

1. Integrated Farming System

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Abstract

Agriculture plays a vital role in the economy of different developing countries, including India. In India, small and marginal farmers are key positions constituting 85 per cent of the total farmers. Continuous shrinkage in average farm size along with financial constraints for higher investment in agriculture is very prominent to small and marginal farmers. For securing food and nutrition security for the sizable population, productivity enhancement may provide a vital solution. Under this situation, there is very little scope for horizontal expansion of land for food production and vertical expansion is possible by integrating appropriate farming enterprises that require comparatively less area and time to achieve handsome and regular income to farm families. A system approach may be considered as a need of the time for fulfilling the requirement of farm output without disturbing the ecology. An integrated farming system (IFS) seems to be one of the possible solutions in this regard with the stability of income, nutritional security, and sustainability of livelihood for the majority. The farming system approach is not only the best possible way of assuring fairly good productivity with a substantial input economy but also a concept of maintaining ecological balance which ultimately leads to agricultural sustainability. Hence, proper utilization and management of available resources with optimum allocation by IFS is vital to mitigate the risk related to farming sustainability. The present article focuses on the rationale, goal, and integration of different enterprises, along with the advantages of IFS.

Introduction

Indian economy is mainly agrarian, and the prosperity of the nation is highly dependent on the farm output. Agriculture plays a vital role in the economy of the country. Out of the total population in the country, 54.6% is engaged in agriculture and allied activities (Census, 2011) and it contributes 17% to the country's Gross Value Added (GoI, 2017). Small and marginal farmers are a key position in the Indian rural economy, constituting 85% of the total farmers possessing about 44% of the total farmland (GoI, 2014). The average size of operational land holdings has reduced from 2.28 ha in 1970-71 to 1.16 ha in

2010-11 (Kumar et al., 2018). In our country, the holding size of a farm is continuously decreasing. The declining trend of per capita land availability poses a serious challenge to the sustainability and profitability of agriculture (Siddeswaran et al., 2012). Shrinking average farm size in India along with financial constraints for higher investment in agriculture is very prominent because a major portion of farm families belongs to small and marginal categories, further heighten the challenge. For securing food and nutrition security for the sizable population, productivity enhancement may provide a vital solution. This requires proven and scientific agronomic management and the inclusion of the latest technologies that can assure the maximization of the productivity of so-called traditional and existing agricultural systems. In this regard, it should be remembered that input-driven agronomic practices like the assured irrigation, use of chemical pesticides and fertilizers increased farm productivity remarkably during the 1960s onwards but later it was realized that adoption of these technologies created genetic erosion, degradation of agro-ecosystem, vulnerability of the system along with increase in cost of production (Soni et al., 2014). All these adverse impacts ultimately raised a question mark in achieving agricultural sustainability.

Under this situation, there is very little scope for horizontal expansion of land for food production (except the conversion of fallows under cultivation). Therefore, vertical expansion is possible by integrating appropriate farming enterprises that require comparatively less area and time to achieve handsome and regular income to farm families (Gill et al., 2009). In urban and peri-urban areas, vertical farming is catching up to fulfil the requirement of farm-fresh daily requirements. In the post-Green Revolution era, India witnessed deterioration of soil health, increased risk of crop failure, yield plateauing and downward trends in crop productivity (Rahman and Sarkar, 2012). Steady growth in population, urbanization, industrialization and income growth in developing countries like India during the past few decades caused the increasing demand for food of animal origin, while there is an expansion of cropping areas and decline in rangelands.

In these consequences, a system approach may be considered as a need of the hour for fulfilling the requirement of farm output without disturbing the ecology. The integrated farming system seems to be one of the possible solutions in this regard with the stability of income, nutritional security, and sustainability of livelihood for the small and marginal farmers with limited resources. The farming system approach is not only the best possible way of assuring fairly good productivity with a substantial input economy but also a concept of maintaining ecological balance which ultimately leads to agricultural sustainability. Moreover, the resource-poor farmers of the country face so many hurdles to adopt modest technologies. Hence, proper utilization and management of available resources with the optimum allocation of resources is important to mitigate the risk related to farming sustainability. Recently, India

focused to double farmers' income by 2022. As small and marginal landholders are the majority of Indian farmers, emphasis may be given to assure their sustainability. However, the planning and implementation of different enterprises in an integrated farming system in our country lack scientific and systemic approach. Moreover, a proper understanding of interactions and linkages between the components would improve food security.

1. Farming System Approach and Integrated Farming System

The need for Farming Systems Approach (FSA) in the present situation is mainly due to the increased price of agricultural inputs, market price fluctuation of farm produce, risk involvement in crop raising due to climatic abnormalities and other biotic factors. Environmental degradation, depletion in soil fertility and productivity, fragmentation of land holdings are in the acute stage, and these are limiting agricultural production. Food insecurity and poverty are the major challenges for two-third of the world's hungry and poor people. The small and marginal farmers of developing countries who live on subsistence farming generally concentrate only on crop production, that too cereals production with high risks of natural calamity. Due to the failure and abnormality of monsoon, they hardly get sufficient net returns from agriculture to sustain their family (Kumar et al., 2013). The only solution to the problem is to adopt a more holistic, resource-based, client-oriented and interacting approach, popularly known as Integrated Farming System (IFS). Biswas and Singh (2003) defined integrated farming as the integration of two or more enterprises for each farm according to the availability of resources to sustain and satisfy as many necessities of the owner as it is possible which leads to increase productivity per unit area, efficient recycling of farm wastes, better utilization of resources, generate employment, reduce the risks and ensure sustainability.

FSA is a problem-solving approach for the farmer, and it requires a homogenous type of farmers. It is an inter-disciplinary approach that is participatory, and bottoms-up planning commonly depends on the concept of learning by doing with socially desirable technologies.

The farming system is a set of components that are interrelated which interact among themselves and enhance the best farm output. At the centre of the interaction is the farmer exercising control and choice regarding the types of results of interaction with various determinants. The income from crop components alone from the small and marginal farms may not be insufficient at present to sustain the farmers' family as well as the improvement of livelihood. A judicious mix of different enterprises with

agronomic crops should complement the farm income and help in recycling the farm residues and wastes and thus less dependence on off-farm inputs for different farming activities.

Farming systems involve a complex combination of inputs, managed by farming families but influenced by environmental, political, economic, institutional and social factors. IFS is defined as a complex, interrelated matrix of soil, plants, animals, Implements, power, labour capital and other inputs controlled in part by farming families and influenced to varying degrees by political, economic, institutional and social forces that operate at many levels. The farming system, therefore, refers to the farm as an entity of interdependent farming enterprises carried out on the farm. The farm is viewed holistically.

2. Rationale of IFS

The rationale behind IFS is to minimize wastes from the various subsystems and use more of on-farm inputs. Wastes or by-products from different subsystems are used as inputs to other subsystems which can lower the cost of production of the various enterprises in IFS (Gill et al., 2009). At present, there are so many changes in the agrarian scenario of India, where problems like land fragmentation, degradation of natural resources, constraints associated with climate change, increase in the cost of cultivation, volatility in market and so on appeared as major concerns and these ultimately narrowing down the net profit from the farming. The holistic perspective in agricultural use may be a suitable option to combat these. IFS provides an opportunity to increase the economic yield per unit area per unit time by adoption of diversification of crops and integration of allied activities. It not only offers enough scope to nutrient recycling within the system to economize and sustain the system but also minimizes the dependence on off-farm and fossil fuel-based chemical inputs in farming (Ganesan et al., 1999).

Overall IFS fulfills various objectives of making small farmers self-sufficient by ensuring a balanced diet to the family members, employment of family labourers, improving the standard of living through maximizing the total net returns and minimizing the risk and uncertainties and maintaining the ecological balance (Mali et al., 2014 and Kumar et al., 2018). Simultaneous production of crops and different compatible allied activities increases the efficiency of resources and individual activities (Gill et al., 2005).

3. Goals of IFS

Following are the goals of IFS:

- To earn a steady income with regular cash flow and rejuvenation of the system's productivity.

- To achieve agro-ecological balance through application of on-farm inputs (and less reliance on chemicals), maintenance of pests and diseases population dynamics below the economic threshold level, management of cropping system and creation of synergy among enterprises.
- To provide environmentally sustainable and economically viable technology by utilizing local resources.
- To conserve the natural resource base and move towards attaining production sustainability.

4. Integration of enterprises in a farming system

IFS is based on the concept that there will be a minimum waste, and a major portion of waste can become a valuable input for another activity. IFS combined with livestock, aquaculture, agriculture, and agro-industry in a unique synergistic system so that the wastes of one process become the input for other processes. The concepts associated with IFS are practised by numerous small farmers throughout the world and more particularly in developing countries.

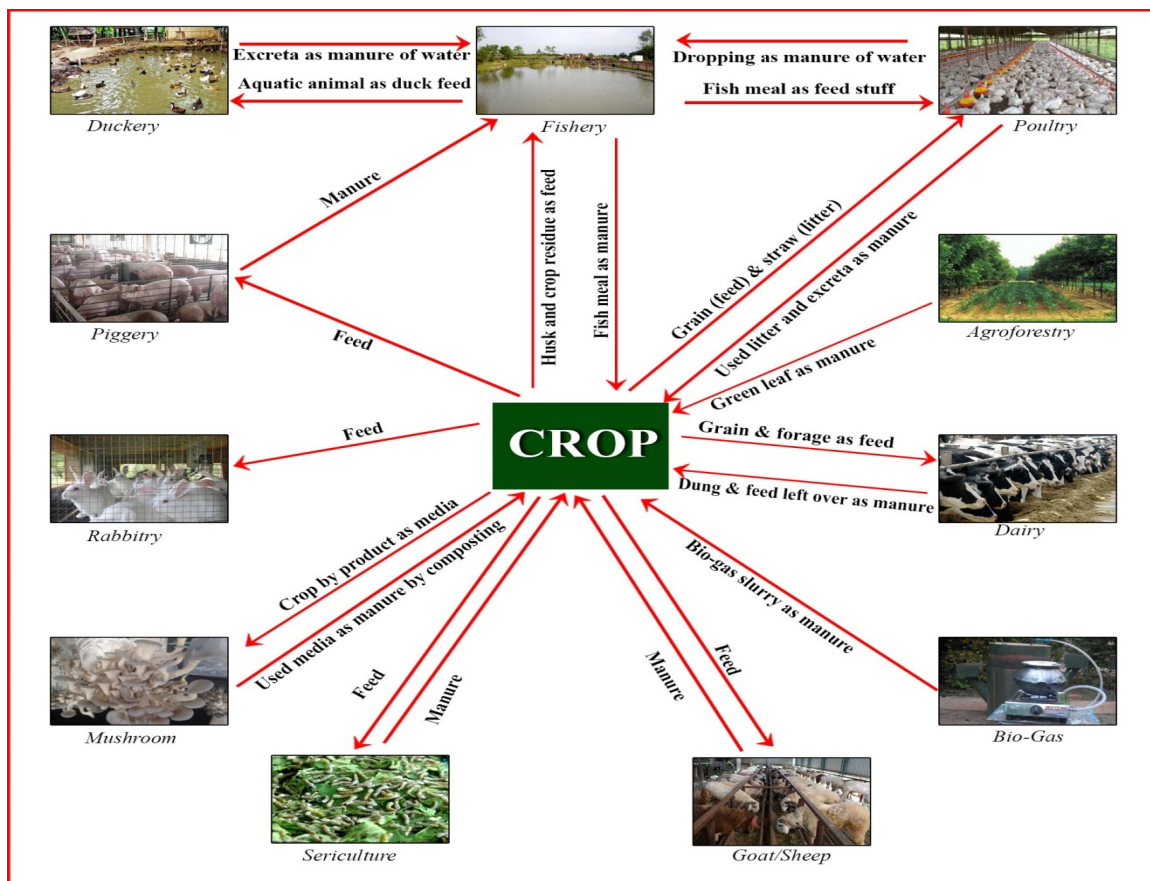


Figure. 1: Integration of different farm enterprises and possible synergy among enterprises

There is a clear difference between mixed farming and integrated farming system. The IFS is comprised of different enterprises that interact ecologically, biologically, spatially and temporally. In other words, it may be stated that these interactions show a maximum level of synergy amongst enterprises. The synergy and interaction among the enterprises are presented in figure 1. In the integrated farming system, different enterprises are included based on farmer's priorities, strategies and resource allocation decisions. An IF is a mix of different farm enterprises in which a farm allocates its resources to utilize these efficiently to attain the goal of the farmer. These farm enterprises are listed below with a brief description.

4.1 Aquaculture

Aquaculture is one of the important options for the lowland ecosystem where fish and other aquatic crops like prawn (*Macrobrachium rosenbergii*), fish, etc. can be included with other enterprises. Diversification is also observed in IFS based on freshwater aquaculture, and some of the examples are as follows.

4.1.1 Paddy-cum-fish

In coastal areas, paddy-cum-fish culture is a common practice in freshwater aquaculture. In low lying areas, deep water paddy is cultivated, and in the field, trenches are made (with a depth of 1.0-1.5m), or in the lower side small pond, the ditch is excavated. The composite culture of Indian major carps like Rahu, mrigel, catla, and exotic carps also like silver carp, grass carp, Cyprinus, etc. are included in the system. Different catfishes (e.g. *Heteropneustes fossilis*, *Clarias batrachus*, *Anabas testudeneus*) also perform well in paddy-cum-fish culture. However, a huge amount of chemical fertilizers and pesticides are generally not used for paddy in this system as these can harm the fishes.

4.1.2 Duck-cum-fish

Integration of freshwater aquaculture and duck farming is another initiative which is very much prevalent in eastern India. The droppings of duck are useful for the development of planktons in water and fishes can get their natural food. In this system, the duck shed is made in one corner of the pond, and a major portion of a shed or entire shed is kept above the water surface as the dropping can fall on the water body. Ducks are allowed in the pond during the day time while these are kept in the shed in the night. In this system, ducks are allowed in pond water during day time, and at night these are kept in the shed. Khaki Campbell and Indian Runner ducks are preferred for rearing in this system. Under the optimum level of management, each Khaki Campbell duck may lay about 150-200 eggs per year whereas Indian Runner can produce about 100 eggs per annum. In the freshwater pond, commonly carp culture is practised, and from one acre of the pond, 1500-2000 kg fish per year may be harvested.

4.1.3 Poultry-cum-fish

Like a duck, poultry shed can be constructed, and it may be either broiler or layer hen. Even backyard poultry rearing is also practised in a poultry-cum-fish system with suitable varieties of poultry such as Aseel, Rhode Island Red, Black Australorp, and Vanaraja. However, in backyard farming the litter output will be less as because the birds are allowed in the shed only during the night, whereas in the captive system the volume of dropping and litter will be more which may increase the fertility of pond water. About 200-300 birds can provide sufficient poultry pens under a captive system to manage the productivity of the fish pond. Five to six batches of broiler poultry can be reared in one year, but layer flocks are kept for one and a half years.

4.1.4 Pig-cum-fish

Pig-cum-fish farming is another option in aquaculture based integrated farming systems. Pig sheds may be constructed on the pond embankment. Manures generated from pigs (faeces and urine) are drained directly into the pond water. Pig excreta not only act as manure but also contain more than 65 per cent digestible food for the fish and fishes consume it. Therefore there will not be the requirement of providing supplementary feed to fishes in this system. 10-15 numbers of pigs can be kept for one acre of the fish pond.

4.2 Animal husbandry

4.2.1 Dairy

Dairy is an imperative allied enterprise that can provide regular cash flow and so it is highly preferred wherever the facilities are available. Among different facilities, availability of feed, green fodder, and better marketing are the critical issues for the success of a dairy unit in any locality. Generally, farmers prefer desi breeds with moderately good productivity or crossbred animals. Desi cow breeds like Gir, Red Sindhi, Sahiwal yield satisfactorily under diverse agro-climatic regions of India, however, cross-bred of Jersey and Holstein Frisian are mostly preferred as these animals can give an average of 6-8 litres of milk per day in a lactation period of 280-300 days under optimum management. Buffalo is another milking animal that is also included in a farm to get milk with a higher fat percentage. Murrah is the most popular breed for rearing in Indian conditions.

In dairy farming, feed cost accounts for about 65-75 per cent of the total cost of production. Therefore, in the farming system, the cultivation of fodder crops should be included as on-farm input to reduce the cost of production of milk. The byproducts of cereals and pulses may also be used as a feed component. Other than feed management, standard operations should be followed in a dairy unit like management of the

health of animal and hygiene of farm, providing comfortable shed to animals, routine medication (for deworming) and vaccination (against deadly diseases like a black quarter, foot and mouth, anthrax, hemorrhagic septicemia). Generally, after 6-7 calving, the aged animal should be culled and new milch animals (of four years old or gave birth of one calve) should be purchased. One of the important advantages of inclusion of dairy as a component of IFS is a better engagement of unutilized work-force or family labourer as the dairy unit requires daily care and management.

4.2.2 Goat rearing

Among different small ruminants, the goat is very popular for meet purposes. Goat is having an advantage as it can thrive on various types of foliage and grasses. Besides, goats are very hardy in nature and less susceptible to different diseases. Among diseases goats may be infected by foot and mouth disease (FMD), Peste-des-Petis Ruminants (PPR), goat pox and these can be managed efficiently by regular vaccination. Barbari, Yamunapari, Beetal, Black Bengal, Sirohi are common breeds of goat which can easily be reared in India under diverse climatic conditions. Meat (chevon) of Black Bengal breed of goat is considered as highly delicious. Generally, the goat is reared by small farmers in the partial backyard method in IFS for the reduction of feed cost. Under an intensive system, less space is required for goat rearing, but stall feeding and supply of concentrated feed enhance the cost of rearing. A female goat of Black Bengal breed generally produces two or more kids at a time and gives birth to kids after every eight months. From the breeds like Yamuna Pari, Beetal, etc. milk is also obtained. Small farmers can maintain about 15-20 goats on the farm under IFS for augmentation of income. Besides, goat manure is also useful for crop cultivation.

4.2.3 Sheep rearing

Sheep rearing is also a profitable enterprise. Chennai Red, Trichi Black, Garole, Marwari, Sahabadi, Muzaffarnagri, Gaddi, Kendrapara are common breeds of sheep preferred by Indian farmers. Like other small ruminants, investment in sheep rearing is less. On a small farm, a flock of 20 females and one ram can be maintained easily. This animal can be reared with poor grazing facilities and marginal farm resources. Manure is obtained from sheep, which is useful in agriculture. It can also be reared for the harvest of wool. Lamb meat (mutton) is having a very good local demand, and so sheep rearing is profitable. Like the goat, PPR is a pernicious disease for sheep. Other abnormalities like blue tongue and malnutrition problems should be solved to make sheep rearing profitable.

4.2.4 Piggery

Pig farming is also a profitable enterprise, and it has popularity among different sections of rural mass. Pig has a high feed conversion ratio which in turn assures a higher return. Generally, pigs can convert 2.5-3.0 kg concentrate feed into 1.0 kg of body weight. Moreover, a female pig can produce 10-16 piglets in each farrowing. For pork purposes, a piglet can attain maturity at 6-7 months.

Piglet mortality is a very common problem in poorly managed farms. Some diseases like piglet anaemia, swine fever, malnutrition may be observed in piggery farms and proper preventive, as well as protective measures, are essential, which include regular health checkup, vaccination, and medication.

To make pig farming a profitable venture, it is obvious to select the right breeds. Among exotic breeds, Yorkshire or Berkshire can be chosen, whereas indigenous breed *Ghungru* also performs well as it has wider adaptability under Indian conditions. Inbreeding must be avoided in a pig farm for assuring steady productivity for a longer period.

4.2.5 Rabbit rearing

Domestic rabbit rearing has got momentum in peri-urban areas as the meat of the rabbit is highly nutritious with low content of cholesterol. Due to the health consciousness of urbanites broiler rabbit farming is catching up in the different parts of the country. In the areas where demand is there, rabbitry can be included as a component in IFS. Rabbit farming is suitable for small farmers, and it can be easily incorporated into IFS as it requires comparatively less shade area than other livestock. It can be reared in cages having two or three stacks with less investment for infrastructure. Soviet Chinchila, Gray Giant, New Zealand white, New Zealand red are some common breeds of rabbit reared in India. Feed management of the rabbit is easy as it feeds on carrot, turnip, leafy vegetables, green fodder and some quantity of concentrate feed. Breeding management is important in rabbit rearing. After every four months, a female rabbit (doe) can give birth (kindling) of three to four kits. In a small farm under IFS, about 20-30 rabbits can be accommodated easily for augmentation of income.

4.3 Avians

4.3.1 Duck

Ducks belong to the birds of the *Anatidae* family. In India, duck farming plays a vital role in the rural economy. They form about 10% of the total poultry population and contribute about 6-7% of the total eggs produced in the country. Duck rearing is very common in the eastern and southern parts of India because of the availability of ponds and coastal regions. However, traditionally the resource-poor farmers

rear indigenous stocks from which less productivity is obtained. These are comparatively harder than chicken and are easily manageable.

Khaki Campbell duck is famous for egg production and while White Pekinis considered for meat. Indian runner duck is also very common in India, but productivity is less than formers breeds. A brief description of Khaki Campbell and White Pekin is given below.

Khaki Campbell: Khaki Campbell is egg-type parent stocks imported from the United Kingdom. These are prolific layers which can give up to 300 eggs per laying cycle. Egg weight varies from 65 to 75 g. These birds are very much suitable for rural India as these have wider adaptability. The ducks weigh about 2 to 2.2 kg and drakes 2.2 to 2.4 kg.

White Pekin: White Pekin is a native of Vietnam, brought to India for meat purpose, and it is also having a wide range of adaptability with suitability to environmental conditions of India. White Pekin is the most popular duck in the world known for table purpose, faster growth rate and excellent meat convertibility. It attains about 2.2 to 2.5 kg of body weight in 42 days of age, with a feed conversion ratio of 1:2.3 to 2.7 kg.

4.3.2 Poultry

India has a long tradition of poultry farming, but there was mainly rearing of backyard poultry during seven decades back. Indigenous chicken constituted a significant share. The laying of *desi* backyard poultry was hardly 60-70 eggs per bird per year. During the past four decades, the poultry scenario in the country has changed dramatically. Today poultry farming is upgraded into an industry with steady growth. The importance of the poultry sector in India is solving the problems of unemployment and under-employment, and in IFS it is augmenting the farm income with regular cash flow. Though there is diversity in food habits amongst Indians, eggs, and chicken are by and large preferred to non-vegetarians. The egg production has gone up to 70 billion, and broiler production has gone to 3.8 million tonnes. Poultry is the most organized sector in animal agriculture with a growth of 6-8% in layers and 10-12% in broilers per year against the growth of agriculture as a whole which is around 2.5%. India is the third-largest egg producer after China and the USA and the fourth-largest chicken producer after China, Brazil, and the USA. The per capita egg consumption is 68, and the chicken is 2.5 kg per year. There are approximately 20 million poultry farmers in India. Robust growth in the poultry output, coupled with future growth potential and favourable socio-economic factors over the last decade makes India one of the fastest-growing world markets in this segment.

For poultry rearing, generally, two systems are followed in our country, namely, cage system and deep litter system. The cage system of rearing birds has been considered as a super intensive system providing

a floor area of 450-525 square cm. Per bird. In cage the birds are kept in one, two or three per cage, arranged in single or double or triple rows. In a cage system, a higher number of birds is reared per unit of area, facilitates proper maintaining of records and clean egg production. Layer poultry birds are generally reared in cage system. However, broiler poultry birds are commonly reared in deep litter system, which is less costly and economically viable. In layer poultry farming, an economically viable unit may be comprised of 2000 flocks; however, for broiler rearing minimum flock size should be with an intake of 200 chicks weekly. Generally, for IFS, broiler is preferred. Some of the farmers also like to adopt backyard poultry in IFS. Under captive farming of poultry, all necessary biosecurity measures are to be adopted along with routine medication and vaccination to reduce disease incidence in the farm and mortality of birds.

Japanese Quail

Quail is a small type of bird that belongs to the Pheasant family, and it was first domesticated in Japan in 1595. The brown-coloured Japanese quail (*Coturnix Coturnix Japonica*) is reared for commercial purposes. Quail was introduced in India in 1974 from California. Quail egg is roughly one-fifth the size of a chicken's egg and weighs around 10g. Nutritionally, the quality of these eggs is at par with that of chicken eggs; rather, they contain less cholesterol. Quails have specific distinct characteristics that made them suitable for both egg as well as meat production as these are of early marketing age (five weeks for meat purposes), early sexual maturity (they require six weeks of age to produce eggs), high rate of lay (about 280 eggs per year) and occupancy of a minimum floor space (eight to 10 birds can be kept in the same space housing a single chicken). Quails can be reared on the floor (deep litter) or in the cages. The space requirement per bird is as follows (Table 1).

Table. 1: Space requirement for Quail rearing

Age (in Weeks)	Space Requirement (square cm/ bird)		Feeding Space (square cm.sq/bird)	Watering Space (square cm.sq/bird)
	Deep litter system*	Cage system		
0-4	75	75	2.0	1.0
5-6	200	150	2.5	1.5
6 onwards	250	175	2.5-3.0	1.5

In deep litter, 6 quails can be reared in one square-foot of floor space. But rearing in a cage system can be done in a confined manner with less space. A cage of 6 feet in length and 1 foot in width may be

subdivided into 6 subunits. To save space, the cages can be arranged upto 6 tiers high (height of 10-12 inches of each tier. There can be 4 to 5 cages in a row. Water troughs are placed at the back of the cages. Commercial egg layers are usually housed in colonies of 10-12 birds per cage. To obtain fertilized eggs, male and female birds are maintained in a proportion of 1:3 respectively. Central Avian Research Institute (CARI) developed some highly productive varieties of quail which are having the following characteristics (Table 2).

Table. 2: Characteristics of different varieties of Quail as developed by CARI

(Adapted from https://icar.org.in/cari/varieties_deve.php)

Characteristics	CARI Uttam	CARI Ujjwal	CARI Pearl	CARI Sweta	CARI Brown	CARI Sunheri
Bodyweight at fourth week (g)	150-155	140	140	135	148-160	-
Body weight at fifth week (g)	240	175	-	155-165	180-185	182
Feed efficiency in the fourth week	2.51	-	-	2.6	-	-
Feed efficiency in the fifth week	2.6	2.8	-	2.7	-	2.8
Daily feed consumption (g)	25-28	25-28	20-25	25	-	-
Hatchability (%)	70-75	65	70-80	50-60	60-65	68

Feed management for quail is very simple. Initially broiler starter feed can be fed. After two to three weeks, farm-made feed can be fed by mixing locally available ingredients. In India, at present commercial feed for quail is not available, one has to specially get it prepared as it should contain about energy of 2800 KCal/ kg with a protein content of 24-28 percent for broiler quails.

4.3 Mushroom

Mushrooms are delicious and choicest foodstuff for vegetarians and all because these are rich in protein with various medicinal properties. Mushroom cultivation is generally considered as an important enterprise in IFS. It is profitable because agricultural wastes are abundant in our country and these are considered as mushroom growing media. Wastes and byproducts of agriculture used for mushroom production are paddy and wheat straw, cotton waste, hulled maize cobs and so on, but paddy and wheat straw are very common growth media. In the case of paddy straw mushroom only paddy straw is chosen as a growing medium. Moreover, after mushroom crop cycle the growing media can further be recycled and composts are made from these.

Basically, cost involvement in mushroom cultivation is very less and it requires a shed. However, vertical proliferation is possible which ensures more production from the unit area. Generally, three types of mushrooms are widely cultivated in India, and these are (i) paddy straw mushroom (*Volvariellavolvacea*; *Volvarielladiplesia*), (ii) oyster mushroom (*Pleurotuscitrinopileatus*; *Pleurotussajorcaju*) and (iii) button mushroom (*Agaricusbisporus*). The different species of mushrooms have a specific requirement for the growing environment (Table 3). The inclusion of mushroom in IFS not only enhances farm income but also assures the supply of nutritious food, engagement of family labour and frequent cash flow and all these are key indicators for livelihood improvement of small farmers.

Table. 3: Growing environment and production efficiency of different mushrooms

(Adopted from Palaniappan and Annadurai., 2014)

Mushroom species	Crop cycle (days)	Temperature requirement (°C)	Humidity requirement(%)	Bio states efficiency (%)
Paddy straw mushroom	24	30-36	80-90	10
Oyster mushroom	35-45	20-35	70-90	25-100
Button mushroom	90	14-15	85-95	25

4.4 Agroforestry

Agroforestry is growing of trees or perennial shrubs around or among crops or in pastureland. By adoption agroforestry, a farmer can get food, fuel or timber and forage to support other enterprises in IFS. The multifunctional agroforestry system is crucial to smallholder farmers and other rural people because it can ensure food supply, income, and health with a wide range of economic, sociocultural, and environmental benefits (FAO, 2019). There are different agroforestry systems which are as follows:

4.5.1 Agri-silviculture system

Agri-silviculture system is the combination of agricultural crops and tree crops. In the interspace between the trees, field crops are grown. Under this system, crops can be grown up to two years in protective irrigated conditions while in rainfed crops up to four years. After the said period canopy of trees will be developed, and the fodder crops can be grown.

4.5.2 Silvipasture system

Trees are planted in the poor, degraded soils, and fodder grass and legume mixtures are being raised in the interspace of trees. The trees should be multipurpose and provide shade, fodder, fuel, drought-tolerant and

leguminous. The land may be considered as grazing area where animals may get the shade of the tree canopy and pastures will be palatable feed to the livestock.

4.5.3 Silvi-Horti-pastoral system

In this system, trees are grown along with fruit trees and in the interspace grass, and legume mixtures are raised.

Now monoculture is out-dated, especially intensive agriculture and system approach can assure sustainability. In this direction, agroforestry may be an integral part of the farming system towards the improvement of livelihood of small and marginal farmers.

4.5 Sericulture (Mulberry)

Sericulture is widely practised in India, and our country is the fifth largest producer of silk in the World. Generally, four types of silkworm are reared, namely, mulberry, tassar, eri, and muga. Out of these, mulberry silkworm rearing is widely practised. Being an eco-friendly, biodegradable and self-sustaining material; silk has assumed special relevance since a long period. *Sericulture* has considerable socio-economic importance in Indian, socio-economy largely due to its suitability for small and marginal farm holdings, self-employment and low investment with high returns. Sericulture offers enough scope for engagement of underutilized familylabour because different activities are involved in it like food-plant cultivation, silkworm rearing, silk reeling and other off-farm activities such as twisting, dyeing, weaving, and printing. Mulberry sericulture has three components, namely, (i) cultivation of food plants of the worms, (ii) rearing of silkworms and (iii) reeling and spinning of silk. The cultivation of mulberry plants is called moriculture. Amongst different cultivated mulberry plant species, *Morus alba*, *M. indica*, *M. serrata* and *M. latifolia* are commercially preferred to the farmers. Mulberry is generally propagated at the farm level by stem cuttings. Cuttings are planted directly in the field or first in nurseries to be transplanted later. After the plants have grown, pruning is carried out routinely, which serves two purposes, induction of growth and sprouting of new shoots.

Generally, a rearing house is required measuring 50 feet x 20 feet x 10 feet to accommodate 200-250 disease-free laying (DFL) which can easily be arranged by a small farmer in IFS. Provision of 3 feet *verandah* surrounding the rearing house is required. Sufficient windows and ventilators are kept for the free circulation of air inside the rearing house, and these windows and ventilators are covered with a nylon net to restrict the entry of uzi flies (a pernicious pest of the silkworm).

Mulberry silkworms are of two types, namely, multivoltine and bivoltine. At present farmers are rearing hybrids. Some common multivoltine hybrids are PM × CSR2, L14 × CSR2 and among bivoltine hybrids, CSR2 × CSR4, FC1 × FC2 (double hybrid) are preferred. Each 100 DFL can produce 60-70 kg cocoons.

The crop cycle is of three to four weeks. Four to six crops can be taken in a year if the mulberry plantation is managed in a staggered manner for supplying feed to silkworm and thus the activity assures regular cash-flow.

5 Advantages of IFS

5.1 Enhancement of productivity

IFS provides an opportunity to increase economic yield per unit area per unit time by virtue of diversification of crop and allied activities.

5.2 Increase in profitability

The system as a whole provides an opportunity to make use of the produce/ waste material/ by-product of one component on another component at the least cost. The reduction of cost of cultivation ultimately increases profitability which leads to a higher benefit-cost ratio.

5.3 Journey towards sustainability

Reliance on on-farm inputs and recycling of wastes reduces the use of chemical inputs in crop production. Further, the creation of healthy crop ecology minimizes the threat from the incidence of pests and diseases, which also decreases the use of plant protection chemicals. Thus IFS provides an opportunity to sustain the potential of production base for a longer time.

5.4 Opportunity of balanced food

In IFS, different components are linked to varied nature, enabling to produce different sources of nutrition, namely, protein, carbohydrates, fat, minerals, and vitamins from the unit area. This provides an opportunity to solve the malnutrition problem of the family members of small and marginal farmers by the creation of the opportunity of a regular supply of balanced food.

5.5 Assurance of environmental safety

The agri-wastes and by-products generated in crop production if ignored these can pollute the environment. However, there is enough scope for proper recycling and making these into composts (Behra and Mahapatra, 1999). These composts not only provide nutrients to the crops but also reduce the use of chemical fertilizers. Maintenance of a healthy ecosystem reduces the chance of pest-disease outbreak, and fewer chemicals are required for plant protection. Thus IFS greatly reduces environmental pollution.

5.6 Surety in regular cash flow

Unlike conventional crop activity where the income is expected only at the time of disposal of the economic produce received after four to fifteen months depending upon the duration of the crop, the IFS provides flow of money to the farmer round the year by way of disposal of products from allied activities like egg, milk, mushroom, honey, and cocoons of silkworm. This will help the resource-poor farmer to manage the different needs of the family and monetary requirement for purchasing of inputs for farming activities.

5.7 Adoption of new technology

In IFS, farmers adopt agriculture and allied activities, and by the adoption of all these, they learn about management technology of these enterprises by hands-on practice and get a skill which was not in practice earlier before the adoption of IFS.

5.8 Saving of energy

In IFS by way of adoption of effective recycling of the organic wastes available biogas can be generated, and dependence of fossil fuel-based energy can be minimized.

5.9 Development of agro-industries

When the production of different components linked in IFS is increased to a commercial level, there will be a surplus for value addition leading to the development of allied agro-industries.

5.10 Provision of employment generation

Combining crops with livestock enterprises would increase the requirement significantly and would help in reducing the problem of underemployment to a great extent. The integrated farming system provides enough scope to employ family labour round the year.

5.11 Increasing input efficiency

The integrated farming system provides a good scope to use the inputs in different components very effectively leading to greater efficiency and benefit-cost ratio.

5.12 Meeting fodder, fuel and timber crisis

As in IFS land area is effectively utilized, and there is a provision to grow perennial fodder legume trees in the borders and watercourses and planting of fuel and timber-producing trees around the farm boundary with or without adoption of agroforestry concept which ultimately will provide fodder, fuel, and timber.

This practice not only helps in supplementing fodder, fuel, and timber but also enriches the soil by fixing the atmospheric nitrogen and carbon sequestration.

5.13 Empowerment of women

Women play a vital role in household management and agricultural operations. There is enough scope to improve household profitability by judiciously utilizing family labour using various household resources through location-specific training, need-based support, and policy intervention (Soni et al., 2014). Social and financial empowerment of women engaged in agriculture can lead the rural population towards a holistic and sustainable.

5.14 Growth in the standard of living of the farmer

As IFS assures balanced and nutritious food, employment generation, regular cash flow and vertical expansion of enterprise in terms of value addition and agro-industries, certainly it creates the potential for growth in standard of living and improvement of livelihood as a whole (Paroda, 2014).

Conclusion

The addition of organic residues helps in improving soil health and thereby fertility and productivity over a longer period in an eco-friendly manner with an increased profit margin. IFS model comprising of crop, dairy, poultry and fishery is the most suitable and efficient farming system model giving the highest system productivity for irrigated agro-ecosystem of northeastern plain zone while suitable IFS model for Indian Central Himalaya region is fishery + poultry + vegetable farming which has considerable potential to provide food security, nutritional benefits, employment generation and assuring more return from small landholdings. In general, IFS enables the agricultural production system sustainable, profitable (3-6 fold) and productive in the long term. About 90-95% of nutritional requirement is self-sustained through resource recycling which curtails the cost of cultivation and increases profit margins and employment (Kumar et al., 2018). The future of Indian agriculture depends significantly on the holistic development of the appropriate farming system as it fits small and resources poor farm families of different agro-climatic conditions and the small and marginal farmer is the major portion of the farming community. The integration is to be designed in such a manner that by-products or wastes generated from one component should be one of the valuable inputs for other enterprises with a high degree of complementary and synergistic effects on farming enterprises (Gill et al., 2009). The challenges associated with present-day farming can be mitigated by the adoption of IFS with a further intervention of enhancement of efficiency and resilience of agriculture in IFS. Further, the up-gradation of technological and social disciplines on a continuous basis and integrated manner will ensure increased production and ecological sustainability

with assured equitability. In conclusion, it may be stated that an IFS is one of the best options for achieving desired profits with sustainable farm output while minimizing the ill effects of intensive farming and creating a healthy agro-ecosystem. There is a need to intensify the agro-climatic region and micro-situation specific research and demonstration of improved technologies with all possible enterprises.

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