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Re-purposing Agricultural Subsidies to Ecosystem Services

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The widespread adoption of high-yielding crop varieties has significantly increased food production in India, transforming the country from a state of severe food scarcity to food surplus. However, this achievement cannot be attributed solely to improved crop varieties. Realizing their full production potential necessitated the use of supplementary inputs, particularly fertilizers and irrigation water. To this end, both the central and state governments have promoted on-farm irrigation systems and the adoption of chemical fertilizers. Consequently, irrigation coverage has expanded from approximately one-fifth of the gross cropped area in 1965-66 to 55% in 2022-23. Chemical fertilizer usage skyrocketed from 5 to 141 kg per hectare. Notably, agricultural subsidies in 2023-24 amounted to Rs. 4051.56 billion, with fertilizer subsidies comprising 43.2%, electricity 46.9%, and canal irrigation 9.9%.[1]

However, the continued provision of fiscal incentives has become unsupportive of sustainable development of agriculture. While the provision of fiscal incentives in its current form has proved unsustainable, it is worth noting that agriculture, when aligned with sustainable practices, offers viable solutions to these environmental challenges. The expansion of irrigation occurred at the expense of declining groundwater levels and even over-extraction in intensive cropping systems, such as in Punjab and Haryana, where precipitation is insufficient for replenishment. The increased use of chemical fertilizers has caused the degradation of soil, water quality, and the environment. Importantly, the intensification of agriculture is associated with increased emissions of greenhouse gases (GHG), contributing to global warming and climate change. Climate change affects agriculture both directly and indirectly through its effects on natural resources. It may be noted that input-use efficiency has declined, leading to diminishing returns to the additional use of inputs.[2]

Nonetheless, agriculture offers solutions to several of these challenges. In addition to being a source of food, feed, fiber, and fuel, it performs several other ecosystem functions, such as carbon sequestration, enhancing biodiversity, improving soil quality, preserving water resources, and regulating climate.[3] However, the capacity of agriculture to generate ecosystem services depends on factors such as climatic conditions, farming methods, and the choice of inputs and their application rates.

Scientific studies have shown that several agricultural practices, such as crop rotations, cover crops, reduced tillage, organic inputs, water management, sowing and planting techniques, integrated nutrient and pest management, natural farming, and agroforestry, contribute to enhanced ecosystem services, both provisioning and non-provisioning. Nevertheless, our understanding of the economic benefits of non-provisioning services offered by sustainable practices to society remains limited primarily because there is no established market for these services. While farmers tend to be cautious about adopting sustainable farming practices because of their potential negative impact on crop yields, the lack of a market for ecosystem services discourages them from adopting these practices.

What policy interventions are needed to incentivize farmers to adopt environmentally friendly agricultural practices? Reallocating subsidy expenditures to sustainable practices is a plausible policy option for

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[1]Deveshwar, A., and Panwar, S. (2024). Overview of agricultural subsidies in India and its impact on environment. Current World Environment, 19(1):393-403.

[2]Kumar, S., Birthal, P.S., Chand, P., and Kingsly, I. T. (2024). Technology and Policy Options for Efficient Use of Fertilizers in Indian Agriculture. Policy Brief 54, ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi.

[3]Food, feed, fibre, and fuel are termed as provisioning ecosystem services, while others are classified as non-provisioning services.

incentivizing the adoption of sustainable agricultural practices. This strategy, however, necessitates assigning monetary value to the ecological services that these practices provide to society as well as establishing a system to reward farmers for their contributions. When their costs and benefits are not accounted for, resources are misallocated, resulting in a decrease in social welfare. The economic valuation of ecosystem services offers a comprehensive understanding of the costs and benefits associated with sustainable agricultural practices, and an economic justification for investment in the conservation of natural resources, biodiversity, and the environment.

This brief note provides estimates of the monetary values for provisioning (marketable) and non - provisioning (non - marketable) ecosystem services of selected improved agricultural practices, and examines the trade-offs between them. Quantifying these services monetarily aids informed decision making for resource allocation and sustainable agriculture management. Analyzing the trade-offs between provisioning and non-provisioning services is vital for agricultural policy reform.

Sustainable agricultural practices and their ecosystem services

Several sustainable farming practices have demonstrated significant technical potential for incorporation into agricultural systems. This brief looks into techno-economic potential of direct-seeded rice (DSR), zero-tillage wheat, legume crops, organic or farmyard manure, and integrated nutrient management (INM). The physical values of their ecosystem services compared to those of their conventional farming practices are presented in Table 1.

DSR is associated with an 11% lower yield than the conventional puddled transplantation method because of increased weed infestation and fewer spikelets per panicle. Nonetheless, DSR entails substantial environmental benefits, including 18% less use of water for irrigation, 38% lower greenhouse gas emissions, 12% higher soil organic carbon content, and 20% improvement in soil nutrients. Similarly, zero tillage in wheat augments ecosystem services, although it is not as significant as in the case of DSR. Zero tillage contributes positively to crop yield but not significantly.

Compared with the sole application of chemical fertilizers, the exclusive application of organic manure leads to higher carbon sequestration (15%). The potential to conserve water and enhance nutrient availability is comparatively low. A drawback of using organic manure is that it results in a slight increase in greenhouse gas emissions and a reduction in crop yields compared with synthetic fertilizers. Integrated Nutrient Management (INM), which combines organic manures with inorganic fertilizers, sequesters 22% more carbon, improves soil nutrients by 13%, and improves water retention by 12%. Furthermore, INM leads to a 16% increase in crop production. Nevertheless, these advantages of INM are accompanied by a 36% increase in greenhouse gas emissions.

The incorporation of legumes into farming systems offers substantial environmental benefits. These require 25% less water for irrigation, reduce greenhouse gas (GHG) emissions by 33%, and improve the soil organic carbon content by 17%. Furthermore, these exhibit no reduction in yield, but instead demonstrate a 24% increase in cropping system yield.

Table 1. Ecosystem services of agricultural practices[4]

Ecosystem service	Direct seeded rice	Zero-till wheat	Legumes	Integrated nutrient management	Organic manure
Provisioning services					
Yield (t ha^{-1})	-0.58 (10.80)*	0.08 (1.91)*	0.87 (23.64)*	0.76 (15.80)**	-0.31 (6.04)**
Regulating services					
Water use (mm ha-^{1})	-334 (18.02)*	-55.81 (8.4)*	-297 (24.87)*	-57.53 (11.40)*	-49.25 (7.86)**
Carbon sequestration (t ha^{-1} CO_2 eq)	1.20 (12.30)*	0.76 (6.0)*	2.31 (16.84)*	2.09 (21.79)*	2.16 (14.75)**
GHG emission (Kg ha^{-1})	-170 (37.77)*	-31.80 (14.12)*	-597 (32.52)*	295 (36.05)**	40 (6.29)**
Supporting services					
Nutrient availability (NPK (Kg ha^{-1}))	80 (20.40)*	51.74 (14.86)*	28 (6.83)*	60 (13.06)**	21 (4.87)**
Nitrogen fixation (Kg ha^{-1})	19	-	70.03	-	-

**and *indicate 1% and 5% levels of significance. Values in parentheses indicate percentage change relative to the control. For ease of comparison, the crop yields of legume-based systems, integrated nutrient management, and organic manure were converted to wheat equivalent yield.
Source: Kumara *et al*.2024

[4]Source: Kumara, K.T. M., Birthal, P. S., Meena, D. C., and Kumar, A. (2024). Economic Valuation of Ecosystem Services of Selected Interventions in Agriculture in India. IFPRI Discussion Paper 2250, International Food Policy Research Institute, Washington, DC.

Monetary value of ecosystem services

The net economic values of ecosystem services, both marketable and non-marketable, associated with different sustainable farming practices are presented in Table 2. Legumes have the highest value at Rs. 32694 per hectare, with an approximately even distribution between marketable and non-marketable services. Additionally, the value of supporting ecosystem services is notably higher than that of regulating services.

INM is next in the order of contribution to ecosystem services. The net economic value of ecosystem services of INM is estimated at Rs. 23,314 per hectare, with non-marketable services contributing nearly two-thirds to this. Notably, supporting services comprise three-fourths of the total value of non-marketable services. Conversely, the use of organic manure is not financially beneficial, because of the negative income resulting from lower crop yields.

The net economic value of ecosystem services of zero tillage in wheat is estimated at Rs. 7,684 per hectare, with the bulk coming from supporting services. In the case of DSR, despite its negative impact on crop revenue, the net economic value of its ecosystem services is positive *albeit* at the margin. Nevertheless, the non-marketable ecosystem services of DSR are valued at Rs. 13,335 per hectare, with supporting services accounting for the bulk.

The key takeaway is that while sustainable farming practices are generally beneficial for ecology, their implementation may lead to unintended consequences and trade-offs between provisioning and non-provisioning ecosystem services. This complexity underscores the need for a more nuanced and context-specific approach to agricultural policy.

Policy implications

For a long time, both central and state governments have been providing subsidies for fertilizers, electricity for irrigation, and canal irrigation. In 2023-24, a total of Rs. 4051.56 billion were spent on agricultural subsidies, comprising 43.2% on fertilizer subsidies, 46.9% on electric power subsidies, and 9.8% on irrigation subsidies.

Repurposing agricultural subsidies entails redirecting financial support from traditional agricultural inputs, such as fertilizers and electric power, which are no longer supportive of sustainable agricultural development. Instead, subsidy expenditures are allocated to practices and inputs to improve the health of natural resources, preserve biodiversity, and conserve the environment.

Table 2: Economic value of ecosystem services generated from improved farm practices (Rs per hectare per year)

Ecosystem service	Price	Direct seeded rice	Zero-till wheat	Legumes	Organic manure	Integrated nutrient management
I. Provisioning services						
Yield (t ha^{-1})	Minimum support price of crops, 2022/23	-11832	1700	17531	-6247	15314
II. Regulating services						
Water saving (m^3 ha^{-1})	Rs.0.8 per m^3	2672	446	2376	394	460
Carbon sequestration(Net change after accounting emission, t ha^{-1} CO_2 eq)	Voluntary carbon market price of Rs.726 ton^{-1}, 2022	994	639	2215	1616	1369
Subtotal		3666	1085	4591	2010	1829
III. Supporting services						
Nutrient availability (NPK (Kg ha^{-1})	Economic price of fertilizers 2022/23 Rs.110.9 Kg^{-1} of N Rs.132.2 Kg^{-1} of P Rs. 86.6 Kg^{-1} of K	7562	4899	2806	2235	6171
Nitrogen fixation (Kg ha^{-1})	Rs.110.9 Kg^{-1} of N	2107	-	7766	-	-
Subtotal		9669	4899	10572	2235	6171
IV. Value of traded services (I)		-11832	1700	17531	-6247	15314
V. Value of non-traded services (II+III)		13335	5984	15163	4245	8000
Total economic value (IV+V)		1503	7684	32694	-2002	23314

Notes: All the values are estimated at current price

[5]Source: As for Table 1.

By following this approach, governments can ensure alignment of agricultural policies with the principles of sustainable development.

The political economy of agricultural incentives is complex. Once provided it is challenging to withdraw or even repurpose these. The transition from conventional to sustainable farming methods may initially result in decreased crop yields, discouraging farmers from adopting these practices. To address this, it is crucial to educate farmers and other stakeholders on the environmental and societal advantages of sustainable agriculture through workshops, training, and successful case studies. During the transitional phase, governments offer financial compensation to farmers to offset potential income losses.

To effectively repurpose agricultural subsidies, a system is necessary to measure, verify, and monitor the ecosystem services of sustainable farming practices as well as to determine their economic value. This necessitates evolving institutional frameworks that include stakeholders from the public and private sectors. Following this, a mechanism for the payment of ecosystem services needs to be developed to encourage farmers to adopt sustainable agricultural techniques and practices.

The Government of India recently launched the Green Credit Program (GCP), which aims to create a market-based system to incentivize the adoption of environmentally friendly practices across the board. In agriculture, practices such as direct-seeded rice (DSR), zero tillage, green manuring, organic manures, legume-based crop rotations, water conservation, organic or natural farming, precision agriculture, and agro-forestry are part of the GCP.

To effectively implement the GCP, it is crucial to develop a scalable framework for quantifying ecosystem services and determining their prices. However, the prices of green credit derived from agricultural practices need to be distinct from the prices of practices in other sectors. Furthermore, given India's diverse agro-climatic conditions, the assessment of green credits must be tailored to specific regions, considering factors such as cropping patterns, resource endowments, and the diversity of native species. Towards this end, application of technologies, such as remote sensing, GIS, and IOTs, for generating precise estimates of ecosystem services and their monitoring.

Carbon credits generated through eco-friendly farming techniques can be traded in carbon markets, making it vital to enable farmers to engage in voluntary carbon-trading systems. The sale of carbon credits provides an opportunity to earn additional income. However, current carbon credit prices fail to adequately compensate for the potential trade-off arising from the adoption of sustainable agricultural practices. Therefore, it is crucial to establish a carbon credit price that, at least during the transition phase, covers any economic loss incurred by farmers.

By providing a safety net and financial incentives, crop insurance programs can play a pivotal role in facilitating the shift towards more sustainable agricultural practices while ensuring food security and economic stability for farming communities. These programs can be designed to incentivize farmers by linking insurance premiums to the adoption of environmentally friendly agricultural practices. For example, farmers who adopt soil and water conservation techniques may be eligible for reduced premiums or enhanced coverage.

Effective execution of market-oriented approaches to promote sustainable agriculture requires a multifaceted strategy involving both government and private sector collaboration. While the government can establish regulatory frameworks and provide financial incentives, the private sector can leverage resources and expertise to implement innovative solutions. The corporate sector can invest in agricultural programs that incentivize farmers to conserve ecosystem services as part of their corporate social responsibility.

Establishing certification marks or labels for sustainably grown agricultural products serves as a powerful tool to recognize and reward farmers' commitment to preserving ecosystem services. This strategy opens up opportunities for farmers to access high-end markets, both domestically and globally, where environmentally conscious consumers are increasingly seeking sustainably produced goods and are willing to pay premium prices for them.

Expanding the market for ecosystem services requires the involvement of grassroots organizations and farming communities, such as Farmer Producer Organizations (FPOs) and cooperatives. Governments and carbon-trading companies can facilitate their participation by providing technical support, capacity building, and financial incentives. FPOs and cooperatives can act as intermediaries between individual farmers and larger market players, aggregating ecosystem services and reducing transaction costs.

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