95.2	1.73
5	750	7.1	144.9	1.93
6	1000	8.1	201.6	2.02
7	1250	9.6	268.8	2.15
8	1500	10.6	343.0	2.28

Light
Broiler house should be so located as to make best use of day light. For which proper lighting pattern has to be followed to encourage the chicks to feed day and night to make them grow fast. even distribution of light should be given over all feeders and waterers. Sometimes dim all night lights are used to prevent crowding.

Litter management
Litter has to be turned quite often after 2 weeks of age. If litter is wet around the waterer it has to be replaced immediately with fresh litter. Damp crusted litter invites trouble from coccidiosis and other litter-borne diseases. When the litter gets moist due to humidity in the rainy season, slaked lime powder or super phosphate may be mixed with the litter at the rate of 1 kg for 10 sq metre area. Litter need not be changed during one brooding period but it should be removed and replaced with clean litter between broods.

Feeding
On the first day broiler chicks are fed with maize grit (broken). From the second to 35 day broiler starter ration 923% protein and 3200 L cal Me/kg) has to be fed, and finally rounded off from 36th to

56th day with broiler finisher (20% protein and 3200 K cal Me/kg). The best way is to administer the feed two or three times in a day by filling 3/4 of the feeders, as more frequent feeding stimulates consumption and reduces feed wastage. Feed should be stored where rats do not get access. Rodents and others would reduce the net return because 60 to 70% of the expenditure goes for the feed cost.

Prevention and control of diseases

Vaccination

Ranikhet - Day old first time with F1 strain vaccine
Fowl pox - Fourth day - pigeon pox vaccination
Cannibalism - If there is pecking slight debeaking may be done otherwise there is no need since birds are disposed off at 6-8 weeks.

Coccodiosis

Coccidiostats like Bifuran or Amprosol or Embasin are being added ad preventative doses in the feed as recommended by drug manufacturers. This disease is usually noticed during 3rd week onwards. In spite of using preventive doses, if any symptom of coccidiosis is seen, immediate medication is a must. The best method of medication is to give coccidiostats in the water other than used earlier in the feed. Codrinol or Amprosol or Sulmet should be given in the drinking water as recommended by the manufacturers.

Integration with fish farming

The waste animals feeds and animal excreta is utilised to increase the biological productivity of water. Probably supplemental feed and fertilisers may not be needed in such a system and the cost on inputs, therefore, may be reduced.

The ponds are prepared and stocked in the same way as in duck-fish farming. The built up poultry litter removed from the poultry sheds is suitable place and is applied to the pond in daily doses @ 40 - 50 kg per hectare per day every morning after sunrise. The application of litter is deferred on the days when algal bloom appears in the pond.

It has been estimated that one tonne of deep litter fertiliser is produced by 25-30 birds in a years time. As such 500-600 birds are adequate to produce manuring for a hectare of water area under polyfish culture.

Problems and recommendations associated with poultry-fish system

Poultry-fish association generally yields very high profit. A comparison of the variable cost of production of broilers, its farm-gate sale price and its retail market price show that farmer’s profit is quite high. the profit from fish culture is much higher than from poultry farming and requires very little investment capital. The association of both further reduces the capital involved in fish farming and make the system more profitable.

The turnover and total profits are both very high for such a small farm and should enable the farmer to make adequate saving, for his working capital, considering his cost and standard of living. To improve the farmer’s living standard, technical assistance is more important than financial assistance. This should include instruction in modern farm management techniques and efficient utilisation of farm resources, such as land, labour and capital. Most of the farms are relatively small scale and produce only small quantities of fish, fowl and other agricultural products mainly for farm-gate sales or low volume sales at local markets. The buyers at the farm-gate are usually local merchants from the area. The farm-gate prices fluctuate in relation to the market prices, but are usually below current market prices by an amount which depends on the quantity of produce, its seasonal availability, and the existing arrangements between farmers and buyers. The larger farms which produce high quantities seems to have a higher bargaining power, which is reflected in the higher farm price that they receive. Large farms, therefore have less marketing problems than smaller ones.

11. UTILISATION OF DOMESTIC SEWAGE FOR AQUACULTURE

Development and pollution are two interrelated processes that have been causing great concern to the planners. With increasing population in the country, the quantities of wastewaters generated have been increasing beyond treatment capacities, apart from a host of industrial effluents in the recent years and solid wastes. Several processes of treatment include the conventional activated sludge and trickling filter methods, oxidation/waste stabilisation ponds, aerated lagoons and variations of anaerobic treatment systems, the latest one being the Upflow Anaerobic Sludge Blanket (UASB) process.

It is increasingly being recognised that sewage is just not a pollutant but also a nutrient resource, as evidenced by about 90 t of nitrogen, 32 t of phosphorous and 55 t of potassium valued at Rs 61million that could be recovered from the country's domestic sewage daily. Traditional practices of recycling sewage through agriculture, horticulture and aquaculture, they being basically biological processes, have been in vogue in several countries. The sewage-fed fish culture of Munich in Germany and Bheries in Calcutta are world-famous. Emphasis on these practices has been on the recovery of nutrients from the wastewaters. Taking culture from these practices and deriving from the new databases in different disciplines of wastewater management, aquaculture is being proposed and standardised as a tool for treatment of domestic sewage. A successful demonstration in related area pertains to treatment of distillery effluents through fish culture in Madras.

Aquaculture for wastewater treatment

Several variations of models of aquaculture for treatment of domestic sewage have been proposed. Employment the biotic components in an aquatic ecosystem that include bacteria, algae, duckweeds, macrophytes and fish/shellfish, the principles of all the models has primarily been dilution, oxidation, reduction of BOD, COD and the suspended solids along with nutrient recovery in terms of biomass. Several food chains operate in these systems, rendering the influent, nutrient-deficient and less harmful to the environments to which they are discharged.

Fish ponds serve as facultative ponds for sewage treatment, also providing oxygen output form to photosynthesising algae and macrophytes. The macrophytes also serve as nutrient pumps, reducing the eutrophication effects that the sewage is likely to cause in the natural waters. It has been demonstrated that the ponding reduces the bacterial loads by 2-3 long units and bacteiophage loads by 3-4 long unit seen at sewage loading of 100 kg COD/ha/day. With no evidence of build-up on the concentration of excreted micro-organisms in pond water with either an increase in organic loading or time, it has been shown that the faecal coliform concentrations reduced by 4 log units within 24 hours of retention in the ponds.

Studies have also shown that about 1 MLD of domestic sewage could be treated over an area of one hectare through water hyacinth reducing the BOD and COD by 89 and 71% respectively, along with removal of nitrogen and phosphorous to extents of 89 and 50%. Aquaculture being a product-oreinted practice, public health concerns are being raised with regard to sustainability of consumption of fish/shellfish from such systems. These pertain to the microbial load of the produce, possibilities of harbouring human pathogens, accumulation of pesticides residues, heavy metals etc. Accordingly, the sewage-fed aquaculture models are being modified with incorporation of plant cultivation prior to application of wastewaters in his fish pond, also followed by necessary deprivation measures.

A new STP model

The new aquaculture model for treatment of domestic sewage established at Cuttack city at Matagapur near Kathojori river integrates the culture of algae, duckweeds and fish/shellfish. The aquaculture system network comprises 18 duckweed ponds (25 m x 8 m x 0.5 m) and two fish culture ponds (50 m x 20 m x 2 m). In addition, two marketing reservoirs (40 m x 20 m x 2 m) are also provided for the depuration and marketing of fish/shellfish produce. The treatment strategy consists of allowing a retention time of two days in duckweed ponds and a further retention time of three days in fish ponds at the second stage of treatment. With a total retention time of 5 days n the integrated culture system, a reduction in BOD levels of the influent to the extent of 60-80% has been observed during different methods.

The system employs the aquaculture components of the highly-priced, protein-aceous blue-green alga, *Spirulina* Sp; duckweed, viz, *Lemna*, *Wolffia*, *Sprirodela* and Azolla; carp species of catla (*Catla catla*), rohu (*Labeo rohita*), Mrigal (*Cirrhinus mrogala*), silver carp (*Hypophathalmichthys molotrix*) and grass carp (*Ctenopharyngodon idella*) and freshwater prawns (*Macrobrachium rosenbergii*) and (*M. malcolmsonii*). The yield rates of different components are 2-3 g/m^2/day for *Spirulina* sp., 75-100 g/m^2/day in case of duckweed and 3-4 t of fish/ha/yr.

It is noteworthy that this model of treatment of treatment of domestic sewage serves the dual purpose of sewage treatment rendering the effluent fit for disposal into river systems as per the prescribed standards and recovery of nutrients into the protein-rich fish flesh. Requiring about one hectare land area for the network of duckweed ponds, fish ponds and marketing reservoir along with the bunds and road for treating 1 MLD of sewage, the process does not have power requirements as in cases of other treatment methods. While the alga, *Spirulina*, and fish/shellfish have ready market for human consumption, the duckweeds produced could be processed as cattle/fish feed as also biofertilisers in agriculture and aquaculture. The model thus envisages a wholesome, integrated, eco-friendly practice for treatment of wastewaters that could be adopted elsewhere in the country, ideally suited for towns with about a lakh human population.

PROBLEMS IN INTEGRATED SYSTEM

Most of the current integrated farms in south east Asia are operated in the traditional way without proper planning, modern technology or modern farm management techniques and rely on personal experience. Marketing is therefore a recurrent problem except in years where demand is sufficient. Fish disease constitute a further major problem with the farmers cannot solve by themselves since they have inadequate experience and knowledge, and such knowledge is not as readily accessible as with other farm animals where feed manufacturers or veterinary supply companies offer services to assist farmers in many cases. A further problem for farmers is the shortage of credit and working capital, which forces them to contact their produce sales to middlemen, usually at unfavourable prices.

FUTURE TRENDS

Fish is relatively cheap and higher in protein content than other animal protein sources. Increase of food supply to cope with the high rate of population increase requires much more than an increase in agricultural land. Land is a limited resource and if more land is used in agriculture, the forestry will soon be reduced to a degree which will be harmful to the environment. Also, the cost of production could rise. Therefore, a method is needed to produce more food from existing agricultural land, and integrated farming offers a possible solution. Integrated farming will probably play a very important role in natural development, as well as in the national economy.

RESEARCH NEEDS

Although integrated farming has now been proved to be highly profitable, its practice remains very limited in scale. This is because the relevant scientific and technological information on diversification of methods is unavailable to farmers. To remedy this, there must be a bridge between the information sources and the farmers, perhaps through extension services. A multidisciplinary approach is needed, including technological, economic, social and political aspects which are interrelated. Any approach must, however, be relevant to national economics, social and environmental conditions and to the farmers need.

Appendices

Nutrient contents (%) of animal faeces

Animal	Organic content	H	P_2O_5	K_2O	Protein
Chicken	50	1.6	1.25	0.90	10.00
Cow	30	0.7	0.30	0.65	4.38
Goat	60	2.7	1.78	2.88	17.31
Horse	60	0.7	0.34	0.53	4.38
Pig	30	1.0	0.75	0.85	6.25
Rabbit	50	2.0	1.33	1.20	12.50
Sheep	60	2.0	0.54	1.54	12.54

Source: Gaddie, E.R. and D.E. Douglas (1975). Earthworm for ecology and profit. Vol. 1, Scientific Earthworm farming, Bookworm publishing company, Ontario, California, USA.

Average Chemical composition (%) of some organic manure

Material	Nitrogen	Phosphorous	Potash
Farm yard manure	0.5 - 1.5	0.4 - 0.8	0.5 - 1.9
Cattle dung and urine	0.6	0.15	0.45
Dried blood	10.0 - 12.0	1.0 - 1.5	0.6 - 0.8
Fish manure	4.0 - 10.0	3.0 - 9.0	0.3 - 1.5

Source: Fertiliser statistics (1988-1989). FAI - New Delhi, 1-91, Dec. 1989.

Nutrient content of fresh poultry droppings

Water	78%
Nitrogen	1%
Phosphoric acid	0.8%
Potash	0.5%

The nutrient content of air dried chicken manure

Nutrients	Cage raising	Ground raising with some dust bedding
Moisture (%)	11.40	12.30
Crude Protein (%)	26.70	21.50
Crude fat (%)	1.76	1.70
Non-nitrogen extract (%)	30.60	30.00
Crude cellulose (%)	13.04	17.20
Minerals (%)	16.50	16.90
Calcium (%)	7.80	1.95
Phosphate (%)	2.20	1.26

One adult chicken produces about 25 kg of compost poultry manure in one year. Thus 40 birds in one year produce one tonne of compost manure. The manure value of chicken manure is better than that of cowdung. The composition of the chicken compost manure is: Nitrogen 3%, Phosphorus 2%, Potash 2%

Nutrient content of sun-dried poultry droppings

Dry matter	88.4%
Crude protein	21.0%
Crude fat	1.9%
Crude Fibre	15.8%
Ash	18.4%