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Ecosystem services from horticulture-based farming systems: Looking beyond yield and income

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Horticulture-based farming systems provide much more than fruits and vegetables. Combined with field crops, fish, poultry, composting and boundary plantations, the farm delivers food, nutrient recycling, soil improvement, carbon sequestration, biodiversity and livelihood diversification. A five-year horticulture-based integrated farming system at ICAR-IIFSR, Modipuram, produced 32 food items, held 39% perennial cover and 310 days of soil cover, while returned ₹2.94 lakh/ha/year, recycled substantial N, P and K, and recorded a net GHG balance of −6,093.2 kg CO_2-equivalent. This provides evidence that such farms should be assessed through the ecosystem services they generate, not through production and profit alone.

Keywords: Biodiversity, Carbon sequestration, Food and nutrition security, Integrated farming system, Nutrient recycling

HORTICULTURE is an important component of diversified farming. Fruit and vegetable crops provide food, income and employment while contributing vegetation cover, biomass and resource cycling. Integrated with field crops, fish, poultry and composting, the resulting system performs functions extending well beyond the production of individual commodities.

An orchard provides fruit but also perennial vegetation and biomass; vegetables provide food and income while keeping soil covered; residues and poultry manure are recycled on farm; ponds and boundary vegetation aid water management and habitat. A diversified horticultural farm is therefore a multifunctional agroecosystem rather than a set of separate enterprises. Conventional farm accounts miss most of this with soil protection, nutrient recycling, carbon sequestration, biodiversity and nutritional diversity rarely enter the profitability calculation. Ecosystem accounting makes them visible by linking the condition of the system with the services it supplies and the benefits received.

A diversified horticulture-based farming system

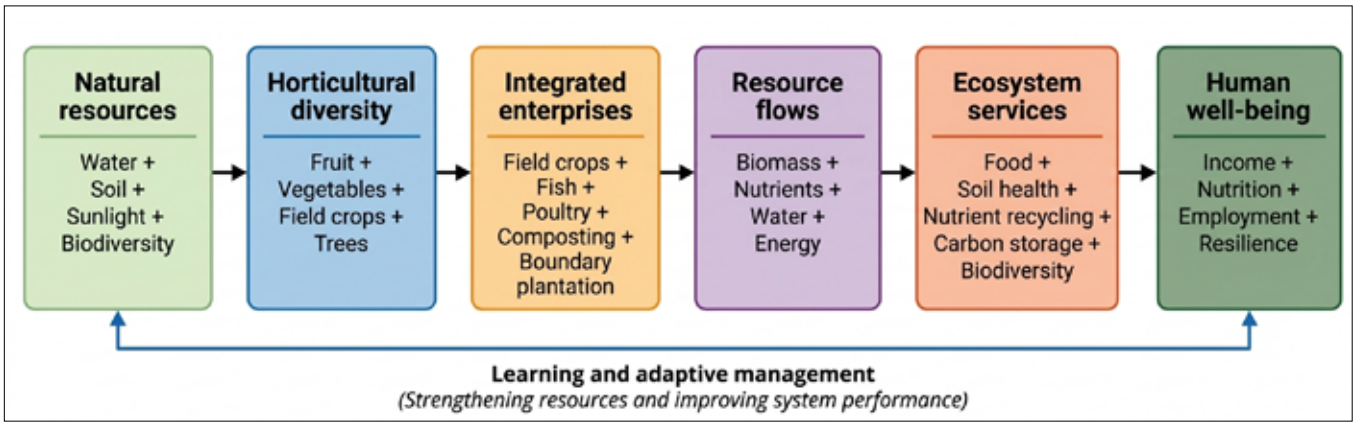
The horticulture-based integrated farming system (HIFS) at ICAR-Indian Institute of Farming Systems Research (IIFSR), Modipuram, was designed around diversification and integration. It contains:

- Horticulture component including Amrapalli and Dashehri mango, guava and kinnow with seasonal intercrops (0.4 ha)





View of components of a horticulture-based integrated farming system



Horticulture-based farming system as a multifunctional agroecosystem

- Vegetable component including brinjal, potato, beans, onion, bottle gourd, cauliflower, okra, radish, pumpkin, fenugreek, coriander, lobia and carrot (0.6 ha)
- Field crop component of rice–wheat and sugarcane–ratoon–wheat (0.4 ha)
- Fish pond (0.1 ha) with dyke vegetables, 20 poultry birds, a composting unit and boundary plantations.

The important feature of such a system is not the number of enterprises but the connections among them. Crop residues and poultry waste become inputs for composting, pond dykes produce vegetables, perennial trees supply biomass and soil cover, and different enterprises distribute production over time, so a change in one component influences the performance of others.

Generating ecosystem services through horticulture-based farm

The functioning of a horticulture-based system can be read as a connected pathway. Farm resources and diversity support horticultural and complementary enterprises, which drive biological and ecological processes, which in turn generate ecosystem-service flows contributing to food, income, nutrition, environmental quality and resilience. The same land area can simultaneously produce food, protect soil, store carbon, recycle nutrients and provide habitat — the multifunctionality that characterises integrated horticultural farming.

Table 1. Selected provisioning and livelihood benefits of the horticulture-based IFS

Indicator	HIFS result	Significance
Food items	32	Diverse food basket
FAO food groups represented	10 of 12	Broad nutritional coverage
Annual energy availability	30.714 million kcal	Food-energy contribution
Annual protein availability	1,395 kg	Protein contribution
Protein diversity score	6	Multiple protein sources
Net return	₹2.94 lakh/ha/year	Direct economic benefit
Benefit:cost ratio	2.58	Economic viability
Economic efficiency	₹495.75/ha/day	Income-generation efficiency

Diversity as the foundation of the system

Diversity is the most visible characteristic of the HIFS, which contained 16 crop families and 26 crop types annually, with perennials covering 39% of the system and soil covered for about 310 days. Of 30 enterprise types recorded, vegetables accounted for 58.1%, fruits 16.1%, fish 9.7%, cereals 6.5% and poultry 6.5%.

Different crops occupy different ecological niches, with different production periods, rooting patterns and nutrient requirements. Perennial fruit trees provide continuity of vegetation while seasonal crops provide regular production, and complementary enterprises create opportunities for recycling. Agroecosystem biodiversity supports nutrient cycling, soil protection, pest regulation, carbon storage and production stability, reflecting the close relationship between biodiversity, management and the capacity of farming systems to deliver multiple services.

***Provisioning services: Food, nutrition and income*:** The most visible service is food production, but the diversity of food supplied is more informative than any single yield. The system produced 32 food items across 10 FAO food groups i.e. 13 vegetables, four fruits, three roots and tubers, three pulses and legumes and three fish products, supporting year-round availability and reducing dependence on one commodity. Fruits and vegetables matter particularly for dietary diversity in cereal-dominated systems.

The nutritional contribution was notable. Annual energy availability was 30.714 million kcal against 5.376 million kcal in the conventional rice–wheat system, and protein availability 1,395 kg against 152 kg. Protein came from several sources: pulses and legumes 720 kg, cereals 380 kg, eggs 160 kg, vegetables 90 kg, fish 36 kg and poultry meat 9 kg, illustrating how diversification contributes to nutritional as well as production outcomes.

***Regulating services: Carbon and climate*:** An important environmental contribution was the carbon balance. The system emitted 1,293.2 kg CO_2-eq while sequestering 7,386.5 kg CO_2-eq a net balance of −6,093.2 kg CO_2-eq indicating that sequestration exceeded emissions within the accounting boundary. Perennial fruit trees, vegetation, soil organic matter and other biomass contribute to carbon storage, while diversified

production and internal cycling shape the overall footprint. This is a farm-level observation rather than a universal value. Carbon balance depends on crop composition, biomass accumulation, input use, soil characteristics, water management and the accounting boundary.

***Supporting services: Soil and nutrient recycling*:** Healthy soil is a less visible asset. Soil organic carbon was highest in pond-dyke soil at 6.93 g/kg, followed by mango (5.46), guava (4.84), sugarcane (4.56) and vegetables (3.86). Dehydrogenase activity peaked under vegetables at 515.6 µg TPF/g soil/24 h and field crops at 461.3, and microbial biomass carbon under mango at 786.8 mg/kg, with greater activity in upper soil layers. Soil is not merely a growth medium, its organisms, organic matter and nutrient cycling sustain productive capacity and reduce dependence on external inputs.

Nutrient recycling: Resource recycling is a further supporting service. The HIFS recycled nutrients equivalent to 106.5 kg urea, 226.8 kg SSP and 168.3 kg MOP. These quantities can be converted into monetary savings at prevailing fertiliser prices, but the physical quantity is itself an important indicator of how much nutrient demand was met internally.

Water use and resource efficiency: Water requirements varied considerably among modules: Module 3 required 22,784 m^3 against 8,124 m^3 for Module 4, nearly 2.8 times higher. Such differences matter because ecosystem service assessment should identify resource requirements and trade-offs as well as benefits, a high-producing component may demand more water, while another delivers greater output with less. This information supports the choice of crop combinations, irrigation scheduling and the design of water-efficient horticultural systems.

Bringing the services together

The HIFS data can be organised into a simple ecosystem service account distinguishing the condition of the system, the service flows it generates, and the resulting benefits. Condition appears as diversity, perennial cover, soil cover, soil carbon and biological activity; flows as food and protein production, nutrient recycling, carbon sequestration and soil functions; benefits as income, nutrition, employment, resource efficiency and resilience. The distinction matters because condition is not itself a service; perennial vegetation and soil organic carbon are stocks supporting services such as carbon storage and soil retention and separating them avoids double counting.

Table 2. A simple ecosystem service account for the horticulture-based IFS

Component	Indicator	HIFS value
Farm condition	Simpson Diversity Index	0.75
	Perennial plant cover	39%
	Soil cover	310 days
Provisioning service	Food items	32
	Food groups	10 of 12 FAO groups
	Protein availability	1,395 kg/year
	Net return	₹2.94 lakh/ha/year
Regulating service	Net GHG balance	₹6,093.2 kg CO_2-e
Supporting service	N recycling	48.99 kg N
	P recycling	36.29 kg P
	K recycling	100.98 kg K

Value computation of ecosystem services

Not every ecosystem service needs immediate conversion into rupees. A practical assessment first measures the physical flow of the service and then applies monetary valuation where reliable information exists. Market prices serve for fruits, vegetables, fish, poultry and other marketed products; nutrient recycling can be valued from fertiliser expenditure avoided; and carbon sequestration from an appropriate carbon or shadow price, provided measurement and accounting boundaries are clearly defined.

For soil retention, water regulation, pollination and pest regulation, replacement cost, avoided damage and production-function approaches may suit. Non-market benefits such as recreation, landscape amenity or cultural values may need contingent valuation, choice experiments or travel-cost methods, and benefit transfer can give preliminary estimates. Recording 48.99 kg of recycled nitrogen is meaningful in itself; its monetary value can follow, reducing the risk of assigning arbitrary values to ecological processes.

From individual enterprises to a whole-farm perspective

A diversified horticultural farm should not be judged solely by the output of individual enterprises. Vegetables provide food and income, fruit trees perennial vegetation and biomass, field crops cereals and residues, fish and poultry animal-source food, and composting reconnects nutrient flows. A residue of little value in one enterprise becomes an input for another, and boundary vegetation supplies biomass and ecological function linkages central to integrated farming.

Integration does not, however, make every component equally efficient. The differences in water demand show that resource trade-offs exist, and the absence of milk products and oilseeds from the food basket indicates scope for further diversification. Ecosystem service assessment is most useful when it identifies such gaps rather than only positive outcomes.

A simple pathway for ecosystem-service assessment

For practical farm-level application, assessment can begin with farm diversity and the resource base — soil, water, biodiversity and the combination of horticultural crops, field crops, livestock, fish and trees. These components interact through resource flows and ecological processes such as biomass production, nutrient cycling, decomposition, water use and carbon accumulation, generating a range of ecosystem services.

Services can first be assessed biophysically such as food production, nutrient recycling, soil organic carbon, water use, biodiversity and carbon sequestration and, where reliable data allow, expressed in monetary terms, while ecological and social benefits that cannot be reliably monetised are retained as non-monetary indicators. The combined assessment then informs farm management and policy, particularly on resource-use efficiency, diversification, environmental quality and long-term resilience.

Implications and policy dimensions

The HIFS results show that horticultural diversification can simultaneously strengthen food and nutritional security, farm income, soil health, resource recycling and climate benefits. The TEEBAgriFood framework offers a pathway for bringing these outcomes into decision-making by assessing changes in natural, human, social and produced capital and the service flows they generate. Indicators such as crop diversity, soil organic carbon, nutrient recycling, water use, food diversity and carbon balance could enter the planning, monitoring and evaluation of MIDH, NMSA, PKVY, the Soil Health Card Scheme, PMKSY and watershed development programmes.

SUMMARY

A horticulture-based integrated farming system is more than a combination of fruit and vegetable enterprises. Its diversity, perennial vegetation, soil biological activity, nutrient recycling and integration with fish, poultry and other enterprises generate multiple ecosystem services alongside food and income. The HIFS at ICAR-IIFSR provided evidence of the ecosystem services produced and value generation of the ecosystem services. Ecosystem service assessment is thus a practical bridge between farm productivity, environmental sustainability and human well-being. The services should be measured in physical terms first, then value them where reliable data exist.

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