Original Research Article

DOUBLING OF SMALL AND MARGINAL FARMERS INCOME THROUGH INTEGRATED FARMING SYSTEMS

Abstract

India is a farming country, and agriculture is the primary source of income for most Indian households. Monocropping is used by the majority of small and marginal farmers. Low yields, low income, a late monsoon, pest and disease concerns, and other risk factors are all linked. Integrated farming systems (IFS), or the integration of many crops and enterprises, are the current day's answer to increasing income. With the growing demand for animal products and the increasing stress on land, it's more important than ever to make sure that feed features, such as grain deposits, are used properly. It is clear that the Integrated Farming System (IFS) focuses on enhancing farmer profitability by improving and integrating properties, reusing wastes, and reducing chemical dependency. One of the changes in farming standards is improvement. Because monocropping entails a high level of risk for a little yield, the issues include low pay and, sometimes, unclear income. Paddy, fish, maize, stew, feed grass, dairy, and poultry are among the efforts undertaken in five areas of the homestead property to aid the enterprise. It has been established that the expansion of agribusiness leads to an increase in farmer efficiency within the development zone, as well as a reduction in human resources. Diversification in the cropping systems and integrated farming systems are very beneficial for enhancing livelihoods and socioeconomic status.

Keywords: Integrated farming system; Diversification in agriculture; Farming systems

Introduction

Agriculture makes a big contribution to the financial growth of India's rural networks and accounts for a large portion of the country's GDP. Despite its recent drop in GDP share, India's agricultural industry remains vital owing to modernisation, which has resulted in a considerable increase in GDP for the government. In this context, a change in the horticultural structure in the legislature is urgently needed to meet the challenges that rural regions face in the changing domestic and global financial landscape, as well as steps to improve farmers' lifestyles.

The Integrated Farming Method (IFS) uses the term "integrated farming" to describe integrated farming as opposed to monocropping. Horticulture, agriculture, animal husbandry, fishing, and other fields are all included. An interconnected collection of enterprises can be used in this IFS system so that unnecessary or waste or output from one section of the system can be used as an input for another, cutting input costs and improving efficiency or income. As a consequence, these programmes work together as a system of systems to reduce waste (Anon 2010; Chakrabarti et al., 2014; Soni et al., 2014; Reddy et al., 2018).

Diversification has been one of the most widely used concepts in reference to agricultural production during the previous decade. Rural growth includes the transformation of assets from a low-esteem item blend to a high-esteem product blend. Horticulture, dairy, poultry, and aquaculture are the main sectors covered. The essence of each crop/livestock production's risks and predicted net returns, as well as how to change them to maximise revenue creation. One solution for the agro-industry is diversification (Reddy et al., 2019). Diversification has traditionally been seen as as a sort of agricultural maintenance in which farmers cultivate a range of crops on their property. During the past decade, diversification has increasingly been used to describe an expansion in the field of high-value crops. Furthermore, value-added crops are one of the most essential techniques to improve crop preparation and boost the agricultural community's earning potential. Crop diversification is therefore quantified in terms of the economic returns of value-added crops, where efficient land and human capital utilisation enhances agricultural productivity. Crop diversification increases global crop output in terms of efficiency, quantity, and economic value under a variety of agro-climatic situations (Reddy et al., 2019). Incorporating India's current rice and wheat planting practises into farming systems may be done in a number of ways. Vegetable planting, floriculture, fruit cultivation, mushroom farming, and medicinal and herbal plant production are all examples of horticulture. Apiary also allows for a wide range of variation, as well as the most effective use of human resources, increased productivity, and environmental protection. In addition, fisheries-based systems such as fish ponds, horticulture/agricultural vines, dairy, poultry, goatery, piggery, and duckeries increase farm revenues while also boosting job opportunities (Reddy et al., 2018; Reddy et al., 2019). This chapter of the book focuses on an interconnected agricultural system, one of which is fisheries, which doubles farmers' revenues.

Horticulture

Population growth is posing new concerns and challenges for Indian agriculture, such as land shortage, water scarcity, air pollution, and urbanisation. These issues put a strain on the development of successful horticulture systems. In India, more than 86 percent of farmers are classified as small and marginal farmers, with land holdings of less than 1.2 hectares. Because of the ever-increasing population and decreasing per capita land availability, there is little room for horizontal horticultural expansion. Natural disasters such as heavy rains, floods, and droughts frequently impact small and farmer farming land, making farming on small farms riskier. Effective use of vertical and horizontal spacing, as well as effective agricultural techniques, are required at this time to assure the farmers' regular revenue creation. Integrated Farming System (IFS) is an effective tool for ensuring income, employment, livelihood and nutritional security in a sustainable manner to the small and marginal farmers (Gururaj et al., 2017).

The productivity of an integrated farming system will be increased while existing resources will be recycled. In the IFS system, a horticulture-based integrated farming system also promotes increased income. Fruit, vegetable, plantation, and flower crop farming all contribute to increased wealth, happiness, regular income, and nutritional security. The many horticultural approaches, particularly with vegetable growing, boost the farming system's increased income and productivity (Kashyap et al., 2015).

In addition to creating jobs, a region-specific horticulture-based agricultural system with a special focus on suitable horticultural crops such as plantation crops, fruit crops, vegetable crops, and flower crops would yield higher production, profitability, and sustainability.

Table 1:Vegetable based integrated farming system for West Godavari district of Andhra Pradesh

Major component	Crops grown	Yield (q)	Cost of cultivation (`in Rs.)	Gross return (`in Rs.)	Net return (in Rs.)	Benefit: cost ratio
Kharif season						
0.3	Marigold	8.25	18750	41,250	22,500	2.2:1

0.2	Okra	15.2	12,000	15,200	3200	1.26:1
Rabi season						
0.3	Cabbage	3000 heads	10,000	23,000	13,000	2.3:1
0.2	Cauliflower	2000 flowers	6000	18,000	12,000	3:1
Summer season						
0.3	Coriander	1000 bundles	3000	9000	6000	3:1
0.2	Okra	13.6	13,500	20,400	6900	1.48:1
Total net profit from 0.5 acre of land in a year					**63,600**	

The production of marigolds and cool-season crops enhanced the socio-economic conditions of the agricultural community, according to (Table 1). Farmers are earning 50,000 to 70,000 dollars from just 0.5 acres of land in 2019-2020, compared to 20,000 to 30,000 dollars from the same amount of land in previous years. It has also been found that vegetable cultivation under the IFS model has grown. Bhardwaj et al. (2014) and Bhardwaj and Nandal (2015) found similar results.

Paddy

Rice is the most widely consumed cereal grain, with more than half of the world's population (most of Asia and Latin America) eating it. Rice farming is best suited to nations and locations with cheap labour costs and abundant rainfall, as it is a labour-intensive crop that needs a lot of water for irrigation. It may, however, be cultivated almost anywhere, even on steep hillsides. Rice straw and other agro-industrial by-products are readily accessible in significant numbers in many agricultural nations following harvest seasons. These farm wastes are used for a variety of purposes, including ruminant feed, mushroom cultivation, fuel (heating, biogas), board or paper manufacture, and organic fertiliser production.

Rice straw is a convenient, economical, and easily accessible form of fodder for ruminants such as buffaloes, cattle, goats, and sheep. During lean months or when good-quality roughages are limited, livestock farmers typically collect and stack rice straw from their rice farm, which subsequently serves as a reserve feed for their animals. Rice straw remains a practical, plentiful, and inexpensive source of fodder for cattle, buffalo, goats, and sheep in places where feed is scarce or where excellent quality forages are scarce. However, the animal's capacity to use and convert nutrients from dietary sources into healthy food products is mostly determined by the availability and quality of fodder provided (Aquino et al. 2020).

Fish culture

Aquaculture sector is increasing at a tremendous pace and generating huge revenue. Effective utilization of resources available within the pond and underutilized water bodies is required to be selected for improvement of aquaculture production. The goal of composite fish culture is to make the most of the pond's resources while also maximising pond productivity (Reddy et al., 2019). Carp polyculture is also useful for increasing output and productivity. Perennial ponds with a size of 0.4 to 1 hectare and a water depth of 2 to 3 meters are preferred for efficient pond production management. Carp cultivation may also be carried out using rainwater collection devices. With a pH of 6.5 to 7.5, loamy or clay loamy soils are ideal. To rectify the pH condition of the soil, apply 200 kg to 1200 kg/ha of quick lime or agricultural lime at 2 to 3 intervals, depending on the pH state of the soil. To rectify the sodic soils, cow dung is mixed with gypsum (CaSO4). Aside from soil management, water quality criteria are crucial throughout the cultivation, since they determine the pond's success. For culture practices, a light green or brown colour is preferred. Aquatic weeds are detrimental to aquaculture activities and can be managed by mechanical removal, chemical, or biological approaches. Predatory and weed fishes can be controlled by using Mahua oil cake (2500-3000 kg/ha), Tea Seed Cake (750-1000 kg/ha), or bleaching powder (300-500 kg/ha), among other methods. Dewatering is always suggested as the best method for removing garbage and predatory fish from tiny ponds (Shyam and Kumar 2001).

Composite culture involving a combination of 6 species, *viz.*,catla (*Catla catla*), silver carp (*Hypophthalmichthys molitrix*), rohu (*Labeo rohita*), grass carp (*Ctenopharyngodon idella*), mrigal (*Cirrhinus mrigala*) and common carp (*Cyprinus carpio*). The surface feeder (catla and silver carp), column feeder (rohu and grass carp), and bottom feeder (mrigal and common carp) with a ratio of 3:4:3, respectively depending upon the water level maintained in the fish pond (Reddy et al., 2019). Weeds control by biological means using herbivorous fishes like grass carp, *Puntius javanicus*, *Puntius punchellus* and Gorami. Stocking density (SD) is assessed by the criteria of species selected, productivity and size of the pond. Generally, the ponds are stocked @ 5000 to 7000 number of fingerlings (10-15 Cm). In zero-point culture, the ponds are stocked with the advanced fingerlings (150 to 250 grams) @ 500-1000 numbers (Ramakrishna et al., 2013). At the time of stocking, fish bath in either 3 % common salt or 3-5% potassium permanganate bath for 15 to 30 seconds will reduce the bacterial infections transferring from one pond to another pond.

Poultry, goat, sheep droppings, cattle manure, vermicompost act as fertilisation for production of natural phyto plankton and zoo plankton. The fishes feed on those plankton.

Usually in integrated farming systems, additional supplementary feed is not required. However, the supplementary feeding like farm made feeds or pelleted feed are to be fed to produces high productivity and more returns and till the fish are reared till it attains table size, weighing more than 700 – 1000 g. (Reddy et al., 2019). Regular monitoring of water quality management during culture practices improves the success of culture. Subsequent accumulation of animal excreta and fish faeces affects the water quality and also leading to slow growth and diseases in fish. Regular sampling of fish at fixed intervals will know the health condition and growth of the fish can be monitored. High stocking density leads to occurrence of diseases. In this scenario, replacement of water with freshwater can solve the issues. Dissolved oxygen (DO) is the critical factor for survival of fish. If the factor increase in stocking density, phytoplankton, and aquatic weeds reduces the DO. Due to this, in the early morning hours before the sun rises, the fishes come to the surface and tries to take the surface. During this time, aeration is required. Aeration in the pond can be done by using the paddle wheel aerator, motor for bring down to upside, using boat motor by disturbing, and using chemicals like calcium oxide in the name of oxygen tablets.

Partial harvesting can be done after 6 months in case of zero-point culture and after 8 months in case of stunted fingerlings and after 10 months in case of fingerlings stocked in the pond. Based on the demand of the fish, the periodical harvesting by using cast net or drag nets. Since, fish attains its marketable size and harvesting of marketing size also reduces the stocking density and pressure in the pond. Release of species once again after harvesting, maintains its ecological balance. The maximum growth was observed in catla, followed by rohu, mrigal, and common carp. The maximum size of catla was attained at final harvest at around 3 kgs. This may be due to the consumption of plankton and feed. Fish production can be obtained @ 5 to 12 tonnes per ha/year. The fish production is dependent on the stocking density and supplementary feeding. The net income from the fish culture is about Rs. 1,20,000 to 2,50,000/- depending of the management practices implemented by the farmers (Reddy et al.,2019).

Integrating aquaculture and rice production is a successful practice for improving water-use efficiency as a management response to increased water scarcity resulting of climate change. It reduces competition for water and other resources and provides additional income and food sources, which provides a small buffer against climate variability (Miao, 2010). Also, the shade provided by the rice plants can keep the water temperature cooler and more amenable for fish production. Since temperature of the water is a significant parameter influencing fish growth and health. Higher water temperatures can have devastating effects

on fish health, with higher incidences of stress and disease and possible mass mortality events. Moreover, high temperatures can decrease the amount of dissolved oxygen in the water. High temperatures can also decrease the feed conversion efficiency of the fish, so that more feed is required to produce the same amount of fish. To combat the effects of temperature increase, farmers can use fish refuges and ditches dug around the perimeter of the pond. These refuges have deeper, cooler water and give the fish a place to shelter during the hottest parts of the day. At the same time, it is essential to choose rice varieties and fish species that are well adapted to local conditions.

Cattle farming

The major agriculture system prevalent in most parts of India is the livestock and crop-based farming system. The combination of crops with livestock on the same farms allows smallholder farmers to diversify income sources and create jobs. Via mutual benefit, crops and livestock complement one another. The animal portion is often raised on farm waste products in the livestock+ crop scheme, while the animal is used to plant the land and provide manure to be used as fertiliser and fuel (Jayanthi et al., 2000). Venkatadri et al. (2008) recorded that 98% of farmers claimed that livestock rearing reduces vulnerability in drought years, 97% of sample respondents reported that farmers in milk developed areas were less suicidal and commercial agriculture in Andhra Pradesh increased suicide rate (96%). Dung includes macro and micro nutrients required for soil fertility and crop growth to be increased. For the processing of biogas, cow dung is used. Renewable, alternative and safe energy sources include biogas (Godi et al., 2013). Alam et al. (2000) announced that the supply of manure was 12 tonnes from a pair of crop-integrated draught cattle. 8 kg of nitrogen, 4 kg of phosphorus and 16 kg of potassium are contained in manure per tonne. Manure application increases the fertility of the soil and the retaining power of precipitation. Where the animals graze under plantations, the cost of weed control is decreased (Kochewad et al., 2017). The findings of Jayanthi (2018) showed that the traditional cropping scheme obtained a net return of Rs. 8422/ and the IFS obtained Rs. 10,913/-. The milk company's net return was Rs. 8987/-. The most significant requirements for a profitable dairy company are the quantity and consistency of feed supplied to the dairy unit (Wanapat et al., 2018). Nirmala et al. (2018) recorded that in care I (fed with paddy straw and natural pasture adlibitum) the average milk output in graded Murrah buffaloes, II (fed with deoiled rice bran-2 kg daily for maintenance and 1 kg / 2 kg milk production along with paddy straw+natural pasture adlibitum) and III

(fed with concentrate feed mixture-2 kg daily for maintenance and 1 kg / 2 kg milk production along with paddy straw+natural pasture adlibitum) The reaction to an increase in milk yield may be attributed to the high protein content present in the enriched feed supplemented by the animals used. Kochewad et al. (2017) recorded that 5-6 adult cattle would provide enough for a pond size of 1 ha. In addition to 9000 kg of milk, the livestock+crop+fish-based farming method will yield between 3000-4000 kg of fish / ha / year. This machine would save labour for the cow dung to be lifted. For an adult cow, the requirement for green and dry fodder is 9-10 and 2-2.2 tonnes respectively and will be satisfied from the crop portion. The compost can be used to improve the soil fertility of the pond. Ponnusamy and Devi (2017) reported that the systems of Crop+Dairy+Poultry+Fishery, Crop+Dairy+Poultry+Horticulture, and Crop+Dairy+Poultry+Sheep and Goat+Horticulture have been found to contribute to higher net income for farm families, as they are interested in profit-oriented farming firms, including fisheries, fruits, flowers, sugarcane, etc. Given their small or medium-sized holdings and small livestock holdings, the study area farmers earned good income from those enterprises because of their intensive management, including the use of family labour.

Duck rearing

The widely beneficial relation between fish and duck is observed since the fish ponds give the duck a splendid disease-free climate. Ducks consume the snails, juvenile frogs, insects etc. In returns the droppings of duck go right into the water and supply the required nutrients for production of plankton. A duck plunges its head up to the base in the deeper zone and disturbs the sand in search of food. This helps in mixing, production of natural food and also acts as natural aerators for increasing the dissolved oxygen content, which is required for fishes and microbial consortia for their sustainability. The ducks waste the feed of about 10-20 % of the given feed. This feed will be consumed by the fishes. Thereby effectively utilisation of feed wastage can be consumed. 500 ducklings can be reared per ha of pond with the average stocking rate of 4 ducks / sqm. Partial shelter and fencing can be done for dry walk of ducks. It is estimated that the 20 to 25 kg of excrement per duck.

Layer ducks are primarily reared, meat and ornamental ducks have also been added lately. Khaki Campbell, otherwise known as Indian runner which is the popular Indian layer duck breed. Khaki Campbell is ideal in most of the places since, it is easily rearing, hard species, availability of free ranging and start laying of eggs after 3 months depending upon the conditions like health condition, proper feeding and environment situations, ducks lays up to

2 to 3 years. Most of the ducks start laying eggs after 6 months of age. The ducks won't lay eggs when they are in the water and usually these lay eggs during nigh time only. It is necessary to keep proper shelter with sufficient paddy straw for collection of eggs without damaging.

Meat consumption purpose, the duck varieties *viz.*,Muscovy, Mule and Aylesbury varieties. These varieties are fast growing and high feed conversion efficiency. Muscovy variety suitable for backyard purpose and the meat is very good with flavour. The average weight attains by males of about 4 to 5 kg, whereas the females are smaller and having 2 to 3 kg. The Mule variety is the product of a cross between the male Muscovy and the female Pekin. It grows quicker than Muscovy and provides a strong yield. Growing of ducks generates an additional income of Rs. 8,886/-. A net benefit of Rs.1,441/- from an area of 0.027 ha was derived from the duck-cum-fish community as a part of the mixed farming scheme. The mixed farming system gained a net additional revenue of Rs.10,327/- over the current cropping system (Ganesan, 1989).

Poultry rearing

Poultry rearing is very well-known practice and each of the rural families are having some sufficient number of birds in their backyard. Depending on the requirement and purpose either meat or egg, the varieties are selected. Many factors like variety, feed, health, environment conditions influence the production and productivity of eggs and meat. The poultry shed can be constructed on the pond dyke or on the side of the dyke where the excreta directly fall into the water or collected using sheets. The housing can be constructed using the locally available materials or the permanent structures. Approximately each bird requires about 1sqm area when they are small and 2 sqm at later stage.

Poultry bird varieties *viz.*,Vanaraja, Srinidhi, Rajasri or kuroiler are the dual-purpose birds for meat and egg and Grama priya, BV-380 is ideal for this integration for egg purpose birds. For one hectare of water distribution area, approximately 500 to 600 birds are expected. After vaccination against infectious diseases and providing other required prophylactic measures to protect against epidemics, about eight-week-old chicks are housed in poultry houses near the pond. Grower mash is supplied to the birds in the Intense Rearing Method between the age of 9-20 weeks @ 50-70 gm / bird / day. Whereas, birds over 20 weeks @ 80-120 gm / bird / day are supplied with layer mash. Nirmala et al (2017b) said that the birds were released for scavenging in the surroundings of the pond and fields from where they fulfilled their feed

requirement under the free-range rearing scheme. The birds generally feed on kitchen waste, earthworms, grasshoppers, ants, green grass, leafy vegetables, seeds, etc. during scavenging. In addition to scavenging, all the participants gave their birds a handful of broken rice, bajra, sorghum, corn, etc. Both the birds are supplied with a sufficient supply of water at all times. Production of eggs starts at the age of 22 weeks and then slowly decreases.

The egg production ranged from 140-200 per year depending on the variety, feeding, health status and environment conditions where the birds are living. The birds are disposed of at the age of 18 months. Karunasree et al (2017) announced that in the case of Vanaraja, Gramapriya and Aseel chicken, the average body weights at 48 weeks of age were registered as 3.22 kg, 2.5 kg and 1.5 kg respectively, and also revealed that egg production for Gramapriya (178) was comparatively higher than Vanaraja (160) followed by Aseel (62) chicken. Fertilization with poultry manure results in the production in one year of 3000-4000 kg of fish, 60,000-100,000 eggs and more than 3,500 kg of meat per year from a hectare of pond. By cultivating tilapia, common carp and murrels with a stocking density of 20,000 fingerlings / ha and a chick density of 4,000 / ha, fish production of 10 tonne / ha could be achieved.

Small ruminants

Sheep and goat rearing are considered to be revenue generated sources for the rural youth and households. Apart from meat and milk, farmers often use their excreta as healthy manure. Each adult goat excretes about 750 g / day and rich in organic biomass, nitrogen, phosphorus, potassium and protein. The urine of goats is also similarly high in both potash and nitrogen. Goat droppings have the benefits of direct application to fish ponds as the size of droppings is around 1.0 cm pellet covered in semi-dried condition with mucus and floats. On the recycling of goat waste, the Rohu and mrigal fish grow healthier. Approximately 3.5 tonnes / ha / yr of fish can be produced by this method without any extra feed and chemical fertiliser.

In India's small and marginal farmers' farming systems, small ruminants are well integrated (Nirmala et al., 2017a). Integrating these industries will improve overall efficiency, preserve ecological equilibrium and resilience in the economy. Ramana et al (2000) recorded that the lambs and children grazed on silvipasture gained at the rate of 54.8 and 36.8 g / head / day in their body weight, while natural grassland showed weight gain of 41.2 and 26.4 g / head / day in the total duration of 478 grazing days, respectively. Nirmala et al. (2017a) recorded that 86.66 percent of goat keepers followed the comprehensive grazing scheme and permitted

their goats to graze on community land and 85.30 percent of respondents had housing facilities mainly during the night to keep the goats.

There was a net income of Rs.25, 400/ ha / year in a sample by combining goat (5 + 1) with crop activity. Rs. 11, 932 ha / year (Kuppusamy 1989) was additional income from the traditional cropping scheme. Dawood et al. (1996) recorded that 66% of the overall IFS revenue was from the crop portion and 17% from the goat segment. The cost-benefit ratio was 2.2, 1.9 and 2.3, respectively, for crops, dairy and goat units. This clearly indicates the viability of rearing goats as a complimentary enterprise to obtain additional economic returns for small farmers in the Cauvery delta district. Therefore, the perfect complementary companies with crop components for the Cauvery delta region farmers will be for the daily flow of revenue, additional job generation and also efficient recycling of waste, dairy and goat units.

Pig farming

Swine farming or pig farming can be combined in the integrated farming systems since the animal housing units can be placed on the bank embankments in such a way that the waste and washing are washed into the pond, pig raising can be fruitfully blended with fish culture. When they develop algal bloom or some other abnormality, a drainage channel is often provided to redirect the excreta away from the ponds. In order to discourage oxygen loss, washings of pigsties are pumped into the pond after sunrise. It is possible to create the pigsties with any inexpensive materials available, but the floor must be cemented with a slope into the pond. A floor space of 1-1.5 m^2 is given for every pig. Based on the pond area, the number of pigs needed would vary. A pond of 1000 m^2 is adequate to fertilise the excreta of three pigs. So, on a pond of 0.1 ha, three pigs may be bred. Two lots of pigs can be raised along with one lot of fish (Tripathi and Sharma 2005) as pigs reach slaughter size within 5-6 months and fish raising of Indian exotic carp is performed for 10-12 months.

At the age of about 8 months, the young female pig reaches puberty and farrows at about 1 year of age. The gestation period is 114 days on average. At the age of about 6 months, pigs enter their final retail condition. Because of the short gestation time, when the temperature, housing and other conditions are favourable, farmers may arrange pig breeding operations to make the pigs farrow. A successful sow can grow 2 litters per year under optimal farming conditions, and can raise 7 or more litters of piglets1. After the age of 7 months, the boars breed and can be dispersed to sows @ 1: 15. At the pace of 3 sows in two days, boars will be permitted to serve. Thus, one may start with a limited number of one or two sows in pig

farming and extend it to a considerable community in about a period of one year. In large and small numbers, pigs may be bred. They need less costly accommodation, less manpower, and from the weaning era (8 weeks) to the marketing age (6 months), the business is versatile. Through feeding 3-3.5 kg of feed, the pig gains 1 kg/ body weight. A cheaper increase of body weight is gained by young animals. Pigs are healthy sources of waste goods such as offal from slaughterhouses, refuse, waste from bakeries and molasses, etc. It is understood that pig manure contains approximately 70 percent digestible fish food and is well suited to integrated fish farming. Since fish feed directly on manure detritus and even products of nutrient release into the system (Yejin et al., 1987), fresh pig manure tends to contribute to faster fish growth than fermented pig manure. The pig dung contains 69-71 percent moisture, 1.36-2 percent nitrogen, 0.36-0.39 percent phosphate, then 16-17 percent protein is fed to the pigs with pig mash.

Azolla

Azolla is a floating water fern and it is a commonly used as bio-fertilizer for paddy crops. In a symbiotic relationship with this fern, blue-green algae (*Anabaena azollae*) emerge and are responsible for the fixation of nitrogen. Of the various species of the genus Azolla, *A. pinnata* is popular. The higher content of crude protein (above 20 percent on the basis of dry matter) and the presence of essential amino acids (high content of lysine) such as vitamins A & B and minerals such as calcium, phosphorus, potassium and magnesium made Azolla a valuable feed supplement for animals, poultry and fish (Nirmala et al., 2017c). For photosynthesis, it requires light and grows well in partial shade. Generally, for its normal growth, Azolla requires 25 to 50 per cent of full sunlight. Water is the essential prerequisite for Azolla's growth and multiplication and is highly susceptible to the lack of water. It is necessary to maintain an appropriate water level (at least 4 inches in the pond). The organisms differ according to their optimum temperature specifications. The optimum, in general, is 20^{o}C to 30^{o}C. The multiplication of Azolla would be seriously affected by temperatures above 37^{o}C. The cultivation of Azolla in the rice field will enhance the species that eat fish. As a result of their swimming, fish farming in rice fields loosens the soil and thereby aerates the soil, increases organic matter decomposition and facilitates the release of nutrients from the soil. Water in rice fields is directly fertilised by the fish excreta, resulting in a rise in the utilizable source of N to the rice crop. In lowland farming, incorporation of allied components such as azolla + fish with rice could provide a broader spectrum of recycling of bioresources (Jayanthi 2018). In addition to the introduction of green leaf manure, rice-rice-azolla + fish

farming with 75 percent suggested N resulted in higher production with enhanced economic returns and improved soil quality by organic residue recycling. In rice-rice-azolla + fish farming with *Sesbania rostrata* incorporation, the quantum of organic residue addition and N added through recycling was higher. There was a greater nutritional value for the unused fish meal, decayed azolla and fish excreta at the bottom of the fish trench, which can be recycled to enrich the soil (Balusamy, 1996).

Ponnusamy and Devi (2017) reported that Crop+Dairy+Poultry+Fishery, Crop+Dairy+Poultry+Horticulture, and Crop+Dairy+Poultry+Sheep and Goat+Horticulture systems were found to contribute a higher net income to the farm families, since they were engaged in profit-oriented farming enterprises, including fisheries, vegetables, flowers, sugarcane, etc. Despite their small or medium holdings and small livestock holding, the farmers in study area earned a good income from such enterprises due to their intensive management, including the use of family labour.

Beekeeping

Beekeeping is an agriculture based enterprise, where farmers can make up for additional income generation. Though, collection of honey from the forests has been in existence over a long period of time, but honey bee keeping has emerged as an income generation activity and make them economically stable even for those who don't have much land for farming. Also, in recent times due to health concerns, there is a increasing market potential for honey and its products which has highlighted bee keeping emerging as a viable enterprise. Among many honey-based products, honey and wax are considered and economically viable products.

Beekeeping is one among the most important agro-based industries which does not require raw material from the artisan like other agriculture sectors. Nectar and pollen from flowers are the raw materials which are abundantly available in nature. Honeybees are one of the important pollination agents which gather nectar from the flowers and convert into honey to store them in the combs of bee hive. Bee keeping can even be started with a single colony. Beekeeping can be adopted as one of the components in Integrated farming systems.

In consideration apairy is to be time saving and much attention is not required, hardly few hours per week to look after the colonies unlike agriculture or animal husbandry for any additional area or input required. Besides this, apiary generated income for sustainability and nutritional security to the rural and tribal families. Since this honey based products like honey, brood and pollen are considered to be high value and protein rich foods. Most of the ayurvedic and traditional medicines, honey is used a main component.

There are four well noted species of honey bees around the world: 1. Rock bee, *Apis dorsata;* 2. Little bee, *Apis florea;* 3. Indian bee, *Apis cerana,* and 4. European bee, *Apis mellifera.* Among these four bees species, *Apis dorsata* and *Apis florea* are wild and are open nesting and cannot be domesticated in modern hives. Each colony of *A. dorsata* produce 30-40 kg of honey per year whereas *A.florea* produce about 500g per colony. *A. cerana* and *A. mellifera* are domesticated in modern hives and are cavity nesting i.e. live in enclosures. Multiple parallel combs were constructed by hive bees while wild bees construct only single comb. The size of the body and comb cell size of the bees varies through a greater extent.

Apis cerana and *A. mellifera* are complementary to one other but have various adaptations. *A cerana* is better adjusted to higher altitude areas. *A.mellifera* is more successful in the plains. The hive consists of floor board, brood chamber, top cover, frames and entrance rod. These parts can easily be separated. The hive may be double or single walled. The single walled hive is light and cheap. The most congenial time for establishing bee keeping in a locality is the arrival of the swarming season. Swarming is a natural tendency of bees to separate their colonies under favourable conditions that are generally beneficial for the survival of both parent colony and the swarm. This occurs during the late spring or early summer. The area/ IFS model should be rich with abundant bee forage crops that provide nectar and pollen. The most important source of nectar and pollen are maize, coconut, cucurbits, guava, cirrus, mango, moringa, banana, sunflower, mustard, lucerne, mustard and sesame etc

Ensure that the bee hives are to be placed near to the field in order to reduce the energy of bees for migration for searching of honey. Italian bees (3 bee hives per ha) and Indian honey bees (5 bee hives per ha) are to be placed near to the field where 10 % flowering is available. Each beehive box should at least 5 to 6 frames having high strength bees with young queen. By placing three *A.mellifera* bee colonies per ha it produces nearly 50 – 60 kg per year and by placing five *A.cerana* bee colonies per ha it produces nearly 25 – 30 kg per year apart from this there is additional benefit of increase in crop yield.

Silvi pasture based farming system

Improved fodder varieties are cultivated on the same piece of land along with annual trees in this scheme. It requires animal feeding and looping tree leaves as animal fodder. This method tackles the lack of green fodder and decreases the expense of feeding livestock with concentrate during the lean time. Improved varieties of fodder, such as fodder sorghum, fodder maize, guinea wheat, napier grass, para grass, stylo, fodder cowpea, berseem, leucerne, hedge leucerne and fodder plants, such as *Leucaena latisiliqua, Bauhinia variegate,*

Albizzia labbek, Albizzaamara, Moringa olerifera, Sesbania sesban, S.grandiflora, Hardwickiabinata, are used in different regions of the country's silvipastoral systems (*Kozzaamara, Moringa olerifera, Sesbania sesban, S.grandiflora, Hardwickiabinata*). Integrated agricultural system, sorghum+cowpea, Leucaena leucocephala+Cenchrusciliaris, Acacia Senegal+ Additional employment of 113 mandays / ha per year in drylands was produced by *Cenchrus ciliaris* with goat integration (Ramasamy et al. 2007).

Ehsanul (2016) stated that animals are supplied with fodder from grass and nitrogen-binding legumes, weeds and seed residues by the mixed crop livestock scheme. Animals graze under trees or on stubble, allowing for crops of draught and compost, while still acting as a savings account. In the above circumstances, the development of Napier grass can play an important role in Bangladesh's mixed farming system. Napier grass 's nutrient value is very high. Harvesting should be performed at least three times in a single year. Farmers can also profit more by selling the grass. Napier grass can satisfy the roughage needs of both local and cross-bred dairy cows quickly. On the terraced embankments of the pond, fodder can be grown and fed to grass carps and animals.

Vermicompost

In fish ponds for natural fish production, fertilisation or manuring is widely practised as it is essential for sustainable aquaculture and to minimise expenditure on costly feeds and fertilisers that make up more than 50 percent of the total cost of input (Oribhabor and Ansa, 2006 & Chakrabarty et al., 2009). Vermicompost is a high-grade nutrient-rich compost of considerable value as a biofertilizer, soil compost. Chakrabarty (2008) reported that the average weight and overall fish yield obtained in the treatment of vermicompost was higher than that of mixed fertiliser and single super phosphate treatment, vermicompost contained remains of the body, and earthworm coconut containing iron (as earthworm produces haemoglobin in its blood serum), protein, growth hormones, etc. for fish production. Ghosh (2004) reported that fish with vermicompost care had a mean weight gain of 1.64 g / individual / day at 15,000 fish / ha density.

Weather and impact on IFS

At present, global warming has been the most critical topic that needs to be tackled. Despite the fact that anthropogenic exercises have exacerbated it by further outflows of ozone depleting chemicals, deforestation and use of petroleum derivatives in a characteristic period. In South Asia (SA), with more prevalent monsoon fluctuations, the effects are increasingly

apparent. In the case of exceptional climate functions, such as heat waves and intense precipitation, there has also been an expansion that dramatically and consequently affects rural development in the food security and livelihoods of various small and limited ranchers. If the flow trends persist until 2050, South Asia's irrigated crop yields are expected to decrease considerably-maize by 17 percent, wheat by 12 percent and rice by 10 percent-due to environmental change prompted water demand.

A multiplication of the present amount of CO_2 in the atmosphere is predicted to result in an expansion of 1.5-4.0 ° C in natural global surface air temperature and improvements in precipitation designs by the end of the 21st century and a mean warming of about 3.1° C by 2050s and about 4.6 ° C by 2080s for Asia (IPCC, 2007). The horizontal expansion of the agricultural region is insane because of industrialization and population growth. In small farms, vertical growth is feasible by integrating suitable agriculture farming systems that require less space and time and guaranteeing farmers with periodic income generation. In this way, the key options for us are to adapt to it, reduce our emission rate and increase carbon sequestration by suitable land use and land use changes such as development of agribusiness and making agriculture, climate smart through location specific integrated farming system in the region.

Through enhancing food security and the work of small and limited ranchers, it would reduce the climatic potential and increase the use of available natural resources and achieve greater productivity. Public trends suggest that the population of non-veggie lovers is expanding over the long term, and similar trends are likely to continue. Interest in domesticated animals and fishery products will also grow in the future. The normal mono harvest or trimming system structure as overarching today is not sufficient to satisfy the nutritional and safe needs of small family units. This can be done clearly by creating a legitimate strategy and a greater extension of the agriculture system.

This can benefit ranchers where one endeavour has been struck by climate caprices such as rain, dry season and considerable precipitation, while ranchers will also produce better pay from various projects due to the extension of usable homestead land that decreases family stress and earns some income during the year that allows to proceed dramatically on troubled occasions board (crop + domesticated animals + fisheries + plants + poultry + plant tree species).

Integrated farming system and weather

The presence of trees guides the temperature and moisture of the soil, facilitates water infiltration during intense precipitation, creates a buffer against fluctuations in the climate and takes into account shifted ecological niches that assist with the presence of different crops. Even though trees have higher transpiration than soils, they can moderate the effects of drought by providing shade to plants and soil below and reduce the evapotranspiration losses. Some trees are designed to draw water from deep soil layers, supply the excess of water to shallow layers of the soil profile and make it available to plants with shallow rooting systems. (Dawson, 1996; Horton and Hart, 1998)

Coordinating the development of aquaculture and rice is an important method for developing water-use efficiency as a management response to the increasing environmental scarcity of water. This decreases competition for water and various resources and results in additional income and sources of food, which creates a little buffer against variability in the climate (Miao, 2010). Similarly, the shade provided by the rice plants will keep the water temperature cooler and more comfortable for the growth of fish. High water temperature is an enormous limit that influences the growth and well-being of fish, with higher stress and disease occurrences and features of mass mortality.

High temperatures will also decrease the amount of oxygen dissolved in the water. High temperatures will also decrease the efficiency of the fish's feed modifications, meaning that more feed is required to produce the same amount of fish. Farmers may use fish asylums and trench burrowed along the side of the pond to combat the impacts of temperature changes. During the hottest periods of the day, these asylums have deeper and cooler water to offer the fish a place to cover. At the same time, the collection of rice varieties and fish species that are highly adapted to local conditions is important.

Concluding remarks

Small and marginal farmers need money from a variety of sources to stay afloat and double their earnings. When compared to monocropping, multiple cropping with diverse cropping systems always yields more income. High-value crops are usually beneficial to farmers as a source of additional revenue. The IFS, on the other hand, are always enriched for production and productivity in order to make the most use of existing resources and market connections.

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