Indian Farming 76 (10): 50-53; October 2026

Accounting for nutrition and dietary diversity in an integrated organic and natural farming system

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This article highlights how integrated organic and natural farming can provide Indian farmers with a practical approach to improve soil health, farm profitability, resource-use efficiency and livelihood resilience. The main innovation is to look beyond crop yield and income by considering soil biodiversity, water productivity, pesticide use, nutrition and dietary diversity as interconnected benefits of a diversified farming system. Integration of crops with livestock, poultry, dairy, horticulture, fisheries and other enterprises can provide farmers with multiple sources of food and income throughout the year, reduce seasonal dependence on a single crop and strengthen household food and nutritional security. Recycling of crop residues, livestock wastes and other farm resources can improve soil fertility and reduce dependence on purchased inputs. Overall, diversified integrated farming offers a farmer-friendly pathway for making Indian agriculture more sustainable, resource-efficient, economically viable and better able to support food, nutrition and livelihood security.

Keywords: Biodiversity, Livelihood security, Soil health, Water productivity

AGROECOLOGY based farming emphasises the integration of ecological principles with traditional knowledge to optimise the interactions among soil, crops, livestock, water, and biodiversity. It replaces the input-intensive, monocrop-oriented approach with a diversified, resource-recycling model that sustains productivity while minimising environmental footprints. Practices such as crop diversification, organic nutrient management, residue and waste recycling, and biological pest management enhance nutrient cycling, soil structure, and ecosystem resilience. By linking scientific innovation with local expertise, agroecological systems strengthen farm self-reliance, reduce production risks, and contribute to climate-smart, low-carbon agriculture for making them a viable pathway for sustainable intensification across India's smallholder landscapes. A detailed benchmark survey covering 120 households across five villages such as Chouki, Kondramall, Majhgaon, Devri and Chiraidongri of Narayanganj block (Mandla district, Madhya Pradesh) was conducted to characterise the existing farming systems, input use patterns, and socio-economic conditions.

Farmer perception towards agroecological practices and adoption constraints

Among the 120 surveyed farmers, the overall perception towards agroecological practices was largely favourable, as most respondents expressed a positive attitude towards adopting such practices. However, despite this positive outlook, the key challenge reported in adopting agroecological techniques was lack of awareness, highlighting that knowledge and information gaps remain the major barrier to practical implementation. The findings emphasise the need for strengthening extension support through focused trainings, demonstrations, and awareness programmes to improve farmers' understanding and adoption of agroecological interventions.

Based on farmer typology and resource endowment, three models such as IFS, Integrated Organic Farming System (IOFS) model and Natural Farming System (NFS) model were designed and implemented on farmers' fields for evaluation and refinement under participatory mode for studying their farm practices and refinement for sustainable livelihood improvement and safeguarding the ecosystem of their undulated and most fragile ecosystems in terms of soil health, biodiversity and water productivity.

Soil health and fertility status

Agroecological interventions brought about significant and consistent improvements in both the physicochemical and biological properties of soil across all evaluated farming models. Among the systems, IOFS model demonstrated the most substantial enhancement, registering the highest soil organic carbon (SOC) content (0.78%). This increase strongly reflects improved carbon sequestration capacity and greater accumulation of organic matter, which are key indicators of long-term soil quality restoration. This was closely followed by the NFS (0.74%) and IFS (0.70%) models, both of which also exhibited appreciable gains compared to conventional practices, indicating the overall advantage of diversified agroecological management. Soil pH remained within the near-neutral range (6.8–7.1), ensuring favourable conditions for nutrient availability, microbial growth, and enzymatic processes responsible for nutrient transformations. Soil fertility status improved steadily, as evident from the enhanced NPK availability, with nitrogen increasing to 276–292 kg/ha, phosphorus to 16–18 kg/ha, and potassium to 215–232 kg/ha. These improvements suggest better nutrient retention, reduced losses, and more balanced nutrient cycling under integrated management. Biological indicators further substantiated the benefits of agroecological interventions. Microbial biomass increased considerably, demonstrating improved microbial activity and organic matter turnover, while earthworm populations rose markedly under the organic and integrated models, reflecting better soil structure, enhanced aeration, and improved decomposition processes. The combined improvement in SOC, nutrient availability, and soil biological activity highlights that eco-friendly, diversified farming interventions can strengthen soil resilience, sustain soil fertility, and support stable productivity over the long term.

Biodiversity and ecosystem services

Agroecological interventions markedly strengthened both above-ground and below-ground biodiversity, thereby enhancing key ecosystem services within the evaluated farming models. The IOFS fields supported richer and more diverse assemblages of functional organisms, including pollinators, decomposers, and beneficial insect predators, which collectively contribute to improved crop health and ecological regulation. In comparison, the NFS model maintained comparatively higher overall microbial activity, indicating strong biological functioning even under low external input conditions. Increased earthworm populations and a noticeable abundance of predatory beetles reflected the development of well-structured soil food webs, improved residue decomposition, and more efficient nutrient cycling. The adoption of diversified crop rotations, inclusion of perennial horticultural components, and integration of livestock enterprises created heterogeneous habitats and stable food resources, leading to greater ecological resilience and reduced pest incidence.

Microbial assessments further confirmed the superiority of IOFS, which recorded the highest populations of bacteria (19.00×10^7), fungi (28.60×10^3), and actinomycetes (35.67×10^5), indicating a biologically active soil environment. The INFS also exhibited strong microbial enrichment, particularly in actinomycetes (29.67×10^5), although bacterial and fungal abundance remained comparatively lower than IOFS. The IOFS recorded the maximum earthworm density (20/0.15 m^3 of soil) compared to conventional practices IFS3 (6/0.15 m^3 of soil), highlighting variations in biological response among systems. Overall, these results demonstrate that diversified agroecological management can significantly improve biodiversity, strengthen soil biological processes, and enhance ecosystem stability in farming systems.

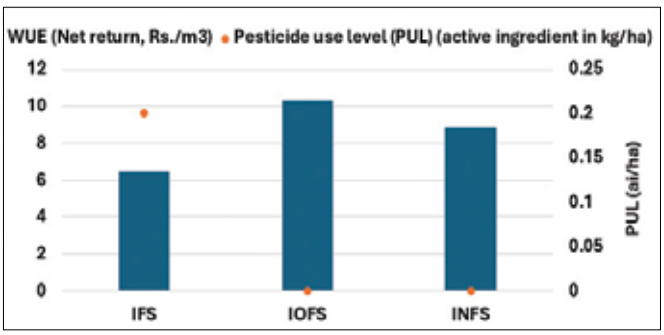
Water productivity and pesticide use level

Integrated resource management practices, including mulching, recycling of crop residues, and utilisation of livestock waste, contributed significantly to improved soil moisture retention and enhanced water use efficiency across the farming models. These practices helped reduce evaporation losses, improved infiltration, and supported better soil physical conditions, thereby ensuring more efficient utilisation of available water resources.

The pesticide use level varied clearly across the evaluated models. The IOFS and INFS systems recorded zero pesticide application, indicating that pest incidence in these models was effectively managed through non-chemical and preventive strategies such as ecological regulation, diversified enterprises, cultural practices, and biological control measures. In contrast, the IFS models still showed reliance on chemical pesticides (0.20 kg a.i./ha). The findings demonstrate that organic and natural farming-based models can substantially reduce pesticide dependence, which has strong implications for enhancing environmental safety, soil biological health, and long-term sustainability.

Economic performance and livelihood impact

Economic analysis revealed that all agroecological models were economically viable, profitable, and relatively resilient to production risks compared to conventional farming. Among the evaluated systems, IOFS generated the highest net return of `54,563/ha



Water use efficiency (WUE) and pesticide use level under various farming systems





Increased water productivity through fingerlings stocking and duck farming

with a benefit-cost (B:C) ratio of 1.8, indicating strong profitability and efficient resource use. This was closely followed by IFS models, which recorded net returns in the range of ₹52,000 to 53,000/ha with a B:C ratio of 1.8. The NFS despite being a low-input model, also performed reasonably well with a net return of ₹42,800/ha and a B:C ratio of 1.7, showing that reduced external inputs can still ensure stable economic outcomes. The integration of multiple enterprises such as dairy, poultry, and horticulture contributed significantly to year-round income generation, reduced income seasonality, and improved household food and nutritional security. Farmers reported visible improvement in soil fertility, lower dependence on purchased inputs, and reduced overall production costs. Importantly, the enhanced profitability and improved system performance increased farmer confidence in adopting organic and agroecological practices for sustainable livelihoods.

Nutrition and dietary diversity dimension

The integration of crops with livestock, poultry, dairy, horticulture, fisheries, apiary and other farm enterprises creates a diversified production base capable of supplying a wider range of food commodities throughout the year. Such enterprise diversification can contribute to improved household food and nutritional security by increasing the availability and continuity of diverse food sources. The integration of dairy, poultry, horticulture and apiary reported in the present study contributed to year-round income generation, reduced income seasonality and improved household food and nutritional security. Thus, the integrated organic and natural farming system provides a relevant framework for accounting not only for productivity, profitability and ecological sustainability, but also for the potential contribution of farm diversification to household nutrition and dietary diversity.

Capacity building and farmer participation

Continuous farmer engagement was central to the initiative. Hands-on trainings on mushroom cultivation, bio-input preparation, composting, and natural pest management were organised. Field demonstrations were held to showcase agroecological innovations such as low-cost protected structures, multi-tier cropping, and rainwater harvesting. Regular scientist-farmer interactions and workshops facilitated knowledge exchange among stakeholders.

Policy implications

Evidence from the IFS provides a strong basis for policy mainstreaming beyond conventional yield and income indicators. Under the TEEBAgriFood four-capitals framework, improvements in soil health, nutrient availability, microbial activity, earthworm populations, biodiversity, water productivity and reduced pesticide use represent gains in natural capital. Diversified farm enterprises, including crops, livestock, poultry, dairy and horticulture strengthen produced capital through improved resource-use







Income enhancement through inclusion of less labour requiring practices and perennial horticultural crops



Hands-on trainings on apiary

efficiency and diversified production. Farmer training, skills, knowledge exchange, nutrition, dietary diversity and adaptive capacity contribute to human capital, while participatory evaluation, community-based demonstrations and scientist-farmer interactions build social capital. Integrating these capital-based indicators into agricultural programmes can make ecosystem services and wider livelihood benefits visible, supporting the mainstreaming of diversified, resource-efficient and climate-resilient farming systems in India.

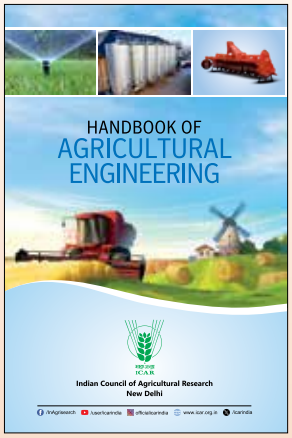
SUMMARY

The agroecological initiative demonstrated the potential of Integrated Organic Farming Systems, (IOFS) in enhancing soil health, productivity, and resilience in central India. Among three integrated approaches, IOFS model recorded the highest soil organic carbon (0.78%), available nitrogen (292 kg/ha), and earthworm density (20/0.15 m^3 of soil), indicating improved biological activity and organic matter turnover. Economically, IOFS achieved a net return of ₹54,563/ha with a B:C ratio of 1.8, closely followed by IFS (Control) and NFS models, all with lower input dependence. Enhanced crop–livestock integration and on-farm recycling reduced fertiliser use by 20% and pesticide requirement by 25%, contributing to cost-effective, low-emission agriculture. The project strengthened farmers' adaptive capacity through continuous training, participatory evaluation, and community-based demonstrations. However, wider adoption requires greater farmer awareness, practical training, field demonstrations and regular technical support. These results reaffirm that agroecological transitions combining with science, indigenous knowledge, and farmer innovation can create profitable, resilient, and climate-smart farming suited to India's diverse agroecosystems.

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