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Promoting Sustainability and Climate Resilience in Agriculture Through Circular Economy: A Review

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ABSTRACT

Global issues such as scarcity of resources, pollution of the environment and growing population that leads to high demand for food are some of the issues affecting the agricultural sector. Services and processes resulting in effective utilization of resources and organisational and environmental consideration are essential for a sustainable life. As to the problem, circular innovation proposes a quite effective solution to redesign the existing agricultural systems according to the circular economy concept. Circular innovation is therefore a break from the cycle and a look at practices that are cyclical in nature. They are techniques such as resource management, reduction of waste generation, utilization of by-products and the use of cyclic systems. This approach least on input dependency increases the utilization rate of resources and disperses adverse effects on the environment. Promoting the use of renewable energy and modern technology like the use of solar energy in irrigation as well as precision farming increases productivity and at the same time decreases the use of water, fertilizers and pesticides. On the same note, circular innovation also looks at waste as input whereby materials such as wastes from agriculture are recycled into, for example, biofuel and fertilizer through composting and bioconversion. Also, circular innovation creates a relationship between the players involved in the food chain thereby encouraging pro-activity between players consisting of farmers, processors, retailers and consumers. This promotes closed-loop supply chains, local food systems and food traceability, minimizes food loss and waste and conserves sustainable and resilient food systems.

Key words: Agriculture, Circular economy, Climate change, Sustainability, Waste management.

A linear economy relates to the Main “take, make and dispose” techno-economic structure (De Jesus *et al.,* 2021). This current global structure of the agri-food system places farmers, processors, seed, fertilisers companies, other agricultural inputs traders and retailers and indeed consumers first and foremost as profit makers or cost minimizers. This conventional model (Fig 1) of the food production system which people believe in the ‘take-produce-consume-discard’ has significantly enhanced crop production due to enhancements in agricultural technological processes, high input and the broad area of land-use (Van Berkum and Dengerink, 2019; Acharya, 2023).

The gradual growth of the global population rise and scarcity of resources’ availability also cast a shadow over the common agricultural model as the long-term growth of socio-economic development causes severe negative impacts on the environment (Hejazi *et al.,* 2014; Yu and Wu, 2018). Sophisticated farming systems, which involve monoculture, excessive food consumption, waste and the improper utilization of resources are maladaptive to nature and climate, damaging to the biome and unhealthy for people in the present and the future (Dudley and Alexander, 2017; Rehman *et al.,* 2022; Mckenzie *et al.,* 2022). For these problems, what is required is a reformulation of agriculturally produced food. There is another more promising approach which is beginning to be discussed by country commissions and worldwide institutions, circular agriculture, which provides solutions to climate change, water scarcity, urbanization, productivity of smallholders, hunger, malnutrition, deforestation and loss of biological diversity (Sindhu *et al.,* 2023; Abirami *et al.,* 2022). The population’s need for cereals and meat is expected to rise dramatically by 2050, so the consumption of the studied types of products should be carried out rationally and minimize the negative impact on the environment (Horrigan *et al.,* 2002; McKenzie and Williams, 2015). Agriculture indicates the destructive effects on soil, water, air, fauna and human health thus raising a concern about other sustainable practices (Scherr and McNeely, 2008). The application of CE solutions in agriculture has been demonstrated to decrease the waste of resources, make

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a positive impact on the creation of employment and ensure business competitiveness (Barros *et al.,* 2020; Cudeèka-Puriòa *et al.,* 2022). It is an important way in the process of reversing some of the negative impacts of the current model of linear economy.

Climate change and agriculture

Climate change, therefore, describes changes in weather over time and more specifically long-term changes in the Earth's temperature attributed to the build-up of greenhouse gases in the atmosphere (Karl and Trenberth, 2003; Singh, 2024). GHG emissions are caused by different activities such as the use of fossil fuel, land use and utilization and changes in use that include deforestation and agricultural practices (Verge *et al.,* 2007). India has pledged to merely cut total carbon emissions by 1 billion tonnes by 2030 at the Glasgow COP26 Summit (Paul, 2021). India is also among 27 nations that have joined a sustainable agriculture action agenda at the end of the first week of the COP26 climate change summit in Glasgow where fresh vows are made regarding reduction in the emission levels of polluting farming (Singh *et al.,* 2023). Using Pathak's (2015) estimations, agriculture is among the biggest emitters of greenhouse gases, especially in India. In 2010, The agriculture sector contributed 18% of the total greenhouse gas emissions in India as per the report published by the Ministry of Environment, Forest and Climate Change of the Indian Government (Jain *et al.,* 2016). However, India has not remained inert in controlling the Greenhouse gas emissions from the agricultural sector. India also targets to reduce pollution within the agriculture sector as decided at the COP26 event (Ahluwalia and Patel, 2021). This system is also known as a circular economy; the concept focuses on the efficient use of resources while trying to minimize the generation of waste (Ghisellini *et al.,* 2016; Korhonen *et al.,* 2018). Increasing the use of a circular economy decreases the emissions of greenhouse gases since the process omits the extraction of more raw materials for the production of other products (Macarthur and Heading, 2019; Yang *et al.,* 2023; Rashid and Malik, 2023). A circular economy model also interrupts the linear economy and recycling processes by taking the material back from landfills and recycling them into the market (Kara *et al.,* 2022). Accordingly, research shows that implementing circular economy principles in four primary industrial materials; cement, steel, plastics and aluminium, could decrease global CO_2 emissions to 40 per cent by 2050 through the efficient and circular

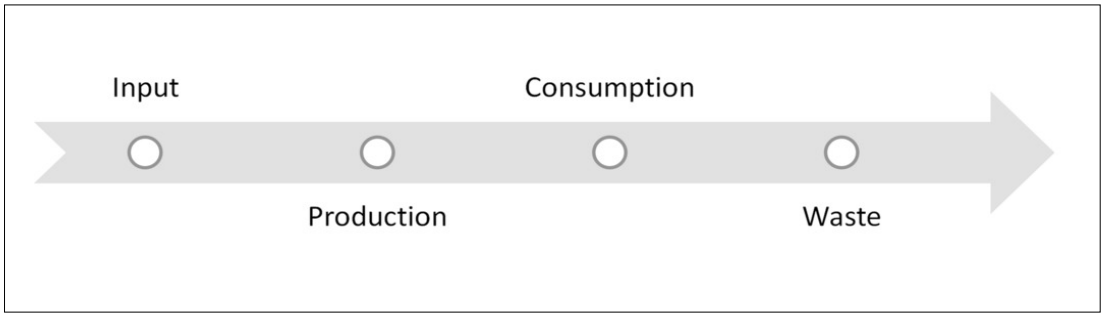


Fig 1: Representation of a linear economy.

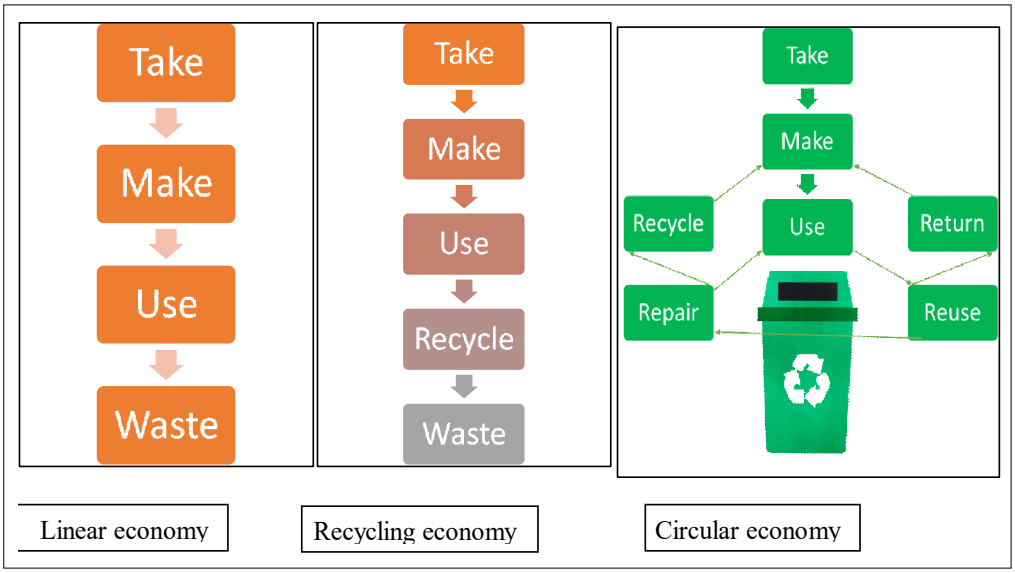


Fig 2: Comparison of linear, recycling and circular economies.

utilisation of the respective product (Macarthur and Heading, 2019; Allwood, 2014).

Circular economy

As per the concept of the circular economy, the three fundamental aspects of the present linear economy system have to be shifted, to make new or redesigned materials and products that can be used again and again to minimize the generation of waste and balance the natural ecosystems (Fig 2). Now, a circular economy is an approach where goods are created and used in a manner that does not strain the earth's resources and reduces on the amount of waste produced and emissions of greenhouse gases. Products are utilized as much as possible, either by repairing them, recycling and redesigning, so that they may be of further use. Ellen MacArthur Foundation defines circular economy as an industrial model which operates on the principle of an intentional and designed restorative loop Since it rejects the notion of end-of-life, it promotes the shift towards renewable energy, bans poisonous chemicals that hinder reuse and works to achieve the abolition of waste via superior design of materials, product, systems and, in this, the business models Which encompasses activities of minimizing, reusing and recycling materials in our systems (Murray *et al.,* 2017). The European Commission, under the EU Action Plan for the Circular Economy, defines this concept by emphasizing the importance of maintaining the value of products and resources at their highest level for as long as possible. It focuses on minimizing waste and resource utilization, while also promoting the recycling or salvaging of valuable materials from end-of-life products, thereby reintroducing these resources into the economy to create additional value.

The benefits of the circular economy

The circular economy offers numerous benefits across economic, social and environmental dimensions (Fig 3). From an economic standpoint, it enables the efficient use of resources, the creation of new markets and enhanced productivity, leading to financial returns and market growth (Roleders, 2023; Siregar *et al.,* 2023). Socially, it generates new job opportunities, encourages community participation and promotes collective resource utilization, fostering long-term economic resilience. Environmentally, the Circular Economy reduces waste, pollution and the burden on raw material exploitation, contributing to a healthier environment and sustainable development goals (Fig 4).

Additionally, transitioning to a circular model allows organizations to create a pro-environmental image, obtain operational benefits and lead in adopting sustainable practices, further reinforcing the advantages of embracing this innovative economic approach (Nowicki *et al.,* 2023).

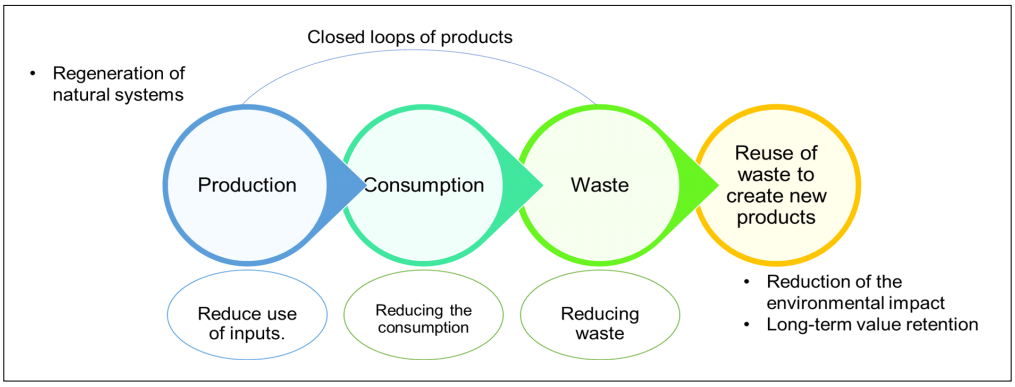


Fig 3: Illustration of a circular economy.

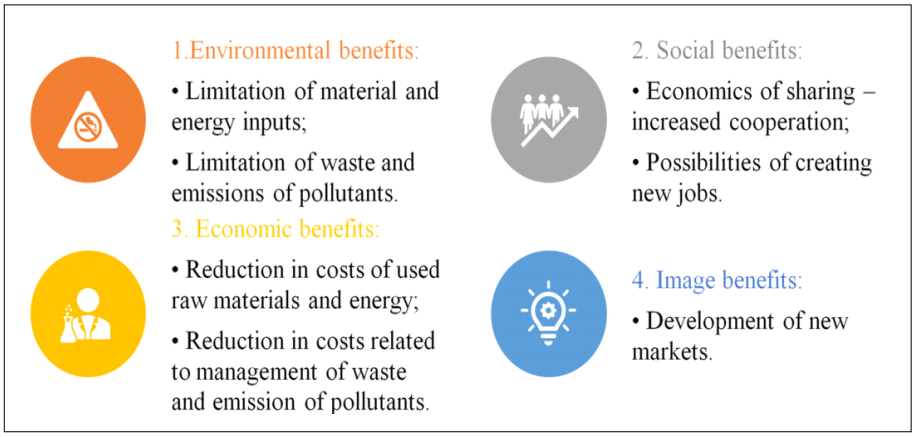


Fig 4: Benefits of circular economy.

Description of key circular pathways

Some strategic areas of application of circular economy include incorporating smart materials into the product's design and construction to improve resource productivity and reduce waste (Alexandris *et al.,* 2023). These pathways also include work areas, such as economy, industrial symbiosis and waste management themes that stress Industry 4.0. However, there are technologies identified in the current study to promote circular economy practices (Rejeb *et al.,* 2023). In addition, the change to a circular economy entails regeneration in goods and services streams within the supply systems; implying a change in the perspectives of responsibility and cycle view of public and corporate well-being (Chilba and Kabiraj, 2023). The transition to circular business models is not easy when considering the contemporary institutional arrangement where the resources are predicated on linearity, thus underlining the need to establish new institutions that would encourage a circulatory economy. Sustainable development goals are important for developing a comprehensive set of strategies that respond to climate change and deliver water, energy and food security; efficient water and energy use in a circular economy (Naidoo *et al.,* 2021). The key circular pathways and their descriptions are provided below in Table 1.

The circular innovation journeys

R^2Pi Consortium used the circular innovation journey. This journey is going to assist businesses to metamorphose into a circular economy and to visualize how they can develop new circular economy business models. The circular innovation journey can be summarised in 6 main steps: This circular innovation process can be simplified into the following 6 main activities (Table 2).

Circular innovation in agriculture

The circular economy principle negates the concept of the 'take-make-waste' model by ceasing the creation of waste and pollution, utilising products and materials and rejuvenating ecosystems (Khaw-ngern *et al.,* 2021). The closed loop area is located in the centre of the circle and it refers to the set of strategies that are supposed to continue the circulation of the technical and biological material within the value circle. Because of the high utilization of products, components and materials that make up the circular economy and provide value to them, the issues to do with resources become scarce. The idea of the circular economy can redesign the linear system of goods and services and help to eradicate pollution, enhance resource durability, create value from waste and mimic organic systems by using other technologies and developing

Table 1: Key circular pathways and their descriptions.

Concept	Definition and details
Re-use	Products are used multiple times in their functional life by different consumers in the economy.
Re-condition	Correction of damage or beautification of a product without providing a new warranty. This includes: i. Rectification: Activities aimed at restoring a product to its functional optimum state. ii. Restoration: Bringing the product back to the required standard in appearance.
Re-make	Also known as "remanufacturing" or "reman," involves performing one or more manufacturing processes on an end-of-life component or product to make it like-new or even better, with a warranty proportional to the process.
Re-generate	Nutrients provided at the end stage of a product's life are metabolized, enabling a cycle of reformation of the initial material.
Circular sourcing	Purchasing materials that are recyclable or biodegradable, enabling their return to the biological or technical cycles. This includes: i. Reduction of virgin material extraction in favour of recyclable materials (technical cycle). ii. Use of renewable and bio-based materials recycled back into the biosphere.
Co-product recovery	By-products or outputs from one process serve as inputs to another, ensuring value chain integration. This includes: i. Direct use/Industrial symbiosis: Waste/by-products from one process used in another, with proximity as a key enabler. ii. Indirect use: By-products like fly ash are sold for reuse in secondary markets.
Resource recovery	At a product's end-of-life, materials are returned to manufacturing cycles as raw materials. This includes: i. Closed loop recycling: Materials are recycled and reused indefinitely, maintaining integrity. ii. Open-loop recycling: Materials serve a new value chain, including Up-cycling (Creating higher-value products) and Down-cycling (Creating lower-value products like construction aggregates).

several new types of value streams. As it is upheld by the UN, it is a form of farming that uses the lowest amounts of extra inputs to regenerate the fertility of the soils and produce comparatively environmentally friendly outputs (Circular Agriculture for Sustainable Rural Development, 2021). In the same way, it offers guarantees that optimal use of land is reduced in parallel with the usage of chemical fertilizers and reduction of waste provided to reduce emissions within the world and contribute to combating climate change.

Society has assimilated the concepts of new sustainable outcomes and innovative models of raising crops like precision agriculture, perennial agriculture, regenerative agriculture, sustainable soil management, integrated farming and organic farming (Das *et al.,* 2025). This way, the symbiosis of agriculture and sustainability allows one to progress from regenerative agriculture and sustainable soil management to organic farming and the CE. This consists of several human acts devoted to the alterations of the climate for offering the world food, which relies on climate as well as the techniques used for making the climate favourable to support the growth of crops. It is considered to be one of the most significant activities for the creation of a complete independent endowment for the countries. In any type of activity that is labelled CE, it is accepted that reuse and recycling are considerations as part of agreed ways of manufacturing. It has to be economically, socially and hence environmentally sustainable.

Three key principles of circular agriculture

The principles of circular economy relevant to the context of agribusiness are the changes that need to be implemented in the food system. Such principles include conservation and improvement of external resources, the rational usage of resources and the maximal utilization of values coming out of waste with attempts at multiple uses as well as attempts at recycling (Bombonatti Filho, 2022). To this end, agricultural practices must be transmuted to organic practices, polycultures and synthetic plant relations

Table 2: Six main circular activities.

Activities	Description
Design	Outlines the role description, expected responsibilities, involved parties and task scope. Typically conducted *via* a telephone conversation with the organizing team in the company.
Understand	Defines the current value creation, delivery and capture for the business model; assesses major factors, threats and opportunities; creates a shared vision for future directions; and selects design parameters for future business models.
Innovate	Develop new options for circular business models and evaluate them against design criteria.
Validate	Compares new circular business model options with significant assumptions to validate the insights gained.
Deliver	Creates an action plan to help the company implement and actualize the new circular business model.
Evaluate	Assesses the receptiveness and feasibility of the existing circular business model during implementation, using integrated evaluation methods.

Table 3: Examples of ICAR technologies for developing circular agricultural practices.

Technology	Description	Benefits
Paddy compost using pusa decomposer	A microbial formulation developed by ICAR to accelerate the decomposition of paddy straw into nutrient-rich compost, reducing the need for burning crop residues and promoting agricultural waste recycling.	Minimizes crop residue burning and enhances soil fertility through nutrient recycling.
Porous bricks from crop residue	A process developed by ICAR to transform crop residues into porous bricks, which can serve as eco-friendly construction materials and reduce the environmental impact of traditional construction materials.	Provides sustainable building materials and reduces environmental degradation.
Fortified rice analogues from broken rice	A value-added technology by ICAR to utilize broken rice from milling to produce fortified rice analogues (FRT) enriched with nutrients, enhancing food security and nutritional value.	Increases food security and adds nutritional value to diets, reducing waste in rice milling.
Corn microbial protein using corn cob	A method developed by ICAR to produce microbial protein from corn cobs for use as animal feed, reducing reliance on conventional protein sources.	Supports sustainable livestock feeding by reducing dependence on traditional protein sources.
Utilization of corn cob powder for kulhad making	A technology developed by ICAR to create eco-friendly kulhads (clay cups) using corn cob powder, promoting waste recycling and sustainability.	Encourages waste-to-resource transformation, aligning with the 3Rs of sustainable development.

for pest control instead of using pollution and waste (Fassio and Chirilli, 2023). In this manner, the principles achieved by the agribusiness sector will promote local circular economy approaches, since the sector will play a role in waste decrease, resource optimization and improved utilization of agriculture by-products for the greatest value (Özçatalbaş, 2023). The following are the measures of circular economy that are relevant to agribusiness. It is significant to note that these principles are regarding biological as well as technical processes and therefore can be incorporated into any type of circle model. In detail, for the food system, the first concept of substituting pollution or waste entails converting from chemical agriculture and pesticides to organic farming, skipping the cultivation of monocultures and applying plant-protection symbiosis. The three key principles of circular agriculture are: They include: (1) protection and improvement of natural resources which are conserving and furthering the utility of such resources, (2) efficient use of resources and (3) getting the maximum utilization from waste materials where possible through utilization in various ways and recycling.

The first principle notes that biological systems and their services should be utilized to enhance agriculture and that non-renewable and toxic materials should be reduced. This includes the exclusion of hazardous substances in products that cannot be recycled or which cannot be recycled easily. Modern agricultural practices that call for single crops, large-scale registrations and the use of chemicals have detrimental effects on the environment, biodiversity and the ecological system. Circular agriculture on the other hand adopts a different strategy by deliberately building for proper agroecosystem performance with a low propensity to fail in retaining the soil functions, resisting pests and diseases as well as unfavourable weather conditions without having to heavily rely on the inputs. This can be done by the use of good species to be planted and less invasive approaches to soil management that involve; conservation agriculture that involves minimum soil turning over and has the effect of sustaining the soil biota and ecosystem services as well as shielding the natural topography from degradation. The second principle of circular agriculture aims at achieving a circular metabolism of resources inside the frame of agricultural processes. This entails the process of emulating natural systems to realize some improved cycling of nutrients, energy and water. Climate-smart agriculture aims at achieving that by smarter use, breeding, substitution or exchange of low-efficient linked natural resources. Also, it encourages the development of flow-producing systems with different species, where waste from one species is fed into another species, thus reducing waste. The third principle of circular agriculture focuses on minimizing food losses and utilizing waste streams as valuable inputs in the food production chain. Mainstream food systems experience losses at various stages of the value chain, but circular agriculture seeks to transform waste into valuable resources. This involves separating and upgrading waste streams, establishing processing facilities, developing markets for the upgraded products and organizing trade logistics (Abinaya *et al.,* 2024). Collaboration among multiple actors is necessary and it presents business opportunities for each participant.

Examples of circular innovation

In the MRI sector, Philips uses a life-cycle and services orientation strategy and sells MRI equipment and its maintenance services to hospitals. Its Smart Path portfolio allows customers to achieve the highest return on their investment in MRI equipment throughout its useful life. They do so through acquisitions in terms of software and hardware to get optimality services, rebuild the capacity and utilities of the machines and overhaul to ensure that the machines are updated since they practice circular sourcing through harvesting used components. Some machines may be returned to customers who in turn are bought back by the firm, disassembled and resold on the market. More parts are applied to the steps of the recovery of resources. Philips also has operating leases under which people are allowed to use the machine but the device remains under Philips.

Circular pig breeding enterprise, China

A case of a pig breeding enterprise is in Pingxiang City, Jiangxi province, China; where in 2015 the linear production model was changed to a circular organic production system. One Biogas production, which was used by the farm as the most important method, was the process of creating high-methane fuel and organic fertilizer through the anaerobic digestion of pig manure. This transition sought to deal with several issues concerning the farmer (Zhu *et al.,* 2019).

Aquaponic farm, Egypt

In Sheikh Zayed City, Giza governorate, Egypt, a former banker from London established Bustan Aquaponics, an aquaponic farm, driven by his desire to provide pesticide-free food for his child. He received training in hydroponics abroad and cultivated Nile tilapia, various vegetables and olive trees on 1000 m^2 of land. The farm utilizes a closed-loop system where the sludge collected serves as fish feed, while duckweed is grown on the sludge. This case study is based on Sarubbi (2017).

Urban organic waste management, Ghana

There are four communal Service Blocks located in the slum area of Accra Ghana; Safi Sana group introduced three facilities which provide water for drinking and washing and lavatory facilities in one structure. Safi Sana gets urine, facial waste and organic waste from various places and picks them up at their factory located in Ashaiman. There, the waste goes through a digester to generate biogas, water for irrigation, as well as organic fertilizer. The produced biogas is utilized in generation of electricity which is marketed to the national grid. Safi Sana also uses the by-products to cultivate vegetable seedlings (PELIZAN *et al.,* 2019).

Some circular ideas from ICAR technologies

ICAR (Indian Council of Agricultural Research) technologies (CWFAW, ICAR) contain important inputs to engage in the construction of circular agricultural practices (Table 3).

Fig 5 explains the procedure of paddy (rice) cultivation, several inputs required for paddy cultivation are depicted in yellow colour in the middle of the chart which includes water, fertilizers and labour. It also contains one example using these inputs where the utilisation is low, hinting at the use of either organic or efficient farming methods. Paddy production has the following outputs, symbolized by several arrows from "Paddy" on the right side of the bag - Economic part of Rice, Rice husk and Broken rice. From rice husk and broken rice, animal feed can be produced and from broken rice fortified rice analogues are produced. Also, the abbreviation of one of the possible products developed from the rice production cycle or process is represented by the eighter the bricks on the right-dependent side of the cycle.

Fig 6 explains the flow of the corn farming procedure and products and services related to corn farming including the aspects of sustainability as well as use of wastes. At the centre, there is corn with rays pointing outwards as arrows to mean a decrease in inputs to imply efficient farming. The economic side penetrates corn into branches like consumption where in the primary corn usage was identified to be as a food product. Thirdly, the diagram also depicts that waste from corn especially the cob part can be reused. One branch explains microbial protein feeds using corn cobs and another explains the use of corn cob powder in making kulhad cups, showing the further outlook of agricultural waste.

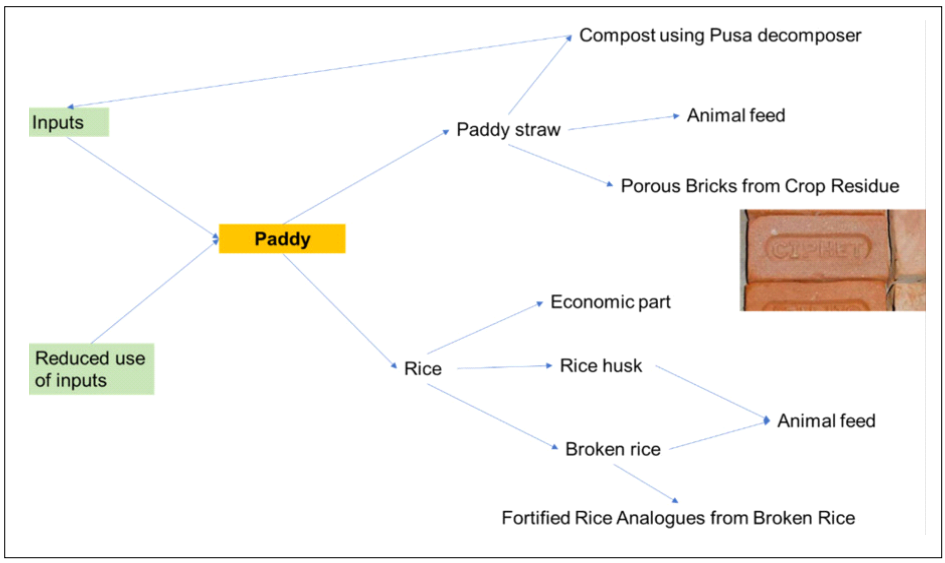


Fig 5: Illustration of the circular economy of paddy.

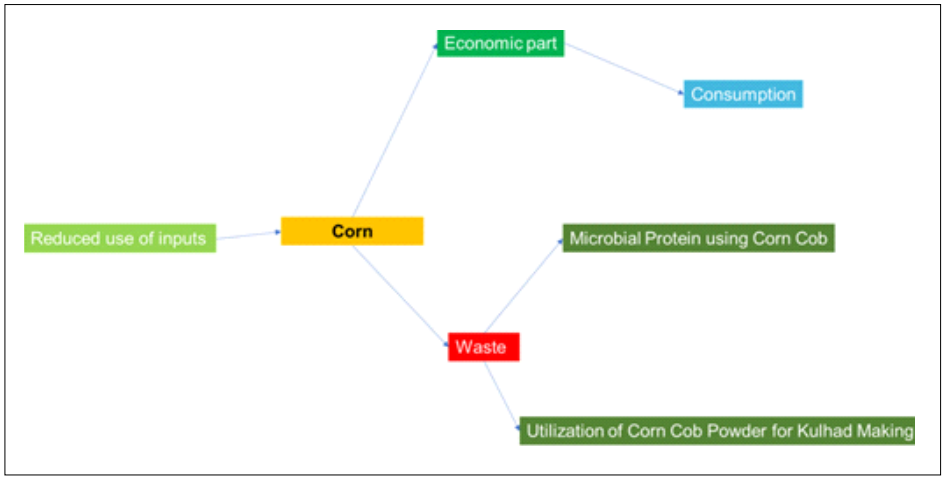


Fig 6: Illustration of the circular economy of corn.

Drivers and barriers to adoption and scaling of circular innovations

The adoption of innovations in agricultural practices is a complex process, often met with various barriers. However, certain drivers and strategies have been identified through project reviews to facilitate adoption. These include the importance of tangible demonstrations, farmer groups or cooperatives and tailored information (Rizzo *et al.,* 2024; Molina *et al.,* 2021). Allowing farmers to experiment with new practices builds their confidence in their usefulness and influential farmers can play a crucial role in encouraging their peers. Customized information should be provided to clustered groups of farmers based on specific characteristics, such as market orientation or gender. While radio broadcasts can disseminate information, they are typically generic and lack customization for individual users or farmer groups. Farmers in low- and middle-income countries consult multiple information sources, choosing the ones they trust the most. Building a trusted relationship with farmers from the outset is essential for successful adoption. Private sector advisors and middlemen may be viewed as less trustworthy compared to government extension workers and researchers (Labarthe and Laurent, 2013). Risk aversion among smallholder farmers is another barrier to adoption, as even small risks of crop failure can have severe consequences for their food and income security. Risk management strategies common in developed countries may not be available or affordable for smallholders. Additionally, labour availability is often overlooked but can significantly impede the uptake of innovations. Farmers prioritize labour efficiency to maximize income and the perception of abundant labour in LMICs may not align with reality (Jones *et al.,* 2022). Scaling of innovations becomes feasible once a critical mass of interested farmers has adopted the practices. Approaches to scaling include replication through peer learning, commercialization and integration into larger projects by establishing linkages with commercial actors. Providing increased support and institutional arrangements to farmers or communities already adopting new practices can enhance horizontal scaling.

Role of extension

In implementing circular agriculture in India, the role of extension services is crucial. Extension services play a vital role in disseminating information, providing technical assistance and facilitating the adoption of new practices among farmers. The roles can be broken down into five steps (Fig 7).

Identifying the issue

The first cord to determine the challenges currently faced in the agriculture sector and for which circular innovation is to be implemented. Some of the environmental problems we see especially in India are soil degradation, water pollution or even lack of it, chemical pollution and negative farming techniques. Hence, circular agriculture has been posited to solve these problems due to its thrust in the efficient and optimized use of resources, prevention of waste and encouragement of ecosystem benefits.

Communicating the issue with research and development

Extension services are in between the researchers, policymakers and farmers in implementing change processes. They act as a link since they disseminate the identified problems to research and development organisations. Population is an asset which extension agents use in giving feedback that reflects the ground realities and aligns the research priorities.

Technology development

Based on the inputs from extension services, research and development institutions align themselves to work on essential and relevant technologies and innovations for circular agriculture as depicted by Pound and Conroy (2017). Such technologies could include, better plant breeds, efficient and effective ways of planting, watering and feeding crops besides efficient ways of controlling pests. Indeed, extension services can help in the practical application of these technologies and state how feasible and efficient the technologies are.

Integrating technologies to develop circular agriculture model

The extension services are useful in propelling the uptake and incorporation of the developed technologies in the circular agriculture system. Training sessions, seminars and demonstrations are conducted by them to aware the farmers regarding circular practices and their utility along with methods for their adoption. These technologies are researched and developed but extension agents often involve farmers in the adoption of these technologies to avoid failure.

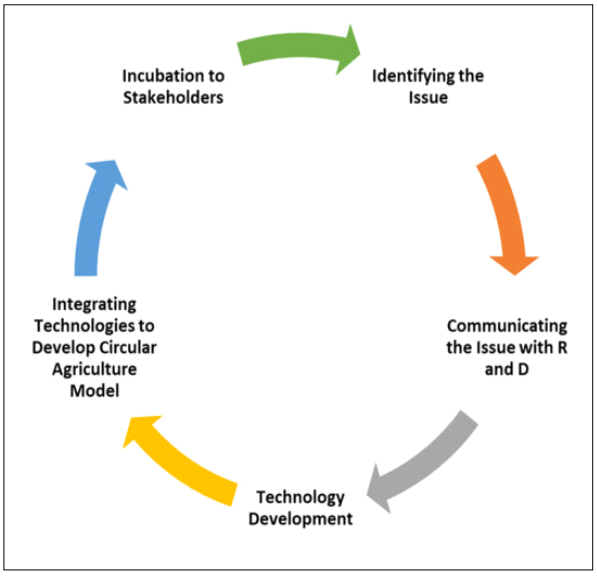


Fig 7: Role of extension.

Incubation to stakeholders

Last but not least; extension services enable the nurturing and scaling up of circular agriculture practices among the various entities such as the FPOs, farmers and society. They sustain it through Farmer Field Schools, Learning Facilities, farmer to farmer learning/knowledge transfer facilities. Farmers receive assistance from the extension agents in acquiring resources, funds and markets for their circular agriculture products.

CONCLUSION

Circular agriculture is instrumental in cutting down on greenhouse gas emissions in the agricultural value chain. By embracing cyclic inputs and outputs, recycling and more efficient resource utilization, the farmer can reduce his or her effects on the natural environment and global warming. Activities such as proper disposal of organic waste, using remnants from the agricultural sector and appropriate use of soil and nutrients minimize the use of artificial fertilizers that cause a release of highly potent greenhouse gases such as methane and nitrous oxide. Furthermore, circular agriculture leads to other sources of renewable energy for instance the generation of biogas from organic wastes which reduces more on the use of fossil energy. Thus, the implementation of circular strategies in the agricultural context leads to progress towards the development of a sustainable and climate-resilient food production system, which helps reduce climate change and maintain the longevity of agriculture.

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Conflict of interest

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