

INTEGRATED FARMING SYSTEM FOR SUSTAINABLE DEVELOPMENT OF SMALL AND MARGINAL FARMERS

An E-booklet

(For all Graduate and Post- Graduate Students and Research Scholars)



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Abstract

Integrated Farming (IF), integrated production or Integrated Farm Management is a whole farm management system which aims to deliver more sustainable agriculture. Integrated Farming combines modern tools and technologies with traditional practices according to a given site and situation, often employing many cultivation techniques in a small growing area. The International Organisation of Biological Control (IOBC) describes integrated farming according to the **UNI 11233-2009 European standard** as a farming system where high quality organic food, feed, fibre and renewable energy are produced by using resources such as soil, water, air and nature as well as regulating factors to farm sustainably and with as few polluting inputs as possible.^[1]

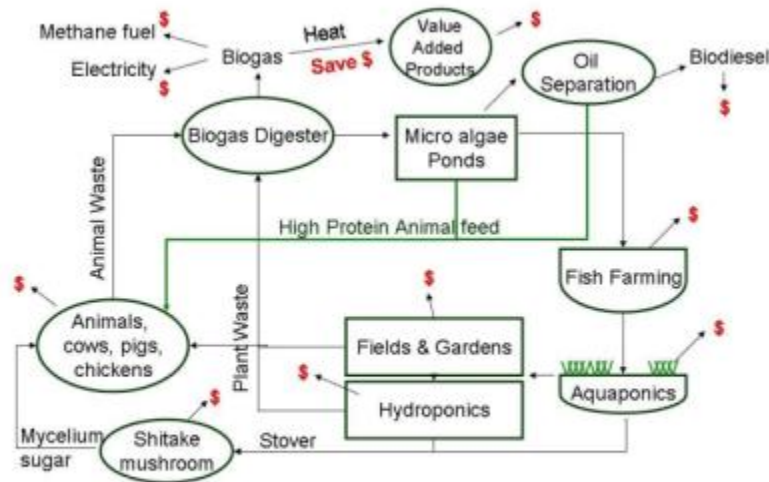
Particular emphasis is placed on an integrated organic management approach looking at the whole Bio farm as a cross-linked unit, on the fundamental role and function of agro-ecosystems, on nutrient cycles, which are balanced and adapted to the demand of the crops, and on health and welfare of all livestock on the farm. Preserving and enhancing soil fertility, maintaining and improving a diverse environment and the adhering to ethical and social criteria are indispensable basic elements. Crop protection takes into account all biological, technical, and chemical methods, which then are balanced carefully with the objective to protect the environment, to maintain profitability of the business and fulfill social requirements.^[2]

European Initiative for Sustainable Development in Agriculture (EISA) has an Integrated Farming Framework,^[3] which provides additional explanations on key aspects of integrated farming. These include: Organisation & Planning, Human & Social Capital, Energy Efficiency, Water Use & Protection, Climate Change & Air Quality, Soil Management, Crop Nutrition, Crop Health & Protection, Animal Husbandry, Health & Welfare, Landscape & Nature Conservation and Waste Management Pollution Control.

LEAF (Linking Environment and Farming)^[4] in the UK promotes a comparable model and defines Integrated Farm Management (IFM) as whole farm business approach that delivers more sustainable farming.^[5] LEAF's Integrated Farm Management consists of nine interrelated sections: Organisation & Planning, Soil Management & Fertility, Crop Health & Protection, Pollution Control & By-Product Management, Animal Husbandry, Energy Efficiency, Water Management, and Landscape & Nature Conservation.

Classification

The Food and Agriculture Organization of the United Nations (FAO) promotes Integrated Pest Management (IPM) as the preferred approach to crop protection and regards it as a pillar of both sustainable intensification of crop production and pesticide risk reduction.^[6] IPM, thus, is one indispensable element of Integrated Crop Management, which in turn is one essential part of the holistic integrated farming approach towards sustainable agriculture.¹



Simple Zero-Waste Agriculture System

Forum des Agriculteurs Responsables Respectueux de l'Environnement (FARRE)^[7] defines a set of common principles and practices to help farmers achieve these goals:

Principles:

- Producing sufficient high quality food, fibre and industrial raw materials
- Meeting the demands of society
- Maintaining a viable farming business
- Caring for the environment
- Sustaining natural resources²

Practices:

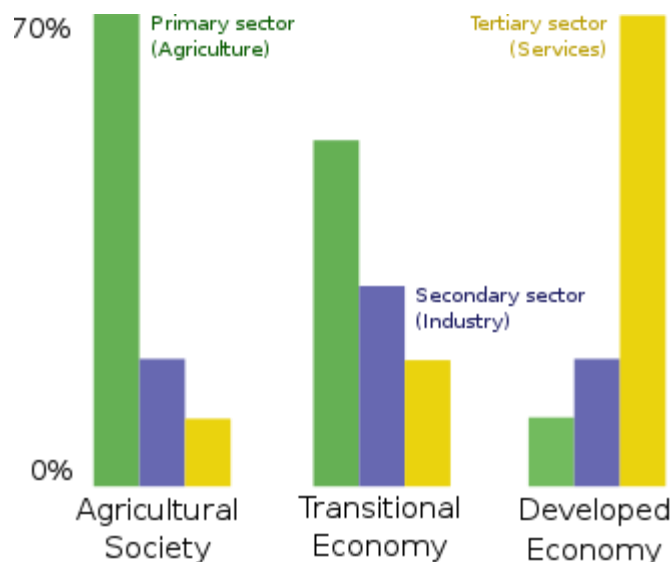
- Organization and management
- Monitoring and auditing
- Crop protection
- Animal husbandry
- Soil and water management
- Crop nutrition
- Energy management
- Waste management and pollution prevention
- Wildlife and landscape management
- Crop rotation and variety choice³

Keller, 1986 (quoted in Lütke Entrup et al., 1998 1) highlights that integrated crop management is not to be understood as compromise between different agricultural production systems. It rather must be understood as production system with a targeted, dynamic and continuous use and development of experiences which were made in the so-called conventional farming. In addition to natural scientific findings, impulses from organic farming are also taken up.⁴

History

Integrated Pest Management can be seen as starting point for a holistic approach to agricultural production. Following the excessive use of crop protection chemicals, first steps in IPM were taken in fruit production at the end of the 1950s. The concept was then further developed globally in all major crops. On the basis of results of the system-oriented IPM

approach, models for integrated crop management were developed. Initially, animal husbandry was not seen as part of such integrated approaches⁵



In the years to follow, various national and regional initiatives and projects were formed. These include LEAF (Linking Environment And Farming) in the UK, FNL (Fördergemeinschaft Nachhaltige Landwirtschaft e.V.)^[8] in Germany, FARRE (Forum des Agriculteurs Responsables Respectueux de l'Environnement)^[7] in France, FILL (Fördergemeinschaft Integrierte Landbewirtschaftung Luxemburg) or OiB (Odling i Balans)^[9] in Sweden. However, there are few if any figures on the uptake of Integrated Farming in the major crops throughout Europe for example, leading to a recommendation by the European Economic and Social Committee in February 2014, that the EU should carry out an in-depth analysis of integrated production in Europe in order to obtain insights into the current situation and potential developments.^[10] There is evidence, however, that between 60 and 80% of pome, stone and soft fruits were grown, controlled and marketed according to "Integrated Production Guidelines" in 1999 already in Germany for example.^[11]

LEAF is a sustainable farming organization established in 1991. LEAF promotes the uptake and knowledge sharing of integrated farm management by the LEAF Network, a series of LEAF demonstration farms and innovation centres. The LEAF Marque System was established in 2003 and is an environmental assurance system recognising more sustainably farmed products. The principles of integrated farm management (IFM) underpin the requirements of LEAF Marque certification, as set out in the LEAF Marque Standard. LEAF Marque is a global system and adopts a whole farm approach, certifying the entire farm business and its products.⁶ In 2019, LEAF Marque businesses were in 29 countries, and 39% of UK fruit and vegetables are grown by LEAF Marque certified businesses.⁷

Animal husbandry and integrated crop management (ICM) often are just two branches of one agricultural enterprise. In modern agriculture, animal husbandry and crop production must be understood as interlinked sectors which cannot be looked at in isolation, as the context of agricultural systems leads to tight interdependencies. Uncoupling animal husbandry from arable production (too high stocking rates) is therefore not considered in accordance with the principles and objectives of integrated farming (Lütke Entrup et al., 1998 1). Accordingly, holistic concepts for integrated farming or integrated farm management such as the EISA Integrated Farming Framework,^[3] and the concept of sustainable agriculture are increasingly developed, promoted and implemented at the global level.⁸

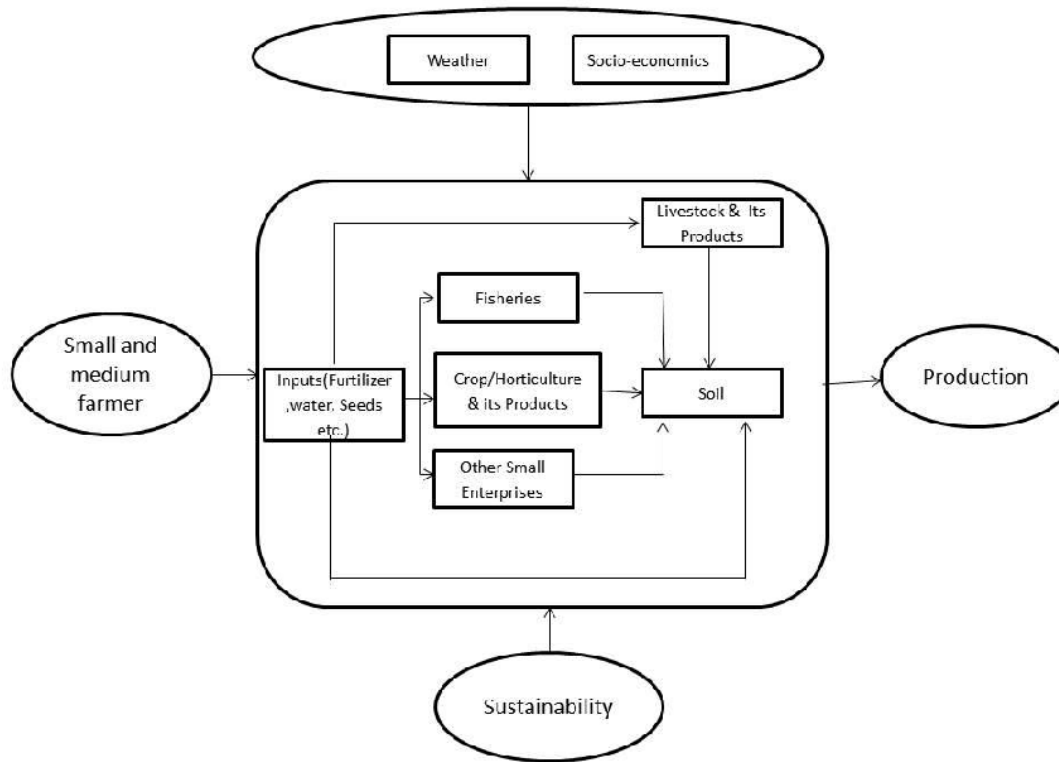


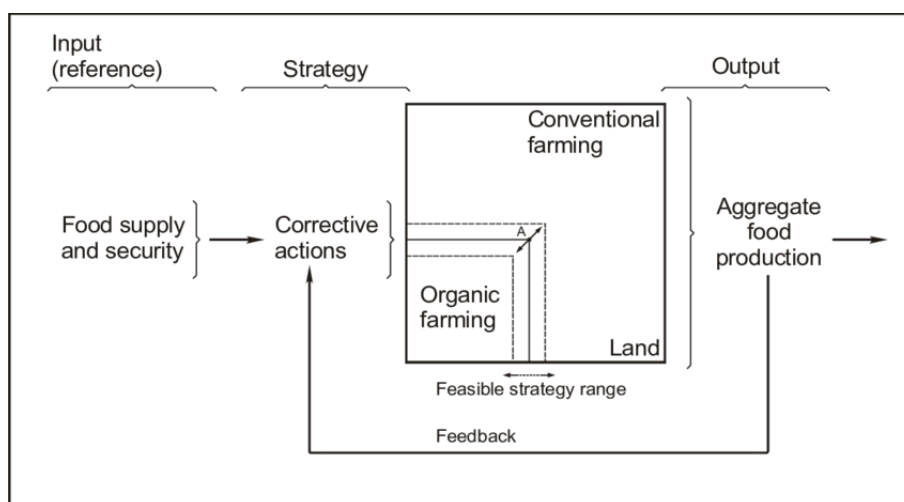
FIGURE 4.1. A SMALL AND MEDIUM FARMER'S PRODUCTION SYSTEM

Related to the 'sustainable intensification' of agriculture,^[12] an objective which in part is discussed controversially, efficiency of resource use becomes increasingly important today. Environmental impacts of agricultural production depend on the efficiency achieved when using natural resources and all other means of production. The input per kg of output, the output per kg of input, and the output achieved per hectare of land—a limited resource in the light of world population growth—are decisive figures for evaluating the efficiency and the environmental impact of agricultural systems.^[13] Efficiency parameters therefore offer important evidence how efficiency and environmental impacts of agriculture can be judged and where improvements can or must be made.⁹

Against this background, documentation as well certification schemes and farm audits such as LEAF Marque^[14] in the UK and 33 other countries throughout the world become more and more important tools to evaluate—and further improve—agricultural practices. Even though being by far more product- or sector-oriented, SAI Platform principles and practices^[15] and GlobalGap^[16] for example, pursue similar approaches.¹⁰

Objectives

Integrated farming is based on attention to detail, continuous improvement and managing all resources available.^[17]



Being bound to sustainable development, the underlying three dimensions economic development, social development and environmental protection are thoroughly considered in the practical implementation of integrated farming. However, the need for profitability is a decisive prerequisite:¹¹ To be sustainable, the system must be profitable, as profits generate the possibility to support all activities outlined in the IF Framework.^[17]

As a management and planning approach, integrated farming includes regular benchmarking of targets set against results achieved. The concept of the EISA Integrated Farming Framework has a clear focus on farmers' awareness of their own performance. By regularly benchmarking their performance, farmers become aware of achievements as well as deficiencies, and by paying attention to detail they can continuously work on improving the whole farming enterprise and their economic performance at the same time:¹² According to findings in UK, reducing fertiliser and chemical inputs to amounts according to the demand of the crops allowed for cost savings in the range of £2,500 – £10,000 per year and per farm.^[18]

Prevalence

Following first developments in the 1950s, various approaches to integrated pest management, integrated crop management, integrated production, and integrated farming were developed worldwide, including Germany, Switzerland, US, Australia, and India.^{[19][20][21][22][23]} As the implementation of integrated farming should be handled according to the given site and situation instead of following strict rules and recipes, the concept is applicable all over the world.¹³

Criticism

Environmental organizations have criticized integrated farming. That is in part due to the fact that there are European Organic Regulations such as (EC) No 834/2007^[24] or the new draft from 2014^[25] but no comparable regulations for integrated farming. Whereas organic farming and the Bio-Siegel [de] in Germany for example are legally protected, EU Commission has not yet considered to start working on a comparable framework or blueprint for integrated farming. When products are marketed as Controlled Integrated Produce, according control mechanisms and quality-labels are not based on national or European directives but are established and handled by private organisations and quality schemes such as LEAF Marque.^[14]



Small and marginal farmers are the core of the Indian rural economy constituting 85% of the total farming community. Integrated farming system (IFS) is recognized as a solution to the continuous increase of demand for food production, providing stability to the income and nutritional security particularly for the small and marginal farmers with limited resources.

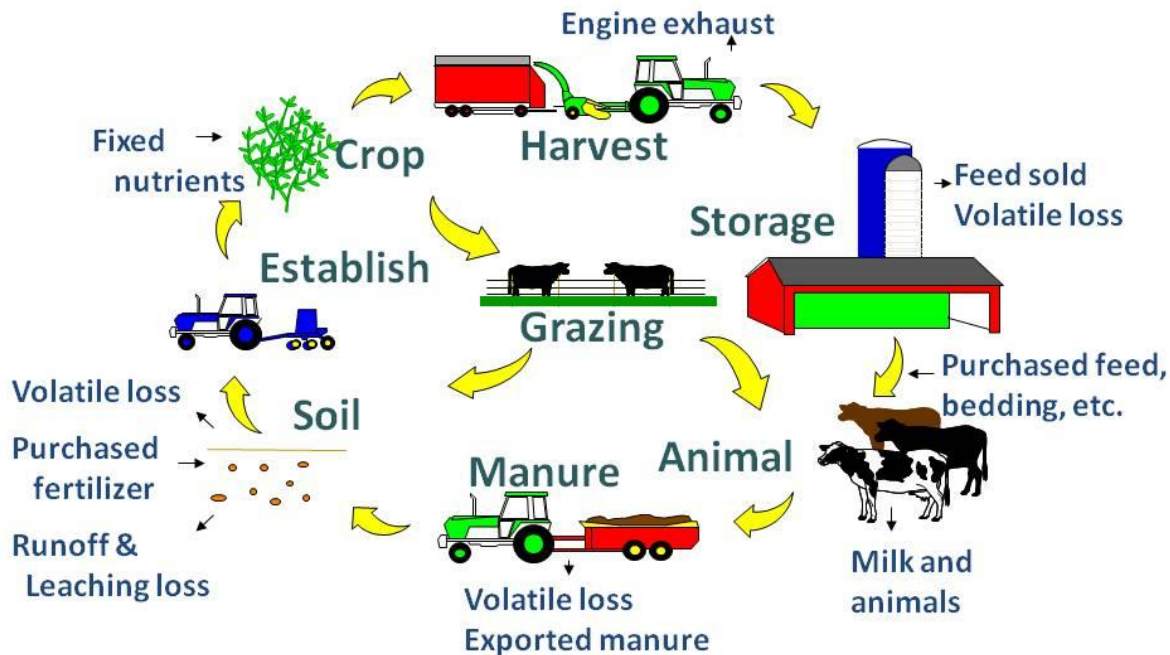
IFS is a mix of farm enterprises such as crop, livestock, aquaculture, poultry, sericulture and agro-forestry to achieve economic and sustained agricultural production through efficient utilization of resources. The principle of IFS model is developed such as wastes generated from one component becomes an input for other system and hence there is efficient recycling of farm and animal wastes in the integrated system. There is increase in yield per unit area through intensification and diversification of crops. Apart from this IFS helps in controlling insect pests and diseases and weeds through natural cropping system management and there is less use of harmful agro-chemicals for farm production.¹⁵

Integrated farming system development model

The IFS model combines various compatible enterprises such as crops (field crops, horticultural crops), agroforestry (agri-silvi culture, agri-horticulture, agri-pastoral, silvi-pastoral, horti-pastoral), livestock (dairy, pigs, poultry, small ruminants), fishery, mushroom and bee culture in a synergistic way so that the wastes of one process become the input for other processes for optimum farm productivity.¹⁶

In an IFS model, the field crops are grown for food production. Horticultural and vegetable crops can also provide 2-3 times more energy production than cereal crops and hence ensure nutritional security and income sustainability in the same piece of land. The crop residues after harvesting can be used for animal feed for dairy and goat production. The animal excreta from the animals can also be utilized as organic fertilizer or vermicomposting which in turn improves the soil fertility and thereby, reduces the use of chemical fertilizers. Again, the animal excreta can be dried, composted or liquid composted for the production of biogas and energy for household use.

The rice based integrated farming comprising of rice and fish in the low land area not only improves the fish production but also increases rice yield as fish improve soil fertility by increasing the availability of nitrogen and phosphorous. When the poultry of duck are raised over the ponds, the dropping are utilized by the fishes as nutrients and hence increases their production. Therefore, crop-fish-poultry farming gave the highest net income with an improvement in soil health than single crop farming.¹⁷



By adoption and integration of various components like vegetables and fruit crops, reduce cost of cultivation and provide nutrients to the household. The IFS comprising of crop, dairy, fishery, horticulture and apiary and mushroom culture also provides employment generation throughout the year.¹⁸

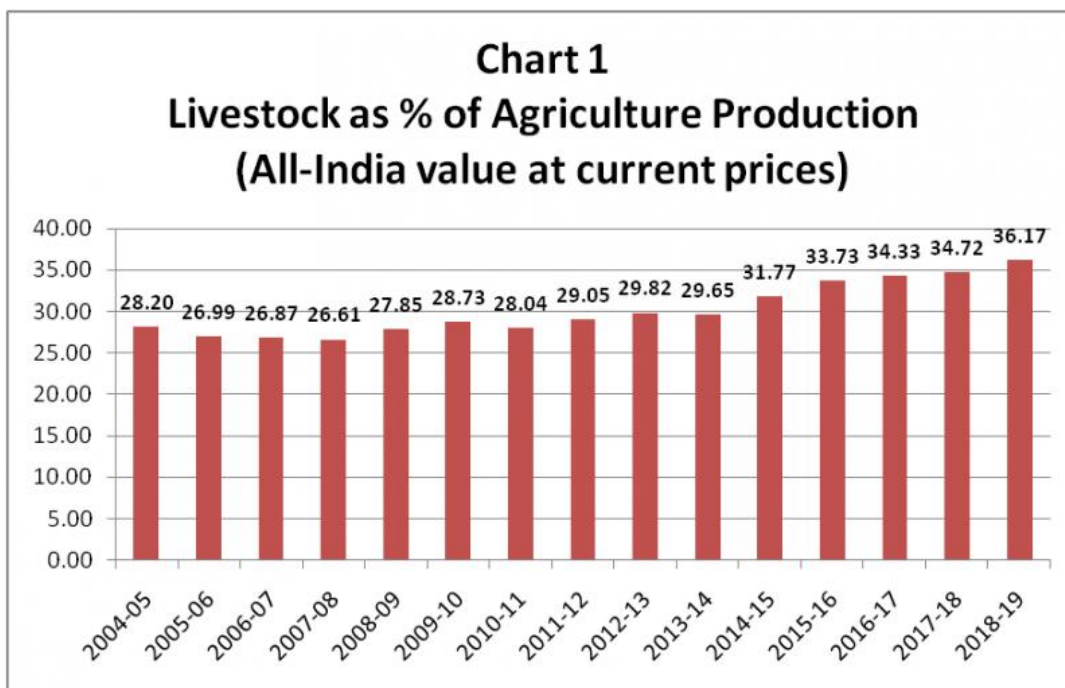
Advantages

- IFS increases productivity per unit area by virtue of intensification of crops and allied enterprises.
- Integration of different production systems provides an opportunity to solve malnutrition problems in our country.
- It improves soil fertility and soil physical structure from appropriate crop rotation and using cover crops and organic compost. It also minimizes the nutrient losses.
- It reduce weeds, insect pests and diseases through appropriate crop rotation.
- There is higher net returns to land and labour resources of the farming family.
- There is also regular stable income through the products like egg, milk, mushroom, vegetables, honey and silkworm cocoons from the linked activities in integrated farming.
- It reduces production cost of components through input recycling from the by-products of allied enterprises. The recycling of wastes for production helps to avoid piling of wates and consequent pollution.¹⁹

In a nutshell, an integrated farming system fulfils the multiple objectives of making farmers self-sufficient by ensuring the family members a balance diet, improving the standard of living through maximizing the total net returns and provide more employment, minimizing the risk and uncertainties and keeping harmony with environment. India has the rich diversity of livestock, poultry, crops and horticulture. Utilization of our national resources efficiently is very much important for sustainable development. Thus, this system of farming is very promising for improving overall farm productivity, profitability, generating employment opportunities, conserving natural resources and maintain the sustainability of agroecosystem by effective recycling the farm by-products and efficient utilization of available resources. Integrating Farming System is the unique approach for overall upliftment of rural community and conserving the natural resources and crop diversity.²⁰

The role of livestock in Indian economy is special one. One fourth of the country's total revenue is come from the Agriculture. Animal husbandry contributes 33 per cent. Livestock farming is livelihood in villages, it removes poverty of

the farmers, helps to improve their economic status. Daily revenue yielding milch cow farming was considered as important profession by the small and marginal farmers. Their milch animals largely depends on plant residues like straw and sorghum stalk, due to this milk production is low.²¹



In integrated farming system, production of Azolla can be utilized for fodder and also as organic fertilizer. In addition to this, Azolla is become a non chemical fertilizer based alternate fodder. Hence, it is suited to all livestock. This can be used as protein rich feed there by we can reduce the production cost.²²

Our Agriculture profession is connected with nature. Our people not only natural lovers in habitat and life style and also they used cow dung, poultry waste and dried leaves are used as fertilizer. This kind of Agriculture provided healthy and wealthy life. But today, synthetic fertilizers are degrading soil fertility. At this point, in integrated farming system with the use of livestock residues panchakavya can be prepared and used for agriculture and fodder crops to minimize disease incidence and growth promoter.²³

In Integrated farming system, agriculture can be integrated with livestock, poultry and fish are maintained at same place to generate employment around the year and also get additional income. For example, same place poultry in upper layer and utilize their excreta. Pigs are in lower layer, residual water from pond was utilized for Agriculture and fodder crops production.²⁴

We can see in lot of villages coconut gardens are intercropped with fodder and allow the livestock and country hens to graze the pasture. The excreta can be recycled as manure for garden as well as forage crops is called as integrated farming.²⁵



Integrated farming system when agriculture was jointly performed with animal husbandry the land, water and plant was fully utilized. Places where one crop in a year, scarcity in irrigation and low rainfall areas, Agriculture practiced with animal husbandry not only gives additional income and employment opportunity to the family members around the year and also livestock excreta utilized as manures lowered the cost of fertilizers. Additional yields from crops. Soil fertility was protected. Crop residues used as livestock feed will reduce the feed cost. In this method agriculture along with fodder and azolla production combined with animal husbandry we will get more benefits. In our country, more than 80 % farmers having a hectare or less than a hectare farm holders like small and marginal farmers. So, small and marginal farmers can cultivate part of their land with fodders like sorghum, maize and forage grass like Co-4 and guinea grass and legumes like Pillepesara and Stylo were fed to animals. Small farmer owning one hectare of land could allocate 0.8 hectares of land for agriculture, and 0.2 hectares of land for fodder production with modern technologies and if followed crop rotation, the returns from agriculture, milk and meat were high and realize more income.²⁶

Fodder production in integrated farming system

In integrated farming system, maintenance of cattles, realize more income; good quality fodder production is essential. Fodder cultivation improves soil fertility and soil water holding capacity. Weeds, non-beneficial plants and sedges growth were restricted. Legume fodder cultivation enriches soil nutrients particularly nitrogen.²⁷ Profitable milk and meat production requires protein rich legume fodders to be fed to the animal husbandry. Cereal and grass fodders are mixed with legume fodders will reduce the cost incurred for concentrate.

Guidelines for fodder production

- In minimum land high yielding forage varieties must be selected.
- Select forage varieties suitable for both irrigated and rainfed condition.
- Based on soil testing forage crops could be cultivated.²⁸

Forage crops can be classified as follows

- Grass fodder

- Grain fodder
- Legume fodder
- Tree fodder²⁹

Grass fodders

Irrigated crops: Cumbu-napier hybrid grass and Guinea grass

Rainfed crops : Kollukattai grass and Deenanath grass³⁰

Grain fodders

Irrigated crops: Forage maize, forage sorghum, Forage cumbu

Rainfed crops: Forage sorghum, Forage cumbu³¹

Legume fodders

Irrigated crops : hedge lucerne, lucerne, cowpea, cluster beans, Soya , centro

Rainfed crops : Hedge lucerne, stylo, Desmanthes, Ciratro, sangu pushpam

Short term crops: Pigeon pea, horse gram, lablab, cowpea, cluster beans³²

Fodder seeds, seedlings and fodder cuttings could be purchased at stations of Tamil Nadu Veterinary and Animal Sciences University

1. Veterinary Research Institute, kattuppakkam, Kancheepuram District, Phone: 044-27452224
2. Agriculture Information Technology Center, kattuppakkam, Kanchipuram district. Phone: 044-27452371.
3. Mecherry Goat varieties Research Institute, Pottaneri, Salem District. Phone: 04298-262023.
4. Goat Breeding and Research Centre, Santinalla, Ooty, Phone: 0423-2253089
5. Veterinary Research Institute, Namakkal. Phone: 04286-266491
6. Veterinary Research Institute, Thanjavur. Phone: 04372-234011
7. Veterinary Research Institute, Tirunelveli. Phone: 0462-2336345
8. Krishi Vigyan Kendra, Kunrakkuti, Sivaganga district. Phone: 04577-264288
9. Agricultural Science Institute, Namakkal. Phone: 04286-266345
10. Tamil Nadu Veterinary and Animal Sciences University Research Farm, Madhavaram - Chennai - 51. Phone: 044-25551571

Also,

11. Forage crops, Tamil Nadu Agricultural University, Coimbatore. Phone: 0422- 6611210.

12. Forage production and demonstration Regional Station, Avadi (Alamathy)post, cattle-ranching way, Senkundram, Chennai - 52, Phone: 044-26310360

Approaching these stations you can buy forage seeds and cuttings.

Alternate fodder

Azolla: Presently, due to low rainfall and decline in cultivable land if alternate fodder was used as feed it can reduce fodder scarcity and cost. Azolla is a chemical fertilizer free alternate fodder, which is a balanced feed for all varieties of cattles.³³



Ingredients added in livestock feed grain forages such as Maize, Cumbu, Sorghum and ingredients for the preparation of concentrates like oilseeds price hike caused increasing livestock and poultry feed cost increasing day by day. The protein rich Azolla can be used as regular alternate feed for livestock and poultry we can significantly reduce the production. It has been used as best natural fertilizer for rice.³⁴

Nutrients in Azolla: Azolla contains 25-30% protein, 14-15% fiber, 3-4% fat, 45-50% carbohydrates, minerals and many micronutrients were available.

Production Methods

- More shallow standing water ponds, paddy / rice nursery
- Cement tanks.
- Silpanulin seat spreaded cavity method³⁵

Cement tank method

10 feet long, 2 feet wide and 1 feet deep concrete tank spread with 25-30 kg of soil with this mix 5 kg of decomposed dung, with this soils of gravel quarry or well soil @ 100g could be added. Keep the water level up to 5 cm. in this add 5 kg of Azolla within two weeks we can collect 35-40 kg Azolla. Once in ten days pour the cow dung slurry.³⁶

Azolla as biofertilizer

It had ability to fix atmospheric nitrogen. It contains 4.5% nitrogen. For paddy it can be added @ 200 kg per acre. It gives nitrogen source to the crop and 15-20% yield also increased.³⁷

Feeding cattle

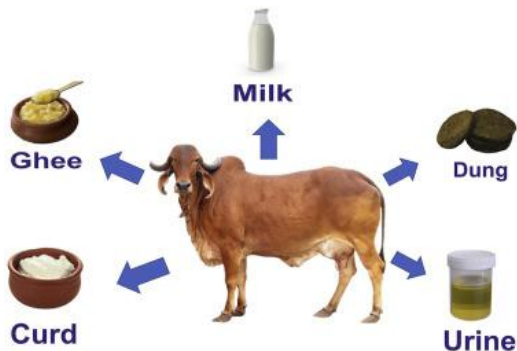
Production of 1 kg Azolla costs about 0.75 paise only. When Azolla is used as feed it could be mixed 1:1 proportion with concentrates and fed to the cattles. After familiar with this, mulching cows will started to consume Azolla alone. One kg of Azolla equal to 1 kg of oil cake. For mulching cows 1-1.5 kg, white pigs 1-1.5 kg, Goat 300-500 grams, Rabbits 100 grams and 25-30 grams of Azolla for chickens might be given to these animals.³⁸

Approximately 15-20% increase in milk production in dairy cows, in addition to this increase in cholesterol and also cholesterol free solids enhanced the milk quality. Azolla feeding chickens showed increase in body weight and size of the

egg. Further, egg yolk seems to be dark in colour. So production of Azolla under Integrated farming system is not only gives income and also protect the environment.³⁹

Panchakavya

In integrated farming system, Panchakavya prepared from milch cows products, clean the environment, fodder and agricultural crops could be protected from spraying of pesticides.



Panchakavyam means it includes five components in naturally produced. Maximize the benefits of Panchakavya, mix cow's milk, curd, ghee, cow dung and urine with this sugar cane juice, coconut water, riped fruit and fermented grapes also to be added in the preparation of Panchakavya.⁴⁰

Materials needed

1. Fresh cow dung - 5 kg
2. Cow's urine - 3 litres
3. Cow's milk - 2 litres
4. Cow's curd - 2 litres
5. Cow's Ghee - 1 litre
6. Sugarcane juice - 3 litres
7. Coconut water - 3 litres
8. Kal or fermented grape juice - 2 litres
9. Riped bananas - 12

Procedure: 5 kg of dung added with 1 litre ghee in a plastic bucket or pot or cement tub and it should be well mixed. Above mixture has to be stirred 2 to 3 times daily for 3 days and should be mixed. Due to stirring daily, methane gas discharged and enhanced fermentation property of cow dung. In addition to this increased its uses and medicinal properties. At any cost don't use metals. With the above mixture of cow dung and ghee add other components and mix it well. The mixture was stirred 2 to 3 times daily. The vessel should be kept open. If the flies are coming cover the vessel with mosquito net with aeration. After 20 days later, it is suitable for usage. For the production of one litre it costs about Rs. 18 to 20.⁴¹

Uses: Panchakavya can be used in Agriculture and fodder crops to control diseases and as growth promoter.

In chickens it was added @ 7.5 g / Kg instead of Antibiotics enhanced body weight than other hens. It was also used as growth promoter for chickens.

Globally, the demand for livestock products has been increasing day by day. To meet out this livestock productivity should be increased in manifold. Livestock not only play a key role in to meet out food demand and also poverty elimination and economic upliftment and there is no doubt on this. So integrated farming system agriculture crops integrated with livestock, poultry and fish farming with the production of fodder, Azolla, Panchakavya like environment friendly pesticides are used means it increased livestock productivity. The improvement in standard of living of the farm holders, there is no doubt back bone of our nation i.e. rural economy will also flourish.⁴²

Exemplification that IFS improves tribal (small and marginal) farmer’s livelihood

Traditional shifting cultivation (*jhum*) practiced in the undulated topography of the Lusei hills often results in loss of soil fertility, disruption of ecosystem services, degradation of natural resources and lower crop productivity. Shifting cultivation is the backbone of rural economy and farmers’ livelihood in Mizoram, as an indispensable part of cultural Mizo ethnicity.⁴³ The *jhum* agro-ecosystem evolved as the maximum degree of crop diversification, dominated mostly by traditional long duration, low yielder crop cultivars.



Jhum cultivation

Moreover, increasing population pressure brought down the *jhum* cycle from 25 years to 5-6 years. Integrated Farming System (IFS) is the potential alternative for the Mizo farmers in order to enhance ecosystem service and reduction in natural resource degradation. ICAR Research Complex for NEH Region, Mizoram center, Kolasib established model rice based IFS under contrasting land form at Kolasib district, Mizoram under Tribal Sub Plan (TSP). The contrasting landforms belong to Mr. Lalsangkhima (24°20'22" N, 92°41'03" E) and Mrs. Lalhmingmawii (24°01'26" N, 92°40'32" E); both of them were adapted for technology demonstration on rice based IFS for the farmers at Kolasib district with proper supervision from the ICAR Research Complex for NEH Region, Mizoram Centre (Kolasib).⁴⁴

Rainfed *jhum* farming with subsistent small scale kitchen gardening on vegetables during winter months was predominant practice for both the farmers till 2016. Fingerlings of Common carp, grass carp were provided periodically from 2016-17 to 2020-21. Irrigation infrastructure were developed with HDPE pipe networking, renovation of ponds and excavation of *jalkund* (20000 L). Native grass species viz. broom grass, congo signal, hybrid napier and guinea grass were used for slop stabilization, restriction of soil erosion and to ensure the year around fodder supply. With the establishment of model IFS, system based rice equivalent yield increased for Mr. Lalsangkhima (424.4 t ha⁻¹ against 59.9 t ha⁻¹, as initial) and Mrs. Lalhmingmawii (435.7 t ha⁻¹ against 77.8 t ha⁻¹, as initial). Most of the inputs/byproducts were recycled through either aerobic composting or vermicomposting (combined contribution 25.98%), with integrated use of supplementary chemical fertilizers (N, P₂O₅ and K₂O; 74.02%). The animal rearing component was mostly relied on traditional on-farm availability

of fodder and kitchen wastes with need based use of mineral mixture and other feed supplements. After five years of ICAR-NEH Mizoram center intervention, cumulative benefit cost ratio (B: C ratio) was increased from 0.93 to 3.20 for Mr. Lalsangkhima (Employment generation: 304 to 3404 man days) and 1.22 to 3.65 for Mrs. Lalhmingmawii (Employment generation: 450 to 3600 man days). Inclusion of diversified animal components (pig, cow, poultry and fishery) resulted in the sharp rise in farmers' income over the period of our study (2017-2021). In courtesy, Cumulative Land Utilization Index (CLUI) was hiked by ~1.4 times for both of them with large scale adaptation of high yielding short duration agricultural and horticultural crop varieties with more areas under irrigated intensified cropping systems⁴⁵

Mrs. Lalhmingmawii completely shifted from practicing rainfed *jhum* cultivation to settle cultivation into arechanut and banana orchard establishment in steep hilly landform with irrigated farming after land development (terracing). Initially, there were very limited scopes for cultivation. With the intervention of ICAR RC NEHR Mizoram center under TSP project, her irrigation water supply channels were built up for applying supplemental irrigation in orchards during non-rainy months and additional scope on winter vegetable cultivation. Before 2016-17, she practiced *rainfed* wet land rice culture (170-180 days) followed by local leafy vegetable system (after rice residue burning at subsistent level;⁴⁶



Rainfed wetland rice culture

duration-30 days) during mid-May to early December. After TSP programme implementation, the long duration traditional rice varieties were replaced by Gomati (duration 130 days; June-mid October). Unlike previous years, the left over fallow period after wetland rice culture were utilized for commercial winter vegetable cultivation (November to February), followed by hybrid sweet corn culture in summer months (mid-March-May) under TSP. In courtesy, Mr. Lalsangkhima practiced long duration local wetland rice (duration 170-180 days) followed by winter fallow before 2016-17 in flat land configuration. Under Tribal Sub Plan, ICAR-NEH demonstrated vegetable cultivation during winter (crucifers and tomato/brinjal) and summer (cowpea/ okra) months.⁴⁷ Thus, 300% cropping intensity were achieved for both the circumstances. Moreover, introduction of improved animal breeds like the Hampshire crossbred pig and Vanrajapoultry rearing in rural backyards secured higher profitability for both the established IFS model.⁴⁸



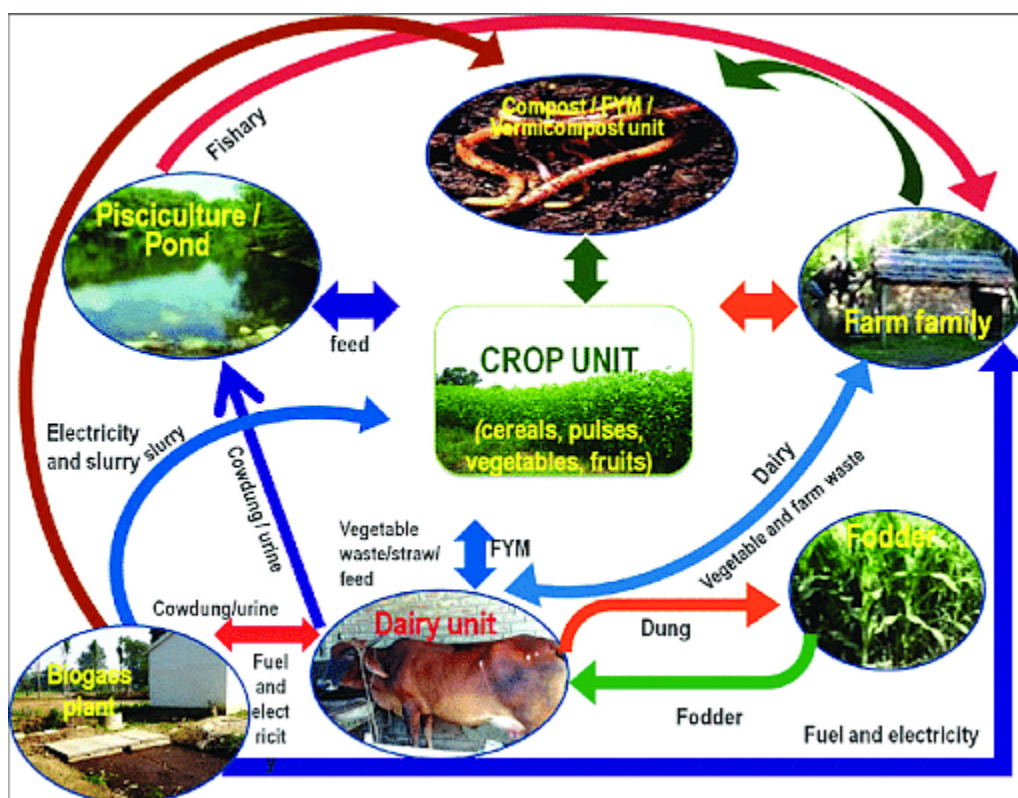
Gradually both of them became model farmers in their respective villages after ICAR NEH Mizoram center interventions with contrasting landform at Kolasib district, Mizoram. Supportive capacity building programme were also organized to sensitize the other neighboring villagers for further replication of the tested IFS models. Hence, the positive impact of resource recycling in hilly agro-ecosystems through IFS system establishment benefited the *Lusei* tribes of Mizoram.⁴⁹

IFS Program

Government of Odisha launched a "Special programme for promotion of integrated farming (SPPIF) in tribal areas" in 40 GPs in 2016 with focus on rainfed production systems targeting Agriculture, Horticulture, Livestock, and Fisheries in an area based approach in Malkangiri District. ATMA is the district level nodal agency for SPPIF. Directorate of Agriculture & Food Production (DA&FP) is the state level nodal agency. Project is implemented by FPOs with support of NGOs at cluster level (10 GPs), State Secretariat (NCDS & WASSAN), ATMA and Directorate of Agriculture & Food Production, Odisha as per the guidelines of SPPIF.⁵⁰

Specification in the IFS program

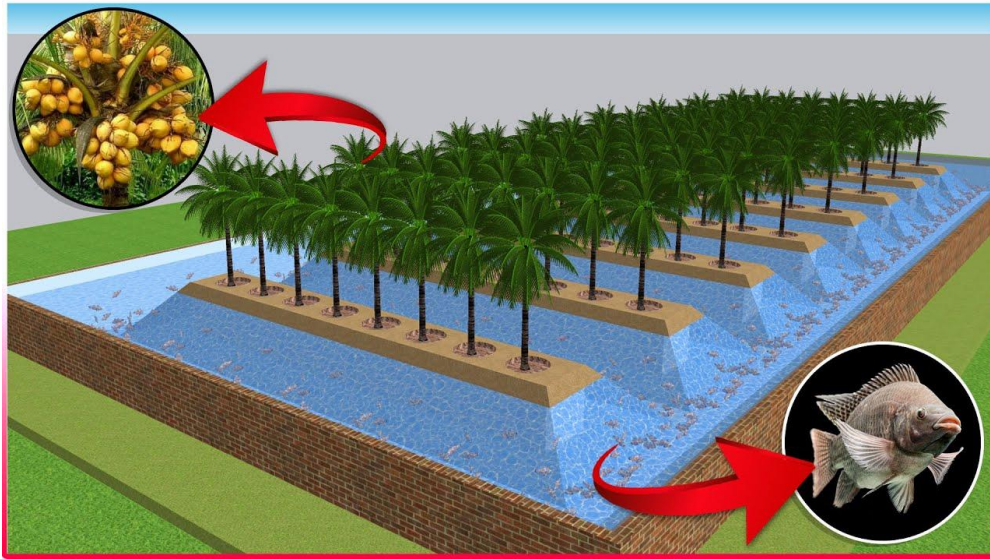
Integrated farming (also known as mixed farming) is a farming system with simultaneous activities involving crop and animal. The main purpose of integrated farming is so that the farming components support one another; hence, reducing external inputs.⁵¹ For instance, the crop can provide as animal feed/fodder for the livestock, and the livestock as fertilizer (manure) for the crop. Some livestock can also act as weedcontrol by foraging on the weeds. A very good example of a successful integrated farming system is the CIPAV system, developed by the Foundation Center for the Investigation in Sustainable Systems of Agricultural Production (CIPAV). This system typifies the success of integrating and using local natural resources to produce several commodities.⁵²



The system consists of the simultaneous cultivation of sugar cane, food crops (like corn or rice) and tree fodder (trees or shrubs used for animal feed), together with the raising of sheep, pigs, ducks and fish. The system works by minimising external inputs so that each component in the CIPAV system sustains one another. Essentially, the crop residues serve as feed to the livestock and fish, and in turn, the wastes from the livestock and fish serve as fertiliser to the crops. Moreover, their wastes, together with crop residues, are digested in a biodigester to produce fuel for household cooking and electricity. This mixed farming system recycles all wastes so that little is thrown away: one's waste is indeed another's food. This system reduces dependency on fossil fuels because of its self-sufficient system means little external input is required; in fact, by being able to generate its own fuel from wastes means even less dependency on fossil fuels. Another example of integrated farming systems is rice-fish culture.⁵³

Coconut-based integrated farming could help sequester carbon, improve farm productivity

Coconut-based integrated farming, which allows for other agricultural crops to grow under the canopy, not only offers scope for improving crop biodiversity and farm productivity, but also a means to sequester carbon, according to a new study that cites Kerala as an example. A coconut-based farming system (CBFS) involves growing many shade-thriving or 'sciophytic' agricultural crops in coconut plantations. The system has a two-fold benefit: it ensures economic benefits by improving crop productivity, and it can serve as an example of a nature-based solution (NbS), finds the study.⁵⁴ It was conducted by a team led by Jacob John, a professor at the Kerala Agricultural University. The International Union for Conservation of Nature (IUCN) defines nature-based solutions as "actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits."⁵⁵



John's team developed a coconut-based integrated farming system (IFS) model suited for lowlands, at the Integrated Farming System Research Station (IFSRS), Karamana under Kerala Agricultural University. Based on their previous estimates, the model uses an area of 0.2 hectares (ha), which matches the average per capita land availability of the marginal farmer in the state.⁵⁶

Increased crop biodiversity and farm income

Apart from the major crop coconut, the model includes intercropped crops such as vegetable, fruit, spices, fodder and tuber crops. It also incorporates allied enterprises such as livestock; farming of azolla, an aquatic fern that lives symbiotically with a blue-green algae and is a good bio-fertiliser; and agroforestry. Tree species added to the model include teak, jackfruit, breadfruit, garcinia and mango. Data collected over five years for this research showed that the productivity under the IFS model was enhanced tenfold compared to that under the sole crop of coconut for the same area, the team wrote in an article published in the *Journal of Plantation Crops*, highlighting their research. The model generated food products in excess; more than the requirement of a four-member family, and the surplus production could contribute to a farmer's income, while also generating considerable employment. The IFS model can also generate plant nutrients within the farm through organic recycling. "Coconut, when grown as a monoculture, often leads farmers to distress mainly due to crop loss associated with the pest and disease incidences and market price fluctuations," John told Mongabay-India. Coconut-based integrated farming can enhance the yield from the unit area and bring about a considerable hike in farm income, apart from environment-friendly effects resulting from saving fertilisers, he says. The social relevance of such systems also is quite promising, as evidenced by the generation of more employment opportunities, as detailed in the study.⁵⁷

Further, it is a 'climate-smart' solution as it reduces the use of chemical fertilisers, through the generation of plant nutrients from crop residues, and dung and urine obtained from livestock, the report says. On an average, plant nutrients to the tune of 177 kilograms (kg) nitrogen, 89 kg phosphorus and 98 kg potassium were generated annually from the model.⁵⁸

The model also results in net negative emissions of greenhouse gases, mostly through agroforestry. The inclusion of tree components like teak, mango, jackfruit, garcinia, rose apple, and breadfruit, along with the main crop coconut contributes to the build-up of above and below-ground plant biomass, which can sequester carbon. The agroforestry component contributes over 90 percent carbon sequestration, the researchers detailed.⁵⁹

Coconut farming is one of the most natural agricultural systems, says Rajeswari Raina, a specialist in agricultural economics and Professor at the Department of International Relations and Governance Studies at Shiv Nadar University near Delhi.⁶⁰



In India, the traditional practice of burying coconut husks in the soil helps in soil water retention, and by thus preventing soil water run-off, helps in groundwater recharge, she points out.

“Further, the conversion of small farmer holdings into profit-making ones through the intensive use of land through diversification of crops, involving an integrated farming system with several crop combinations, helps generate additional income,” Raina explains. Such systems spread out risks due to climate vagaries and pest attacks, as farmers do not have to depend on income from a single crop.⁶¹

A separate study by Odisha University of Agriculture & Technology (OUAT) based in Bhubaneswar, showed that coconut-based agroforestry systems play an important role in terms of improving productivity, soil quality and providing food, fodder and fuel wood.⁶²

Apart from pure coconut plantations, many farmers are engaging in combining different crop combinations along with coconut. CBFS offers wide spacing and higher incidence of light under the canopy, while the limited effective root zone of the coconuts allows other crops to grow well within the grove.⁶³

The pressures of a growing population, lesser land to cultivate and worsening conditions of farmlands are triggering an interest in farming systems that optimise the use of the limited land resources, and as a result, an interest in intercropping.

The study found that coconut-based agroforestry systems, particularly up to 1.2 acres (0.49 hectares) in size, provide not only financial benefits, but also other benefits such as food, fuel, timber, fodder, thatching, shade, a good microclimate and a habitat for birds.⁶⁴

A project by the Indian Council of Agricultural Research – Central Institute of Women in Agriculture (ICAR-CIWA) attempted to standardise suitable intercrops in coconut-based multi-storey cropping model with banana, papaya and guava as second storey crops, in order to improve the productivity and utilization of land, energy and water resources, as well as income of farm women. Different ground storey intercrops such as cowpea, turmeric, elephant foot yam and pineapple were grown in the interspaces of the main crop.⁶⁵

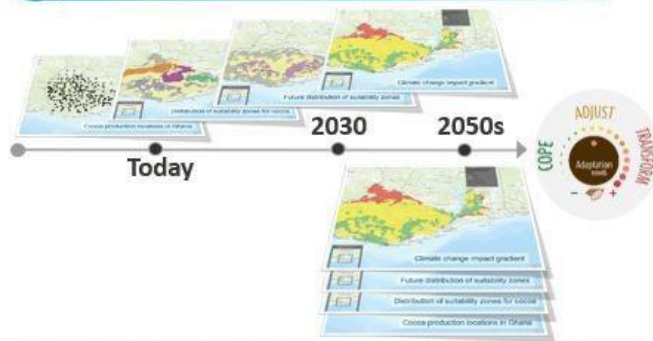
“This system enables a steady supply of farm products the whole year round,” the project found. “This system will give income 4-5 times more as compared to traditional system,” the project report added.

Coconut-based farms as climate smart agriculture

The Philippines, Indonesia and India are the three largest producers of coconut, one of the earliest domesticated plants. In India, over 21.7 lakh (2.17 million) hectares were under coconut cultivation in 2020.

Mainstreaming Climate-Smart Agriculture

- 1 Map the impact gradient to understand the risk of climate change over time



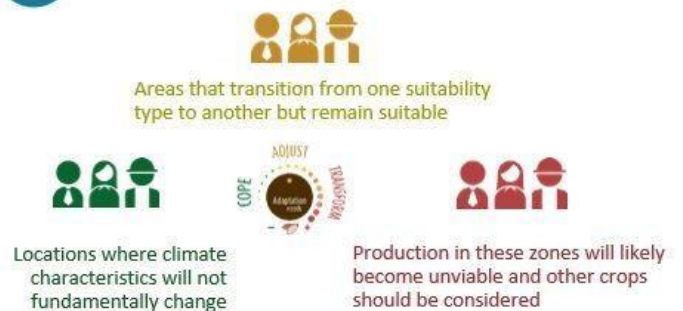
- 3 Scale CSA through sustainability standards and impact investors



- 2 Identify and prioritize relevant CSA practices by exposure gradient and analyze costs and benefits.



- 4 Convene value chain actors along the exposure gradient



A recent paper in the journal *Nature Based Solutions* found that CBFS offers some key benefits. The system provides innumerable opportunities for integrating diverse forms of crops in the same land management system, including food crops, fruit trees, roots and tubers, permanent plantation crops, medicinal plants and multipurpose trees. Such integrated farming systems are generally more productive than the single-crop plantation systems, and contribute to improved food security, environment management along with economic returns.⁶⁶

Secondly, the coconut palm is very resilient as it can withstand natural calamities like cyclones and flooding, which makes it useful for combatting increased cyclones, floods and droughts unleashed by a changing climate.⁶⁷

CBFS also offers scope for enhanced carbon capture and storage in soil-crop systems, which has the potential to minimise CO₂ emissions. This includes carbon sequestration in soil and biomass, as well as the substitution of fossil fuels with biodiesel made from biomass or coconut oil. Such systems can serve as carbon pools or sinks that absorb carbon.⁶⁸

The report in *Nature Based Solutions* cites a study from Sri Lanka which estimates that the ecosystem (plant and soil) carbon stock of CBFS in Sri Lanka ranged from 32 megagrams (Mg) to 72 Mg (1 megagram = 1,000 kilograms) of carbon

per hectare, while the net carbon balance ranged from 0.4 Mg to 1.9 Mg of carbon per hectare per month under various growth conditions.

Raina, however, points out that it is erroneous to assume that they will all lead to net negative emissions in of greenhouse gases. Net emissions will be negative only if no chemical fertilisers are used on the farm, and the farms use totally on-farm or local organic inputs, she says.⁶⁹

Another study on climate-smart villages in the Philippines by the CGIAR showed how growing intercrops such as coffee, black pepper, banana, cacao and other trees were grown on coconut farms could raise incomes considerably by 2025. The study was based on 29 households that were interviewed in the Himbubulo Weste and Magsaysay villages in the Philippines in 2020, where almost half of the income earners depended on coconut farming for their livelihoods. The study showed that the community as a whole would have the opportunity to increase their cash position when the climate smart agriculture interventions such as intercropping and backyard livestock growing are in use.⁷⁰

Special Program for Promotion of Integrated Farming in Tribal Areas

The proposed program intends realize the **sustainable growth potential of agriculture, livestock and fisheries in 40 Gram Panchayats** in Malkangiri (out of the total 108 GPs in the district) in 4 years. Enhancing production, income and household level food security & reducing climate risks will be the focus.

Program focuses on the four production systems in an Area Based Approach:

1. Agriculture
2. Horticulture (vegetables)
3. Livestock
4. Fisheries⁷¹

SCALE OF THE PROGRAM

Scale of the Program is

- Strengthening **agriculture in 4 Blocks** (40 GPs) **covering 40,000 Acres** 20,000 households.
- Comprehensive **Livestock Programs** in 4 Blocks (40 GPs) covering **2 lakhs livestock population**.
- Expansion of **Fisheries program** in all 7 Blocks covering 50 out of 70 accessible GPs in the District. (Total 108 GPs) to cover **2500 water bodies**.⁷²

APPROACH OF THE PROGRAM

The approach is to

- Establish and strengthen service delivery systems institutionalized in farmers’ organisations and local enterprises (seed systems, vaccination, fingerling production etc.)
- Promoting integrated & diversified production systems (integrating NRM, Production Systems, input and output markets and Livelihoods; & diversification at household level)
- Community led knowledge transfer/ management / extension systems
- Setting up convergence mechanisms at field level⁷³
- Build local capacities: institutional, technological and managerial

Summary of Roles and Responsibilities

S.No	Stakeholder	Level	Responsibilities
1	Farmers’ Groups & Farmers’ Producers Organisations (FPOs)	Village & GP Cluster	Responsible for implementation of the program with support from the network partner organization. FPOs will be formalized at the Cluster of GPs (with the local shandy/ market as an operational unit) These will work with trained Community Resource Persons
2	Facilitating Agencies	District	Supports formation and strengthening the Farmers’ Groups /CRCs/

		Level	FPOs in planning and implementation of the programs.
3	Program Secretariat(WASSAN) /Farmers Resource Center	District Level	Works with NGO Partners responsible for interfacing with the Departments, compilation of reports, M&E, Documentation and external interfacing.
4	District RRA Committee	District Level	Facilitates convergence, disbursement of program funds and facilitation funds by line departments to Community organizations and Facilitating agencies respectively. Regularly monitors the program on a monthly basis.
4	Program Secretariat (WASSAN) & Research Secretariat (NCDS)	State Level	Program Management, M & E through web based advisory, Co ordination with State Department, Capacity Building, Convergence and Research.
5	Directorate of Agriculture and Food Production	State Level	Nodal Agency for the program. Appoints a Nodal person to work with Program Secretariat. Periodically monitors the program.
6	State Level RRA Committee	State Level	A State level committee to policy aspects such as scaling up, reconfiguring public investments.

Expected Outcomes/ Deliverables:

Expected outcomes of the Program are:

Agriculture:

- Securing Crops through Protective Irrigation in at least 200 ac in each cluster. A total of 1600 ac of land to be secured from crop failures in district that will create more local demand.
- Establishing Diverse Seed Support Systems at cluster level to meet 25 – 30% of Seed requirement (i.e. to achieve seed replacement rates)⁷⁴
- Enhancing Soil Productivity through composting and organic manuring practices in 2000 HHs leading reduction of 30% of production costs.
- Promoting SRI in Rice based systems and SCI in others leading to 20% yield increase in 2000 acres
- Comprehensive revival of millets in 4 blocks. Improving food and nutritional security through inclusion of millets in various state nutrition programmes.
- Establishing Custom hiring centres and addressing draft power for increasing yields.⁷⁵

Horticulture

- Establishing Support systems leading to Bari Khet vegetable cultivation in 2240 acres and intensive vegetable cultivation in 240 acres.

Livestock

- Establishing a demand driven primary healthcare services leading to reduction of 15% in mortality and saving 9 crore annual losses in the district; Area based Goat Program leading to assured income of Rs.20,000/-per year/HH and generates goat economy of Rs 5.2 Crores
- 16 Breed Farms to supply Chicks and Growers to 1600HHs generating Desi Poultry Economy of Rs. 2.4 Crores⁷⁶

Fisheries:

- Expansion of Fisheries program in all 7 Blocks covering 50 out of 70 accessible GPs in the District. (Total 108 GPs) to cover 2500 water bodies targeting 1250 acre of water spread area.
- Productivity increases by at least 1 quintal per acre

Institutional

- Federating CBOs into Farmers Producers' Organisation at block level in 4 blocks.
- Capacities of the CRPs, CBOs and farmers' organisations increased substantially
- Institutional capacities to manage aggregation of commodities worth Rs. 1.00 crore at district level.

Overall:

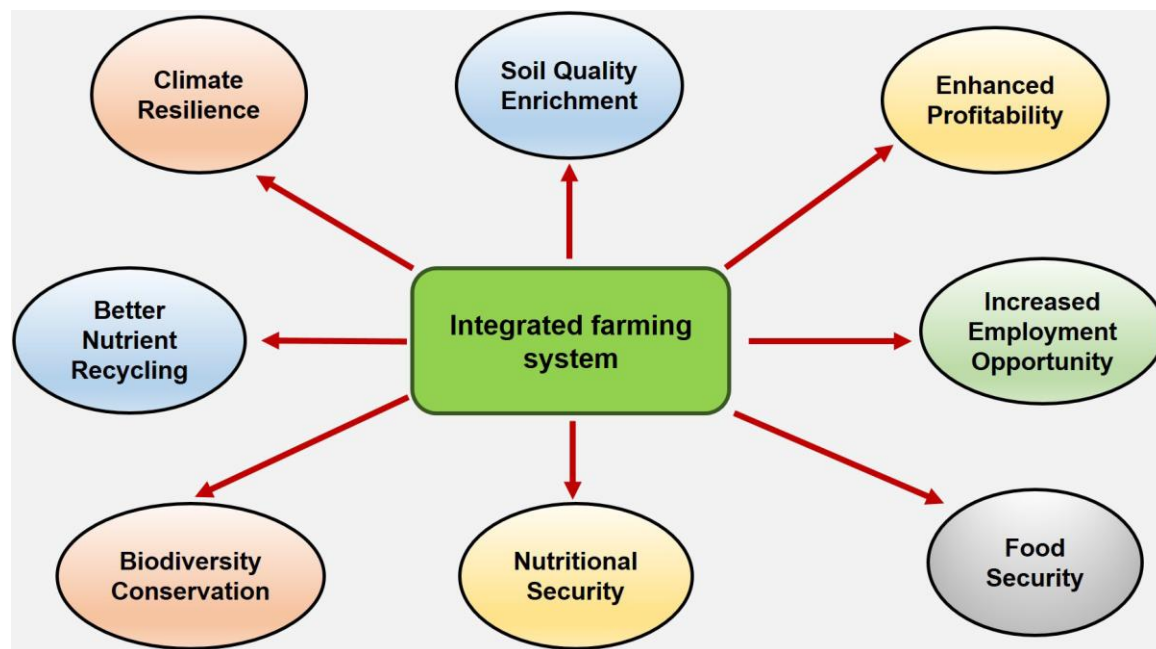
- Increase in assets and income; achieving a growth rate of about 10%
- Hunger free households with better nutritive food with millets.⁷⁷

Biologically Integrated Farming is the identification and encouragement of particular existing biological relationships within a farm system in order to reduce or avoid potential negative impacts of the farm's operations on habitats, natural resources, and communities. Long-term effects of agricultural production, such as nutrient leaching, soil erosion, and habitat damage are increasingly impacting global food production capacity. By drawing on agro-ecological concepts and taking a "whole system" approach, many biologically integrated farming practices may be potential alternatives that will reduce some of the negative external outcomes of conventional, input-driven agriculture.⁷⁸ The goal of biologically integrated farming systems (BIFS) is to use biological and cultural farming practices to reduce chemical inputs such as pesticides and fertilizers, and thereby reduce the degradation of natural resources caused by these inputs. The promotion of these farming systems originated from partnerships formed between agriculturalists and environmentalists hoping to lessen the impact of agrichemical pollution. Increasing natural biodiversity has gained significant traction as a method for reducing chemical inputs and maximizing the benefits of ecosystem interactions. The methods aim to take advantage of existing interactions between the components of biological systems and mimic natural habitats where populations of different species are kept in balance.⁷⁹ Some examples of biological and cultural practices promoted in BIFS projects include cover cropping, leaf nitrogen monitoring, and use of crop residues to reduce nitrogen fertilizer input and the need for herbicides to control weeds; use of pheromone mating disruption technology and planting of habitat for natural enemies to control insect pests while reducing pesticide use; and better monitoring practices and use of buffer strips to control pests.⁸⁰

Integrated farming systems can be designed using a wide range of practices and techniques. These can be broadly categorized into those systems involving crop-livestock integration, and those systems that focus on whole-system cycling and mimicking nature to best enhance ecological processes.⁸¹

Biologically Integrated Farming Systems at UC

The first widely recognized integrated farming system research at the University of California began in 1988 with an analysis of two neighboring almond orchards - one conventionally grown, and the other grown organically. With support from the Sustainable Agriculture Research and Education Program (SAREP) the analysis was expanded to include several other almond orchards in California. Demonstration plots were developed across the region and the project came to be known as the Biologically Integrated Orchards Systems program (BIOS). Building upon the success of this program the state funded twelve additional large-scale projects to establish programs providing extension services, training, and incentives for farmers to reduce the use of agricultural chemicals.⁸²



These projects became collectively known as the Biologically Integrated Farming Systems program (BIFS Program). They typically included voluntary on-farm demonstrations of various innovative biologically based farming practices; a

collaborative extension model for sharing information about alternative management systems; and an organized program of monitoring biological and economic variables for on-farm decision-making and projects evaluation.⁸³

In addition to research and publications on the effectiveness of biologically integrated farming systems, SAREP coordinated an outreach project to further expand and improve upon the extension and implementation methods for these farming systems practices.⁸⁴

All over the world, farmers work hard to earn a living. However, not all farmers **make a steady income**, especially small family farmers. There is very little leftover after they pay for all their inputs (seeds, livestock breeds, fertilizers, pesticides, energy, feed, labor, etc.). The emergence of integrated farming systems (IFS) has enabled farmers to develop a framework for an alternative development model to improve the success rate of small sized farming operations. The integrated farming system is a commonly used term to explain a more integrated approach to farming compared to **monoculture approaches**. It refers to agricultural systems that integrate livestock and crop production or integrate fish and livestock and may sometimes be known as integrated biosystems.⁸⁵

Working process of integrated farming

In this system, an inter-related set of enterprises is used so that the “waste” from one component becomes an input for another part of the system. This reduces costs and improves production and/or income. Since it utilizes waste as a resource, farmers not only **reduce waste emissions** but they also ensure an overall increase in productivity for the whole farming system. Integrated farming tries to imitate nature’s principle, where not only crops but also varied types of plants, animals, birds, fish, and other aquatic flora and fauna are utilized for production. The basic principle is to enhance the ecological biodiversity:⁸⁶

- By choosing the appropriate cropping methodology with mixed cropping, crop rotation, crop combination and inter-cropping so that there is less competition for natural resources like water, nutrition and space and by adopting eco-friendly practices
- By utilizing a multi-story arrangement so that the total available area is used effectively and there is a high level of interaction between biotic and abiotic components
- By integrating subsystems by which the various components interact positively, so that the overall farm productivity is increased⁸⁷

The integrated farming system is also a **sustainable agriculture system** which focuses on intensification of farm productivity by increasing diversification, resource integration and creating market linkages.⁸⁸



Thousands of small and marginal family farmers in resource-poor regions in Asia and Africa have converted their farming to this sustainable farming system to diversify farm production, increase cash income, improve the quality and quantity of food produced and the exploitation of unutilized resources. It usually takes three to four years to establish a well-integrated farm with market linkages to ensure nutrition and the livelihood of a family.

In the last few decades, agricultural research and modern technology developments have led to integrated farming being implemented to not only enhance the productivity per acre, but to maximize land use in such a way to ensure sustainability of food production to meet the growing demands created by an increase in global population. Due to the indiscriminate and erratic use of chemical pesticides and fertilizers in the past, our food and ecosystems have been poisoned.⁸⁹

Launch of Integrated Farming System (IFS) portal, for the Department of Agriculture & Farmers' Empowerment, Odisha

NIC has designed & developed an Integrated Farming System (IFS) portal, for the Department of Agriculture & Farmers' Empowerment, Odisha. The IFS portal-<https://ifsodisha.nic.in> automates the entire process of integrated farming system starting from assigning targets to District & block, online application with document uploading by the farmer, and field verification by the Block level official for finalisation of the model to be adopted, etc.⁹⁰

PAU develops integrated farming system for small, marginal farmers, says it will boost income

The Integrated Farming System is an adequate blend of crops, livestock, aquaculture, agro-forestry and agri-horticulture ensuring sustainability, profitability, balanced food availability and employment generation. An Integrated Farming System (IFS) has been developed by the Punjab Agricultural University (PAU), Ludhiana, for small and marginal farmers after rigorous trials for more than a decade.⁹¹



“An economically viable option, it is an adequate blend of crops, livestock, aquaculture, agro-forestry and agri-horticulture ensuring sustainability, profitability, balanced food availability and employment generation,” said experts of the university. Urging the small and marginal farmers to adopt IFS developed by PAU, Dr Satbir Singh Gosal, Vice-Chancellor, said that it will go a long way in enhancing the income and providing balanced nutrition to the family members. Sustained production, cost-effectiveness, meeting diverse requirements of farm households, optimal resource utilisation, waste material recycling, sufficient remuneration and livelihood security of resource-deficient farmers are the added bonus,” he explained.⁹²

Giving out details about landholdings-distribution in the state, Dr Gosal informed that Punjab has 10,92,713 holdings shared by 14.13 per cent small (below 1 ha), 18.98 per cent marginal (1-2 ha) and 33.67 per cent semi-medium (2-4 ha) farmers. About Punjab’s crop income, he revealed that it is 90.5 per cent, while non-farm sources contribute 9.5 per cent to the farmer’s income.

Dr Ajmer Singh Dhatt, Director of Research, disclosed that the Integrated Farming System model launched at the research farm of School of Organic Farming under the ‘All India Coordinated Research Project on Integrated Farming Systems (ICAR)’ provides income round the year in addition to meeting the domestic needs (cereals, vegetables, oilseeds, pulses, fruits, milk, etc.).⁹³

“The combination of crop cultivation, dairy farming, kitchen gardening and other secondary components can be adopted depending on the location. He remarked that specific agri-based enterprises can also be included after acquiring proper training,” he added.

Explaining the nitty-gritty of the project, Dr Sohan Singh Walia, Director, School of Organic Farming, mentioned that the experiment, which was initiated during Kharif 2010, covered an area of 1 ha (2.5 acre) under field crops, horticulture, aquaculture, dairy, agroforestry and goatary components. The kharif crops — paddy, maize and turmeric — were grown on 6,400 sq m area and, in the following rabi and summer season, potato, berseem, wheat, gobi sarson, onion, pearl millet and spring maize were produced. “As horticulture component, guava and citrus plantation was done on around 1,600 sq m area; vegetable crops in inter-row spacing were raised in 1,500 sq m and; 200, 1,000 and 300 sq m were used for dairy (cattle+goats), aquaculture and agro-forestry components, respectively,” Dr Walia said.⁹⁴



Goat farming

The data from the study (average of five years) indicated that adoption of integrated farming system by inclusion of crop based enterprises, horticulture, dairy and aquaculture recorded overall average net returns of Rs 4,95,810/ha with the contribution by dairy (Rs 2,86,201) followed by crop (Rs 1,25,070), horticulture (Rs 30,156), aquaculture (Rs 24,891), boundary plantation (Rs 19,341), kitchen gardening (Rs 8,048), and agro-forestry (Rs 2,104), Dr Walia said.⁹⁵



Aquaculture

According to Dr Walia, the 1 ha model developed for marginal and small farmers churned out gross returns of Rs 8,40,114/ha against the incurred cost of Rs 3,44,304/ha. The net returns by deducting all variable costs were Rs 4,95,810/ha which were far higher than the prevailing rice-wheat cropping system.⁹⁶

Moreover, the total amount of carbon added and sink were 3,042.0 CO₂-e (kg) and 11319.7 CO₂-e (kg), respectively, thereby making the IFS model a climate-smart agriculture system with negative greenhouse gas emission measured at - 5380.7 CO₂-e (kg). Additionally, the said model effectuates 30-45 per cent saving with recycled farm products. It also saves water to the tune of 5.9 kg/m³ versus 0.6 kg/m³ in the rice-wheat cropping system, he stated.⁹⁷

Tabulation

Broad Activity	Sub Activity	Pattern of Assistance	Name of Scheme
Crop Based Integrated Farming System	Cropping System (CS) with rice, wheat, coarse cereal/oil-seed/ibre/pulse based two crops.	50% of input cost limited to Rs. 10,000/- per ha with permissible assistance of maximum 2 ha/ beneiciary.	National Mission for Sustainable Agriculture (NMSA)
	Horticulture Based Farming System (Plantation + Crops/Cropping system)	50% of input cost limited to Rs. 25,000/- per ha with permissible assistance of maximum 2 ha/ beneiciary.	NMSA
	Tree/Silvi-Pastural/in-situ/ex-situ conservation of Non Timber Forest Produce (NTFP) (Plantation + Grass/ Crops/Cropping System)	50% of input cost limited to Rs. 15,000/- per ha with permissible assistance of maximum 2 ha/ beneiciary.	NMSA

Livestock based farming system	CB Cows + Mixed farming + Fodder Buffalo +Mixed farming +Fodder Cow/buffalo+dairy+fodder cow/buffalo + small ruminants	50% of input cost of cropping system including cost of animals with one year concentrated food limited to Rs. 40,000/- per ha (2 milch animals + 1 ha CS) with permissible assistance of maximum 2 ha/beneiciary.	NMSA
	Small Ruminant + Mixed farming + Pasture Poultry/duckery + Mixed Farming Poultry/duckery + Fishery + Mixed Farming	50% of input cost of cropping system including cost of animals/birds with one year concentrated food limited to Rs. 25,000/- per ha (10 animals/50 birds + 1 ha Cropping System (CS) with permissible assistance of maximum 2 ha/ beneiciary.	NMSA
	Fishery Based Farming System	50% of input cost of cropping/vegetable system including cost of ish farming limited to Rs. 25.000/- per ha with permissible assistance of maximum 2 ha/beneiciary ⁹⁸	NMSA

Krishi Vigyan Kendras have been instrumental in helping farmers adopt integrated systems on the farm, thereby helping them produce more and earn more. Lyngrah’s farm, now a model farm, serves as an example of such support provided by KVK.

Shri Wallam Kubar Lyngrah, a dedicated progressive and innovative farmer, hails from the village Mawsiatkhnem of Mawlai C&RD Block, East Khasi Hills district of Meghalaya. He is a graduate and a teacher by profession. He started devoting his time focusing on better farming practices. He owns a total of 4.94 acres of land of which 2.50 acres has been converted into an Integrated Farm.⁹⁹



As an agriculture entrepreneur, Mr. Lyngrah felt that conventional method of agricultural cultivation minimized the yield and income. It is also associated with low productivity, increased cost on agriculture inputs and poor or no utilization of existing resources available on the farm. The conventional method also produced ecological problems in terms of limited crop diversity as well as creating soil and water pollution.¹⁰⁰

His journey towards becoming a sustainable farmer began when he was searching for a solution towards sustainable agricultural methods. It was then when he came into close contact with officials from Krishi Vigyan Kendra, East Khasi Hills district in the year 2013. He received technical guidance on sustainable agriculture through integrated farming. He was also inspired by an exposure visit to Indian Council of Agricultural Research for NEH Region, Umroi Road, Umiam, Ri-Bhoi district, Meghalaya, where he was introduced to the concept and the income opportunities of Integrated Farming System. He gathered technical knowhow by attending a number of trainings programmes, seminars, workshops conducted by the KVK as well as other line departments. He established an integrated farm in a total of 2.50 acres of land area since 2015 with poultry and piggery units as the main components in the farm. Equipped with a strong foundation about integrated farming, Shri Lyngrah further developed his farm by incorporating additional components to his unit.¹⁰¹

Details of Components

The integrated farm at present has the following components distributed over 2.5 acres of land:

i. Horticulture unit

ii. Animal Husbandry and Livestock Unit

iii. Vermicompost Unit¹⁰²

i. Horticulture Unit

The horticultural unit includes vegetable crops like cabbage, cauliflower, chilli, ginger, chow-chow, etc., fruit crops like papaya, pineapple, Assam lemon, orange etc. Krishi Vigyan Kendra, East Khasi Hills District has been giving special emphasis on effective utilization of land by growing assorted vegetables all through the year which increase the farm income and sustain the soil health.¹⁰³



After undergoing numerous training programmes he understood that vegetable crops occupy an important place in diversification and an important role in food and nutritional security. In his village Mawsiatkham, year round production of vegetables is possible inside the polyhouse. Growing second crop in the open field is very difficult due to higher rainfall during May to October. As he could not afford to construct the polyhouse by himself he approached Krishi Vigyan Kendra, which in turn through the Ministry of Agro Textiles in collaboration with SASMIRA has helped him in constructing one polyhouse at a subsidized rate. Now, he produces vegetables throughout the year and is getting year round income from this activity.¹⁰⁴

ii. Animal Husbandry and Livestock Unit

a) Poultry Unit

He started poultry rearing with fifty birds in his farm in the year 2000. However, he was not getting the returns as expected.



Later, he enhanced his poultry farming activities by doubling the number of birds. He started to rear layer birds (*BV 360*) whereby he faced problems regarding scientific poultry rearing. To overcome the problems, he started adopting new technologies. However, he still suffered losses. On keenly observing, he found that the birds are fond of laying eggs on corners and where there are darker shades. Realizing this, he constructed the laying cabins which attracted the birds for laying their eggs. A specific dimension was maintained in the cabins preventing breakage of eggs (0% breakage of eggs) during laying. Provisions for collecting the eggs was made in the form of hinged top covers so as to facilitate easy collection of eggs from the cabin without entering the poultry shed. By adopting this method, he could increase the production of eggs from his farm and at the same time could minimize the death of birds. On an average, the modified innovative technology adopted by the farmer reduced the spoilage of eggs by 90% and increasing the productivity by 80-90%. The method adopted by the farmer involves low investments with high productivity and low mortality rate of the birds, which makes it economically more viable.¹⁰⁵

b) Piggery unit

Pigs are the most common and preferred livestock species in East Khasi Hills district. Almost 80% of farming households in the region rear pigs (mostly 1-2 pigs/household) mainly for fattening purpose. The production process is traditionally based on indigenous breeds. Moreover, pig producers have traditional knowledge and skills for fattening purpose, but few

have the skills to breed pigs. Seeing this opportunity, he started the piggery breeding unit. He is rearing 9 sows and 1 boar where one sow gives at least 1 farrowing per year.¹⁰⁶



The demand for pork meat in the market is high, offering good scope for improvement/expansion.

c) Goatery Unit



The unit consists of 15 numbers of goats which were reared in a fenced area in which they graze. Zero expenditure was incurred for feed. Expenses for fencing and low cost shed was around Rs. 5,000 only. The goats are sold in the local market.¹⁰⁷

d) Fishery Unit



In the year 2018, he constructed 3 numbers of fish ponds with a production capacity of 600 kg/0.3 ha and the average cost of the fishes in the local market was Rs 200/kg. By products from all units of the farm serve as fertilizer and feed to the fish ponds.¹⁰⁸

iii. Vermicompost Unit



He has 2 vermi-beds of 6x4x2 ft. size with an annual capacity of producing 3000 kg of vermicompost on an average. This is entirely used for all the crops on his farm. Raw materials from the farm are the substrates used for composting all year round.¹⁰⁹

Impact

The new technologies developed by the farmer are being practiced by him for the past 3 years, proving to be economically rewarding. Shri Wallam K. Lyngrah's farm is now a model farm. Farmers in his village and of the district who own poultry sheds have been motivated by his success and those having poultry sheds have adopted the award winning innovative idea "*Low cost Poultry Layer shed*".¹¹⁰



He is a role model to other farmers who are aspiring to set poultry layer farm in the district as well as in other parts of the state. He is integrating all the existing resources available on his farm. He is running his farm successfully. As a progressive farmer he has been always open to skill development and is eager to know every aspect of farming through various sources *viz.* trainings, meeting experts from various line departments etc. He is now an influencer and motivator to other farmers with regard to improved farming practices. Hailed as one of the innovative farmers in East Khasi Hills district, he is one of the key trainers on IFS with special reference to poultry and piggery rearing in the district. He has become role model for establishing a successful Integrated Farming System in his block.¹¹¹

Success story of integrated farming for enhancing livelihood

Enhancing productivity from the available piece of land has been a continuous effort under the NAIP sub-project Sustainable livelihood improvement through integrated freshwater aquaculture, horticulture and livestock development in Mayurbhanj, Keonjhar and Sambalpur districts of Orissa. The integration of the various interventions has already started bearing fruits literally !!¹¹²

Baladuan village of Anandpur cluster of Keonjhar district adopted under the NAIP project is predominated by the SC, ST and OBC population. One of the interventions promoted by the consortium partner Central Horticultural Experiment Station, Bhubaneswar, is integrated aqua-horticulture on pond dikes and adjoining areas.¹¹³



Sri. Purnachandra Das is one of the many farmers benefitted by this technological intervention and has now set an example by his uncanny success in the integrated aqua-horticulture in his couple of ponds. With an average educational qualification up to 10th standard, Sri. Das with a family of four members were formerly depended on single crop of rice. The deliberations during one of the farmers' meeting organised by CHES, He was motivated to implement the aqua-horticulture system in less-utilised dike area of his couple of ponds. Being the part of the Self Help Group created for fruit and vegetable nursery, he could raise papaya seedlings of red lady variety in nursery from the seeds provided by the NAIP and planted 25 numbers of seedlings in his dike area with a plant to plant distance of 3mt. After one year he got approximately 1.0 to 1.2 quintal papaya fruits per plant on an average. He harvested papaya fruits twice in the year and grossly he got 60 quintal papaya. He sold papaya in local *haat* and nearby markets @ `8.5/- in rainy season and in summer @ `6.5/- per Kg. Totally he got Rs.38000.00 from papaya cultivation in his unutilised dike area of ponds excluding home consumption. He also cultivated poi, bitter gourd, cucumber as intercrop in papaya and earned Rs.8000.00, Rs.5000.00 and Rs.2000.00 respectively. The candid utilisation of the dike area for economic gains through horticulture besides pisciculture has become a role model for farmers in the region. For his successful integrated farming, he was felicitated in a workshop on "*Horticultural interventions for sustainable livelihood*" on 26th March 2013 held at CHES, Bhubaneswar.¹¹⁴

Integrated Farming Finds Success in India with Help of Nuclear Science

Farmers in India have teamed up with scientists to find new ways to produce more food, improve the quality of their farmland and earn more money. With the help of nuclear techniques, they now have a method for producing high quality livestock and more crops while protecting the health of their soil for a future of more fertile farming. "Given the importance of agriculture and the limited resources available, we need to find ways to make better use of what we have and become more efficient," said V. Ramesh Saravana Kumar, Principal Investigator of this project facilitated by the IAEA in cooperation with the Food and Agriculture Organization of the United Nations (FAO). "With the methods demonstrated in this project, we have shown that sustainable, integrated crop-livestock farming is the answer."¹¹⁵

Approximately 70% of people in India rely on agriculture as a source of income.



Many conventional farming methods involve inorganic fertilizers and using only one crop type each season, which puts a strain on farmers' soil and water resources. This often leads to less productive crop yields, which in turn means less food and lowered incomes. As the already strained situation gets worse due to climate change, farmers are now in need of more efficient modes of production. Scientists at the Tamil Nadu Veterinary and Animal Sciences University have used nuclear and isotopic techniques to study soil and water use and select and grow crops that thrive on local farms. They integrated their findings with effective livestock production methods involving cattle and goats to develop an easy-to-follow, crop and livestock-based organic farming system.¹¹⁶

The project has so far resulted in an increase in organic carbon content in the soil, which gives it structure and makes it healthier and better for growing crops. Livestock reproductive performance has also gone up, including a 15% increase in the cattle's milk production as well as significant increases in the size of the goats. "After seeing the positive results, the farmers understand that integrated crop-livestock techniques, which also lead to more organic farming, are the only way to a healthier life. They are now more willing to take part in similar research and advice," said Kumar. The government at all levels is also now encouraging the use of this method, he added.¹¹⁷

A cycle of growing crops and feeding livestock

The new integrated method is based on a more organic, self-sustaining approach: after farmers grow and harvest crops, they feed livestock the leftover plant parts and grass from the fields, which results in nutrient-rich dung and urine that serves as an organic fertilizer for growing new crops. They then repeat the process. Over time, this revitalizes the soil's structure and replenishes important nutrients for plants to grow, as well as provides a steady source of healthy feed for livestock. "Conventional techniques are not sustainable. Instead of continuing business as usual, we can use this integrated farming approach to make the most of land and nutrient resources not just in India, but also potentially worldwide," said Lee Kheng Heng, Head of the Soil and Water Management and Crop Nutrition Section of the IAEA.¹¹⁸



Ten other countries are now also testing, developing and implementing this integrated livestock-cropping system under the umbrella of this project. So far, in addition to the success in India, Argentina, Brazil, Indonesia, Kenya and Uganda have also been showing promising results. “What is especially encouraging with these techniques is that they are not limited to certain geographical areas or climates. If land is suitable for crop cultivation, it’s suitable for integrated crop-livestock practices,” Heng said. “This project has demonstrated that this integrated farming approach will have a significant impact on the future of agriculture in India and worldwide.”¹¹⁹

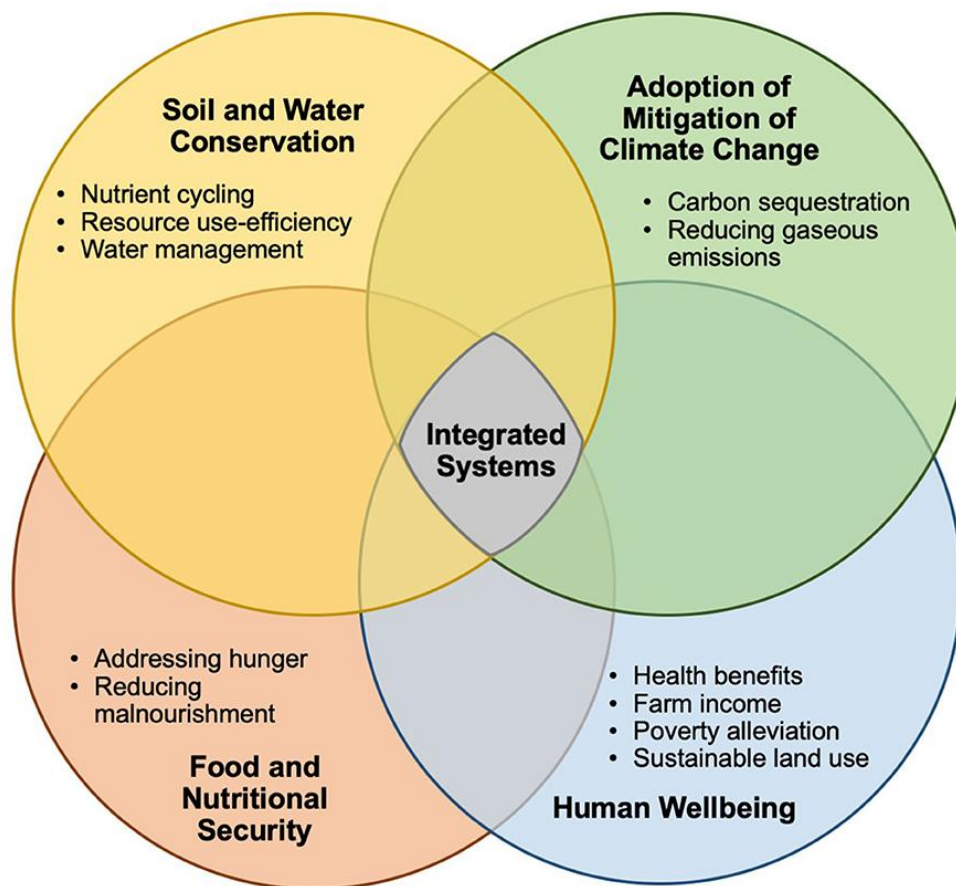
To confirm the effectiveness of the integrated crop-livestock approach, scientists use nuclear techniques involving the nitrogen-15 and carbon-13 isotopes. Nitrogen-15 and carbon-13 are stable isotopes, and scientists are able to track these isotopes to measure, for example, how efficiently crops consume nitrogen. Scientists do this by introducing samples of nitrogen-15 into the soil around the crops. Over several months they observe how much nitrogen-15 is absorbed by the plants. This provides crucial information about how efficiently the crops use the nutrients. Similarly, scientists add samples of carbon-13 to the soil to assess soil quality. As nutrients are recycled in the soil, organic carbon content goes up. Scientists can measure the changes in organic carbon content by tracking the carbon-13.¹²⁰

Integrated Farm Management

IFM is made up of nine sections, which together address the entire farm business. Each of the nine sections is interrelated and an understanding of how they work together is essential for the effective implementation of IFM.¹²¹

Organization and planning; soil management & fertility; crop health and protection; pollution control and byproduct management; animal husbandry; energy efficiency; water management, landscape and nature conservation; engaging society.

Sustainable farming delivers a site-specific farming system supporting the integration of farm economic viability, the environment and society, over the long-term. IFM delivers more sustainable farming by contributing to economic performance, environmental quality and social health. It is also relevant to the fast emerging Natural Capital agenda, which looks to put a monetary value on the goods and services farmers deliver.¹²²



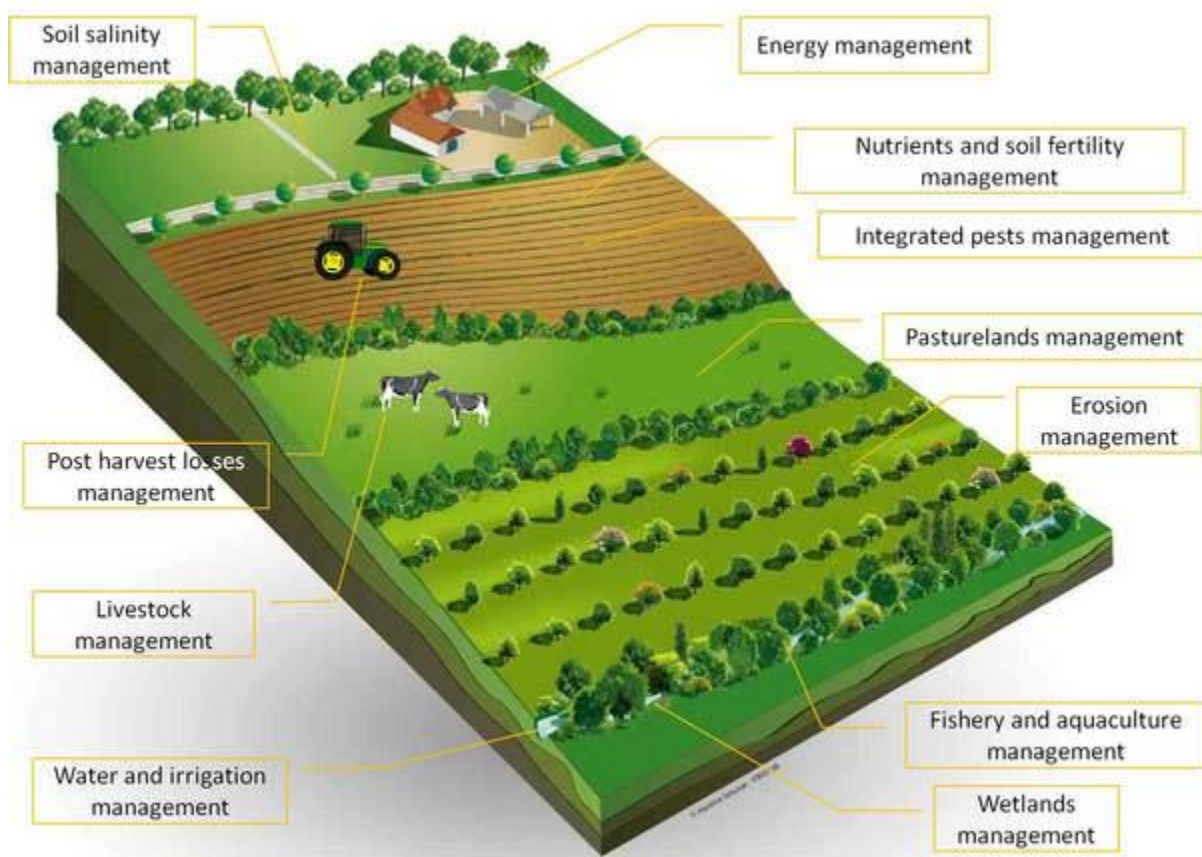
IFM is made up of nine sections, which together address the entire farm business. Each of the nine sections is inter-related and an understanding of how they work together is essential for the effective implementation of IFM.¹²³

Integrated Farming Systems Research Station, Karamana

Integrated Farming Systems Research Station (IFSRS) is located at Nedumcaud, Karamana, 3.0 km south east of Thiruvananthapuram Central railway and bus stations. The station has an area of 7.65 ha of which 6.25 ha is double cropped wet land and 1.40 ha garden land. The centre established in 1955 as Model Agronomic Research Station was upgraded as Cropping System Research Centre (CSRC) in 1989. Later, renamed as IFSRS in 2017, in view of modified mandate and various activities on integrated farming. The major mandates of the station include development and validation of region specific integrated farming system (IFS) models for enhanced system productivity, profitability and sustainability and undertaking research, training, extension and developmental activities on various aspects of urban and peri urban agriculture. The station was established in 1955 as a project centre of ICAR on Fertilizer Use and Soil Fertility. In 1989, it was upgraded as Cropping System Research Centre (CSRC). All India Coordinated Research Project on Integrated Farming System (AICRP on IFS), one of the largest research projects under ICAR was launched during 2010. The Project Directorate of Cropping Systems Research, Modipuram, Meerut, U.P, which coordinates the IFS activities was renamed in 2010 as Project Directorate of Farming Systems Research and as Indian Institute of Farming Systems Research in 2014. In view of the major mandate of the station, it was renamed as Integrated Farming System Research Station (IFSRS) in 2017.¹²⁴

The challenges of integrated farming system development towards sustainable agriculture in Indonesia

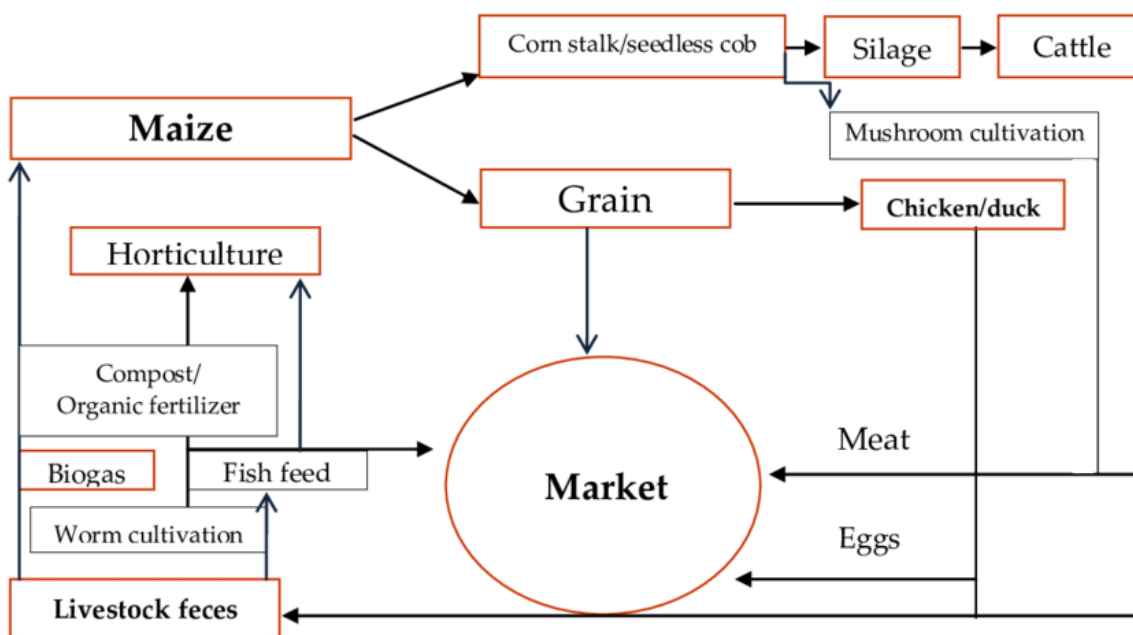
This study was aimed to determine the challenges of developing an Integrated Farming System (IFS)



IFS is one of the solutions for agricultural development in Indonesia by integrating agriculture, livestock, fisheries, forestry and other sciences related to agriculture. It is expected to be able to increased land productivity. This research was conducted with a comparative study from various countries such as Brazil, India,¹²⁵ US, sub-Saharan Africa countries regarding development issues, implementation, and constraints that occur in an IFS. The method of study is literature study. The results of the study show that the implementation of the IFS system poses various challenges, including: a) lack of understanding of farmers towards IFS, b) limited ability of farmers to utilize agricultural technology and c) financial support¹²⁶. However, IFS can increase agricultural food security and increased farmer welfare and expand employment. The implementation of IFS requires government support to create opportunities to increase farm scale in line with farmers' income.¹²⁷

The Integrated Farming System of Crop and Livestock: of Rice and Cattle Integration Farming

The objectives of the study were to describe the concept of the integrated farming system, the importance of integrated farming system development, and the integrated farming system of crop and livestock.¹²⁸



The results showed Integrated farming system is a farming system that combines two or more fields of agriculture, which is based on the recycling biological concept, and linked of input-output between the mutually commodities which approach of low external input utilization, which is done on the land, through the utilization of crop waste, animal manure, fish waste for the purpose of increasing the production and productivity so as to increase farmer income and can create condition that are environmentally friendly farming. The development of the integrated farming system is very important, because the integrated farming system has many usages and advantages and benefits in line with the objectives of the regional development that to improve the social welfare. It can be a solution for the various problems that arise in the regional development. Rice and Cattle Integration System is a rice farming system that is integrated with cattle where there is a reciprocal relationship. Rice plants provide straw and bran for cattle as feed and cattle produce feces that is useful for rice plants as organic fertilizer, so that it can increase the production and productivity of rice and cattle and can increase farmers' income. Implementation of rice and cattle integration system could increase the use family labor, reduced the use of inorganic fertilizers, reduced production costs, and can increase rice farming income and cattle business income.¹²⁹

A Holistic Approach

There are 115 million operational holdings in the country and about 80 % are marginal and small farmers. To fulfill the basic needs of house hold including food (cereal, pulses, oilseeds, milk, fruit, honey, meat, etc.), feed, fodder, fiber, etc. warrant an attention about Integrated Farming System (IFS). Undoubtedly, majority of the farmers are doing farming since long back but their main focus was individual components but not in a integrated manner. At the ICAR and State Agricultural Universities level, lot of efforts have been made aiming at increasing the productivity of different components of farming system like crop, dairy, livestock, poultry, piggery, goat keeping, duckery, apiculture, sericulture, horticulture, mushroom cultivation etc. individually but lacking in their integration by following farming system approach. The integration is made in such a way that product of one component should be the input for other enterprises with high degree of complimentary effects on each other. The preliminary research investigations advocated the benefits of productivity improvement by 30-50% depending upon the number and kind of enterprises and their management. The information on farming system in a systematic way is presented here. The methodology is explained keeping in mind the work done so far to realize better productivity, profitability and sustainable production systems that would help to solve the fuel, feed and energy crisis, create more employment avenues, ensure regular income and encourage agricultural oriented industry.¹³⁰

Role of Livestock based Integrated Farming System for enhancing the farmers' income

Livestock has traditionally been an integral part of farmers' household, as it plays an important role not only in the farm production but also in augmenting rural economy and in recycling of farm wastes. It is a major source of supplementing

family incomes and generating gainful employment in the rural sector, particularly among the landless labourers, small and marginal farmers and farm women.¹³¹

Livestock based integrated farming system is one of the rising agriculture systems in India. The practice of this type of farming system has been continued in our country in a traditional way from time immemorial. The basic principles of the farming system are productive recycling of farm wastes. Different subsystems work together in integrated farming system resulting in a greater total productivity than the sum of their individual production. Fish-Livestock along with Livestock-Crop farming is the major concept in Livestock based integrated farming system.¹³²

An "Integrated crop-livestock system" is a form of mixed production that utilizes crops and livestock in a way that they can complement one another through space and time. The backbone of an integrated system is the herd of ruminants (animals like sheep, goats or cattle), which graze a pasture to build up the soil. Eventually, sufficient soil organic matter builds up to the point where crops can be supported. Animal can also be used for farm operations and transport. While crop residues provide fodder for livestock and grain provides supplementary feed for productive animals. Animals play key and multiple roles in the functioning of the farm, and not only because they provide livestock products (meat, milk, eggs, wool, and hides) or can be converted into prompt cash in times of need.¹³³

Doubling of farmer income and Integrated farming Systems

Indian agriculture is passing through difficult times due to two consecutive drought situations in 2012-13 and 2013-14 in several parts of the country, thereby resulting in wide spread distress among farmers.¹³⁴

The rural areas in these parts are facing food and livelihood crisis, more specifically, the shortage of fodder and drinking water.

Government needs to proactively address the situation and make more long term farmers centric policies related to irrigation, farm diversification, farm profitability and community support programs so as to socially and economically empower farmers. It is important to measure agricultural progress by real income of farmers and not by gross production of agricultural commodities. It was in this context that the Finance Minister in his Budget 2016 speech mentioned about doubling farm incomes. Later the Prime Minister of India gave a call to the nation for doubling farm incomes by 2022 by spelling out a multi-pronged strategy, namely:¹³⁵

- i. Big focus on irrigation with large budgets, with the aim of "per drop, more crop."
- ii. Provision of quality seeds and nutrients based on soil health of each field.
- iii. Large investments in warehousing and cold chains to prevent post-harvest crop losses.
- iv. Promotion of value addition through food processing.
- v. Creation of a national farm market, removing distortions and e-platform across 585 stations.
- vi. Introduction of a new crop insurance scheme to mitigate risks at affordable cost.
- vii. Promotion of ancillary activities like poultry, beekeeping and fisheries.¹³⁶

One of the options to double farmer income and mitigate risk is the adoption of Integrated Farming Systems (IFS). IFS or integrated agriculture is a commonly and broadly used word to explain a more integrated approach to farming as compared to mono-culture approaches.¹³⁸

It refers to agricultural systems that integrate livestock, crop production, fish, horticulture, apiary, sericulture, fungi culture, lac culture, and such other related activities may sometimes be known as integrated bio-systems. In this system an inter-related set of enterprises is used so that the "waste" from one component becomes an input for another part of the system, which reduces cost, improves production and income. IFS ensure that wastes from one form of agriculture becomes resource for another form. Since it utilizes waste as resources, we not only eliminate waste but we also ensure overall increase in productivity for the whole agricultural system.¹³⁷

Livestock based farming systems Livestock+Crop based farming system:

Livestock + crop farming system is a predominant farming system prevalent in most of the parts of India. Integrating crops with livestock on the same farms helps smallholder farmers to diversify the sources of income and employment generation. Crop and livestock complement one another through mutual benefit. In livestock + crop system, the animal component is

often raised on agricultural waste products while the animal is used to cultivate the land and provide manure to be used as fertilizer and fuel.¹³⁸

The animals play important role in enriching the soil gradually and increasing soil organic matter to support the crop. The draft power of animals is used for farm operations, while crop residues provide fodder for livestock and grain provides supplementary feed for productive animals. Animals also provide manure and other types of animal waste. It is reported that the manure availability was 12 tonnes from a pair of draught cattle integrated with crop. Cow dung helps in the overall sustainability of the farming system. Dung contains macro and micro nutrients required for improving the soil fertility and crop growth. Cow dung is used for the production of biogas.¹³⁹

Biogas is a source of renewable, alternative and sustainable energy. Per ton manure contains 8 kg of nitrogen, 4kg of phosphorus and 16 kg of potassium. Application of manure improves the soil fertility and water holding capacity. The cost of weed control is reduced where the livestock graze under plantations. It has been reported that 98 per cent of the farmers opined that livestock rearing reduces vulnerability in drought years, 97 per cent of the sample respondents indicated that farmers suicides were less in dairy developed areas and commercial agriculture increased suicidal rate in Andhra Pradesh (96.%). Integrated farming system with six buffaloes generated 904 of man days of employment against 400 man days in crop alone.¹⁴⁰

Livestock + Crop + Fish based farming system:

Livestock+Crop+Fish farming systems can be followed by integrating fish with Livestock +Crop farming system, raise the fish without any additional feed, rearing fish in the fish pond with the help of available dung from livestock. Integrated Livestock + Crop + fish farming can be carried out for increasing returns from a limited land area and reducing risk by diversifying crops. There should be ample supply of fresh and clean water available throughout the year to maintain water level for fish management purposes.¹⁴¹

The nutrients content in cow dung will help in growth of phytoplankton and zooplankton in fish pond. The by-products of livestock can be used for aquaculture. Direct application of wastes of livestock is common practice. The by-products of livestock are manure, urine and spilled feed. The adult cattle produce about 4,000-5,000 kg dung, 3,500-4,000 liter urine annually. For a pond size of 1 ha of 5-6 adult cattle can provide adequate manure. In addition to 9,000 kg of milk, about 3,000-4,000 kg fish/ha/year can be produced in this system. This system will save labor for lifting the cow dung. The requirement of green and dry fodder for an adult cattle is 9-10 and 2-2.2 ton respectively and will be met from crop component. The manure will be used for improving the fertility of soil. It is reported that inclusion of dairy and poultry components in IFS, the net income have been increased to Rs 37,343/- per year as against Rs 26,511/- from field crops only.¹⁴²

Poultry + Fish based farming system:

Poultry+ fish farming system can be integrated to reduce the cost of fertilizers and feeds in fish farming. Poultry can be reared near or over the fish pond and the poultry excreta will directly drop into fish pond and get recycled. In this system poultry is reared under deep litter system. Poultry droppings in the form of litter contains: 3% nitrogen, 2% phosphate and 2% potash. Poultry droppings acts as a good source of fertilizer which helps in producing fish feed i.e. phytoplankton and zooplankton in fish pond. It is reported that 1000 chicken can be integrated with one hectare fish pond provided the optimal water quality for fish survival and growth and also reported that the excreta load was 3600 kg ha⁻¹month⁻¹(dry matter); water pH 8.6; total alkalinity 65.0 mg L⁻¹; dissolved oxygen 8.0 mg L⁻¹; biochemical oxygen demand (BOD) 2.0 mg L⁻¹; ammonia 0.02 mg L⁻¹and total phosphates 10.0 mg L⁻¹. Fish yield range from 4000-5000 Kg/ha/yr. Poultry-fish integration increases the resource use efficiency and proper utilization of space and eco-friendly¹⁴³. It has been reported that the integrated poultry-fish farming provided additional income of Rs. 4000-5000 per annum and generated 45-50 man days of employment. It has been reported that, the fish-poultry farming system could generate maximum profit of Rs. 33664.06 per 0.025 ha yr⁻¹with B: C ratio of 1.09. Bezbaruah (2012) reported that integrating, Poultry + Fish + Horticulture farmer earned Rs. 40,000 from poultry, Rs. 25,000 from fish and Rs. 6000 from vegetable growing on the bunds of pond. It has been reported that Fish+Poultry integration produced 4500 to 5000 kg fish, 70,000 eggs and 1000 kg (live weight) of chicken meat from 1.0 ha fish pond annually without any supplementary feed.¹⁴⁴

Livestock +Crop+ Backyard poultry

Backyard poultry plays a significant role in rural people's life for generating income and nutritional security of the family. Integration of livestock+ crop farming with backyard poultry farming will improve the nutritional security as well as increase the income of farmers. Backyard livestock comprising of sheep, goats, pigs and poultry provide emergency sources of income for family as reported by Devendra and Pezo (2002). Bird scavenges on the undigested grains in dung as well as the threshing wastes in the fields. Backyard poultry also predate the insect and pests which are responsible for incidence of diseases in the crops. Separate inputs are not required for additional feeding of the birds. Eggs and chicken are good source of protein available to the farm family as well as provide income on regular basis. It is reported that improved backyard poultry as a scientific intervention improved household income.¹⁴⁵

Pig cum fish farming system:

Integrated livestock-fish farming is a practice which links together two normally separate farming systems, whereby the livestock and fish become sub-systems of a whole farming system. The higher fish production is attainable through intensive management inputs, involving high stocking densities of complementary-feeding fish species, addition of energy-rich supplementary feed to a significant component of natural feed, and aeration of fish pond water. The rising cost of high protein fish feed and inorganic fertilizer, as well as the general concern for energy conservation, have brought about increased interest in the utilization of animal manures in aquaculture and in the traditional systems which integrate animal husbandry with aquaculture. The integration of livestock with fisheries aquaculture has received considerable attention lately with emphasis on the incorporation of animal manures as fertilizer and nutrient for promotion of natural feed in fish ponds. The rationale behind integrating fish with livestock is the large amount of nutrients (N-P-K) present in the animal feed being recovered in the manure, with possible proportions of 72–79% nitrogen, 61–87% phosphorus, and 82–92% potassium. These act as fertilisers in fish ponds to produce plankton which comprise high-protein natural food for certain species of fish. Recent experiments have demonstrated that considerable fish production can be obtained when animal manures are properly applied to fish polyculture systems. It is reported that who evaluated fish production and income generation with integration of pig and poultry reported that fish productivity was better in ponds integrated with pigs than with poultry. A stocking density of 10000 number of fingerlings/ha water body within six months gave rise to 9840 kg ha⁻¹ yr⁻¹ in fish-pig system while the fish-poultry system could produce only 8240 kg ha⁻¹ yr⁻¹. The economic analysis and benefit-cost ratio of practicing integrated fish-livestock farming revealed that integrated fish-pig farming could generate maximum profit of Rs. 48023.19 per 0.025 ha yr⁻¹ with B:C value of 2.04 which was higher than integrated fish-poultry farming system (Rs. 33664.06 per 0.025 ha yr⁻¹ with B:C value of 1.09). Livestock based integrated farming system provides an opportunity of increasing economic yield per unit area per unit time in small and marginal farmers. In this system waste materials are effectively recycled by linking appropriate components. Thus, minimize the environment pollution.¹⁴⁶ Recycling of product, byproducts and waste material in integrated farming system are the factors responsible for the sustainability of farming system. Due to integration of different livestock components with crops, production of eggs, meat and milk provide nutritional security and income generation round the year to the farmers. Combining crop with livestock enterprises would increase the labour requirement significantly and helps in reducing the problems of under employment to a great extent. IFS provide enough scope to employ family labour round the year. The nutritional security, natural resource management and environment protection are the major concern for sustainable agriculture. Integration of livestock is the way forward to promote proper utilization of available resources and environment protection for economic growth. Integrated farming system diversifies farm production, increase the income, improve nutritional security and promote nutrient recycling.¹⁴⁷

What's the difference between integrated, sustainable, organic and regenerative agriculture

Sustainable agriculture aims to maintain the conditions for farming in the long-term. This means that humus content and habitats in the soil are preserved, that the climate, water and air are not polluted and that biodiversity is protected. Since 2001, the European Initiative for Sustainable Development in Agriculture (<https://leaf-eisa.frb.io/>) has been in existence, bringing together agricultural organizations from the seven countries of France, England, Germany, Hungary, Luxembourg, Sweden and the Netherlands, and cooperating with five lobbying organizations in the fields of animal feed, fertilizers, animal welfare, plant protection and environmental protection. The aim is to establish, strengthen and further develop sustainable agriculture through the integrated approach in Europe.¹⁴⁸

Integrated farming summarizes practices that combine conventional and organic farming in an environmentally protective manner. This means, for example, that chemical pesticides are still used but only when there is high infestation pressure – before that, biological means are used. Environmentally friendly inputs and methods are generally preferred. The very strict conditions that apply to an organic farm can result in crop losses that a conventional farm cannot afford. Therefore, in an emergency, conventional means and methods can be used so that the increased effort is not offset by a lower yield. The focus on species-appropriate animal husbandry and targeted environmental protection measures is also part of integrative agriculture.¹⁴⁹

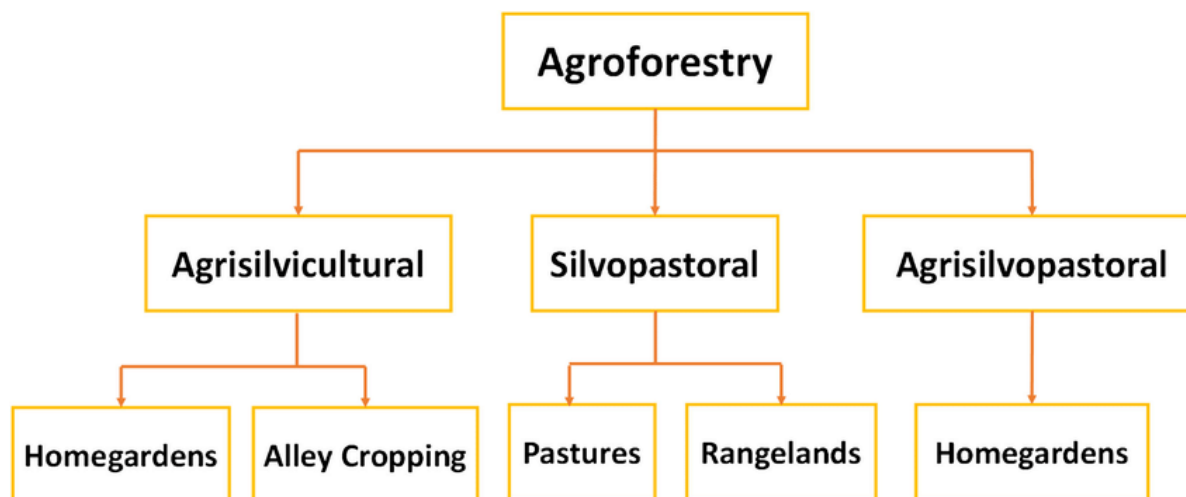
Organic farming is also sustainable but it is bound by strict regulations. In Europe, this is the EU regulation on organic farming. The regulation includes bans on additives, rules for the correct naming and marketing of products, and much more. Organic farming is about keeping cycles as small as possible. Therefore, the feed for the livestock almost always comes from the farm itself or nearby and the manure is composted on site and used to fertilize the fields.¹⁵⁰

While organic farming is largely defined by general action maxims and goals, regenerative agriculture is results-oriented. Not only should the balance in the ecosystem be maintained, but in particular more CO₂ should be bound in the soil than is released – a carbon sink is the goal. Thus, agriculture seeks negative emissions and, when practiced on a large scale, could not only halt but reverse climate change. Restorative or regenerative agriculture is based on the principle of efficient humus buildup. In this context, one also speaks of climate farmers.¹⁵¹

The difference lies in practice

However, to reduce regenerative agriculture to carbon storage alone would ignore many important aspects associated with humus buildup: The prevention of erosion, improved water-holding capacities, permanent enhancement of soil life, and crop security, for example.¹⁵²

Regenerative practices include reduced tillage, associated permanent rooting and permanent mulch layer, and the two key points of "promoting biodiversity" and "integrating animals". This refers, for example, to (syntropic) agroforestry systems that bring together different crops, biotopes and livestock on the same field, thereby generating synergistic effects.¹⁵³



Who will pay for my conversion to regenerative farming

A European organization that provides financial and substantial support for farmers to switch to regenerative practices, measure them and share the knowledge is Climate Farmers¹⁵⁴

There are several other organizations around the world with similar goals:

Those farming in Australia can be helped by Friendly Farms to transition to regenerative agriculture (friendlyfarms.org.au/), North American farmers can find like-minded people and support at

Regenified (regenified.com) and farms across the Southern Hemisphere are already transitioning to regenerative agriculture with the help of Renature (www.renature.co) - definitely worth a look for farmers in Africa, Asia, the Orient and South America!¹⁵⁵

So are Humintech products suitable for integrated, organic or regenerative farming

Yes. Three times yes. Biostimulants are neither fertilizers nor pesticides and are therefore subject to separate regulations. Almost all of our products are certified for organic farming and thus meet the highest quality standards for inputs. By definition, they are also regenerative, actively building soil life, balancing imbalances, enabling the highest possible natural biodiversity below and above ground, reducing emissions of greenhouse gases and leaching of nutrients. They are ideal if you are in the conversion phase and want to take fewer risk, just as they can ensure conventional farms the highest possible harvests.¹⁵⁶

Integrated Farming System (IFS) is the integration of different agricultural methods like crop cultivation with animal husbandry and aquaculture with pig farming. The essence of IFS is that it works like an ecosystem where all the elements are in equilibrium and interdependent. The waste of one element works as a nutrient for another. The final result is the optimum utilization of resources and nutrients, restoration of ecological balance, and increase in the income of the farmers. For example, some part of the agricultural land can be utilized for growing fodder crops for animals to eat. The crop residue can also be utilized as food for animals. The excreta and urine from the livestock are safe to use organic fertilizer. The use of such organic fertilizer restores soil health. The farmers get benefits like an increase in income from crops and animal husbandry; fewer efforts are required to dispose of the waste and soil health improves. All these benefits to farmers also ensure the sustainability of agriculture. However, some of the enterprises maybe just taken up to increase the farmer's income, without any interdependency with agriculture.¹⁵⁷

Sustainable Development is at the core of almost all discussions, all the way from economic to climatic deliberations. The principle of sustainable development is that we should neither sacrifice the needs of today nor compromise the needs of future generations. Food security is one of the most important concerns for the survival of human beings; hence sustainable agriculture is one of the solutions to the above concerns. Sustainability in agriculture is mostly about the sustainability of small farmers since small farmers are about 80% of the farmers in India.¹⁵⁸

Many strategies have been thought of to make agriculture sustainable. These include agro-climatic zoning, various methods of farming like crop rotation and mixed farming, soil and nutrition management, and Integrated Farming Systems (IFS).¹⁵⁹

Sustainable agriculture is somewhere at the intersection of economic profitability, social well-being, and ecological balance. Let's see how IFS enhances each of these components, hence contributing to the sustainability of agriculture.¹⁶⁰

Economic Profitability:

The profitability of farmers is the most important aspect of sustainable agriculture. It is difficult to provide incentives to farmers without the promise of good returns. IFS has the potential to increase productivity multiple times. For example, practicing apiculture (beekeeping) with oilseed cultivation has shown the productivity gain of 2-3 times in oilseed because of pollination services provided by bees. Besides this, farmers also get additional marketable products like honey, wax, bee venom, and pollen from such mix-farming. This further enhances the profits of farmers. For this precise reason, beekeeping is being promoted under the **Mission for Integrated Development of Horticulture**.¹⁶¹

As already pointed out, around 80% of farmers in India are small and marginal farmers. These farmers practice subsistence agriculture; only a few can upgrade to commercial agriculture. IFS increases the productivity of not just crops, but also of farmers. With better productivity and more marketable products in hand, small farmers are also able to generate handsome revenue. The practice of agroforestry on edges of farmlands and fallow lands provides farmers with revenue-generating products like timber, fruits, and herbs. Under 'Har Med pe Ped' initiative of Sub-mission on Agroforestry, a sub-mission of Mission for Sustainable Agriculture, agroforestry is promoted among farmers. Bamboo survives in a variety of climates and matures very fast. For this reason, it is being promoted under National Bamboo Mission.¹⁶²

Social Impact:

The enhanced production of various types of crops and other agro-products ensures food and nutritional security, impacting the overall health of the country. Animal husbandry provides dairy products; apiculture provides honey and agroforestry may provide fruits and medicine. Practices like agroforestry generate employment, which is helpful in solving the problem of unemployment and underemployment in rural areas. Since the availability of agro-products is enhanced by IFS, it promotes allied industries of agriculture in rural areas.¹⁶³

Ecological balance:

IFS methods, if implemented properly, have a positive impact on the ecology of the region. In places where animal husbandry is practiced with crop cultivation, the excreta from animals are utilized as manures. This decreases the dependency on chemical fertilizers, promotes organic farming at a low cost, and impacts soil fertility positively. With this integration, various organic farming models like IFS promote diversification of species in a local area, thereby increasing the complexity of the food web. This induces stability in the local ecosystem and supports more wildlife with time.¹⁶⁴

Resource and Knowledge Centers:

While IFS has many benefits; proper management of farms is of crucial importance. Since all the elements are in the vicinity of each other, care should be taken that food or medicine for one should not harm the other. To enable farmers to make informed decisions, the Indian Council of Agriculture Research (ICAR) has developed 45 IFS models covering all the 15 agro-climatic zones of the country. The information on these models is being imparted through **Krishi Vigyan Kendra (KVKs)**, which are the resource and knowledge centers in the field of agriculture in the district.¹⁶⁵

Though Green Revolution transformed India from a food importer to a food exporter country, monoculture turned out to be a major problem in this transformation. Among other problems, this led to imbalances in soil nutrients and huge consumption of chemical fertilizers required for the intensification of agriculture. Hence comes the realization regarding the unsustainability of our cultivation.¹⁶⁶

IFS mimics the natural environment at least to some extent. Diversification and interdependency among the different agricultural and allied methods lead to food web complexity. Apart from ecological balance, IFS has huge social impacts in terms of nutritional and food security and the creation of employment. Most importantly, it increases the profitability and productivity of small farmers. Hence, **Integrated Farming Systems is going to have a major contribution to the sustainability of agriculture and in the vision of doubling farmers' income.**

Integrated agriculture involves farming systems with environmental, economic, social, and intergenerational sustainability (1). In an integrated, sustainable agriculture system, the goal is not necessarily producing immediate outputs, but rather maintaining a system of healthful production, over time. The major components of a sustainable system include economy, environment, and community. The resources that must be managed in such a system takes all of these related components into account.¹⁶⁷

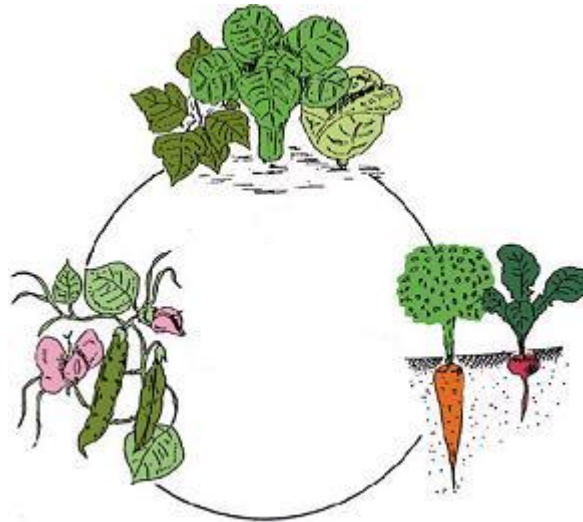
Economically, the farm operations fulfill the financial needs of the farmers and those employed by the operations. The practices in the agricultural system are executed in an environmentally sound manner, with the preservation of natural resources including soil, water, and air.¹⁶⁸ The operations also sustainably provide access to food to individuals in the community, which allows for opportunities for cooperative relationships¹⁶⁹

The following modules will review various components of integrated agriculture:

1. Resource Management
2. Organic Crop Production
3. Livestock Management
4. Elementary Veterinary Services¹⁷⁰

Resource management

Resource management changes continually based on new experiences, knowledge, and advice. Various farming practices depend on where and how agricultural activities are performed. Activities that tend to be sustainable include crop rotation, riparian buffer strips, rotational grazing, and direct marketing.¹⁷¹

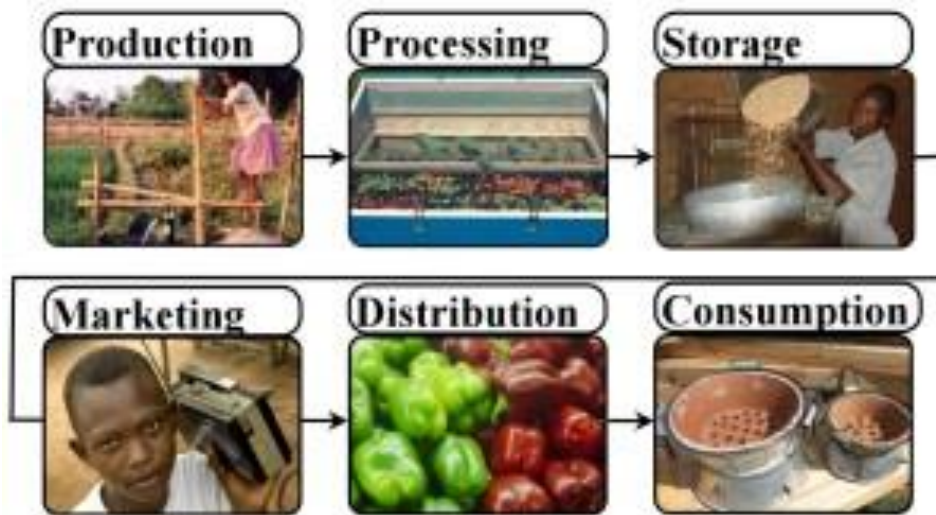


A crop rotation schedule is important for maintaining soil quality, reducing weeds, and improving yields

The overall goal is to create an agro-ecosystem that produces food and fiber. This ecosystem is linked to a food system that produces, processes, distributes, and consumes food. The efficient management of resources is essential when dealing with such complicated systems ¹⁷²

Part 2: Application to Greenhouses

Strong food value chains (FVCs) follow a sequential order, to maximize productivity and limit losses. ¹⁷³



Six general stages of a FVC

With an affordable greenhouse system, the FVC components are as follows:

- Production- The plants grown in the greenhouses rely on the local soil, seeds, fertilizers, and potentially pesticides. The purchased inputs can be limited by reusing seeds produced by plants and using compost as fertilizer. To sustain the soil and limit pests, crop rotation techniques can be established. ¹⁷⁴
- Processing- The processing of the raw farm product includes simple steps including washing or cooking vegetables. The crops sold from the greenhouse typically need minimal processing before sale.

- **Storage-** The storage sites for the crops can include technologies like metal silos or hermetically sealed bags. If not available, crops can be stored for days to weeks, depending on the crop. Storage also may not be necessary, depending on the demand for the crop.
- **Marketing-** The marketing of the produce varies based on the market site established. If the crops are sold from a supermarket, there is limited need for advertising. Word of mouth marketing is useful if the crops are sold from home or a local community center.¹⁷⁵
- **Distribution-** Utilizing expert agents to help secure strategic market linkages, the crops produced from the greenhouses can be distributed. There may also be informal sites established to sell crops, including at home or a local community center.
- **Consumption-** The shelf-life of the vegetables can be increased by refrigeration before sale. Fires, solar cookers, or stoves can be used to prepare the food for consumption.
- **Waste management-** The waste throughout the food production process can ideally be discarded into a compost bin, to be used as fertilizer during another crop cycle.¹⁷⁶

Part 3: Activity

With a greenhouse or another farming system, analyze the levels at which the practice is sustainable. What resources could be optimized to increase sustainability? What are the benefits of a sustainable system?



Organic Crop Production

Part 1: Summary

While organic agriculture is closely related to sustainable agriculture, there are key differences. Depending on the region, there may be certain laws in place that distinguish organic practices that are required, along with farming practices that are prohibited. There may be third-party certifiers to monitor the practices. Generally, organic farmers need to rotate crops to improve soil quality and manage pests. They also need to keep record of operation and minimize off-farm inputs while refraining from using synthetic fertilizers, pesticides, and genetically modified organisms.¹⁷⁶



During the Second African Organic Conference in May 2012, representatives from 35 countries discussed the importance of organic agriculture for issues including poverty reduction, climate change adaptation, and preservation of indigenous knowledge . AfroNet (African Organic Network) is now established as a network for organic stakeholders throughout Africa. While high external input chemical systems could increase food production in Africa, small-scale organic techniques can improve low resource consumption, market linkages, and economic independence of farmers . AfroNet and other partners established the African Organic Action Plan to improve research, training, communication, partnership, and capacity development among farmers and the general public .¹⁷⁷

Part 2: Application to Greenhouses

By refraining from genetically modified plants, fertilizers, and pesticides, you will be on the path to sustaining an organic greenhouse operation. The limited water usage from the drip-irrigation technology further aligns with the organic farming goal of limiting inputs. There is also room to rotate crops within greenhouses to improve soil quality and reduce pests.¹⁷⁸



Part 3: Activity

Consider the seeds, fertilizers, and pesticides that are available to you. Are they classified as organic or not? If there are both options available to you, construct a table of the benefits and disadvantages of each choice. Do you believe that organic farming works well for you? If so, consider joining a network of other organic farmers to share insights and tips.¹⁷⁹



Livestock Management

Traditional livestock systems contribute to 70% of the world's rural poor. In small and medium scale production systems, increasing productivity is a challenge. In order to improve livelihoods and local economic development, the Animal Production and Health Division (AGA) of the Food and Agriculture Organization of the United Nations (FAO) recommends small-scale dairying, small-medium scale poultry, with some emphasis on ruminant (i.e. cattle) systems . AGA aims to provide topical information and technical support to member countries.¹⁸⁰



Basic tips that should be followed to ensure the health of livestock include (2):

- Feed less human food (i.e. limit grain and include high fiber feed)
- Raise regionally appropriate animals
- Keep animals healthy (see next section, Elementary Veterinary Services)
- Find natural supplements (some plant extracts can alter rumen microbial population and more efficiently use nitrogen and energy)¹⁸¹

- Track costs and benefits
- Find best practices

Part 2: Application to Greenhouses

After owning an agricultural technology that increases yields and profits, the funds to purchase livestock increases. In order to maintain the wellbeing of the overall farm, the livestock needs to be appropriately managed. There is the potential for the animals to directly contribute to the health of the farm when dung is composted into manure. Rich in nutrients including nitrogen, phosphorus, and potassium, manure can serve to be a useful fertilizer. Benefits to manure use include improvements in soil structure, aeration, and water infiltration. The highest nitrogen content is generally found in poultry manure, while there is still significant content in hog, steer, sheep, and horse manure.¹⁸²



Steps to turning dung in manure :

- Mix dung, grass clippings and food waste in equal parts of materials like leaves and straw
- Find substitutes for organic material if necessary, including agricultural crop residues, paper products and wood
- Let the pile sit for six to nine months, with exposure to air and water
- During that time, turn the pile periodically
- Use fertilizer wisely to avoid adding an excess of nutrients to crops¹⁸³

Part 3: Activity

If possible, try to use animal manure as fertilizer.



Elementary Veterinary Services

Part 1: Summary

With globalization and climate change, there has been an increase in emerging and re-emerging animal diseases, with some diseases transmissible to humans. FAO asserts that the governance of animal health systems must be improved. Its Animal Production and Health Division identifies four major issues related to animal health, including trans-boundary diseases, vector-borne diseases, veterinary public health (including food safety), and veterinary services¹⁸⁴



In regions where this infrastructure is not yet established, there are basic steps that livestock caretakers can execute :

- Observation (knowing normal behavior of animals is useful when identifying early stages of health problems)
- Animal restraint (when restraining animals for examination, quietly and gently handle them, to reduce undue stress)
- Taking and evaluating vital signs¹⁸⁵
- **Know how to monitor heart rate and respiratory rate**
- Basic wound care
 - Restraint of animal is necessary when treating wounds
 - Clean wound location, removing hair if necessary
 - Bandage
 - Check bandages at least twice daily

- Change bandages every other day¹⁸⁶
- Ruminant hoof care
 - In regions where animals do not walk on rough surfaces, regular hoof trimming is necessary to avoid discomfort
 - Hoof-trimming calendar can be made to schedule regular trimmings, roughly about every four weeks
 - As hooves grow at different rates, schedule should be made depending on animal needs¹⁸⁷

Part 2: Application to Greenhouses

In an integrated farming system, the health of both the agriculture and livestock should be maintained. An understanding of the basic veterinary systems is of the essence when owning a farm with livestock.¹⁸⁸

Part 3: Activity

Practice taking the vital signs of each animal on your farm, if applicable. If listed on the chart above, check if at least the pulse and respiratory rate are within the normal range for your animal.¹⁸⁹



Integrated Farm Management: A Guide

LEAF's IFM principles and practices guide to help you farm sustainably by adopting a whole farm business approach.¹⁹⁰

Resource explained

Integrated Farm Management (IFM) is a whole farm business approach that aims to deliver more sustainable farming.

IFM combines the best of modern technology with traditional methods to help deliver prosperous farming that enriches the environment and engages local communities.¹⁹¹

LEAF develops and promotes IFM and offers a range of services to help support farmers in delivering more resilient and sustainable farm practices.

This guide is designed to give you an overview of the principles involved in IFM and introduce some of the tools available to LEAF members.¹⁹²

Findings & recommendations

- LEAF's IFM is made up of nine sections, which together address your entire farm business at a site specific level. An understanding of the importance of each section and the integration between them is essential for effective implementation of IFM.
- LEAF's IFM is composed of: Organisation and Planning, Soil Management and Fertility, Crop Health and Protection, Pollution Control and By-Product Management, Animal Husbandry, Energy Efficiency, water Management, Landscape and Nature Conservation and Community Engagement.
- LEAF's IFM Guide takes you through the key practices and principles within each of these areas as well as highlighting the synergies between them.
- You usually have to be a LEAF member to access the guide, however it is currently available for all to access for a limited time period.¹⁹³

Integrated agriculture key to farmers' uplift

The income from the livestock sector has quadrupled. Hence, the promotion of dairying and utilisation of livestock excreta can save up to 50 per cent of fertiliser inputs in farms. And, combining social forestry on wastelands in farms can enhance soil fertility restoration. The net result from such integrated farming would be an increase in gainful employment and additional income to farmers.¹⁹⁴

Parveen is an example of a small farmer from Vagarahalli village of Hassan district in Karnataka whose enterprise has made sustainable agriculture a reality on his 1.69-hectare farm. Traditionally, he grew crops such as ragi (finger millet), maize, potato and coconut with a small dairy and poultry unit. The use of improved varieties and hybrids has been supplemented on the farm with introduction of high-value crops such as ginger and sericulture. Drumstick and papaya have been intercropped with coconut. Silver oak has been planted all along the farm borders. Farm waste is being recycled into healthy manure. He has installed a micro-sprinkler irrigation system in the coconut garden in addition to using appropriate farm machineries such as coconut climbers and de-huskers.¹⁹⁵

Despite the challenges of climate change, soil fatigue and reduction of water availability, with the above measures, Parveen has increased his net annual income from Rs 47,740 to Rs 7.28 lakh! Without doubt, technical and capacity-building support from the Krishi Vigyan Kendra (KVK), Hassan, has been a critical resource.¹⁹⁶

The Doubling Farmers Income (DFI) Report, 2017, observes that the integration of farm activities, in both rainfed and dryland areas, when carefully chosen, planned and executed can yield greater dividends for sustainable livelihoods, especially in the case of small and marginal farmers.

The Union Government is implementing the National Mission of Sustainable Agriculture. The objective of this mission is to extensively leverage the adaptation of integrated farming practices and appropriate technologies in conjunction with the Indian Council of Agricultural Research (ICAR), and more importantly, the state governments.¹⁹⁷

Food and nutritional needs of a more health-conscious population entails a diversification of farming from staples towards high-value crops, such as fruit and vegetables. Further, integrated farming with the inclusion of beekeeping, fisheries, sericulture, poultry and mushroom cultivation can give additional high-energy food without affecting the production of food grains.

As per the National Statistical Office's (NSO) Situational Assessment Survey 2018-19, the income from the livestock sector has quadrupled. Hence, the promotion of dairying and proper collection and utilisation of livestock excreta can save up to 50 per cent of fertiliser inputs on farms in addition. Besides, combining social forestry on wastelands on farms can enhance the restoration of soil fertility. The net result from such integrated farming, experts add, would be a substantial increase in gainful employment and additional income to farm families, leading to a better standard of living.¹⁹⁸

In India, the complexity increases with the diversity in integrated farming practices by small and marginal farmers across our 15 agro-climatic zones. These include arid/desert regions and high-altitude, plain and coastal areas. For instance, in a study conducted by the ICAR, the number of integrated farming systems ranged from eight in West Bengal to one in the

states of Jammu & Kashmir, Punjab, Maharashtra and Karnataka. As many as six integrated farming systems are in existence in Gujarat, Chhattisgarh, Madhya Pradesh, Andhra Pradesh, Telangana and Odisha.

In the above context, it becomes absolutely imperative to push institutional policy interventions, first and foremost, to strengthen precision agriculture at the last mile in ‘on-farm management’. This encompasses the application of appropriate technologies to aid small and marginal farmers in the input farming practices of tillage, residue, nutrient, water, weed and mechanisation management.¹⁹⁹

Equally important is the generation and use of quality data and its analytics, both at the national and state levels, for such farming practices.

Concomitant to on-farm management, it is also imperative to strengthen the last mile ‘farmgate’ infrastructure through the requisite investments. This is to connect small and marginal farmers practising integrated farming to both domestic and international markets. They are many a time unable to individually invest in the primary processing infrastructure at the farmgate. This includes post-harvest management activities through “pack houses” such as drying, grading, sorting, ripening, waxing, packaging and quality control assessment. They also include crop-specific cold chain storage/warehousing with pre-cooling facilities, reefer vehicles and distribution hubs for perishable crops. Small and marginal farmers are also sometimes unaware of the crop quality specifications required by different types of buyers and intelligent information about the near-farm, across states and export markets.²⁰⁰

Our KVKs under the aegis of the ICAR have created and nurtured several successful integrated farming system models with crop combinations. The time is ripe for them to learn and dovetail from the good practices of the myriad private sector agritech initiatives, especially agri-startups, in the rural landscape. To name a few, Dehaat, Ninjacart, Sammunati, Waycool, Agrostar and Jumbotail have attracted huge venture capital funding in precision agriculture, on-farm management, supply chain and output market initiatives, according to a 2021 Ernst & Young study.

The creation of the Rs 1 lakh crore Agri Infrastructure Fund (AIF) by the Union Government is also a step in the right direction. It provides access to credit, with interest subvention, for agri-entrepreneurs, farmer producer organisations (FPOs) and governments to invest in rural community assets and post-harvest infrastructure.²⁰¹

There is a tremendous penetration of broadband connectivity and mobile usage in villages. Hence, virtual interaction with farmers on integrated farming ‘package of practices’ has to be supplemented with the physical reach of sufficient numbers of extension officers of agriculture, horticulture and allied departments. The use of Common Service Centres (CSCs), in this context, has to be intensified too. These are last-mile public delivery access points in districts that provide high-quality and cost-effective video, voice, data content and public utility services.

West Bengal

Small and marginal farmers account for about 96% of all farmers in West Bengal. It is a major challenge to improve the livelihood of these small and marginal households. Adoption of integrated farming system with synergistic integration of various farming components is the need of the hour in order to fulfill the basic needs of the households including food (cereal, pulses, oilseeds, milk, fruit, honey, meat, etc.), feed, fodder, fiber, etc. An integrated farming system consists of a range of resource-saving practices that aim to achieve acceptable profits, high sustained levels of production and preserving the environment, while minimizing the negative effects of intensive farming. The integration has to be made in such a way that product of one component should be the input for other enterprises with high degree of complimentary effects on each other, which in turn reduces the cost of cultivation, provides a regular source of income and employment. IFS also reduces the dependence on chemical inputs and thus helps to cope with aberrant climatic conditions and ensures for the establishment of a climate smart agriculture and maintains sustainability on a long term basis. The research of the project (AICRP on IFS) is, therefore, directed towards development of efficient, economically viable and environmentally sustainable farm production technologies for improving productivity and resource use efficiency. On-farm testing, verification and refinement of system-based farm production technologies are also some of the important research activities of the project.²⁰²

Integrated Livestock Farming System

Livestock plays a significant role in rural economic development by supplementing family income and generating gainful employment, especially for landless laborers, smallholders, and marginal farmers, as well as for women. Historically, livestock rearing has been recognized as an integral part of the agricultural sector, and it has been observed that combining livestock with other farming systems such as fisheries, apiculture, horticulture, agro-forestry, etc. can be more productive and sustainable than specialized and intensive systems. This system of combining livestock with different farming systems termed as Integrated livestock farming system (ILFS) which helps in efficient utilization of natural resources and wastes/organic residues and involve recycling of bio resources. For example paddy straw a by-product from rice crop can be used as a valuable input for mushroom cultivation or as a source of dry fodder for dairy animals. Similarly, spent of mushroom cultivation (used straw) can be used as a raw material in compost or vermicompost pits and by-products from dairy unit like dung can be used as fish feed or raw material for vermicompost unit. In this way an integrated approach to farming can becomes more beneficial than monoculture and specialized farming and it can generates employment around the year along with additional income.²⁰³

A system of integrated livestock farming is based on the philosophy that “there is no waste” and “waste is only a misplaced resource that can be transformed into another useful material for another purpose”. It is a way of efficient waste utilization generated under different farming systems and assists the farmers in becoming self-sufficient and self-reliant. At present most of the farmers have small and fragmented land holding (< 1 ha) and area under crop cultivation is also shrinking day by day resulting in decrease in productivity from different crops. In agricultural operations the sowing and harvesting of crops are seasonally dependent and during other times of the year the farmers are free and under this scenario, integration of livestock sector with different farming systems can provides income and employment round the year and can meet the household’s requirements of the farmers with small land holding.²⁰⁴

Different approaches under Integrated Livestock Farming System (ILFS)

There are different approaches farmers can adopt to implement ILFS for better utilization of their landholdings and to establish a source of sustainable income round the year as explained below in brief:

1. Crop livestock farming system

Combinations for adoptions can be:

- Horticulture-Agriculture-Cattle/Goat/sheep farming system.
- Fodder-Vegetable-Dairy farming system.

In integrated crop livestock farming system, agriculture crop residues can be used for feeding animals, while livestock manure can increase agricultural productivity by improving soil fertility and fortifying nutrients that reduce the use of chemical fertilizers. A healthy cow excretes over 4,000-5,000 kg dung, 3,500-4,000 L urine on an annual basis which can be applied as manure to the fields as a replacement of chemical fertilizers after proper composting.²⁰⁵

- **Crop livestock fishery farming system**

Under this different crop, livestock and fisheries components can be combined as:

- **Crop-Goat/Cow-fish farming system**
 - **Crop-Azolla-cattle-fish farming system**
 - **Crop-Fish-Pig farming system**

In this crop residue i.e. paddy straw after rice crop harvesting can be fed to livestock. The manure from livestock can be applied in agriculture fields to improve soil fertility by increasing the availability of nitrogen and phosphorus in the soil. On the other hand fish production can be associated in rice fields where rice fields can provide better planktonic, periphytic and benthic food to fishes. In Livestock plus crop farming system the fishes are reared without any additional feed, with the help of available dung from livestock which is used to initiate zooplankton and phytoplankton growth. Fishes like rohu, catla, mrigal, grass carp, common carp and silver carp are well adopted in integrated system.²⁰⁶

The fish stocking rates may vary from 8000 to 8500 fingerlings per hectare. A species ratio of 40% surface feeder (Silver carp and catla), 20% column feeder (rohu), 20 to 30% bottom feeder (common carp and mrigal) and 10 to 20% macro vegetation feeder (grass carp) are preferred for higher fish yields under integrated farming systems.²⁰⁷

- **Crop livestock backyard poultry farming system**

Integration of livestock with crop and backyard poultry farming can improve the food security as well as farmers' incomes. Backyard livestock comprising of sheep, goats, pigs and poultry provide emergency sources of income for family. Bird scavenges on the undigested grains in dung as well as on the threshing wastes in the fields. Backyard poultry also predated the insect and pests which are responsible for incidence of diseases in the crops.²⁰⁹

- **Crop livestock poultry fishery farming system**
- **Horticulture/Agriculture-Pig-Poultry-Fisheries farming system.**
- **Horticulture/Agriculture -Goat/Sheep-Duck-Fish-Poultry farming system**

Duck/Pig/Poultry plus fish farming system can be integrated to reduce the cost of fertilizers and feeds in fish farming. Poultry can be reared near or over the fish ponds in which the poultry excreta will directly drop into fish pond and get recycled. In two tier housing system in integrated farming the upper floor can be used for rearing poultry and lower for pig over a fish pond. Excreta from poultry utilized by pig and pig excreta by fish and further it helps in better growth of zooplankton and phytoplankton which are eaten by fish and in this way the resources get recycled.²¹⁰

- **Crop livestock fishery biogas/vermicomposting system**
- **Agriculture-Dairy- biogas-fisheries farming system.**
- **Horticulture/Agriculture-Goat/sheep-vermicomposting farming system.**

Dung from livestock used for biogas production which can be utilized in cooking and electricity production etc. and slurry produced used as a fertilizer for crop production. Vermicompost can be produced from the cow dung which has better quality as a fertilizer for field crops in terms of high fertility and productivity.²¹¹

- **Small ruminants-Silvipastoral farming system**

In this system, a combination of improved pasture species or a mix of grasses is grown on one piece of land along with perennial trees. The animals graze on tree leaves and chop the leaves as fodder. During the lean period, this system reduces the cost of concentrate feed for animals by solving the problem of green fodder. Livestock species mainly include cattle, buffalo, sheep, goat and pigs. Neither fisheries nor poultry are considered livestock, even as they have been studied together, and forestry, sericulture, and apiculture are not included but have been integrated into livestock farming.²¹²

Scope of ILFS

A system of integrated farming is meant to mimic the natural principle of producing food throughout the year by using animals, plants, birds, fishes and other aquatic organisms. Farming enterprises include crop, livestock, poultry, fish, tree crops, plantation crops, etc. A combination of one or more enterprises with cropping, when carefully chosen, planned and executed, gives greater dividends than a single enterprise, especially for small and marginal farmers. Farm as a unit is to be considered and planned for effective integration of the enterprises to be combined with crop production activity. Integration of farm enterprises should be done based on many factors such as:²¹³

1. Soil and climatic features of the selected area.
2. Availability of resources, land, labour and capital.
3. Present level of utilization of resources.

4. Economics of proposed integrated farming system.

5. Managerial skill of the farmer.²¹⁴

In the context of India, there are a number of situations and conditions that can be alleviated by an ILFS. The situations ideal for the introduction of ILFS where farmer wishes to improve the soil quality, earn more profits, reduce waste disposal and use of chemical fertilizers.²¹⁵

Advantages of ILFS

1. **Productivity:** IFS provides an opportunity to increase economic yield per unit area per unit time by virtue of intensification of allied enterprises with livestock.
2. **Profitability:** Reduction in cost of production and linkage of utilization of waste material and elimination of middleman interference in most inputs used. No extra cost is involved for fertilizer which can be generated inside farm. Cost benefit ratio is increased thereby, improving purchasing power of farmers.
3. **Sustainability:** Organic supplementation through effective utilization of by-products of linked component is done thus providing an opportunity to sustain the potentiality of production base for much longer periods.
4. **Balanced Food:** All nutrient requirement of farmer's family can be met by consuming different sources of nutrition like vegetables/pulses, fruits, eggs, milk and meat products.
5. **Environmental Safety:** Waste materials are effectively recycled by linking appropriate components, thus minimize environment pollution. Dung>Biogas + slurry utilize in different process of cooking, lighting, engine fuel and slurry as fertilizer.
6. **Recycling:** Effective recycling of waste material (crop residues and livestock wastes) with less reliance to outside inputs – fertilizers, agrochemicals, feeds, energy, etc.
7. **Income Rounds the year:** Due to interaction of enterprises with crops, eggs, milk, mushroom, honey, cocoons silkworm, it provides flow of money to the farmer round the year. There is higher net return to land and labour resources of the farming family.
8. **Saving Energy:** Utilization of biogas as fossil for cooking, electricity and engine fuel for pumping water helps in conserving energy.
9. **Meeting Fodder crisis:** Plantation of perennial legume fodder trees on field borders and also fixing the atmospheric nitrogen. By-product and waste material of crops are effectively used as fodder and product like grains can be used as feed for poultry and pig.
10. **Employment Generation:** Combining crop with livestock enterprises would increase the labour requirement significantly and would help in reducing the problems of under employment to a great extent. ILFS provide enough scope to employ family labour round the year.
11. **Increasing Input Efficiency:** ILFS provide good scope to use inputs in different component greater efficiency and benefit cost ratio.²¹⁶

Limitations

1. A lower digestibility and protein content of crop residues leads to lower nutritional benefits. It is technically possible to increase the structure and functionality of crop residues by physical or chemical treatment, but it is not feasible for small, poor farmers because it requires machinery and chemicals that are expensive or not readily available.
2. Crop residues have the primary role of regenerating soil, however they are neglected too often or misapplied.
3. Intensive recycling can cause nutrient losses.
4. If manure fertilizer use efficiency cannot be improved, production and transportation costs will rise, as well as the surpluses lost to the environment.
5. Chemical fertilizers are preferred over manures for their quicker and easier uses.
6. Manure transportation is an important factor in manure use because mixed farms tend to use more manure in comparison to crop farms. Investments are required to improve the intake and digestion of crop residues.²¹⁷

Opportunities

1. Intensification of agriculture which is currently occurring in most farming systems favours livestock based integration.
2. Poor soil fertility, unavailability or increases in prices of fertilizers, and labour shortages, have forced farmers to rely on alternatives such as manure and traction.
3. Farmers can grow crop in the wet season and engage in livestock enterprises in the dry season.
4. Livestock enterprises are more lucrative than crop farming so it is advantageous to integrate livestock into farm activities.
5. Many indigenous, emerging and developed technologies are available to support sustainable crop–livestock integration.²¹⁸

Sustainability through ILFS

A sustainable livestock development must encompass an integrated farming system that includes efficient soil, water, crop, and pest management practices, which are cost-effective and environmentally friendly. The system allows for self-sustainability since the system is self-sustaining and reduces dependency on external inputs such as seeds, fertilizers, etc. The system provides balanced and rich nutrition to the farming family as well as reduces the money spent on cultivation and increasing profit margins on the same piece of land, which is a part of maintaining sustainability. On any farm, four natural ecosystem processes like energy flow, water cycle, mineral cycle and ecosystem dynamics work. By balancing food production, profitability, safety, animal welfare, social responsibility, and environmental care, the principles of ILFS are meant to be reconciled with those of sustainable development.²¹⁹

Economic importance

A livestock-based integrated farming system improves the economic viability of small and marginal farmers by increasing the yield per unit area per unit time. In integrated farming system, since more than one component is involved, yields and net returns assessment of this system becomes important. ILFS generate incomes to other families as labour requirement generally increase and labour will be busy round the year than traditional farming. Based upon economic returns, desired models can be promoted among the farmers. Table no. 1 and 2 shows economic viability of ILFS models developed in different states of the India in terms of high net returns in comparison to prevailing systems.²²⁰

Table no.1- Economic viability of ILFS models developed in different states of the India having equal or greater than one hectare.

States	Prevailing system	Net return	Suggested ILFS Model	Net Returns	References
Kerala	Rice + Fishery	181725 .58	Coconut+ Banana + Poultry + Goat + Cow	1964503 .57	Sabu <i>et al.</i> , 2020
Telangana	Rice-Maize	1,38,373	Crop-dairy-hen-sheep-rabbit-quail-manure	6,09,160	Goverdhan <i>et al.</i> , 2018
Karnataka	Sole crop red gram, paddy and cotton	43632.69/ha	Crop – Dairy – Vermicomposting	151414.3	Rashtrarakshak <i>et al.</i> , 2016
Crop – Dairy (2 cows, 1 buffalo) – Goat rearing	159071.3				
Crop – Dairy – 3 Sheep – 3 Goat rearing	183221*				
Bihar	Cropping alone (Rice-Wheat)	53000	Crop-Fish-Goat	19900.3	Kumar <i>et al.</i> , 2017

Crop-Fish-Cattle	14000.4				
Crop-Fish-Duck-Goat	21500.9*				
Telangana			Paddy-Brinjal-Cotton-Goat	36918.4	Srinika <i>et al.</i> , 2017
Paddy-Okra-Cotton-Dairy-Poultry	49307.8				
Paddy-Tomato-Cotton-Goat-Poultry	42434.8*				
Karnataka	Crop (Maize, cotton, Bengal gram, vegetables)	58,488/ha	Crop-Dairy-Poultry-Vermicompost -Fishery	1,50,170/ha	Desai, 2015
Rajasthan	Crops-Dairy (Cow and buffalo)	33385 /ha	Crop-livestock-horticulture (Fruit, Vegetable and flowers)	52161	Singh <i>et al.</i> , 2013

*System had higher benefit cost ratio

*System had higher benefit cost ratio

Table no.2- Economic viability of ILFS models developed in different states of the India having equal or less than one acre.

States	Prevailing system	Net returns	Suggested Model	ILFS	Net Returns	References
Mizoram	Fish only (Rohu, Silver carp and Grass carp) (0.06 acre pond)	15545.2	Fish-pig		48023.19*	Sahoo & Singh, 2015
Fish-poultry	33664.06					
Punjab	Cropping (Rice + Wheat)	32,328 per acre	Crop-Dairy-Fish farming		53,030	Singh <i>et al.</i> , 2020
Nagaland			Agriculture-Horticulture-Fishery-Piggery (5 pigs)		24394 per acre*	Kumar <i>et al.</i> , 2018
Agriculture-horticulture-fishery-poultry (50 bird), mushroom unit and <i>Azolla</i> (15 m ²)	32040 per acre					
Agriculture-Horticulture-Fishery with a duckery unit at the bank of pond.	11720 per acre					
Horticulture-Fishery-Piggery (3 pigs)	14840 per acre					
Bihar	Rice – Wheat	46122 /2 acre	Rice-Wheat-Vegetable-Dairy-		150865	Kumar <i>et al.</i> , 2012

			Fishery		
Rice-Vegetable-Fruits-Poultry-Goat-Beekeeping	128693				
Chhattisgarh	Crop + 2 bullocks + 1 cow	14184	Crop-2 Bullocks-1 Cow-1buffalo -10 Goats- 10 Poultry -10 Ducks	33076	Ramarao <i>et al.</i> , 2006

***System had higher benefit cost ratio**

***System had higher benefit cost ratio**

Integrated livestock farming system is an economically viable avenue for marginal and small farmers for livelihood security and sustainability. Conventional cropping system cannot fulfil household requirements of farmers and they need to switch to integrated farming system now. ILFS not only ensuring economic returns but also generating employment for families, maintain ecological balance through nutrient recycling and environment protection. Adoption of ILFS will double farmer income and provide nutritional security without adverse effect on environment and natural resources.²²¹

Making the most out of a patch of land, smallholder farmers in Karnataka, India are adopting integrated farming systems to sustain themselves and the environment.

Since his teens, Anjaneya has been actively involved in his two-acre family farm in Haliwana village, Karnataka, India. Now in his forties, he feels rejuvenated and has begun a new wave of innovations on his farm, even after all these years. In August, 2017 Anjaneya began applying Integrated Farming System (IFS) practices to his farm and he's excited that the change is finally paying off, helping him to secure his livelihood and enabling him to further invest in his farm.

Indian agriculture faces a serious challenge due to a recent decline in the size of land holdings. According to the Indian Agriculture Census, the size of the average landholding has declined from 2.28 hectares in 1970 to 1.16 hectares in 2010. This trend has made it increasingly difficult for farmers – particularly small and marginal farmers like Anjaneya – to run a sustainably profitable farm, and, should it continue, farmers would be reduced to working a mere 0.68 hectares by 2020 and only 0.32 hectares by 2030.²²²

As landholdings dwindle in size and India's farmers and consumers grow more concerned about the environmental toll of their agricultural systems, farmers are beginning to doubt whether the strategies of the green revolution era are still applicable to the future they want to create for their land and their food. More and more Indians are advocating for alternative practices, such as natural and organic farming.

IFS presents an opportunity to align traditional knowledge with holistic farming techniques in order to develop a new strategy for living with nature, nurturing it for sustainable production and livelihoods. Project Saathi – a four-year Local Economic Development project implemented by TechnoServe with the support of Cargill – aims to support smallholders in the Davangere District of Karnataka by training farmers in best practices for agricultural development and diversification. Based on initial surveys, the TechnoServe team decided to focus on increasing the profitability of small landholdings by teaching farmers IFS techniques that are designed to require less space and time, and that ensure reasonable returns to farming households.²²³

A happy and confident Anjaneya reports, “the Saathi project team met me and discussed in detail about IFS. They guided me on better planning of my land with a combination of agriculture, horticulture, forestry, and livestock. The project team also guided me on good agricultural practices and farm management, including the selection of suitable varieties of vegetables, staking tomato and beans, proper spacing for good growth of plants, and optimum utilization of my land. I am so happy that I got additional income within six months of practicing IFS.”²²⁴



Integrated Farming Systems, a Holistic Approach to Sustainable Agriculture

Using IFS, Anjaneya has been able to better allocate resources, efficiently utilizing his existing systems while simultaneously enhancing their productivity and profitability, and reducing risk. A bird's eye view of Anjaneya's two acres would reveal 1.5 acres of areca nut, banana, and legumes, with vegetable crops covering the remaining land. Drip irrigation systems water Anjaneya's crops without wasting a single drop of water. Along the border of his plot he has planted silver oak, *Sesbania*, castor, and drumstick trees. It's a pretty bounty, but more than just crops they are also an interconnected system that helps his farm to thrive.²²⁵

Within the plot, the legumes fix nitrogen into the soil, boosting the health and harvest of the vegetables that feed Anjaneya's family (and his cattle). Anjaneya owns three cows, which he feeds with paddy straw and green leaves from the border crops of his farm. These trees also create a fence to prevent the cattle from extending their grazing to the more tempting farm plot, and provide firewood and a natural trellis that Anjaneya uses to grow creeper plants. In addition to improving the nutritional diversity of his family's meals, these plants also provide premium prices, all through the power of carefully planted trees.²²⁶



Increasing Profitability with Integrated Farming Systems

In addition to increasing his production and targeting premium crops, Anjaneya is also improving his farm's profitability by using IFS to save resources and money. Manure from his livestock is saved and used to produce vermicompost. This compost uses certain worm species to create nutrient-rich soil for his farm, and also helps him to minimize his use of chemical fertilizers. This strategy helps Anjaneya to improve his yields while saving money on inputs, and is better for the health of his family and the planet. With healthy soil, Anjaneya's land can support more crops, and TechnoServe teams advised him to intercrop his farm with vegetables such as tomato and spinach, and to add banana trees to his areca nut plantation.²²⁷

These integrated approaches to farming have not only transformed Anjaneya's agricultural mindset, but have changed the business dynamics on the farm, yielding better returns. Anjaneya has already sold more than \$500 worth of vegetables in the local market and expects sales of over \$5,000 from his bananas over the course of the year.²²⁸

Looking toward a more prosperous future, Anjaneya plans to invest this increased income in mechanized farming equipment that will help him to more efficiently scale IFS on his farm. He also plans to rent the machines to other farmers, and ultimately aims to improve the quality of children's education through his new financial stability.²²⁹

Anjaneya's success story has motivated other farmers in his village as well. The growth of his farm showcases the key opportunities of IFS: stabilizing income, rejuvenating soil, improving productivity, strengthening resistance to pests and diseases, and generating chemical-free, health-conscious produce that benefits the environment and society. Five other farmers in his area have now taken up IFS, with Anjaneya providing valuable periodic guidance to ensure that the farms are progressing well.²³⁰

The Saathi Project works in 27 villages in the Davangere district and has enabled 95 farmers to implement IFS across 670 acres of land, using the model to combine traditional agricultural practices with more profitable techniques for a better future for farms, families, and the environment.²³¹

Integrated Agricultural System Helps Farmers

In the midst of land scarcity and uncertain weather, an integrated agriculture system is deemed to be the solution for farmers to manage their lands productively. Integrated farming uses multiple cultivation initiatives in the same area to deliver more sustainable agriculture. This system combines agriculture, farming, fishery, and other activities using the same land area – enabling farmers to gain additional income rather than relying on a single crop.²³²

Farmers can continue to earn income from livestock, gardening and fishery between harvests of their main crop, ensuring a more reliable revenue stream and helping eliminate poverty. As a company that supports the development of small and medium businesses around its operational area, APRIL has been championing this since 1999. This program is part of the Community Development initiative providing training for farmers and facilitating technical assistance to increase their income. To date, there are over 2,200 farmers and 119 farmers groups with 1,632 hectares of land participating in the program.²³³

Back in 2017, 167 farmers were trained to cultivate farmland under the program, while 57 farmer groups were supported with agricultural materials. So far, 2,200 households have received support for agricultural materials via the IFS. Farmers who are selected to be part of the IFS are often members of farmer groups which are recognized by the Indonesian government, and who not only own their own farming land, but who possess a robust interest in farming. Typically, horticulture farmers receive seeds, fertilizers, and farming equipment from APRIL in addition to assistance and monitoring of their farms by the company. APRIL also provides baby calves to animal husbandry farmers. The company provides assistance to the farmers to rear the animals, including providing regular medical checks and treatments for the cattle. Those involved in the fishing industry – including fishermen and pond fish farmers – are also included in APRIL's IFS program. Pond fish farmers may receive fish and fish food, while fishermen receive fishing equipment such as fishing nets. Farmers who take part in the program not only acquire more knowledge with training and subsequent income from farming, they also have networking opportunities such as through group meetings where they are able to share their opinions. At the moment, APRIL conducts all main IFS activities at its IFS Training Centre. Besides being a place where farmers gather for

training, discussions and consultations about their small and medium businesses, the training centre is also where fruit seeds and plants for the IFS farmers' use are produced, and where they can experiment with hydroponic plants (which are cultivated by using water and no soil).²³⁴

Integrated farming can fight climate change

In today's time, climate change has become a most pressing issue. Though a natural process, anthropogenic activities have speeded it up through more emissions of greenhouse gases, deforestation and burning of fossil fuels.²³⁵

Climate change has profoundly affected the environment as manifested in the vagaries of nature. It has also impacted agriculture and the natural resource base of the Earth.

It is need of the hour to cope with the devastating effects of climate change and the only options for us are to adapt to it, lower our emission rate and increase carbon sequestration through suitable land use and land use changes like afforestation.²³⁶

Making agriculture secure

Making agriculture climate smart through integrated approach is also an ideal solution to ensure the food security of the ever-increasing global population at a time when there are twin problems of land degradation and carbon emissions.

A multi-pronged strategy is required to check climate change and integrated farming is one of the options to achieve it. It provides multiple benefits that are sustainable and can pave the way for climate-smart agriculture (CSA).²³⁷

In present times, emission of greenhouse gases from industries, burning of fossil fuels and agricultural activities, including deforestation, burning of residues and so on, have accelerated global warming. Climate change has become a fundamental threat against sustainable development and the fight against global poverty.

From shifting weather patterns that threaten food security to rising sea levels that increase the risk of flooding, the impacts of climate change are undoubtedly global in scope and unprecedented in scale.²³⁸

CSA is an integrated approach to develop technical, policy and investment conditions in such a manner so as to ensure sustainable development for food security.

The main aim is to achieve sustainable higher productivity, ensure livelihood and food security, adapt to climate change and bring down emission of greenhouse gases.

CSA ensures increased productivity in a sustainable way which can strengthen the farming community against the consequences of climate change. It can also increase the mitigating potential of climate change through carbon stocking.²³⁹

There is an urgent need to go for CSA. It is expected that the world population will increase by 1/3 of the present in 2050 which will put huge pressure on our existing resources. Climate change will affect food productivity across the world. We have to be ready for these challenges and ensure that there is enough food for our growing population.²⁴⁰

Being an integrated approach, CSA includes soil/water conservation practices like watershed management, water harvesting and mulching and grazing management, plantation of multi-purpose tree species, agronomic practices like crop rotation and multiple cropping of legumes alternating with non-legumes, conservation farming, agroforestry, integrated farming, generation and use of climate-smart varieties of crops, development and use of high-yielding genetic stocks of crops and livestock, forecasting weather and market risks and alerting farmers through the media.

The integrated farming system is a combined approach aimed at efficient sustainable resource management for increased productivity in the cropping system.²⁴¹

It involves different components like trees, crops and livestock arranged spatially and temporarily over the same unit of land for the best utilisation of available resources. Various types of plants, livestock, mushroom, aquaculture and other aquatic flora and fauna are managed for maximum productivity in such a way that one complements the other. The waste generated from one component is recycled and used as a resource for the other.²⁴²

It is system to protect and conserve land and water resources from depletion. In countries like India where majority of farmers holding less than two hectares of land practice subsistence farming, risks are heightened through monocropping.

Becoming climate smarter

Integrated farming has immense potential to make farmers climate smart through the cultivation of different crops on the same land and using farm resources sustainably:

- CSA involves integrated resource management for maximum productivity
- It involves best utilisation of the growing space through the integrated farming approach
- Nutritional and economic security is ensured for better health of the farm family as they get different fruits, cereals, vegetables, livestock products and cash crops from their own land. It boosts food security through local production and consumption and checks migration²⁴³
- This improves soil's physical and chemical properties, its nutrient status and biological components. Such interactive systems affect the microclimate and provide a strong base to good agricultural practices for increased productivity

Future prospects

As CSA follows an integrated approach, inter-sectoral management of natural resources needs to be strengthened for progressive sustained productivity rather than simple sustainable productivity. For the same, time to time evaluation of resources needs to be done, along with benefits accrued from their management and use.²⁴⁴

Due care should be taken for germplasm conservation and improvement and management, keeping in view weather forecasting models for different regions. Promotion of high-yielding germplasm with climate-smart attributes like pest resistance and drought tolerance needs to be done at farmers' fields for climate-smart farming.

Both the public and private sectors need to come forward for livelihood improvement through integrated farming for climate-resilient agriculture promotion. This can be achieved through micro-finance approach and creating awareness among producers.

Transportation cost of different farm products needs to be minimised. This will check emissions on one side and promote consumption of the produce locally on the other.²⁴⁵

Let us take up the initiative for integrated farming and promote CSA before climate threatens our food security.

Scientifically designed, tailor-made Integrated Farming Systems being promoted to achieve Prime Minister Shri Narendra Modi's vision of Doubling Farmers' Income by 2022: Agriculture Minister

Scientifically designed and tailor-made Integrated Farming Systems (IFS) is being promoted to achieve the vision of Hon'ble Prime Minister Shri Narendra Modi of "Doubling Farmers' Income by 2022". This was stated by the Union Minister of Agriculture and Farmers' Welfare Shri Radha Mohan Singh today at the in-session meeting to discuss Integrated Farming Systems (IFS) for livelihood security and enhanced income of the farmers. Members of the Parliamentary Consultative Committee of Ministry of Agriculture and Farmers' Welfare, Government officials and scientists of Indian Council of Agricultural Research (ICAR) participated in the in-session meeting.²⁴⁶

Shri Singh said that the IFS can be classified as natural and intentional integrated systems. The intentional integrated systems are one which addresses the multiple objectives of increased production, profit, cost-reduction through recycling, family nutrition, sustainability, ecological security, employment generation, economic efficiency and social equity.

The Agriculture Minister said high-yielding grain varieties heavily dependent on chemical fertilisers were used to reduce India's dependence on food imports and meet the country's food requirement. However later, due to the use of low fertilizers, productivity fell leading to decline in the income of farmers. He highlighted the Economic Survey of India 2017-18 tabled in Parliament which indicates that over a period of 10 years, the share of income of farmers from crop production increased by only 1% while it increased by 7% for livestock.²⁴⁷

Shri Singh further said that small farms (up to 2 ha) hold the key to ensuring food and nutritional security of India. Therefore, location specific integration of field crops, orchard, floriculture, agro-forestry, livestock such as dairy, poultry, piggery, fishery and other less land requiring activities such as mushroom, apiary, and boundary plantations is being done for improving the livelihood of marginal and small households.

Expressing happiness, the Minister said ICAR has partnered with 25 State Agricultural universities (SAUs), 5 research institutes and 1 Central University through All India Co-ordinated Research Project (AICRP) and developed 45 Integrated Farming System (IFS) models suitable to 23 states and 1 Union Territory for providing better production and income.

He concluded by requesting the committee and the Members of Parliament to urge upon states to promote these location specific IFS models and initiate the National Mission on Integrated Farming Systems by converging the schemes of crops, horticulture, livestock and fisheries in order to give impetus to integrated farming systems among farmers for fast tracking the goal of doubling farmer's income by 2022.²⁴⁸

Integrated farming is another approach or farming practice which originally devised in China and now being supported world wide as a all round development of agriculture along with animal husbandry and other such occupation which is related to core agricultural practices. Integrated farming has the capability to make the agriculture sector profitable which otherwise has been proved largely as a subsistence sector and a major reason behind leaving this age old occupation and migration to cities.

Example

An example of integrated farming could be fish and livestock cultivation along with general farming practices which support each other. The fishes can be fed with the residuary materials of farms such as leaves, stalks or other waste products. Additionally, the plankton which are major fish feed can grown using the manures provided by the livestock which are getting raised at the side of fish farms. Near the fish farms, silk warms can also be raised (i.e. sericulture). The silkworm pupae and other wastes can then be used to feed the fish. In return the fish pond silt provides an excellent manure and fertilizer for land crops and highly solicited by farmers. This way integrated farming has multicultural approach which is environment friendly and sustainably provide the economic means to prosper.²⁴⁹

In India

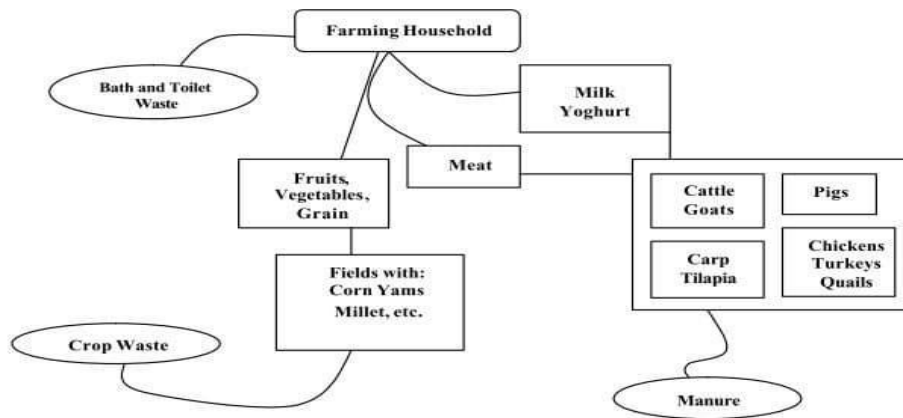
An Indian example of Integrated farming can best be understood by the fact that once a degraded land in Jodhpur, Rajasthan having very less crop production (and income) with the use of integrated farming practices such as plantation of improved qualities of Ber along with intercropping, honey been keeping and a goat unit turned into a major revenue generator along with improving the quality of soil and decreased expenditure on fertilizer and pesticides, produced good quality fruits using organic farming which has high demand overseas.

Integrated farming can have many variants which can be used according to the environmental conditions of the place. It can include combinations such as Fish-Duck Integrated farming, Livestock-Fish Integrated farming (explained above), Cattle-Fish Integrated farming, Polutry-Fish Integrated farming, livestock-honeybee integrated farming etc.²⁵⁰

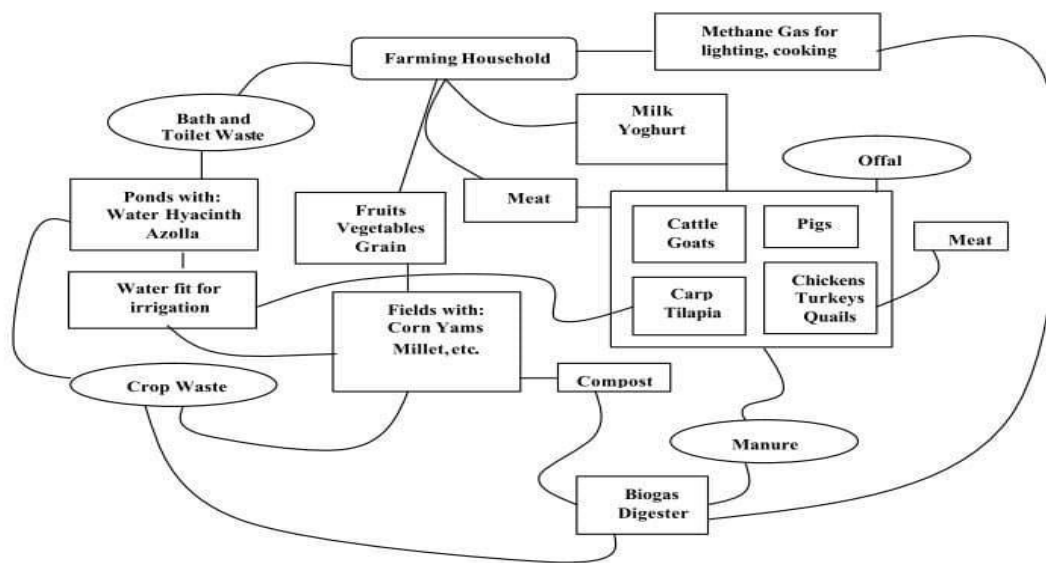
However, despite having many advantages of integrated farming, it is so far not yet popular as expected and hence the farmers are not able to reap its benefits. There may be many reasons attributed to this failure such as

- The unawareness of farmers about the benefits of this farming practice – It keep the farmers away implementing best practices of integrated farming.²⁵¹
- The lesser resources – Around 80 percent of the farmers do not have lands more than 5 acres. Hence, they can't be used mechanised farming with sophisticated tools. Also, the lack of capital acts as an impediment in buying the expensive livestock and its maintenance.
- Government policies – Though government has many schemes to provide on low rates loan for cattle rearing, agriculture and purchasing mechanical equipments. However, the procedure along with inherent corruption in government departments further discourages the farmers to approach them.²⁵²

India with this majority of the population depending upon agriculture (around 58 percent) for its sustenance surely needs to look into all such practices which make agriculture economically viable and environmentally suitable to fulfil its goal of 'Inclusive and Sustainable development'. The integrated farming is one such approach which has the potential to turn the contribution of agriculture and allied activities in the country's GDP which as of now is only 18 percent (feeding the total population of 58 percent). The development of agriculture is our utmost priority which found its true value in the year 2002 when the agriculture (and not industry) was declared as the engine of growth of the country. The National Agricultural Policy, 2000 also suitable emphasizes the need to improve integrated farming along with other agricultural practices to make the country food sufficient and tame the increasing food inflation.²⁵³



Conventional Farming System



Integrated Farming System

Integrated farming systems may comprise more than one farm enterprises (viz. crops, dairying, poultry, beekeeping, fisheries, agro forestry mushroom cultivation etc.)/subsystems on a farm to harness maximum efficiencies and obtain sustainable resources use systems which will optimize their use minimize degradation and induce regeneration capacity as well as increase overall productivity, income and employment. This needs intensive cooperation between the various agricultural sectors that could contribute to the sustainability of the region's broad base agriculture.²⁵⁴

The integrated farming system aims at a sustainable, highly-productive, socially desired mixed farm. This will be reached by minimizing the nitrogen supply and biocide use per unit produce while maintaining high yields and product quality. This aim is characteristic for the so-called globally-oriented agriculture where high productivity and efficiency are combined by making maximal use of the biological mechanisms that dictate the functioning of these agricultural systems. This type of agriculture does not exclude particular inputs such as fertilizers and biocides, but maximizes their efficiency and effectiveness at the global scale. It is based on lower external inputs and a more natural crop protection system than conventional farming.²⁵⁵

Thus integrated farming is particularly useful for developing countries, as it requires minimal inputs in terms of expensive chemicals or technology. This has a core component of the most dependable farming system, for instance field crop, around

which other complementary farming systems, like livestock/aquaculture/ beekeeping/mushroom culture/poultry/ agro forestry etc., are integrated for obtaining maximum productivity, profitability and sustainability.

An integrated farming system could comprise agri- livestock or agri- livestock- poultry, or agri-horticulture-silviculture, etc. By using the by-products or wastes of one component as inputs to another, such farming systems are able to increase the net efficiency of the entire system and at the same time minimize overall waste production and reduce dependency on industrially derived external inputs.²⁵⁶

Advantages of the Integrated farming system

- Increase in food supply: Vegetable or horticulture crops can provide two to three times more calories than cereal crops on the same piece of land. Also if beekeeping, mushroom growing, silviculture and aquaculture are integrated in a multi-tier system, they can give additional food and increase without affecting the production of food grain crops.
- Recycling of crop residue: For instance in India, more than 200 metric tonne residue produced per annum. If one percent of this is used for mushroom cultivation then the production would grow several folds. Good vermin compost can also be produced from crop residue for restoring the soil fertility. Cost of production is reduced.²⁵⁷
- Use of marginal and waste land: Marginal and wastelands can be efficiently used for a combination of fisheries, poultry, dairying, mushroom cultivation and bee keeping with crop raising.
- Increased employment: Studies conducted on integrated farming systems in India show that adoption of crop+ fisheries+ livestock on arable land can give three times more gainful employment than crop alone. If other farm enterprises like silviculture, beekeeping and mushroom cultivation are also adopted, they can provide greater income and gainful employment to farm families to increase their standard of living.
- Restoration of soil fertility and conservation of the environment: With efficient recycling of crop residue and farm waste in crop- livestock- poultryfishery system, soil fertility can be restored. It will also reduce the dependence on chemical fertilizers and a cleaner environment can be maintained.²⁵⁸
- Affect Human development
 - ▶ It can make farmers more self-sufficient as well as self-reliant. There is a substantial generation of knowledge and innovations because of the different systems involved.
 - ▶ Poor and landless farmers can be assisted to generate income and thus participate in the development process.
 - ▶ External inputs needed in the system are minimized. It also provides for better utilization and distribution of labour. Costs are generally reduced and productivity of labour is increased.²⁵⁹

Integrated Intensive Farming System (IIFS)

The green revolution technologies are often associated with environmental harm. Such damages caused by the excessive use of mineral fertilizers and chemical pesticides as well as enhanced vulnerability to pests and diseases as a result of genetic homogeneity in high yielding hybrid crop varieties cultivated over large cultivated areas. With increasing population there is a steady decline in the per capita availability of land and water. This makes higher productivity per unit pf land and water imperative.

Components of IIFS

IIFS involves intensive use of resources of the farm. Intensification is based on techniques which are knowledge based rather than capital intensive based. The inputs are used are biological. This is brought about through integrated farming involving animal husbandry, fisheries and agroforestry. This provides scope for organic recycling. On farm and off farm employment can then be linked in a symbiotic manner.²⁶⁰

1. *Soil health care*: Soil health is fundamental to sustainable intensification. Stem nodulating legumes such as *Sesbania rostrata* and incorporating Azolla, blue green algae and other sources of symbiotic and non-symbiotic nitrogen fixation are a part of the farming system. Vermiculture constitutes an essential component. Green leaf manure and small quantities of powdered neem cake are used. These bulky organic supplements have to be generated on the farm itself to avoid transportation costs over long distances.
2. *Water harvesting and management*: Included in the agronomic practices are measures to conserve rain water so that it can be used in a conjunctive manner with other sources of water. Maximum emphasis is placed on on-farm water use efficiency and adopting drip and sprinkler irrigation to optimize the benefits from the available water. Efficiency, economy and equity in water use are to be ensured through cooperative management of watershed and command areas.
3. *Crop management*: Integrated nutrient supply is an important component. Plant nutrient can be supplied through different sources viz., organic manures, crop residues, bio-fertilizers and chemical fertilizers. Integrated nutrient supply has to be chosen on the basis of farming system and the agro-ecological and soil conditions of the area. Hybrids and high yielding varieties have to be cultivated. IIFS has to be based on both land saving agriculture and grain saving animal husbandry.
4. *Pest management*: Integrated pest management system forms a component. Antagonistic fungi such as *Trichoderma viride* and other beneficial bacteria like *Pseudomonas fluorescens* are used to control a host of pathogenic infection in a wide variety of crops. A wide range of botanical pesticides such as neem derivatives, extracts of *Vitex nigundo*, custard apple seed oil, and a host decoctions of local plants are used by farmers for either repelling or eliminating pests. The use of biological agents such as parasites and predators are used in place of toxic pesticides.
5. *Energy management*: Energy is an essential input. Every effort should be made to harness biogas, biomass, solar and wind energies to the maximum extent. Solar and wind energy is to be used in hybrid combinations with biogas for farm activities such as pumping water, drying grains and other farm produce.²⁶¹
6. *Post harvest management*: Best available threshing, storage and processing measures should be adopted. Value-added products from every part of the plant or animal have to be produced. Post-harvest technology assumes importance in the case of perishable commodities such as fruits, vegetables, milk, meat, eggs, fish and other animal products.
7. *Information, skill organization and management empowerment*: A meaningful and effective information and skill empowerment system is necessary for the success of the IIFS system. Decentralized production system will have to be supported by a few centralized key services such as supply of seeds, bio-pesticides, and diagnostic and control methods in respect of diseases. Timely information has to provide to farmers on meteorological, management and marketing factors. Organization and management are key elements and depending on the area and farming system, steps have to be taken to provide small producers the benefits of scale in processing and marketing.

IIFS is best developed through participatory research among scientists and farmers. IIFS can succeed if it is human centered rather than a mere technology driven programme. The essence of IIFS is the symbiotic partnership between farmers and their natural resources endowment of land, water, forests, flora, fauna and sunlight. It will be difficult for small farmers to adopt IIFS without appropriate public policy support in areas such as land reform, security of tenure, rural infrastructure, input and output pricing and marketing. IIFS methodology shows the path to achieving the goal through agricultural intensification, diversification and value addition in an ecologically, economically and socially sustainable manner. IIFS programme properly implemented will trigger an Ever Green Revolution if naturally reinforcing packages of technology, training, techno-infrastructure and trade are introduced.²⁶²

Tamil Nadu Integrated Farming Scheme

The State Government of Tamil Nadu has initiated a new Yojana called 'Tamil Nadu Integrated Farming Scheme' for the benefit of the farmers. The Agriculture Department of Tamil Nadu is vested with its implementation of this scheme. The scheme is envisaged to promote mixed farming which will, in turn, increase the productivity levels and the income of farmers.

Requisites for the Scheme

Farmers of Tamil Nadu are facing several issues as the productivity levels. This has led to a decrease in their income levels. Considering all these ill-effects, the Tamil Nadu State Government launched this scheme to aid the farmers and to increase their financial capability.²⁶³

Merits of Tamil Nadu Integrated Farming Scheme

- The Scheme would be benefiting the poor and economically weaker farmers of the State.
- The scheme facilitates the farmers to grow their crops naturally and utilize their agricultural land appropriately.
- In addition to this, they may also perform a few other basic agricultural practices which would ensure an increase in their income ratio.
- These practices may include works such as Poultry, Dairy Farming and others.
- Through this scheme, the Tamil Nadu State Government is also trying to adopt the Micro irrigation procedures instead of the primitive farming methods.
- Apart from contributing to the increase in the income of farmers, the substances provided by the Scheme helps in improving the irrigation potential of soil through recycling farm waste.²⁶⁴

Budget allocated

- The State Government has allotted INR 5 Crore for the implementation of the scheme in the District of Thanjavur.
- Each farmer enrolled as a beneficiary under this scheme gets a subsidy worth INR 1 lakh in order to promote mixed farming and to purchase other required equipment which could enhance the outcome of cultivation.
- Throughout the district, fifty beneficiaries will be selected from each of the villages, and finally, a total of 500 recipients will receive the subsidy amount offered by the Government.
- Apart from Thanjavur, the Government is also looking forward to implement this Scheme in Tirunelveli, Madurai, Villupuram and Erode districts during the fiscal year 2018-2019.

Eligibility Criterion

In order to avail the credentials offered under the Tamil Nadu Integrated Farming Scheme, an individual should satisfy the following criterion:

- Only the native farmers belonging to the State of Tamil Nadu are eligible to apply for financial aid through this scheme.
- Individuals applying for this subsidy must be marginal scale farmers.
- The applicants should possess a valid Government Identity Card.²⁶⁵

Fruit based integrated farming system for sustainable income

Integrated farming means two or more production technologies to function together on parallel basis resulting to increase productivity, increase income, more additional employment, reduction cost of cultivation of the farm, enhance efficiency in resource utilization and decreased investment risk through collaboration of various crops and commodities. When the fruit plants are the major commodity of Integrated Farming, the system is known as fruit based integrated farming.

China is the leading country in adopting the principles of integrated farming in the world. Indian agriculture is dominated by small and marginal farmer. A farmer having an area of 1-2 ha of land is called small farmer and less than 1 ha is marginal farmer. In Manipur due to geographical location, nature of topography of land and many other reasons, most of the farmers are all under marginal farmers. Such small area should be effectively used for generating sustainable farm income by adopting two or more production technologies. Manipur is located in between latitude 23050/N to 25042/N and longitude 92058/E to 94045/E. The area of Manipur is 22,327 km². Out of the area, about 9/10 of the total area is in hilly region and 1/10 is in plain. Circumstances compel to grow fruit trees in such larger area of hill region. Therefore, it has tremendous scope for trees and fruit crops, to grow in such hilly undulated area and it also can prevent soil erosion and help in reducing the present problem of climate change conditions. It may be planned that higher elevation portion of the hills

will be allotted trees and the bigger fruit crops, middle portion of the hill will be shared between other dwarf fruit crops and vegetables. In the low foothill areas, other activities like suitable agro-horticultural crops, poultry, piggery, fisheries etc. can be taken up.

The fruit crops of Manipur on priority are Mandarin Orange, Passion fruit, Pineapple, Banana and Lime/Lemon. Papaya also can be considered as mandate crop if it is used as filler plants as well as one line single planting on the dykes of the pond and can generate a regular income to meet daily cash requirement of the small farm families. Some hints for scientific cultivation of such mandatory fruits are given below:²²²

A. Pineapple (*Ananuscomosus*)

- Variety : Kew, Queen
- Sucker Size : 300 to 400g
- Seed Treatment : Carbendazim 3g l-1 + cloropyriphosh 2 ml 1-1
- Planting Season : March to June
- Mulching : Preferably with black polythene mulch
- Fertilizer : 16:8:16g NPK/plant
- Spacing : 25x50x80 cm
- Intercrops : Rajma, Soyabean (1st year) in spaces between double row
- Planting system : Double row system
- Plant Population : 61,538 suckers ha-1
- Formula for finding out plant population (PP) : $PP=2 \times \text{Area} / 0.25(0.50+0.80)$

B. Banana (*Musa sp.*)

- Variety : Local Hei and Grand naine
- Sucker tupe : Sword Sucker
- Seed treatment : Carbendazim 3 g l-1 + cloropyriphosh 2 ml 1-1
- Pit size : 60 x 60 x 60 cm
- Spacing : Tall 2.5 x 3 m, Dwarf 1.5 x 1.5 m
- Plant population : Tall 1333 plants h-1, Dwarf 4444 Plants h-1
- Fertilizers : 100 : 50 : 30 g NPK Plant-1 + 15 kg FYM plant-1
- Mulching : Black polythene mulch
- Intercropping : King chilli& Ginger, Turmeric in the 1st year
- Irrigation : 1-2 times/month during dry period²⁶¹
- Desuckering : To start 45 days after planting; Not to keep more than 2 suckers at a time; to pour 4 ml kerosene is best for de suckering after cutting down the sucker at the ground level.
- Harvesting : To be harvested when the fruit is round in structure; Mattocking at 0.6 m height.

C. Mandarin Orange (*Citrus reticulata*)

- Variety : Tamenglong, Khasi, Nagpur
- Propagation : Preferably budded plants
- Pit Size : 50 x 50 x 50 cm
- Fertilizer : 20-25 kg FYM+0.5 kg SSP at the time of planting Afterwards 450 : 450 : 900 g NPK/plant.
- Trimming and Pruning :(i) Up to 50 cm height not allowed to bear any branch. (ii) To be low headed with dome shaped. (iii) Removal of water sprouts suckers. (iv) Allows stem with 4-6 well spacing branch. (v) Bearing trees require little or no pruning. (vi) Best time for pruning is after harvest during late winters or during early spring when they are dormant stage.
- Spacing ; 4.5 x 4.5 m
- Plant population : 500 plants h-1
- Intercropping : Shallow rooted preferably leguminous crops like soya bean, blackgram, pea, cowpea etc. & King chilli, ginger, turmeric. In the 1st year papaya can also be used and it is more economic.
- Mulching : Organic and preferably inorganic can be used. · Irrigation : 1-2 during summer if mulching is practiced.

D. Passion fruit (*Passiflora edulis*)

- Variety : Purple, Yellow, Kaveri
- Propagation : Preferably by cutting (after rooting in a poly bag)
- Pit size : 50 x 50 x 50 cm
- Trellising : Telephonic/Knifin wire system
- Fertilizers : 100 : 50 : 120 g NPK/plant+10 kg FYM/plant
- Spacing : 1.5 x 4 m
- Plant population : 1667 plants h-1
- Intercropping : *Eryngium foetidum* (Awa phadigom)
- Av. No. of seed/fruit : (i) Purple ; 100 (ii) Yellow : 150 (iii) Kaveri : 225
- Harvesting : Two main periods of harvesting (i) March – May (ii) August – December.

Advantage of Integrated Farming System

As integrated farming system has interdependent, interrelated thereby many advantages over other system of farming are found. It has more productivity as the system provides more opportunity to increase productivity per unit area per unit time by intensifying the crops and allied components using the concept of “time and space”. It has more profitability as the system has two components or more are in the same adjoining filed thereby reducing the cost of production.

Integrated Farming System also provides income all the year round to the farmers for selling of fruits, vegetable, eggs, milk, fish, mushrooms, honey etc. The organic waste/cattle dung can be used for production of biogas thereby saving energy and the residue of biogas cab be profitably used as manure for various crops production. This system reduces the use of chemical fertilizer turning to the organic cultivation and reducing environmental pollution. The system can convert degraded land into a productive land. Drought hardy fruit trees component in a planting system provide insurance during drought year when annual crops fail or their production is highly impaired. Integrated Farming System reduces the risk of farmer as failure of one component will not affect much to the system as a whole.²³¹

It also increased employment generation by increasing input use efficiency as combination of a number of components would increase the labour requirement significantly and helping in reducing under-employment and makes use of farm labour all the year round. Once these provisions are made at the farm level to generate bio-energy produce fruits, vegetable, mushrooms, eggs, milk, fish, honey etc. It increases the standard of living and social economic status of the farmers.

Scope of Integrated Farming System for all farmers

In largely populated countries, the land is a big concern in a point of view of living and growing food. Upcoming Time will be so challenging for people because of the population and food.

An integrated farming system is a scientific and eco-friendly way to solve the issue of food production in enough quantity.

In India, there is a huge number of small farmers in those face losses every year. Let's understand possibilities of integrated farming system among small Indian farmers.²⁶²

Scope of Integrated farming system

Let's understand first what is integrated farming system-

Integrated farming system definition

The word Integrated farming says about the integration of multiple types of farming at once on the same Land.

An integrated farming method combines plant and animal farming both at once on the same Land. This method is helpful to increase income in a limited amount of investment on small agricultural land.

Only food crops or non-food crops or animal farming haven't the capability to provide you a bigger amount of profit from small land. So that's why the system developed to integrate all types of farming to achieve the best output. This system combines fish farming, **Poultry farming, Dairy farming, mushroom farming, sheep farming, bamboo farming, organic vegetable farming,** etc.

Integrated farming system is best for all kinds of range of farming land. But only a few percent of farmers practice this method.²⁶³

Why Rural areas have lack awareness of what is integrated farming

In rural areas, most people are not aware of **What is integrated farming.**

Rural people follow the traditional way of doing seasonal crops farming like **Rabi crops, Kharif crops, and Zaid crops.** There are people in villages who practice Dairy farming and poultry farming but still, they are doing things as they learnt from their forefathers.

Apart from their tradition, Rural people not aware of an integrated farm because they have never been taught about this. There are differences among the farmers of populated countries, farmers of average population countries, and low population countries.

In larger population countries, farmers are not that much aware because of poverty and backwardness. They are mostly illiterate. Their first challenge is to come out from these basic problems only then they can practice modern farming techniques.

The quote is quite popular - *poverty can't make you a philosopher.*

On the average population, there is a better system of awareness of modern farming and methods of the integrated farming system.

Low population countries have enough resources and reach. They can easily switch their entire system quickly than other countries.

That's why even most farmers are rural but they are aware of modern Methods of integrated farming systems.²⁶⁴

Why rural people are not able to start integrated farm in bigger countries

Most of the rural farmers are poor and illiterate. It is not easy for them to read and aware of modern methods of profitable farming Business.

In bigger countries, it is too hard to make a system that can take information further to the most backward rural areas.

A small percentage of farmers are those who don't want to start integrated farm because they don't want to take risk in new methods which are not well established in their eyes. They want to follow the same ordinary way of seasonal crops.²⁶⁵

Integrated organic farming

Integrated organic farming is based on organic feeding to organic compost in an integrated farm. Integrated organic farming provides the most ecofriendly, productive, and best output for health.

Organic feeding for cattle and poultry farms is the fundamental purpose of this model. Fish feeding should be organic and mushroom and vegetable compost should be organic.

The best organic **productive feed for cattle** is **green fodder**. Wasted vegetables like Cabbage, peas skin, and sugarcane leaves. You have to give them 40 to 45 kg of green fodder daily.

In **dry fodder**, you can use rice fodder, wheat fodder, and millet. There is 5 kg of dry fodder is enough in a day.

For fishes, you can use the dung of chickens. For chickens, you can use cereals and grains like wheat and broken rice.

In mushroom farming, you have to use organic compost instead of a chemical one. Also, Your vegetables need organic fertilizers to get the best crop of mushrooms.²³³

Integrated farming system in India

According to worldometers.info India has 17.7 % of the global population. In India, the local system does not match the modern techniques because of the reach of government. There is a total of 50 million farmers who directly own the lands. 85% of them are small farmers.

In rural areas, people are only dependent on farming including their families. There are 70% of rural households are directly dependent on agriculture.

In this number, most farmers are poor or small. These farmers are not able to enhance the income instead they are in deeper debt. In India on average, 8 to 9 farmers suicides every day, which is horrifying and injustice with the food provider.

The integrated farming system can be a solution for the small farmers but it needs proper willpower. Govt. Needs to provide small rural farmers training and loan on a larger subsidy. It can change the life of rural farmers if they practice it.²⁴⁴

Which type of farmers should try Integrated farming

So far, I think you understand what is integrated farming purposed for. Now you will understand which people should try it.

As you know now the integrated farming system includes poultry farming, goat/sheep farming, mushroom farming, vegetable farm, fish farming, and Dairy farming.

These parts are cost an initial investment to establish a business. Once it is established then you can enhance your profit and business both.

So those farmers who can invest the amount to establish an initial model which cost high in arranging to house, buying cattle and fishes, fish pond, poultry farm chickens, mushroom compost and seeds, vegetable seeds and most importantly land.

The small farmers are not able to do so because of a lack of initial investment.

They have landed but not enough to produce profit for them. If the government supports them to train them and provide them a loan for an initial boost then it can be easily possible in rural areas farmers.²⁵⁵

But as we mentioned above it is not easy to create such an ecosystem with simple ease instead it takes time to develop if everything goes in the right direction.

In cities, farmers are comparatively better than rural farmers, so this will be great for them to practice a profitable business model.

Advantages of integrated farming systems

- It is an almost one-time investment and then the system works for a long-term profit.
- IFS helps small farmers to generate extra revenue in limited resources.
- It helps to get variety in the food like meat, vegetables, milk, and others.
- It is a modern way of farming that can erase poverty and development of economy further.
- It is **organic farming** that's why it is directly beneficial to the health of people.



Hindustan Coca-Cola Beverages

One of the goals at HCCB is to simply improve the lives of people and communities. And, the way we are doing that is by acting as a catalyst to bring change to Indian communities. We have embraced sustainability in innovative ways and have been reducing our carbon footprint greatly. But, we are not alone on this sustainable journey. We are growing and developing with Indian rural communities around us. The Integrated farming system (IFS), being implemented in Bidadi, Karnataka, is a perfect example of this.²²³

The aim was to help marginal farmers transform into progressive farmers and increase their yield and income. To do this, we distributed horticulture saplings, cycle weeders, waste decomposing cultures, and more, free of cost to farmers to adopt modern farming.

In addition to that, we conducted training sessions for farmers to best utilise the equipment given. Farmers were educated about double cropping, sustainable agriculture, and plant protection and other such methods that would increase their yields. Soil testing was done to help farmers decide on a suitable crop to grow. This helped farmers make the right decisions and minimise their risk. We also constructed composting pits and helped farmers understand how to best implement and reap the benefits of vermicomposting.

Our dual approach of providing modern equipment and teaching new farming methods had a far-reaching impact. These better methods of farming improved their agriculture approach and made them more sustainable. We have implemented many such programs to improve the livelihood of marginal farming community. With these initiatives, we empowered the marginal farmers to earn a respectable income in a sustainable manner.

Our action in Bidadi is proof that even the smallest steps can create a large ripple of change. As we evolve, our partners and Indian communities should evolve with us. Our dream is to build a culture of sustainability and ownership among the farming community that can be proud of.²²⁴

How Integrated Farming Can Help Ensure a Sustainable Income

Integrating crop production with livestock management helps to reduce operational input costs of farming and augments productivity, production and income per unit area. Agriculture is not just about growing crops, nor is it about the physical drudgery involved or about the vagaries of monsoon playing with the lives of farmers. It is more about the scientific management of crop husbandry and its successful integration using the available technical guidelines.²²⁶



For a farmer to earn a decent living, it is not enough to be content with growing some crops alone. Along with crops, he must rear some animals to ensure stability in income.

In order to reduce the load of food from fragile land, integrated natural resource management is a proven way to ensure a monthly income, reduce operational input cost of farming, augment productivity, production and income per unit area and ensure food and nutritional security to ever growing population of India.²²⁷

Kavindra Kumar Maurya from Charuipar village in Nalanda district, Bihar, is a good example of displaying entrepreneurial spirit. His fish farm is located about 2 km east of Noorsarai and 50 km southeast of Patna, and is well-connected by road and rail.

“After the completion of my masters in botany, I started farming on my 6.10-acre land 20 years back but I could not get enough returns to sustain my family requirements. One of my friends inspired me to start fish rearing on my land. As per his suggestion, I first started fish farming in the year 2000. I started rearing fish in one pond of about 0.75 acres by purchasing fish seeds from the government fish seed farm. ”

He invested about Rs 40,000 of his savings on fish seed, feed, fertiliser and labour, but lack of scientific know-how proved to be an obstacle in getting the desired production and income. He earned Rs 25,000 as net profit from the sale of fish. He realised that the profit margin through aquaculture is higher when compared to agriculture and started to gather technical information on the subject.²⁵⁵

He approached the fisheries department for training, which then guided him towards the Central Institute of Fisheries Education regional centre at Kakinada, Andhra Pradesh in 2006. Upon the completion of his training programme, he expanded his pond area in 2006 and started fish farming in a scientific way.

“I was introduced to Tun Tun Singh in 2006, currently working as a lecturer at fisheries training and extension centre in Mithapur, Bihar. During my training programme, he advised me to integrate available resources such as horticulture, livestock, vermicompost and honey bee farming and helped me integrate my available resources. He also advised me to participate in a training programme on horticulture and honey bee farming. At present I have seven ponds (covering three acres), a one-acre *bundh* (dike) used for banana and vegetable farming, about 32 honeybee boxes for honey

production, one cow and remaining 2.10 acre land for turmeric, potato, ginger, elephant foot etc production. I also installed a three HP solar water pump from the fisheries department of fisheries on 90% subsidy which helps in maintaining water level in the ponds and also for irrigating the crops,” Maurya said.

According to him, Singh regularly visited his farm and gave the scientific input to increase productivity per unit area. He produces all the above mentioned crops in his own land and as a result his dependence on local market for buying has come down.

“A perfect farmers is one who never depends on market for his daily food items,” Maurya added.²³¹

During the year 2014-15, he sold fish worth about Rs 7 lakh, banana worth Rs 25,000, vegetables worth Rs 15,000, honey worth Rs 25,000 and other crops amount to Rs 1.25 lakh. The total net profit of this integrated fish farm in 2014-15 was Rs 5.90 lakh. He never sold milk and vermicompost.

Maurya has developed and trained more than 100 farmers in integrated fish farming and acts as a master trainer in their area. Integrated fish farming is the best example of more crops per drop of water to ensure economic viability, income and environmental sustainability to the marginal and small farmers, and it can be effectively developed through participatory approach of extension workers, scientists and farmers families, says Singh.²⁶⁵

Integrated Farming Model for Small Farmers Under Indian Conditions

Integrated Farming System (IFS) is an interdependent, interrelated often interlocking production systems based on few crops, animals and related subsidiary enterprises in such a way that maximize the utilization of nutrients of each system and minimize the negative effect of these enterprises on environment.

Under Indian conditions where large population of farmers comes under small and marginal farmers, it becomes very necessary to find out the farming techniques which are best suited to them. Traditional farming system of cultivating only specific crops and some livestock species in some specific season is found not that much profitable and sustainable as compared to integrated farming system.

Advantages of Integrated Farming System

Benefits or Advantages of Integrated Farming System-

- **Productivity:** one of the main benefits of maintaining IFS, to increase yield of different components in terms of per unit area or per unit of cost involved with it.
- **Profitability:** by utilising each other by-product as a raw material of other components reduce cost of cultivation/maintenance as well as enhancing soil fertility for sustainable production, leads a higher BC ratio by managing waste of by-products and full utilization of investment.
- **Potentiality or Sustainability:** In long term aspects, by linking of different components act as organic supplementary through effective utilization of available resources, provides an opportunity to regain potentiality of production.
- **Balanced Food:** different component supplies different nutrients which can fulfill ones daily required nutrients.²⁴⁵
- **Environmental Safety:** Effectively recycling of waste material as others raw materials through IFS models, thus minimize environment pollution.
- **Recycling:** In IFS, Effective recycling of waste material (crop residues and livestock wastes) helps to make a farm self-sufficient in terms of avoiding outside inputs – fertilizers, agrochemicals, feeds, energy, etc.
- **Income Rounds the year:** Due to maintenance of different enterprises with crops, eggs, milk, mushroom, honey, cocoons silkworm, it provides income throughout the year.
- **Adoption of New Technology:** IFS not only for marginal and small farmer make sustainable production. As a resourceful farmers (big farmer) can fully utilize available technology to get greater benefit from it. Flow of money throughout the year induce acceptance phenomenon in farmers to adopt latest technology to get the work done easily with less time.²³⁵
- **Saving Energy:** An alternative energy source can be established to reduce our dependence on fossil energy source within short time. From organic wastes available in the system, it can be utilized to generate biogas. It will be used at crisis time or when it requires.

- Meeting Fodder crisis: Due to effectively use of land, plantation of perennial or annual fodder crops or combination of it can make availability of feed for animal throughout the year. Some legumes fodder can fix nitrogen in soil in terms of increasing soil fertility. By maintaining this much one can avoid fodder crisis in lean period.
- Solving Fuel and Timber Crisis: By linking of agro-Silviculture can avail fuel or timber without deteriorate of other components. This will also greatly help to keep forestation, preserving our natural ecosystem.²²⁵
- Employment Generation: IFS provide enough scope to employ family labour round the year. By combing different enterprises would increase the labour requirement significantly and would help in reducing the problems of underemployment to a great extent.
- Agro-industries: When one of produce linked in IFS are increased to commercial level there is surplus value adoption leading to development of allied agro-industries.
- Increasing Input Efficiency: IFS provide good scope to use inputs in different component greater efficiency and benefit-cost ratio.

There are several climatic zones of India having different scope and perspectives for integrated farming. Different climatic zones of India are as follows:²¹⁵

Temperate:

This class of fruits grows successfully in cold regions where temperature falls below freezing point during winter. During the cold season, the trees shed their leaves and enter into rest period. For breaking this rest period or dormancy, a definite chilling period is required. This class includes fruits like apples, pears, walnut, almond, plums, cherries, peaches etc.

Tropical:

This class includes fruit crops which are unable to endure freezing temperatures, some of them being severally injured by even temperature somewhat above the freezing point. This class required hot and humid climate in summer and milder winter. It includes fruits like mango banana, pineapple, and cashew, Pomegranate, Guava, Amla and Chicku²⁶⁵.

Sub - tropical:

These classes of fruits grow mostly in plains where the climate is hot and comparatively dry and the winter is less severe. It includes fruits like citrus papaya and fig.

The States growing the above three types are given below

Temperate	Tropical	Sub-tropical
Kashmir, Kuluvally, Kahgravalley in Punjab, Kotgiri and Nahan in Himachal Pradesh Kumaon Hills in Up	West Bengla, some parts of M.S., Orissa, A.P., Karnataka, Tamil Nadu and Kerala	Plains of Punjab and U.P., some districts of Bihar, M.P. and West Bengal, Rajasthan and some parts of M.S.
Crops : Apple, Pears, Peaches, Cherry, Almond, Grapes, Cabbage, Saculta flower, Roes	Crops : Mango, Coconut, Aracanut, Cashewnut, criop, Tomato Chillies, Chrysanthemum, Jasmines.	Crops : Mango, Grape, Banana, Guava, K. lime, Mosambi, Santra, Fig., Phalsa, Tomato, Brinjal, Bhendi, Potato, Star, Mary gold, Rose etc.

³Methodology for selecting appropriate integrated farming model

Key element	Description
Goal	To improve the welfare of farmers through enhancing the relevance of R&D in developing their farming system.
Research aims	To develop and share knowledge and understanding of what, why and how farmers do and the effect that change would have on farmers system.
Target	Defined farmer's domain as its clientele. Example- small scale dry land crop farmers with sheep as secondary enterprise.
Leadership	Requires facilitators who understand the principles of system thinking and practice, science, community and local agriculture.
Multidisciplinary mode of action	Define most important components of farming system and seeks solution to constraints through participation by farmers.
Types of research	Allows people from different disciplines to work towards common aims.
Participation	Contemporary approaches to farming system research involve farmers, specialists and policy makers in various levels of

	participation.
Holistic	Considers whole system. May emphasize certain components while considering the system as a whole and always including human aspects.
Learning and co- learning	There must be an acceptance by researchers that they have as much to learn from the farmers as they themselves can offer to the process.
Feedback	True participation allows constant feedback.

Various important suggested models for different areas of India

1. Integrated farming models for northeastern hilly regions of India
2. Integrated farming models for coastal regions of India
3. Integrated farming models for central India

Integrated farming models for northeastern hilly regions of India

This region consists of Arunachal Pradesh, Meghalaya, Nagaland, Mizoram, Manipur, Sikkim, Assam, and Tripura. Existing undulated terrain and dual effects of water are the main limiting constraint in storing/ concentration of runoff water.²¹⁴

Following integrated farming model will be suitable:

- Integrated Fish cum Pig farming
- Integrated Fish cum Duck Farming

- Integrated Fish Farming-Chicken
- Integrated Fish farming-cum-Cattle farming
- Integrated Fish farming-cum-Rabbit farming
- Integrated Fish farming-cum-Agriculture

Table 9: Productivity and profitability of different IFS modules for Eastern region of India (mean value of 3 years)

Treatments	RGYE (t/ha)	Net returns ($\times 10^3$ Rs/ha)	Net returns (Rs/ha/day)	Income sustainability index (%)
Field crops (FC)	9.23	62.8	172	19.3
FC + fish + poultry	18.61	139.5	382	67.4
FC + fish + duck	15.36	114.1	313	51.5
FC + fish + goat	19.63	151.6	415	75.1
FC + fish + duck + goat	21.20	159.5	437	80.0
FC + fish + cattle	21.18	128.5	352	60.6
FC + fish + mushroom	16.56	127.9	350	60.2

CAU, IMPAL RGYE=Rice grain yield equivalent Kumar *et al.* (2011)

Integrated farming models for coastal regions of India

This region has tropical type of climate. Indian coastal region consists of:

S. No.	State	Length of the coastline (in Kilometres)
1	Gujarat	1214.7
2	Andhra Pradesh	973.7
3	Tamil Nadu	906.9
4	Maharashtra	652.6
5	Kerala	569.7
6	Odisha	476.4
7	Karnataka	280
8	Goa (with Daman & Diu)	160.5
9	West Bengal	157.5
10	Puduchery (Union Territory)	30.6

Following models are suitable for this region:

- Integrated Fish cum Duck Farming
- Integrated Fish Farming-Chicken

- Integrated Fish farming-cum-Cattle farming
- Integrated Fish farming-cum-Rabbit farming
- Integrated Fish farming-cum-Agriculture ²²⁴

Table 3 : RGYE, economics and employment generation in different IFS models for rainfed regions

Treatments	RGEY (t/ha)	Net returns (Rs/ha)	B:C ratio	Employment (days/ha/yr)
T1:Field crops + poultry + fish + banana	14.90	48,503	1.83	532
T2 :Rice + fish + banana	13.25	17,642	1.89	438
T3 :Rice+Fish + banana + apiculture	14.40	12,812	1.96	454
T4: Cropping alone (Rice-rice system)	7.50	14,500	1.47	398



RGYE=Rice grain yield equivalent

ANGRAU, AP

Sekhar *et al.* (2014)

Integrated farming models for central and northern India

This region consists of Punjab, Haryana, Uttarakhand, Uttar Pradesh, Bihar, Madhya Pradesh, and Chhattisgarh.

Following models are suitable for this region:

- Agriculture + livestock
- Agriculture + livestock + poultry
- Horticulture + fish culture + poultry
- Pig cum fish culture
- Agricultural + silvipasture
- Sericulture + fish culture
- fish culture + sericulture
- Agricultural(rice) + fish+ mushroom cultivation
- Agricultural + duckery + poultry
- Poultry + fish culture ²³⁴

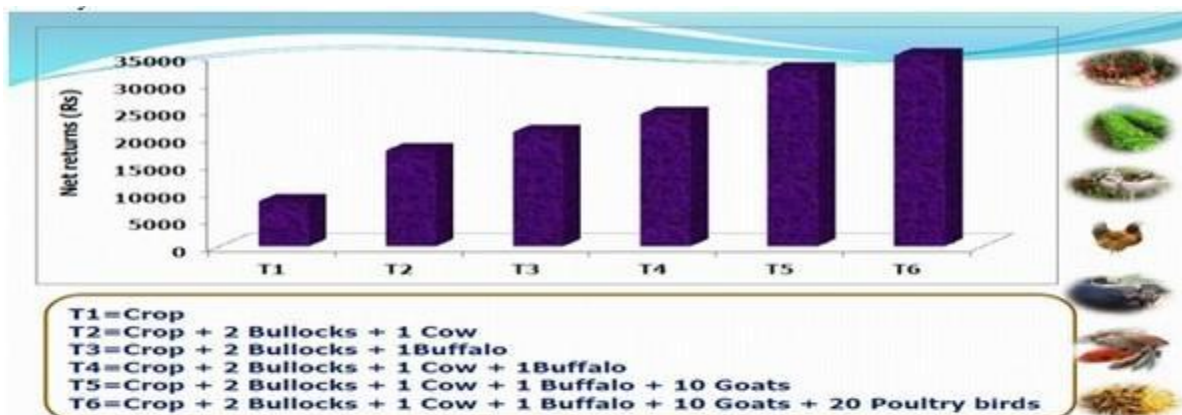


Figure 7 : Profitability of different IFS models in rainfed regions of Rajasthan (0.6 ha)

RARI Durgapur

Yadav and Sharma (2013)

Table 6 : Productivity of different IFS modules in irrigated agro-ecosystem of Eastern Uttar Pradesh

Farming system	Component productivity (Rice grain equivalent yield q/ha)				System productivity (q/ha)
	Crop	Dairy	Poultry	Fish	
Rice-wheat	21.61	-	-	-	86.44
S+ SBM + D	32.70	236.33	-	-	1076.12
S+ SBM + P	32.70	-	30.37	-	252.28
S+ SBM + F	28.57	-	-	15.06	174.52
S+ SBM + D+ P	32.42	236.33	30.37	-	1196.48
S+ SBM +D+ F	28.09	236.33	-	15.06	1117.92
S+ SBM + F+ P	28.09	-	30.37	15.06	294.08
S+ SBM +D+ F+ P	27.61	236.33	30.37	15.06	1237.48

S=Rice-table pea-okra, P =Poultry, F=Fish, D=Dairy, SBM=Sorghum- berseem -maize

Singh *et al.* (2007)

Selection of ponds can be seasonal or perennial.

The perennial ponds which retain water throughout the year are selected for culture of table fish. The newly excavated ponds should be rectangular in shape and of manageable size (0.4 ha).

Construction of low cost water harvesting pond for IFS

Small ponds of sizes ranging from 0.01 – 0.10 ha with desired depth of 1.0 – 1.5 metre with side slopes of 1- 1.5 m can be developed. Figure shows water harvesting pond constructed and lined with 300 micron LDPE at KVK Aizawl. Since lined the pond base is treated with 3-5 cm layer soil (approx).²⁴⁴



Water harvesting pond constructed and lined with 300 micron LDPE at KVK Aizawl

Stocking:

The pond is stocked after the pond water gets properly detoxified. The stocking rates vary from 8000-8500 fingerlings per hectare (100m x100m) and a species ratio of 40% surface feeders, 20% column feeders, 30% bottom feeders and 10% macro vegetation feeder is preferred for high fish yields. Mixed culture of Indian Major carps can be taken up with species ratio of 40% surface feeders, 30% column feeders and 30% bottom feeders.

Examples of:

Surface feeder fishes: **Catla** (*Gibelion catla*),

Column feeder fishes: **Rohu, Silver carp**

Bottom feeder fishes: **Murrail, Mrigal**

Liming

Lime is applied @ 250-350kg/ha/yr depending upon the soil and water conditions. Half the quantity is applied before stocking the fish and the rest in 2-4 installments as and when necessary.

Periodical netting

Netting is done once a month to check the growth of fish. It also helps in timely detection of parasitic infection, if any.²⁵⁴

Harvesting

Keeping in view the size attained, prevailing market rate and demand of fish in the local market, partial harvesting of fish is done. After harvesting partially, the stock replenished with the same number of fingerlings. Final harvesting is done after 12 months of rearing. Fish yields ranging from 6000-7000kg/ ha/yr is generally obtained whereas pigs attain slaughter size (70-80kg) within 6-7 months.

The system has obvious advantages:

The pond dikes provide space for erection of animal housing units. Pond water is used for cleaning the pigsties and for bathing the pigs. The system cannot be adopted in all parts of India due to religious consideration but it has special significance in the North Eastern Region as it can improve the socioeconomic status of weaker rural communities, especially the tribals who traditionally raise pigs at their backyards and fond of eating fish. They can take up fish-pig farming easily.

Integrated Fish cum Duck Farming

Raising ducks over fishponds fits very well with the fish polyculture system, as the ducks are highly compatible with cultivated fishes. 100-150 ducks are sufficient for 1 Hectare pond. The system is advantageous to farmers in many ways:

- Ducks keep water plants in check.

- Ducks loosen the pond bottom with their dabbling and help in release of nutrients from the soil which increases pond productivity.
- Ducks aerate the water while swimming; thus they have been biological aerators.
- Duck houses are constructed on pond dikes; hence, no additional land is required for duckery activities.
- Ducks get most of their total feed requirements from the pond in the form of aquatic weeds, insects, larvae, earthworms, etc. They need very little feed, and farmers normally give kitchen wastes, molasses and rice bran, for the purpose.²⁰³



Integrated Fish farming-cum-Cattle farming

Cattle dung, urine as well as the washing of cattle shed has superb manurial value. The waste cattle fodder can also be utilized as fish feed. The cattle shed can be constructed on the widen embankment of fish pond itself, so the waste and washing are directly drained into the fish pond. 5-6 cattle will suffice for 1.0 ha pond.

Integrated Fish farming-cum-Rabbit farming

In rabbit-fish integration, rabbit-house is built alongside the embankments so that the wastes and washings are drained directly into the pond. The excreta provided by 300-400 rabbits is sufficient to fertilize 1.0 ha of pond. Fish yields to the tune of 3500 to 4000 kg are obtained by stocking 15,000 fingerlings/year/ha.²⁰⁴

Integrated Fish farming-cum-Agriculture:

Fish farming-cum-Horticulture farming: Generally, to meet the daily needs of fruits for a family of 4-5 members a land space of about 200 m² is needed. Normally, embankments of a fish pond provide more than 200 m² area. Pond bunds account for 25 to 33% of farm area.

Fish farming-cum- Vegetable farming

Usually a land space of 200 sq.m. is needed for kitchen gardening and embankments of a fish pond provide more area than this. In a year, two crops of vegetables can be grown. The vegetables which are considered ideal for growing on pond embankments are bitter guard, lady's finger, bottle gourd, brinjal, lobia, cucumber, french beans, pumpkin, tomato, cauliflower, cabbage, peas, palak, etc.²⁰⁹



There are always integrations at different levels in the existing family farming system practiced by the small holding farmers in the region. Better food security, moreover, the system help poor small farmers, who have very small land holding for crop production and a few heads of livestock to diversify farm production, increase cash income, improve quality and quantity of food produced and exploitation of unutilized resources.

National Mission for Sustainable Agriculture

National Mission for Sustainable Agriculture (NMSA) has been formulated for enhancing agricultural productivity especially in rainfed areas focusing on integrated farming, water use efficiency, soil health management and synergizing resource conservation.²⁰⁶

Mission Objectives

1. To make agriculture more productive, sustainable, remunerative and climate resilient by promoting location specific Integrated/Composite Farming Systems;
2. To conserve natural resources through appropriate soil and moisture conservation measures;
3. To adopt comprehensive soil health management practices based on soil fertility maps, soil test based application of macro & micro nutrients, judicious use of fertilizers etc.;
4. To optimize utilization of water resources through efficient water management to expand coverage for achieving 'more crop per drop' ;
5. To develop capacity of farmers & stakeholders, in conjunction with other on - going Missions e.g. National Mission on Agriculture Extension & Technology, National Food Security Mission, National Initiative for Climate Resilient Agriculture (NICRA) etc., in the domain of climate change adaptation and mitigation measures;
6. To pilot models in select blocks for improving productivity of rainfed farming by mainstreaming rainfed technologies refined through NICRA and by leveraging resources from other schemes/Missions like Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), Integrated Watershed Management Programme (IWMP), RKVY etc.; and
7. To establish an effective inter and intra Departmental/Ministerial co - ordination for accomplishing key deliverables of National Mission for Sustainable Agriculture under the aegis of National Action Plan on Climate Change (NAPCC).²⁰⁸

Mission Strategy

- Promoting integrated farming system covering crops, livestock & fishery, plantation and pasture based composite farming for enhancing livelihood opportunities, ensuring food security and minimizing risks from crop failure through supplementary/ residual production systems;
- Popularizing resource conservation technologies (both on - farm and off - farm) and introducing practices that will support mitigation efforts in times of extreme climatic events or disasters like prolonged dry spells, floods etc.
- Promoting effective management of available water resources and enhancing water use efficiency through application of technologies coupled with demand and supply side management solutions;
- Encouraging improved agronomic practices for higher farm productivity, improved soil treatment, increased water holding capacity, judicious use of chemicals/ energy and enhanced soil carbon storage;
- Creating database on soil resources through land use survey, soil profile study and soil analysis on GIS platform to facilitate adoption of location and soil - specific crop management practices & optimize fertilizer use;
- Promoting location and crop specific integrated nutrient management practices for improving soil health, enhancing crop productivity and maintaining quality of land and water resources;
- Involving knowledge institutions and professionals in developing climate change adaptation and mitigation strategies for specific agro climatic situations and promoting them through appropriate farming systems
- Programmatic interventions as per land capability and conducive to climatic parameters in select blocks as pilots for ensuring integrated development through dissemination and adoption of rainfed technologies with greater reach in disadvantaged areas & location specific planning by way of coordination, convergence and leveraging investments from other Schemes/Missions like MGNREGS, IWMP, RKVY, National Food Security Mission (NFSM), Mission for Integrated Development of Horticulture (MIDH), National Mission for Agricultural Extension & Technology (NMAE&T) etc.²⁶¹

Mission Interventions

NMSA has following four (4) major programme components or activities:
Rainfed Area Development (RAD)

RAD adopts an area based approach for development and conservation of natural resources along with farming systems. This component has been formulated in a 'watershed plus framework', i.e., to explore potential utilization of natural resources base/assets available/created through watershed development and soil conservation activities /interventions under MGNREGS, NWDPR, RVP&FPR, RKVY, IWMP etc.. This component introduces appropriate farming systems by integrating multiple components of agriculture such as crops, horticulture, livestock, fishery, forestry with agro based income generating activities and value addition. Besides, soil test/soil health card based nutrient management practices, farmland development, resource conservation and crop selection conducive to local agro climatic condition are also promoted under this component. A cluster based approach of 100 hectare or more (contiguous or non contiguous in difficult terrain with close proximity in a village/adjoining villages) may be adopted to derive noticeable impact of convergence and encourage local participation and for future replication of the model in larger areas. Supplementary support from this component will be admissible for gap - filling resource conservation activities under converging programmes. RAD clusters should have soil analysis/soil health card /soil survey maps to justify the interventions proposed and at least 25% of the farming system area will have to be covered under On Farm Water Management. Farming Systems recommended by ICAR's Contingency Plans and successful findings of NICRA projects shall also be considered in development of integrated project plan. Besides, creation and development of common property resources/assets/utilities like grain bank, biomass shredders, fodder bank, group marketing etc. will be encouraged under this component.

On Farm Water Management (OFWM)

OFWM focuses primarily on enhancing water use efficiency by promoting efficient on - farm water management technologies and equipment. This not only focuses on application efficiency but, in conjunction with RAD component, also will emphasize on effective harvesting & management of rainwater. Assistance will be extended for adopting water conservation technologies, efficient delivery and distribution systems etc. Emphasis will also be given to manage and equitably distribute the resources of commons by involving the water users associations, etc.. To conserve water on farm itself, farm ponds may be dug using MGNREGA funds and earth moving machinery (to the extent manual digging under MGNREGA is not feasible)²⁶²

Soil Health Management (SHM)

SHM aims at promoting location as well as crop specific sustainable soil health management including residue management, organic farming practices by way of creating and linking soil fertility maps with macro - micro nutrient management, appropriate land use based on land capability, judicious application of fertilizers and minimizing the soil erosion/degradation. Assistance will be provided for various improved package of practices based on land use and soil characteristics, generated through geographical information system (GIS) based thematic maps and database on land and soil characteristics through extensive field level scientific surveys. Besides, this component will also provide support to reclamation of problem soils (acid/alkaline/saline). This component will be implemented by State Govt., National Centre of Organic Farming (NCOF), Central Fertilizer Quality Control & Training Institute (CFQC&TI) and Soil and Land Use Survey of India (SLUSI).

Climate Change and Sustainable Agriculture: Monitoring, Modeling and Networking (CCSAMMN)

CCSAMMN provides creation and bidirectional (land/farmers to research/scientific establishments and vice versa) dissemination of climate change related information and knowledge by way of piloting climate change adaptation/mitigation research/model projects in the domain of climate smart sustainable management practices and integrated farming system suitable to local agro - climatic conditions. Comprehensive pilot blocks will be supported to illustrate functional mechanism for dissemination of rainfed technologies, planning, convergence and coordination with flagship schemes/Missions like MGNREGS, IWMP, Accelerated Irrigation Benefit Programme (AIBP), RKVY, NFSM, NHM, NMAET etc. Such an integrated action of input and output flows across agriculture, livestock and other production systems will harness the growth potential of the rainfed production systems, imparting sustainability of local production systems while negotiating climate change risks.²⁶⁵

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