

Circularity in Indian Agriculture

A pathway to sustainability

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Circularity in Indian agriculture is essential for sustainability and efficient resource management. Circular systems can reduce nutrient losses, enhance recycling, and support sustainable food production. Circular agriculture principles like regeneration and integrated management can transition India from a linear to a circular model, benefiting both people and the environment. While the potential benefits include increased resource efficiency and reduced pollution, significant challenges exist such as inadequate infrastructure, high investment costs, regulatory hurdles, and technological limitations. Addressing these barriers requires innovative policies, financial support, regulatory frameworks, and integrating digital tools such as AI into precision agriculture. Government initiatives and policy alignment with circular farming practices are crucial for creating a sustainable and resilient agricultural sector in India.

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A circular form of economy is centred on having as much value from the products as possible, using as little as possible resources, and lessening the impact on environment by using by-products or other materials to produce new products. The target is to sustain value and utility of products through distinct cycles to restrict resource use. The European Sustainable Development also aims to implement the circular economy to optimally share European resources with the least damaging effect on the surrounding ecosystem while at the same time creating value by adopting other management techniques. Circular Economy (CE) as a model that aims to combine the creation of economic value with the preservation of the environment is gaining popularity. Application of circular economy principles in agriculture is essential to sustainable development (SD). It is cost-effective, creates employment, and fosters environmental conservation. Applying a circular economy in agriculture enables efficient resource management,

fosters closed-loop systems, and preserves natural capital. Precision agriculture embedded with Industry 4.0 technologies drives the circular economy by enhancing efficiency, boosting productivity, and optimizing resource utilization. Circularity in agriculture (CA) is also promoted through urban horticulture, which reduces resource use in city environments. However, challenges like policy constraints and high investment costs hinder its full implementation.

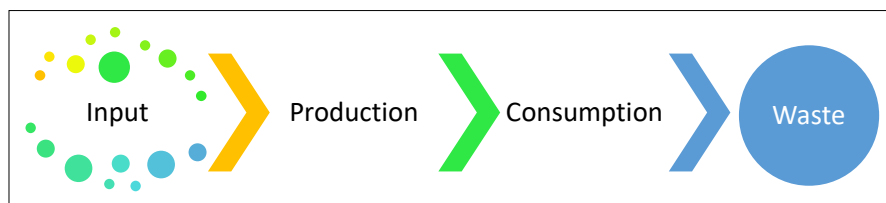
Applying circular economy in agriculture in India, one can witness great impacts concerning the availability of resources and the extent of pollution generated in agriculture. A CE model in agriculture is characterized by reducing reliance on the Earth's virgin resources, curbing environmental impacts from chemical fertilizers by using inputs like biomaterials and treated wastewater. By adopting circular farming practices, farmers in India can reduce costs, create new employment opportunities, and boost the country's economic

returns, while also meeting demand and safeguarding the environment.

Principles of Circular agriculture

The Circular Economy (CE) is a concept that focuses on reasonable reuse of resources in the economic circle. A linear economy is related to a "take, make and dispose" techno-economic structure. This conventional model has significantly enhanced crop production due to enhancements in agricultural technology, high input and the broad area of land use. Circular Economy (CE) has recently emerged as a policy tool for mitigating environmental impacts. It focuses on reducing material input consumption and waste generation, aiming to decouple economic development from resource consumption. Circularity eliminates the existing linear economy model and replaces it with a restorative and regenerative one.

It is possible to name three crucial postulates, that should be learned, to leap forward from linear models (Ellen MacArthur Foundation, 2015,



Linear economy

farming techniques, such as crop rotation, intercropping, and agroforestry, which enhance biodiversity and soil structure, making farms more resilient to climate change.

Reducing chemical inputs:

Circularity enables the reduction of chemical fertilizers and pesticides by substituting them with natural inputs and biopesticides, reducing environmental harm and improving the health of farmers and communities.

Economic benefits:

Implementing circular principles fosters new economic activities, such as organic fertilizer production, biogas, and other value-added products, which can increase farmers' income, physical capital, and reduce economic risk.

Sustainable food production:

Circularity creates beneficial loops that sustain food production and implement practices that support the long-term performance of agricultural systems, ensuring food security for India's growing population.

Community and social benefits:

Circular agricultural practices encourage collaboration within communities to prevent waste and optimize resource use, enhancing rural livelihoods and improving the standard of living.

Strategies for implementing circularity in India

Adopting circular economy (CE) principles in agriculture involves strategies like Reduce, Reuse, Recycle, Reclaim, and Restore. Closed-loop systems should be prioritized while evaluating economic and environmental impacts for better decision-making (Falcone *et al.* 2022). India's shift to circular agriculture requires efficient infrastructure, advanced technologies, and tailored CE strategies. Policies like research grants, eco-labels (ECOMARKS), public procurement, and digital innovations are crucial. Circular food systems can repurpose surplus and waste, creating a sustainable and resilient agricultural model. Agricultural waste by-products

2016).

Preserving and enhancing natural capital: This principle optimizes resource use, prioritizes efficient processes, and supports natural capital recovery and nutrient accumulation for a balanced cycle.

Optimizing resource yields: This principle focuses on renewing, rebuilding and reusing to ensure that every product, part and material is in use and adding to the economic flow.

Fostering system effectiveness: By making negative externalities visible and avoiding them in new operations, external diseconomies such as land degradation, pollution, and Green House Gas (GHG) emissions can be minimized or eliminated, promoting natural capital preservation and encouraging cleaner, greener conditions.

Importance of circularity in Indian agriculture

Circularity in Indian agriculture is crucial for achieving sustainability by minimizing waste, optimizing resource use, and reducing environmental degradation. The importance of Circularity in Indian Agriculture is described below.

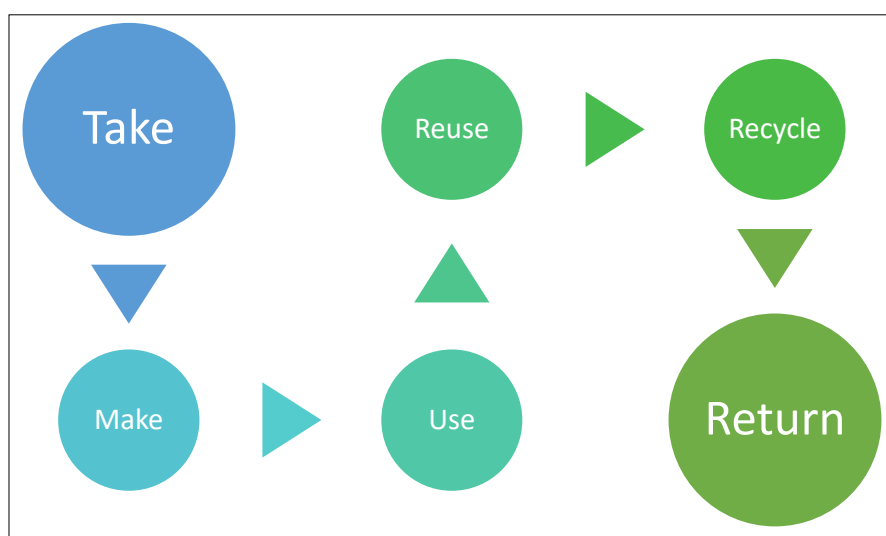


Importance of circularity

Resource efficiency: Circular energy conservation, through minimizing waste and recycling materials, is vital in India, where agriculture consumes significant water and resources. Smart resource use can reduce wastage and enhance sustainability.

Waste management: The waste produced from crops like pulses, oilseeds, and wild-grown crops such as Parthenium can be recycled into valuable products like biofertilizers and biogas, reducing pollution and creating additional income sources for farmers.

Climate resilience: Circular agriculture promotes sustainable



Circular economy

can be transformed into new value-added products, promoting sustainability and resource efficiency. Crop residues like rice husks, wheat straw, and sugarcane bagasse can be converted into biochar, biogas, or bioethanol, while fruit, vegetable, and livestock waste can produce compost, bio-enzymes, or fertilizers. Coconut husks, corn cobs, and banana stems can be repurposed into coir products, biodegradable packaging, and textiles. Even fish waste can be turned into fishmeal or fertilizers, reducing environmental impact and creating economic opportunities.

Challenges and barriers to circularity

Indian agriculture is associated with issues and barriers related to circularity. These include poor infrastructure, immature technology, high implementation costs, and a lack of knowledge about its advantages.

Among the gaps identified by the literature are inadequate recycling policies, high investment costs, a lack of knowledge about how to implement the circular economy, and a lack of enforcement of laws pertaining to it. Besides, other barriers are, the lack of access to necessary funding and capital, the problems experienced in the areas of regulations and operations. In the context of Small and Medium Enterprises (SMEs) in India's emerging economy, the research thus identified some barriers to the effective implementation of

Circular Business Models (CBMs). These include the following: Labour markets, information systems, and cultivation practices act as institutional barriers that shape the resource environment for farmers providing biomass for circular textile systems; therefore, it is necessary to discuss these factors for justice in India's agricultural transition to circularity. In order to address these, India needs laws, funding, and policies pertaining to circularity and sustainable agriculture. Smart farming tools can be utilised while addressing social and cultural factors.

Future prospects

Circularity in Indian agriculture is vital for achieving sustainability and aligning with the Sustainable Development Goals. Principles such as regeneration, land-effectiveness, and integrated management can be strengthened through digitalization, enabling efficient resource use and improved outcomes. However, challenges like inadequate policies, soil degradation, climate variability, and limited awareness hinder progress. Adopting circular practices, such as reducing resource consumption, minimizing pollution, and utilizing biomaterials and treated wastewater, requires strong government support and funding. Integrating livestock with farming and leveraging Industry 4.0 tools like artificial intelligence and precision agriculture can enhance productivity, reduce emissions, and

promote sustainable practices. By addressing resource scarcity, food loss, and climate change, India can transition to a regenerative, circular agricultural system that minimizes ecological impacts and ensures a sustainable future. Consequently, research should focus on circular economy as a way of creating sustainable economic and social returns in the long run.

CONCLUSION

Adopting circularity in Indian agriculture is imperative for achieving long-term sustainability, resource optimization, and environmental conservation. Transitioning from linear to circular agricultural systems can enhance nutrient cycling, reduce waste, and support the overall resilience of food systems. Despite its numerous benefits, challenges such as infrastructure gaps, food losses, and weak policy enforcement must be addressed through well-designed policies, funding mechanisms, and regulatory frameworks. By integrating Industry 4.0 technologies like artificial intelligence and precision agriculture, coupled with government support and increased digitalization, India can unlock the full potential of circular farming. This transition will not only ensure food security and economic growth but also pave the way for a sustainable and regenerative agricultural future.

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If you can't reuse it, refuse it!

