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INTEGRATED FARMING SYSTEMS A WAY FOR LONG-TERM FARMING VIABILITY: A REVIEW

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ABSTRACT

Integrating agro-ecological practices into farming systems has emerged as a viable development option for meeting the basic needs of rural communities. It enhances farmers' socio-ecological capabilities, making it easier for their living. Livestock farming is an important part of farming. Traditional livestock farming, land cultivation, stock breeding, aquaculture, horticulture, agro-industry and related output are all transformed through integration. It's essential for safeguarding ecosystems, maximizing productivity and generating employment opportunities at the same time for those in need. Food security, risk management, income and employment, biodiversity, carbon storage, energy efficiency and other needs of the farm family could be addressed through integrated farming system (IFS). To achieve various socio-economic and ecological outcomes, public extension must consider IFS as a socioeconomic-ecological intervention rather than a technology. It's apparent that integrated farming systems play a significant role, and that numerous elements contribute to their success. High startup costs and a shortage of available labor are cited as the primary obstacles to implement an integrated farming system. Including animals in the farming system can help farmers experience a risein their earnings within the five-year time frame they're looking for, in addition to bringing social and ecological benefits. Farmers saw a higher net return and benefit: cost ratio when using the IFS compared to traditional farming. According to literature, farmers prioritize achieving their socio-economic, cultural and ecological requirements while battling biotic and abiotic challenges. This needs intentional integration of small farm components to decrease stress and hence to benefit farm households.
Keywords : Integrated farming system, Farm productivity, Conventional farming system, Employment generation, Women Empowerment.

Introduction

A significant increase in agricultural output was achieved in the 20th century through agronomic practises such as the widespread application of inorganic pesticides and fertilizers. However, the undesirable degradation of the natural environment resulted from these practises including overuse and exploitation of fertilizers and pesticides along with the rising costs of agricultural operations, gave rise to concerns about the industry's viability and sustainability (Nivia and Ivette, 2009; FAO, 2010). According to a report, roughly seventy-five percent of the households who were negatively impacted were found to be located in rural areas of developing economies (FAO, 2009). The majority of these communities depend on agriculture and related industries for their livelihood. Unsustainable farming practises harm the ecosystem and put subsistence farmers at risk. It is crucial to strengthen agricultural production systems so that they are more eco-friendly and offer higher economic returns in order to boost both income and the possibility that people in developing nations would have access to sufficient food and nutrition (Chen and Ravallion, 2007). Despite the constant exploitation of natural resources and the globalisation of agri-food chains, ensuring the security of food, nutrition, and livelihood through agriculture in a sustainable manner is a challenge in today's world (Koohafkan *et al.*, 2012). That's why the Integrated Farming System, which considers the farm as a whole from a variety of perspectives, may be a powerful tool for improving the lot of small and marginal farmers.

First, let's get a firm grasp on the ideas of "Farming" and "System" on their own before proceeding on to the integrated farming system. As is common knowledge, the act of cultivating crops and/or keeping and/or rearing animals on a farm is the literal interpretation of the term "Farming". Perhaps farm management is also at play here. In contrast, a system consists of interconnected components that act in concert to produce a desired result. Soil, plants, animals, tools, energy, labour, capital and other inputs all form part of the intricate, interdependent matrix that is the farming system. Farm families have some influence over this complex system, which also involves many other political, economic, institutional and social forces. A farming system is the set of interrelated and mutually supportive economic and agricultural activities that occur within a given agrarian setting. In an IFS, farm families diversify the agricultural enterprises under their management, they spend their money, resources, time and effort in these enterprises in order to maximise the returns from their farm in a given time frame, hence increasing both output and income. These agricultural enterprises principally consist of operations in crop along with animal production, aquaculture, agroforestry, and agri-horticulture, in addition to many other enterprises (Sharma *et al.*, 1991).

Now, an integrated farming system can be understood as a collection of interconnected farming endeavours that help small and marginal farmers in several ways, including financial gain, ecological balance, waste reduction, nutritional and food safety. Integrating multiple farm enterprises with crop production as the backbone allows for the recycling of waste products from one farm enterprise as input in another farm enterprise, which in turn increases overall farm income through reduced total costs and can be a good solution for farm waste management through recycling. IFS works as a system of systems. Integrated Farming Systems (IFS) use a distinct resource management approach to achieve financial advantage and sustain farm productivity without jeopardising the resource base or environmental quality. An integrated farming system is a holistic strategy that supports sustainable use of natural resources and it provides a mechanism for natural resource management to be accomplished in an effective manner. It is based on the Low External Input Sustainable Agriculture (LEISA) model, which seeks to eliminate the use of external inputs, thereby reducing the cost of cultivation; to make efficient use of the internal inputs, thereby achieving effective resource management and recycling of waste materials, and finally to double the farmer's income through increased enterprise productivity and the generation of income from more than one enterprise, thereby providing the farmers with income throughout the year.For an instance, compared to crop-based systems alone, a crop-livestock-fish or crop-livestock system is said to have a better net return (Ugwumba *et al.*, 2010; Desai *et al.*, 2013).

Objectives of Integrated Farming Systems

- **Sustainability of production-** Maximising production with minimal impact on the natural world, IFS seeks to reduce waste generation and maximise the use of internal resources primarily by using by-products of one enterprise as an input to another.
- **Productivity improvement-** The economic yield per unit area per unit time can be raised through the intensification of agricultural and associated industries, through adoption of an integrated farming system (IFS).
- **Profitability-** By efficient recycling of waste materials from one enterprise as input in another associated enterprise, IFS lowers the cost of cultivation, thereby boosting the benefit: cost ratio.
- **Soil health-** Soil health is improved in IFS by the utilization of organic manure and existing waste materials as inputs.
- **Balanced food-** The widespread problem of malnutrition among marginal and sub-marginal farming households can be alleviated through the use of a farming system that incorporates a wide range of enterprises, each of which produces a unique type of nutrition (protein, carbohydrates, fats, minerals, vitamins, etc.) from the same plot of land.
- **Environmental safety-** A sustainable agricultural system incorporates bio-control strategies for pest and disease management and makes use of the by-product or waste product of one component as input in another. Reduced use of harmful chemicals is a direct result of these environment friendly methods. Alternatively, IFS can significantly cut down on pollution.
- **Cash flow all-round the year-** In addition to crop cultivation, IFS is home to a wide range of businesses that generate money throughout the year by selling items such as eggs from poultry, milk from dairy, fish from fisheries, silkworm cocoons from sericulture, honey from apiculture, etc.
- **Employment generation-** Multiple ancillary activities on a farm raises the demand for labour, which in turn improves the farm's ability to attract and retain workers. This is especially helpful in addressing the issue of rural underemployment.
- **Saving energy-** A priority right now is finding a way to drastically cut back on our use of fossil fuels. With the right kind of recycling process, the organic wastes in the system can be converted into biogas. Also apart from burning, briquetting stubbles (waste products) can be used to generate energy and reduce environmental pollution.
- **Meeting Fodder crisis-** Every piece of land is effectively utilized in this system. The lack of access to high-quality fodder for the animal component can be mitigated through planting of perennial legume fodder trees along field margins that fix atmospheric nitrogen symbiotically.
- **Agro-industries establishment-** It is also to be noted that when the enterprises undertaken in a farming system have stabilised and reached a commercial level of production, there will be a surplus of product available for value addition, which in turn will boost the growth of ancillary agro-industrial sectors in the region.
- **Increasing Input Efficiency-** As a result of the IFS's flexibility, inputs can be used across multiple components, improving both efficiency and the benefit: cost ratio.

Components of integrated farming system & its modelling

The primary elements or components of any IFS are crops, animals, birds, and trees. A crop may have subsystems such as monocrop, mixed/intercrop, or multi-tier crops of cereals, legumes (pulses), oilseeds, and pasture, etc. Components of livestock can include a milch cow, goat, sheep, poultryor even bees. Trees can serve as timbers, sources of fuel and food and even fruit. The major components of Integrated Farming Systems that are applicable to all agroecological zones in the country are crop production (including the raising of vegetables), dairy, poultry production (both layer and broiler),goat and sheep rearing, piggery, fish farming, duck rearing, turkey rearing, quail rearing, rabbit rearing, beekeeping, sericulture, etc.

As we move towards more efficient, economic and environment friendly agricultural practises, it is crucial to build farming systems that are more efficiently linked. The production of feed, utilisation of animals and recycling of waste, all need to be well integrated in order to reduce negative effects on the environment and improve production efficiency. A comparison between conventional farming system and integrated farming system is given in Table-1 below. Creating a functional integrated farming system is not a simple task. Understanding and appreciating all the dynamics at play within the system might be difficult due to the complex interconnections between the different parts of the farm. An IFS model has been depicted in the figure below (Figure-1).

Table 1 : Major Differences between conventional and Integrated Farming System.

Components	IFS	Conventional farming
Production	Maintains and enhances production.	Less production as compared to IFS.
Resource utilization	Optimum utilization of available on-farm resources.	Extensive use of off-farm resources.
Food/nutritional security	Able to produce food all-round the year, thereby relieving food insecurity.	Can't be fully dependent on it as it has less production rate.
Income generation	Economically viable as generates income all-round the year.	Generates income only in particular cropping seasons, so economically not much sound.
Environment	Environmentally safe as doesn't pose any environmental pollution.	Use of chemical inputs poses environmental hazards, so environmentally unsafe.
Profitability	Higher profitability.	Low profitability.
Biodiversity	Maintains the biodiversity.	Degradation of the biodiversity.
Residual effect of inputs	No adverse residual effect of inputs utilized.	Adverse residual effect of inorganic inputs.

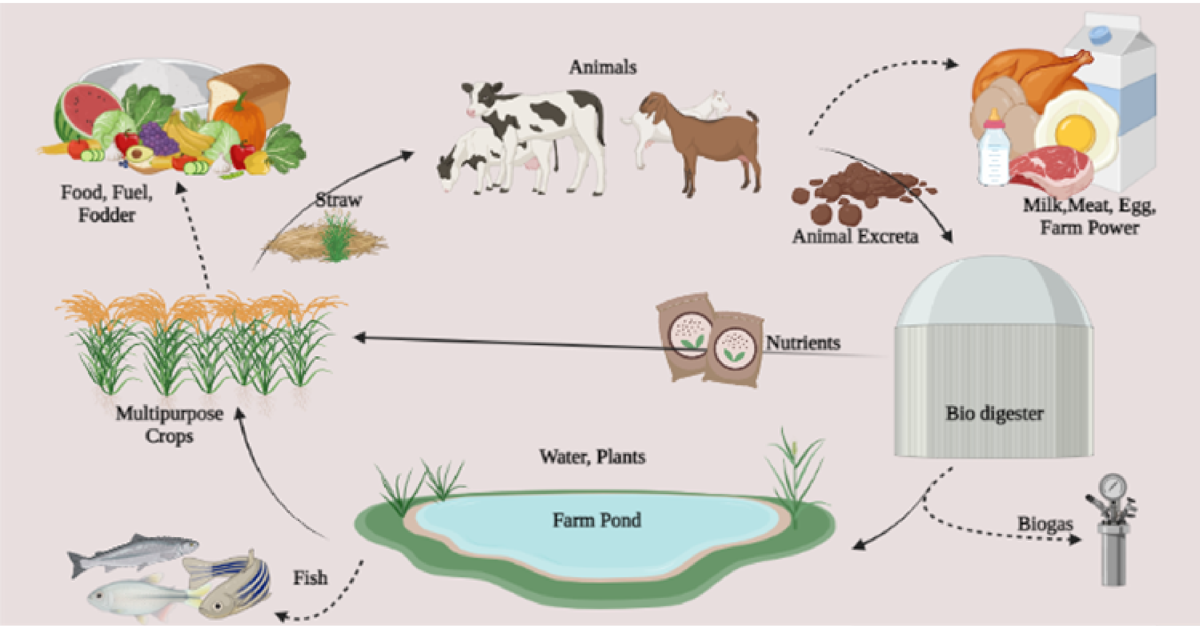

Fig. 1 : A straightforward model of an integrated farming system.

The additional benefits of a crop-fish-poultry integrated farming system are also realised when crop and fish culture are combined with poultry, preferable undertaken near the fish pond. As is customary, the crop part provides for the family's needs. Other agricultural by-products can be used to feed chickens; straw and other farm residues can be used as bedding material. In addition, no additional fertiliser, manure or feed supplements are needed when processed poultry manure is put straight to the fish pond.

An IFS model can be placed into either linear programming models or simulation model categories. The linear programming approach is commonly utilised in economic research approach since it places less focus on elucidating the fundamental processes that make up the system. With this set-up, a group of equations that describe the production system are solved at the same time to find the best solution. Whereas, in simulation model, there is more focus on using mathematics to describe how the parts of a farm work together and to determine their output as a function of time. Hence, simulation usually track farm processes, considering the weather conditions prevalent over the farm over a long period of time, to get an idea or estimate the performance of the farm for the predefined enterprises undertaken under the prevalent agro climatic conditions of the locality.To better utilise the by-products and simplify the complicated interrelationships among the various enterprises undertaken in a particular IFS, integrated simulation modelling is an essential tool. Multi-criteria decision analysis that incorporates linear programming and simulation modelling to address the input-output flow of resources is required under the predicted climate change scenario in order to optimise the multiple input factors for maximum benefit with sustainability.The Silsoe Whole Farm Model (Audsley, 1981) is a useful illustration of the LP strategy. In order to aid in making strategic farming decisions, this model was created. This scale model farm is available for purchase, with the UK as its primary market. Nitrate, ammonia, nitrous oxide and methane emissions are only some of the environmental impacts that have been factored into the model as it has evolved into the MEASURES model in recent years (Multiple Environmental Outcomes from Agricultural Systems; Williams *et al.*, 2003). By analysing data including soil composition, precipitation history and farm size, MEASURES finds the optimal crop rotation for a given farm. Similarly, a deterministic static linear programming (LP) Model was created to examine the results of institutional and technical change on Dutch dairy farms, another application of the LP method (Berentsen and Giesen, 1995). This model was also used to analyse the financial and ecological effects of switching from conventional to biological dairy production, one of the many alternatives considered (Berentsen *et al.*, 1998). Integration of a simulation model has been depicted schematically in the given figure below (Figure-2), along with its input flows.

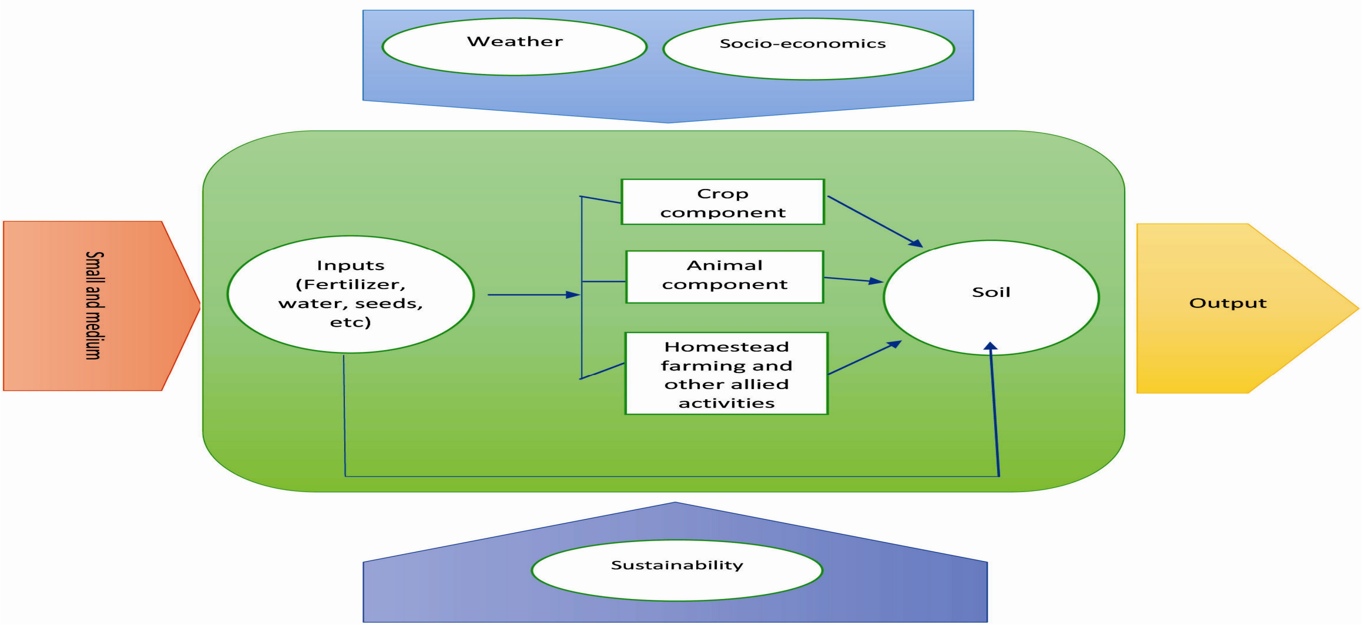

Fig. 2 : Schematic representation of integrated simulation along with input energy flow.

Flow of Energy in Farming System

Energy is crucial in agriculture for both crop cultivation and agro-processing in order to add value to the final product. The energy content of finished goods is generally classified into two categories: direct energy, which refers to the energy purchased by the company/ manufacturer/ farmer (in case of farming) producing and selling the product (farm products in particular); and indirect energy, which refers to the energy used in the production of supplies and in the services the company/ manufacture/ crop grower purchases from the market. Ploughing, land preparation, fertilisation, irrigation, inter cultivation, harvesting and transporting the produce are all examples of direct energy needs in agriculture, while the production, packaging, and transportation of fertilisers, pesticides, and farm machinery are examples of indirect energy needs. However, the quantity of biomass energy captured in the crop through the use of human, animal and fossil energy power to manipulate plants, soil and water is a key indicator of the effectiveness of agricultural production.

Since, the efficient use of energy is vital in terms of increasing the production and productivity of as well as sustainability of rural living, energy auditing is one of the most common practices to examine the energy efficiency and environmental impact of the production system. It's useful for studying farming systems since it allows researchers to easily determine input/output ratios and various energy use pattern in a farming system study. The flow of energy in an IFS has been briefly presented in figure-3 below.

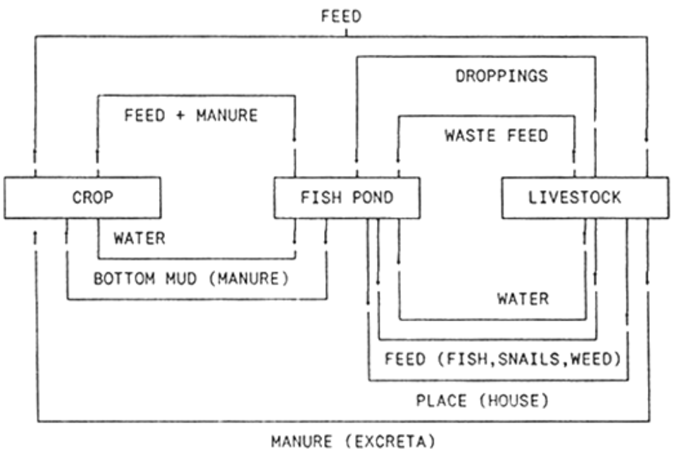

Fig. 3 : Energy flow in a hypothetical IFS with crop, fishery and livestock as its main enterprise (Adopted from "Manual on Polyculture and Integrated Fish Farming in Bangladesh")

Women empowerment through ifs

Women are crucial to all aspects of family management, including farming. This is especially true in mountainous or tribal areas. Family labour can be utilised in a wide variety of IFS-affiliated enterprises. Women are more likely to work in areas such as poultry rearing, cattle rearing, goat/sheep rearing, sewing, vegetable production and selling, nursery reforestation (Sharmin *et al.*, 2012). Furthermore, via women's empowerment, through location-specific trainings and vital need-based support, household resources can be used more effectively. With the increased integration in farms, women get more engaged in farming activities. During the lean agricultural years, men often have to work away from home or travel to their far-flung crop fields, industrial areas, leaving the women at home to run the household as well as a number of businesses. In order to achieve this goal, women must be encouraged and supported with the tools they need, through programmes like as on-farm trainings, mandatory education, and assistance from various organisations in areas such as managing agricultural enterprises. Many of the resources are produced on the farm itself, the women do not have to go somewhere else to acquire them. The majority of the farm's outputs are also sold by the women at the neighbourhood markets, providing them with some cash revenue that they may put to use (Goswami and Dasgupta, 2014).

Multifunctional Benefits of Ifs:

- **IFS and job creation** - IFS encourages job creation, especially in rural areas where underemployment is a major problem and is a driving factor in the distressing migration of rural people to urban areas. Integration of several other components in farming system in addition to crop production will assure on-farm employment generation as well as effective usage of the family labour. Compared to conventional farming, IFS is shown to produce more man-days on the farm (Tipraqsa *et al*., 2007).
- **IFS and doubling farmer's income**-According to reports, IFS generates higher farm revenue and profitability than conventional farming in developing countries' smallholder systems (Edwards, 1989; Behera and Mahapatra, 1999; Routaray *et al*., 2005; Tipraqsa *et al*., 2007). IFS is able to produce a higher cash income due to an increase in the number of animals and fish it supplies. By combining the profits from several enterprises into one, farmers may secure a more stable income than that would be possible with the profits from a single farm enterprise.
- **IFS and food/nutritional security-** By maintaining agricultural production and the availability of various food products, IFS guarantees that all members of the family will be fed in a sustainable manner throughout the year. The provision of animal proteins and vegetables/fruits through IFS increases household food consumption, particularly among the most vulnerable members of the household (children, pregnant/lactating mothers and the ill ones) (Prein and Ahmed, 2000).
- **IFS and energy efficiency**-The amount of energy used in a crop directly correlates with its yield. Energy that is utilised directly on the farm, as opposed to energy that is used indirectly, comes from on-site activities. The use of fertilisers, herbicides, machinery and other direct energy consumers is more common in conventional farming. Low or no external inputs are used in IFS and less machinery is used, which means less energy is consumed compared to conventional farming. Many of these integrated farms are also subsistence farms which reduces the amount of time spent moving about the farm and the amount of energy expended when transporting crops.
- **IFS and waste recycling**- IFS promotes efficient utilization of the waste products/ by products of one enterprise as input in another enterprise, thereby ensuring effective recycling of the wastes. Utilization of on farm inputs (reducing the dependence on off-farm inputs) also promotes effective resource management.
- **IFS and soil health**- In IFS, the use of on-farm natural resources as inputs, rather than using chemicals as external inputs helps in improving the soil health. The organic wastes generated on-farm adds to the organic matter of the soil thereby improving its health. Furthermore, IFS has high erosion control potential.
- **IFS and environmental stability**- Reducing the use of external inputs in IFS also reduces the environmental hazards, mainly environmental pollution through use of chemical inputs. On per- hectare scale, the CO_2 emissions are found to be 40-60% lower in IFS then in conventional farms.
- **IFS and carbon storage**- Carbon sequestration is defined as the capture and secure storage of carbon that would otherwise be emitted to or remain in the atmosphere (FAO, 2000). IFS has a huge potential to store carbon in the eco-system because (a) trees are seen as an important part of the system (b) livestock's are raised and organic manures are used a lot in farming which helps to add carbon in the soil (c) external inputs like fertilisers are kept to a minimum which saves fossil fuel indirectly and (d) farming uses a small amount of fossil fuel.
- **IFS and biodiversity**- IFS encourages the maintenance of biodiversity in the agro-ecosystem by growing a greater number of crop species and varieties (often by mixed and intercropping), by increasing the size and breed of ruminants and non-ruminants raised on the farm, by keeping a greater variety of tree species, shrubs and herbs in the homestead and on the farm (to meet the needs), by promoting the integrated management of pests and by enhancing soil microbial biodiversity by incorporating more organic matter into it.

Conclusion

There is a huge potential for uplifting majority rural farms to their maximum potential levels by integrating a considerable number of enterprises into a farming system model, specific to the agro-climatic and socio-economic conditions, in order to make agriculture a profitable venture for farmers (including small and marginal ones). Additionally, farmers should be trained and given on-farm demonstrations to help them understand its significance and advantages. Improved farming practises have the potential to play a large part in improving production, remunerative returns and mitigate the requirements for nutrition, in addition to employment prospects in rural regions. Integrated farming systems present one-of-a-kind chances for the conservation and expansion of biological diversity. When it comes to such systems, maximising resource usage of on farm produced resources in addition to increasing the productiveness of each individual component enterprise is where the focus is placed. Through the Integrated Farming Systems (IFS), it is possible to ameliorate the plight of underprivileged farmers by pooling the insights and labours of farmers, scientists, researchers and students from a variety of nations whose ecological and sociological conditions are analogous to one another. IFS do play a vital role in preventing the depletion of land and water resources as well as environmental contamination. With women's educational status expected to rise in the coming years, IFS must include them as a core element. IFS must be viewed as a versatile socio-ecological intervention rather than a technology with a wide range of desired socio-economic-ecological results. This calls for recognising its multifaceted functions and creating adaptable farming systems that are location and demand-driven. Furthermore, the role of highly educated and skilled youth will be very useful in managing knowledge intensive farming systems.

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