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True value accounting of ecosystem services in organic farming: A multi-capital perspective

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The true value of organic farming extends beyond crop yield and farm income. Using the TEEBAgriFood multiple-capitals framework, it explains how natural, human, social, and produced capital interact through stocks, flows, outcomes, and impacts. Organic management strengthens natural capital through improved soil organic carbon, nutrient availability and soil biological activity, while farmer knowledge, collective action and farm infrastructure enable ecological management. Ecosystem services such as nutrient cycling, climate regulation, water regulation and biodiversity conservation remain largely invisible in conventional accounting; true value accounting offers a more comprehensive assessment of agricultural sustainability.

Keywords: Ecosystem services, Organic farming, Soil health, TEEBAgriFood

STANDARD farm account begins with a simple question: how much was produced and how much income was earned? Yield, cost of cultivation, gross return, net return and benefit-cost ratio are therefore central indicators of agricultural performance. They are necessary, but not sufficient to represent the full value generated or depleted by an agricultural system.

A farm derives its productive capacity from a much wider asset base. Soil supplies physical support, water and nutrients; soil organisms decompose residues and mobilise nutrients; pollinators and beneficial organisms contribute to ecological regulation; vegetation and soil store carbon; and farmers contribute knowledge, labour and management skill. Farmer organisations and community networks enable cooperation and knowledge exchange, while infrastructure such as composting units, water-harvesting structures and storage allows these resources to be managed productively.

Most of these contributions remain partly or wholly invisible in conventional economic accounts. This is the central concern of the TEEBAgriFood Evaluation Framework, which recognises that agri-food systems interact with the environment, society, the economy and human health, and organises these interactions through four capital stocks: produced, natural, human and social; distinguishing them from flows, outcomes and impacts on human well-being.

Organic farming is an important case for such an approach. Its objective is not simply to replace one purchased fertiliser with another input; it relies on coherence, integration and complementarity of crop diversification and rotation, regenerative practices, recycling of crop residues, farmyard manure, compost, vermicompost, oilcakes, green manuring and diversified production. These practices influence both current output and the underlying capital base that determines the capacity to produce in future. The relevant question is therefore not only what the crop harvested this year is worth, but what changes the farming system has created in the stocks of capital and ecosystem services that support future production and human well-being. This is the essence of true value accounting.

The framework reveals the true value of agriculture by linking capital stocks, flows, outcomes and impacts. Natural, produced, social and human capital form the foundation of agri-food systems; their interactions generate agricultural outputs and ecosystem-service flows, leading to measurable outcomes and, ultimately, environmental, economic, social and health impacts. For organic farming, this makes visible the often unaccounted benefits of healthy soils, biodiversity, nutrient cycling, farmer knowledge and collective action, enabling a shift from yield-based to true value-based decision-making.

Organic farming practices: Building the capital base

Organic farming practices can be read through the multiple-capitals framework, in which farm management influences stocks of natural, human,



TEEBAgriFood evaluation framework: A multi-capital assessment

social and produced capital that in turn generate flows, outcomes and impacts.

- Organic nutrient management and biomass recycling through FYM, compost, vermicompost and crop residues build natural capital directly by improving soil organic carbon, nutrient availability and soil biological activity, supporting flows such as nutrient cycling, soil fertility maintenance and climate regulation.
- Cover crops, crop rotation and diversification strengthen natural capital by supporting soil biodiversity and ecological functioning while reducing production risk. Reduced use of synthetic agrochemicals further lowers pressure on soil and environmental resources and limits adverse externalities.
- Integrating crops, livestock and other enterprises promotes internal recycling of biomass and nutrients, creating stronger linkages between components of the farming system, while water- and biodiversity-friendly management maintains the quantity and quality of natural capital.

The case studies demonstrate how integrated farming contributes to the sustainability of agri-food systems through interactions among multiple capitals. Natural capital is enhanced through biomass and nutrient recycling; produced capital through improved maize, poultry, piggery and dairy technologies and infrastructure; human capital through farmers' skills and adaptive capacity; and social capital through collaboration and technology support. Together, these capitals promote diversified production, efficient resource use and improved livelihoods, contributing to environmental, economic and social sustainability.

These practices require adequate human capital in the form of farmer knowledge and skills, social capital through knowledge sharing and collective action, and produced capital such as composting, water-management and other farm infrastructure. Organic farming practices are therefore best understood as investments in multiple capital stocks whose interactions generate ecosystem-service flows, measurable outcomes and, ultimately, environmental, economic, social and health impacts.

TEEBAgriFood: Evidence from Uttar Pradesh

The first phase of the TEEBAgriFood project (2019-2023) applied the four-capitals approach to assess organic farming systems in Meerut, Bulandshahr, Aligarh, Mirzapur and Hamirpur districts of Uttar Pradesh. The findings demonstrated sustainability benefits beyond conventional measures of yield and income. Under natural capital, the Agro-Diversity Index (ADI) improved by 12.5% in Meerut, 23.6% in Bulandshahr, 22.8% in Aligarh, 22.1% in Mirzapur and 18.8% in Hamirpur, averaging approximately 20% improvement over conventional farming. The assessment also incorporated produced capital, reflecting productive farm assets and resource efficiency; human capital, including farmers' skills, knowledge and capacity to adopt sustainable practices; and social capital, covering community participation, collective action, livelihood inclusion and women's empowerment through greater participation in farming activities and decision-making. These outcomes were integrated through the Sustainable Livelihood Security Index (SLSI), based on the three sustainability pillars of ecological security, economic Efficiency and social equity. Organic farming recorded a higher composite SLSI in the majority of the study districts, with improvement over conventional systems ranging from 3.9 to 6.7%, demonstrating its potential to generate broader environmental, economic and social benefits.

***Natural capital - The invisible foundation of organic farming*:** Within the TEEBAgriFood multiple-capitals framework, natural capital represents the ecological foundation from which agricultural production and ecosystem service flows are generated. In organic farming, soil organic carbon and soil health are important indicators of natural capital, reflecting


Green manuring with Sesbania


Legume intercropped with maize



Improved maize production integrated with poultry and piggery at Chandel



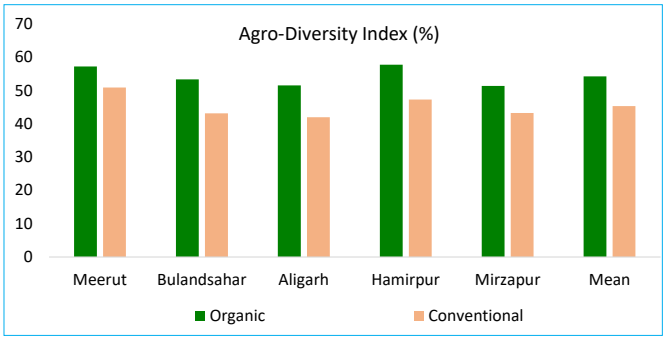
Improved maize production integrated with dairy farming at Bishnupur

Case studies of integrated organic farming systems in Manipur

the soil's capacity to store carbon, retain nutrients and water, and sustain biological processes. Organic management increased soil organic carbon by 33.3% (8.8 vs. 6.6 g/kg), available nitrogen by 16.4% (293.5 vs. 252.1 kg/ha), available phosphorus by 37.8% (40.8 vs. 29.6 kg/ha) and available potassium by 20.3% (249.6 vs. 207.4 kg/ha) compared with inorganic management, with a higher soil quality index (0.60 vs. 0.53).

Soil biodiversity and biological activity constitute the living component of natural capital. Organic management recorded higher microbial biomass carbon (0.45 vs. 0.32 mg/g), bacterial population (40.6 vs. 25.4 × 10^6 CFU/g soil), fungal population (36.2 vs. 25.8 × 10^4 CFU/g soil) and actinomycete population (17.5 vs. 12.4 × 10^6 CFU/g soil) than inorganic management. Soil organisms drive decomposition and nutrient transformation, the processes that underpin ecosystem service flows.

Nutrient cycling is strengthened by recycling FYM, vermicompost, oilcake and green manure. In a 15-year rice–wheat experiment, organic management received 7.84 t/ha FYM, 3.13 t/ha vermicompost and 853 kg/ha neem cake, while organic manure inputs supplied 8.21 Mg C/ha/year, with a further >9.58 Mg/C/ha/yr through green manuring. These inputs improved the soil's capacity to support nutrient cycling and other regulating services.



Assessment of Agro-diversity index under natural capital in Uttar Pradesh (2019-23)

Organic management also enhanced climate-regulating functions through greater carbon accumulation and improved soil quality, with a soil quality index of 0.60 against 0.53 under inorganic management, and substantially greater soil biological diversity, strengthening the ecological basis for resilience and biodiversity conservation.

***Human, social and produced capital*:** The true value of organic farming extends beyond natural capital. Its performance also depends on human, social and produced capital, which interact with natural resources to generate agricultural and ecosystem service flows. Human capital covers the knowledge, skills health and capacity of farmers and other stakeholders. In organic farming, the capacity to manage nutrient recycling, crop diversification and biological pest management is crucial to translating knowledge into improved farm and environmental outcomes.

Social capital comprises the institutions, networks, trust and collective arrangements that enable cooperation. Farmer groups, knowledge-sharing platforms and collective institutions facilitate adoption of organic practices, strengthen access to information and inputs, and improve coordination, enabling the other capitals to function more effectively.

Produced capital refers to human-made assets and infrastructure such as machinery, equipment, irrigation and water systems and storage. In organic farming, composting facilities, farm ponds, irrigation infrastructure and appropriate equipment provide the physical base for efficient resource management, complementing rather than replacing natural capital.

True value accounting should therefore not assess organic farming solely through changes in soil, water or biodiversity. A comprehensive assessment must recognise how human knowledge, social institutions and produced infrastructure interact with natural capital to generate flows, influence outcomes and contribute to the environmental, economic, social and health dimensions of human well-being.

From capital stocks to ecosystem service flows

The framework explains how the four capital stocks underpin different flows i.e. ecosystem services, agricultural outputs, purchased inputs and residuals which in turn change capital stocks (outcomes) and contribute to the environmental, economic, social and health dimensions of human well-being.

In organic farming, this chain is clearly visible. Healthy soil (natural capital) supports nutrient cycling and water regulation (flows), giving improved soil condition and crop production (outcomes). An important principle of true value accounting is avoiding double counting. Pollination, for instance, contributes to crop yield, but the value of pollination and of the resulting yield should not be added together if the pollination benefit is already embodied in the market value of the harvested crop. The framework assesses the complete causal pathway while valuing flows, outcomes and final impacts without duplication.

Challenges in valuing ecosystem services

Valuing ecosystem services remains difficult because many benefits of organic farming are invisible, indirect and untraded. Nutrient cycling, soil biological activity, carbon sequestration, water regulation and biodiversity conservation require appropriate scientific indicators and may take years to become measurable. Their values vary substantially with soil type, climate, location, cropping system and management, so no single universal value applies, and limited long-term, location-specific data restrict reliable assessment of changes in stocks and flows.

Monetisation presents a further challenge, as several ecological and social benefits cannot meaningfully be expressed in monetary terms, and double counting must be avoided where improved nutrient cycling is already reflected in the value of the harvested produce. Therefore, developing robust, practical and locally relevant indicators is essential to capturing the contribution of ecosystem services without oversimplifying their interactions.

Policy implications for Indian agriculture

Indian agriculture needs to move beyond yield and short-term farm income as the sole measures of performance. Policy should recognise that farming systems influence multiple forms of capital and generate both visible outputs and invisible environmental and social benefits. Farmers who maintain soil health, conserve water, recycle biomass and enhance biodiversity contribute value that market prices do not reflect.

Mechanisms are needed that recognise and reward the maintenance and enhancement of natural capital, alongside investment in farmer knowledge, ecological management skills, extension and farmer institutions to strengthen human and social capital. Practical true-value accounting indicators should be developed for agricultural research, farm-level assessment and programme evaluation.

Integrating ecosystem services into agricultural planning would allow policymakers to assess productivity, profitability, environmental sustainability and human well-being together. A multiple-capitals approach helps identify synergies and trade-offs among these objectives and supports location-specific strategies, shifting decision-making from maximizing production alone towards maximising the long-term value, resilience and sustainability of farming systems.

SUMMARY

Organic farming should be assessed not only by what it produces today but by the capital it maintains and regenerates for future production. The TEEBAgriFood multiple-capitals perspective makes visible the links between natural resources, farmer capacity, social institutions, infrastructure and ecosystem service flows. The evidence presented shows that organic management strengthens soil organic carbon, nutrient availability, soil biological activity and biodiversity, while generating wider environmental, economic and social benefits that conventional accounts omit. Challenges of measurement, monetisation, spatial variation and double counting call for scientifically robust and locally relevant indicators combining biophysical, economic and social measures. Integrating true value accounting into agricultural research, planning and policy can support a transition towards resilient, sustainable and resource-efficient agri-food systems in India.

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