Indian Farming 76 (10): 88-92; October 2026

True value accounting of soil health: Recognising soil as natural capital in sustainable agri-food systems

Raghavendra Singh*, Subham Mukherjee and Vijay Singh Meena

ICAR-Mahatma Gandhi Integrated Farming Research Institute, Motihari, Bihar 845 429

Healthy soil supports crop production, stores carbon, holds water, recycles nutrients and protects land from erosion. Yet most farm assessments count mainly yield, cost and income. This leaves many benefits of soil improvement outside the farm account. True value accounting offers a simple way to connect better soil condition with the services it provides to farmers and society. The approach can help India recognise the wider value of conservation agriculture, integrated nutrient management, crop diversification and integrated farming systems, and can support better decisions on technology, incentives and soil restoration programmes.

Keywords: Crop diversification, Ecosystem services, Integrated farming systems, Soil restoration

INDIAN agriculture has achieved major gains in food production, but intensive farming has also placed pressure on soil, water and other natural resources. Loss of organic matter, soil erosion, compaction, nutrient imbalance and declining biological activity can reduce the capacity of soil to support crops. These changes may not be visible in one season, but they slowly increase the need for fertilisers, irrigation and other inputs. Soil is therefore more than a medium for plant roots. It is a living natural asset. A healthy soil supplies nutrients, stores and filters water, provides habitat for soil organisms, stores carbon and helps crops withstand drought and other stresses. When these functions improve, both the farmer and society gain. When they decline, the cost is often paid later through lower efficiency, more land degradation and greater environmental damage.

Overlooked benefits of healthy soils

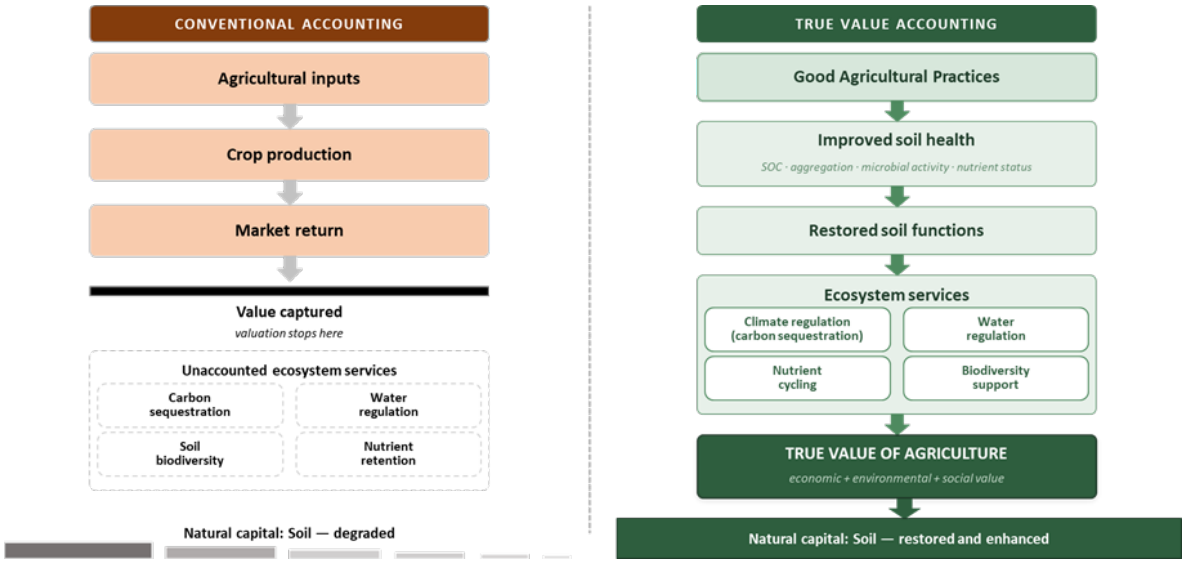
Farm performance is commonly judged through yield, market price and benefit-cost ratio. These measures are useful, but they do not show the full effect of a farming practice on soil and the environment. For example, crop residue retention may increase soil carbon, reduce erosion and improve water infiltration. These benefits may not appear directly as cash income in the same year. The same problem occurs with environmental losses. Nutrient leaching, greenhouse gas emissions, residue burning, soil erosion and excessive groundwater use are rarely included in farm accounts. As a result, two farms with similar crop income may have very different effects on soil health and future productivity. True value accounting tries to make these hidden gains and losses visible.

Soil as a natural capital

Natural capital means the stock of natural resources that continues to provide useful services. In farming, soil is one of the most important forms of natural capital. The condition of the soil is the stock, while services such as nutrient cycling, water regulation, erosion control and carbon storage are the benefits that flow from it. The TEEBAgriFood approach provides a useful way to think about this connection. At field level, the sequence is simple: a management practice changes the soil; the changed soil affects an ecosystem service; and that service creates a benefit or avoids a cost. True value accounting therefore adds to normal farm economics rather than replacing it.

Benefits of improved soil health

Soil health depends on physical, chemical and biological processes working together. Good soil structure allows rainwater to enter the soil and gives roots space to grow. Organic matter and clay help retain nutrients and water. Soil organisms break down residues, release nutrients and help form stable aggregates. Improvement in one part of the soil system often supports the others. The main services from healthy soil include carbon storage, nutrient cycling,



Transition from conventional agricultural valuation to true value accounting of soil ecosystem services

Table 1. Major soil functions and their services

Soil function	Simple indicators	Main service	Main benefit
Carbon storage	Soil organic carbon and carbon stock	Climate regulation	Carbon is retained in soil
Nutrient cycling	Microbial activity and available nutrients	Soil fertility	Better nutrient-use efficiency
Water regulation	Aggregation, bulk density and infiltration	Water storage and recharge	Less runoff and better drought buffering
Erosion control	Surface cover and stable aggregates	Soil conservation	Less loss of topsoil, nutrients and carbon
Biological habitat	Microbial biomass, earthworms and mycorrhiza	Biodiversity and resilience	Better biological functioning of soil

water regulation, erosion control, filtering of pollutants, habitat for soil organisms and better crop resilience. Some services mainly benefit the farmer, while others also benefit nearby communities or society as a whole.

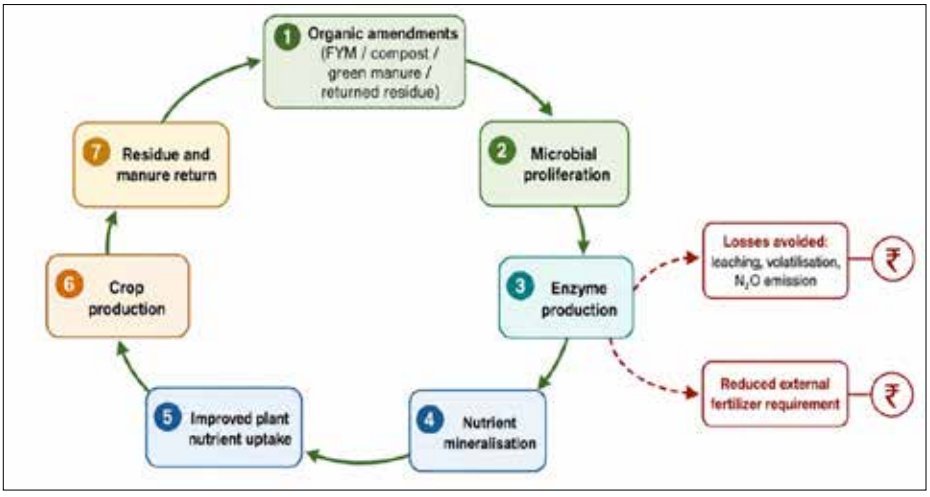
Good agricultural practices that restore soil

Good agricultural practices improve soil in different ways. For true value accounting, it is important to keep the link clear that the practice should produce a measurable change in soil, the change should improve a service, and the final benefit should then be assessed. This avoids giving a monetary value to every soil process and reduces the risk of counting the same benefit more than once.

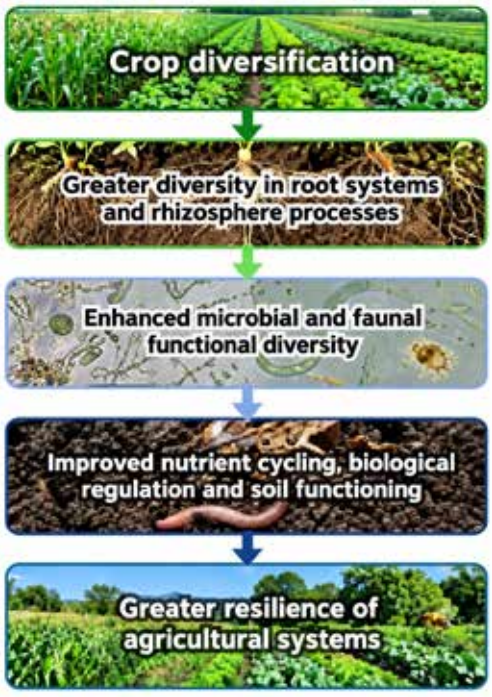
***Conservation agriculture*:** Conservation agriculture is based on minimum soil disturbance, keeping the soil covered and diversifying crops. In rice–wheat systems, this may include zero-till wheat, retention of crop residues, reduced-disturbance rice and inclusion of legumes. Residues protect the surface and provide food for soil organisms. Less disturbance helps maintain soil aggregates and pores. These changes can improve infiltration, conserve soil moisture, reduce erosion and support root growth. Farmers may also save fuel, labour and irrigation water. The wider benefits include carbon storage and lower emissions from residue burning. However, soil carbon builds slowly and the gain can be lost if good management is stopped.

***Integrated nutrient management*:** Integrated nutrient management combines mineral fertilisers with organic and biological sources. Mineral fertilisers meet the immediate need of the crop, while farmyard manure, compost, crop residues and other organic inputs improve soil organic matter and biological activity. Their combined use can improve nutrient retention and nutrient-use efficiency. Biological inputs such as *Rhizobium* and nutrient-solubilising microorganisms can further support nutrient cycling under suitable conditions.

***Crop diversification and rotation*:** Repeated cultivation of a narrow crop rotation gives the soil a



Role of organic inputs in restoring soil nutrient cycling



Ecological pathways associated with crop diversification

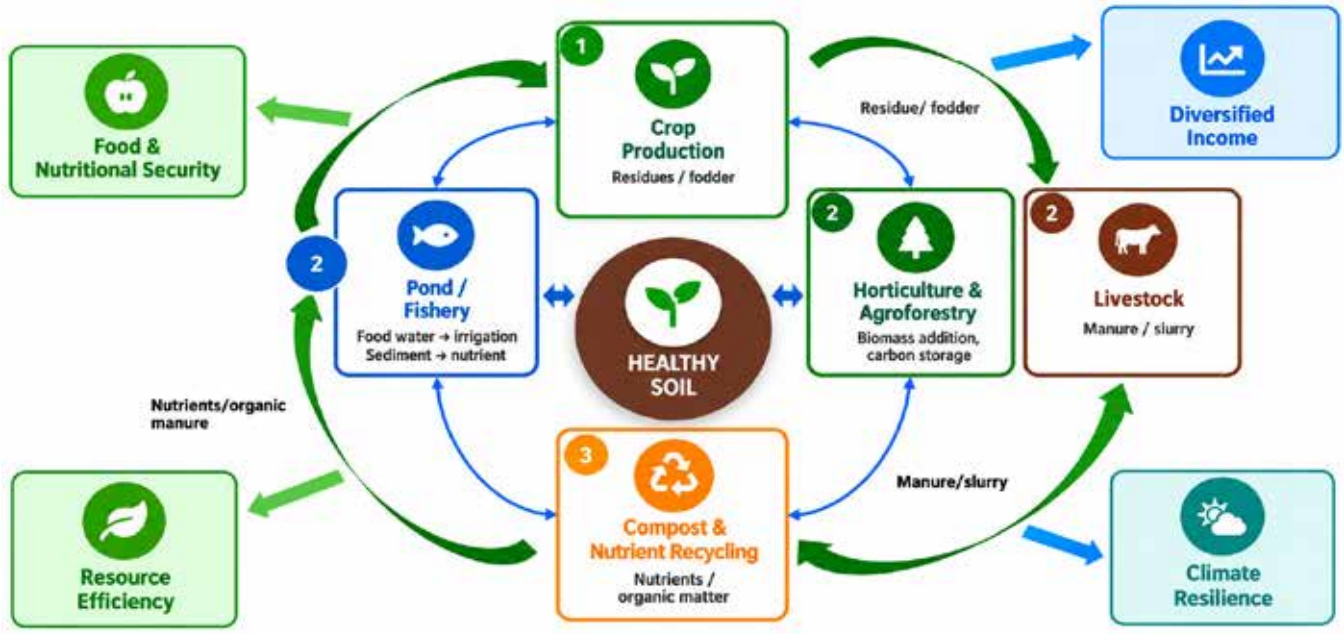
limited range of roots and residues. Diversification brings different root systems, nutrient demands and residue qualities. Legumes can add biologically fixed nitrogen, while deep-rooted crops can use nutrients and water from deeper soil layers. A diverse cropping system can improve nutrient cycling, support soil biological activity and reduce the build-up of some weeds and pests. It also spreads production risk. This resilience has value even when it does not immediately appear as extra income.

***Integrated farming systems*:** Integrated farming systems connect crops with livestock, fishery, horticulture or other farm enterprises. Crop residues and fodder can support livestock, while manure and slurry return nutrients and organic matter to the soil. Pond sediment and other farm biomass can also be recycled. Such recycling reduces waste and dependence on purchased inputs. Different farm enterprises also spread climatic and market risk. Milk, eggs, fish, fruits and vegetables can provide more regular income and can improve household nutrition. These benefits are often missed when only crop yield and crop income are compared.

True value accounting of soil health

The value created by better soil health can be viewed in three parts. First is direct agricultural value, such as crop output, lower input cost and more stable yield. Second is ecosystem service value, such as carbon storage, water regulation, erosion control and nutrient retention. Third is social and resilience value, such as climate adaptation, livelihood stability and nutritional security. True value accounting should also recognise environmental costs. A production system with heavy nutrient loss, excessive irrigation, residue burning or soil degradation should not appear highly beneficial only because it produces a high yield. The purpose is to show a more complete picture of both benefits and costs.

However, not all soil benefits should be valued in the same way. Food and fodder are already reflected in market prices. Other benefits, such as carbon storage, water regulation, erosion control and nutrient retention, are often not priced. Supporting processes such as nutrient cycling should normally be linked to the final benefits they create instead of being valued separately at every step. This is important because one soil improvement may create several connected effects. Better aggregation can increase infiltration, reduce runoff and lower erosion. If each of these is given a full



Integrated farming system as a circular nutrient economy



Soil ecosystem service wheel

monetary value without care, the same benefit may be counted more than once.

Key factors for reliable assessments

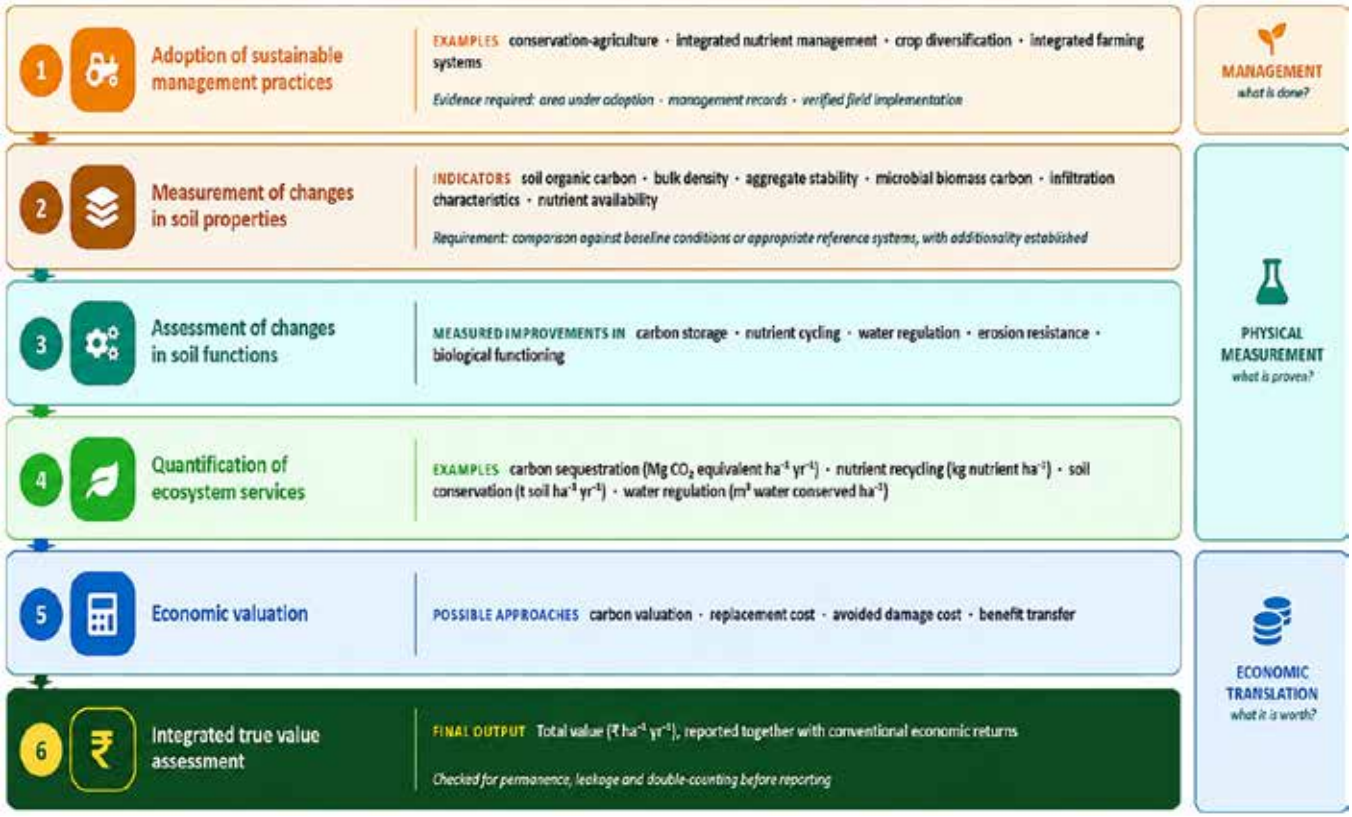
A credible assessment needs a clear baseline. Improved management should be compared with a real control, an earlier condition or another well-defined reference. The same benefit should not be counted twice. The time period and area covered should also be stated clearly. Permanence is especially important for soil carbon because carbon can decline again when restorative practices are stopped. Assumptions should therefore be conservative and transparent. A smaller value based on strong evidence is more useful than a large estimate that cannot be checked.

Opportunities for Indian agriculture

India already has a useful foundation for soil natural capital accounting. The Soil Health Card programme has created a large soil testing network. This can be strengthened by repeated measurement of soil organic carbon and a few important physical indicators at representative sites. Biological indicators can be monitored at long-term experiments, research farms and selected benchmark locations. Farmer producer organisations, cooperatives and village clusters can help reduce the cost of measurement and verification for small farms. Remote sensing and models can support large-area assessment, but field measurements will remain necessary for checking the results. Existing programmes and research networks can also include soil ecosystem services in technology assessment. AICRP trials, KVK demonstrations and other field programmes can report changes in carbon storage, nutrient-use efficiency, water regulation and soil restoration along with yield and benefit-cost ratio. This will show whether a technology is productive today and whether it is also protecting the soil for the future.

Simple ways to value soil services

Some soil services can be linked with money fairly



Framework for true value accounting of soil health improvement

Table 2. List of simple options for valuing important soil ecosystem services

Ecosystem service	What can be measured	Possible valuation	Main caution
Carbon storage	Change in soil carbon stock	Carbon market value or social carbon value	Do not add both values for the same carbon gain
Nutrient cycling	Nutrients supplied or recycled	Replacement cost of fertiliser nutrients	Use realistic resource prices
Water regulation	Water saved or reduced irrigation	Avoided pumping cost	Depends on local water and energy conditions
Erosion control	Reduction in soil loss	Value of nutrients/carbon retained or damage avoided	Avoid double counting with related water benefits
Pest regulation	Reduction in pesticide use	Avoided pesticide expenditure	Use only when the reduction is clearly measured

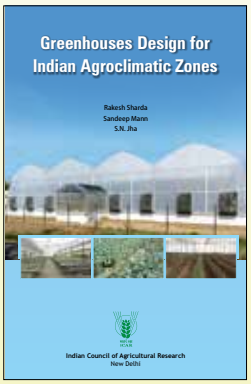
easily, while others are better reported in physical units. A change in soil organic carbon can be converted to carbon dioxide equivalent. Nutrients supplied through legumes or recycled manures can be expressed as fertiliser nutrients replaced. Water saved can be related to pumping cost. Reduced pesticide use can be treated as avoided expenditure. Where the value is uncertain, it is better to report the measured soil or ecosystem benefit than to force a rupee value. Soil biodiversity is a good example. Its importance can be shown through microbial biomass, earthworm abundance or other indicators, even when a reliable economic value is not available.

SUMMARY

Healthy soil creates value far beyond crop yield. It stores carbon, regulates water, recycles nutrients, reduces erosion and supports biological activity. Conservation agriculture, integrated nutrient management, crop diversification and integrated farming systems can strengthen these soil functions. True value accounting provides a way to connect measurable soil improvement with benefits to farmers and society. For India, the approach can build on existing soil testing networks, long-term experiments, farmer organisations and field programmes. The immediate need is to use simple and reliable indicators, avoid double counting, and link verified soil improvement with suitable incentives. In this way, soil conservation can be viewed not only as an environmental responsibility, but also as an investment in productive natural capital.

*Corresponding author email: raghavenupc@gmail.com

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