

Circular Economy in the Agri-Food Sector: Opportunities and Challenges



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ABSTRACT

The Agri-Food sector globally faces food resource scarcity and food waste challenges throughout the food supply chain. There are substantial food losses and food wastes in supply chains globally, from farm gate to table, mainly due to lack of required market infrastructure, ignorance and lack of safe transport, improper packaging, lack of standardization and grading, underdeveloped cold chains, and insufficient processing. The increasing population demands more food and, in several ways, adds to more food waste, too. Adding to this is the scenario where agriculture is facing resource scarcity, degradation of natural resources, and human health hazards due to the adoption of unsustainable agricultural practices. All this is exerting adverse effects on the ecosystem.

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Different types of food wastes cause various degrees of adverse externalities to the society, economy, and the environment. While circular agriculture supports the complete recycling of materials and implies a complete reorganization of the supply chain system, immediate steps are needed to mitigate waste and losses. A circular economy is based on industrial ecology's theories and principles. Circular economy looks for solutions towards food traceability, transparency, integration, and, eventually, sustainability. Eradicating waste by applying circular models of business may lead to enormous benefits. Although circular agriculture is a new concept yet, there is an excellent opportunity for the Agri-Food sector in developed and underdeveloped economies to encourage the sustainable practices of the food chain. Such an approach would help in attaining several sustainable goals globally.

Circular Economy looks to remove reasonable waste within the market. If we look through the angle of a circular economy, waste doesn't discuss the same old meaning of "junk", but it describes any insufficient use of resources or assets. There are different types of waste that circular models designed to remove:

Wasted resources - Material and energy that is unutilized efficiently.

Wasted capacities - Products and assets that cannot be utilized effectively.

Wasted lifecycles - Products reaching service period untimely or early without a second lease of scope.

Wasted embedded values - Constituents, material, and energy unrecovered from the residual current of products.

In a circular economy, food products are derived from a healthy production system to provide healthy nutrition-rich foodstuffs. Food loss and waste can be designed in a way in the entire food supply chain to minimize food wastes and losses. The concepts of **6R** - Reuse, Recycle, Reduce, Recover, Remanufacture, Redesign - are essentially associated with the circular economy. Building upon the foundational framework of 6R, the critical elements in a circular economy include designing for the future, the inclusion of digital technology, preservation, and extension of existing resources, prioritizing regenerative resource use, utilizing waste as a resource/raw material, revisiting business models, and collaborative efforts to create value. The majority of the population does not realize that food waste is a significant problem globally. About one-third of all the food produced worldwide is wasted for various reasons, equivalent to 1.3 billion tons annually.

Waste generated from food also leads to wastage of various resources like water, land, labor, energy, and capital. Apart from natural resource loss, greenhouse gas emissions lead to global warming and climate change, thereby causing environmental and ecological degradation. Additionally, an essential factor of this concept is the need to lower resource consumption and waste discharge into the environment. Basic principles of the circular economy remain the same in the agriculture sector too. The majority of the studies on principles focus on the environmental factors of the sustainable system. Still, the other factors like social and economic are not discussed, following a rather technical approach. In many theories, different social system elements like equity, inclusiveness, and gender remain implicit. Many sectors of the agricultural industry can be described under the circular agriculture concept, which involves agro-ecology. The innovative aspect of circularity is its application to the entire food framework, including handling and utilization. This perspective offers numerous choices for reusing supplements, components, and natural waste on a basic level.

Opportunities and Challenges

Several challenges surface on various facets in the food sector, including resource scarcity, uncertainty, high wastages, product quality, unremunerated prices to farmers, exploitation and environmental impact, no information sharing, and extended channels. In the same lines, circular economy adoption faces several challenges at various food production stages, food consumption, and food waste & surplus management. Simultaneously, there is a paucity of reliable parameters for

measuring and documenting progress in the acquisition of circular economy principles. There exists a gap in understanding and perceiving the potential benefits of technological solutions towards food waste prevention.

Lack of understanding further leads to a lack of guidance towards an advanced technological approach towards circular economy solutions. The current global food production and consumption system have necessitated for change towards circularity in the economy and the agriculture sector. There is a huge wastage of resources and raw materials to produce food globally. The circular agriculture system's primary purpose is to judiciously use the resources along the lines of controlled measures to reduce waste by closing the resources' loops. In circular agriculture, waste can be used as organic material to enhance and develop newer and better products, including food crops, vegetables, fruits, feed, energy, and livestock. Circular economy adoption at the industry level may find an opportunity in green product design, business model innovations, digitalization, and reverse logistics.

Green Product Designing

The increasing legal, social, and economic pressures for adopting sustainability measures in the business make industries focus on designing sustainable and eco-friendly products. The majority of product attributes fixed at the time of product design itself decide its contribution towards waste. That is the reason companies are focusing on product design features to be such that they should not violate the requirements of reuse, recycle, return, remanufacturing, etc., at the end of the life cycle. Designing the products for a long life cycle and designing for the product-life extension can help develop sustainable products towards a circular economy. The fundamental idea behind adopting green design for products is to have a critical consideration at the designing stage itself for environmental impacts of the product in later phases of its life cycle. The product, once manufactured, sold, used, and scrapped, should not contribute towards wastages. The parameters of resource conservation while procuring, production, and distribution stages of the product are considered along with eco-friendliness.

The Digitalization of Agri-Food Supply Chains

The long supply chains from farm to fork have resulted in making the consumers ignorant about the origins of their food and the impact of their production and consumption choices on the overall environment and society. Digitalization enables food supply chains to be highly integrated, effective and responsive to consumer demands and regulatory requirements. Digitally driven supply chains are powerful and more successful. They are enhanced with a new information technology infrastructure that substantially affects supply chains and firm performance. The application of digital technology, blockchain, robotics, cloud acquisition, and artificial intelligence, enables the supply chain to become more responsive and proactive by the implementation of embedded chips, sensors, and software. Transparency, traceability, environmental and social impacts, legal culpability, and e-market accessibility lead to a high-value proposition in the Agri-Food supply chain. The blockchain and big data technologies shorten agricultural supply chains making them more efficient, offering social benefits to the rural and deprived section of the world. It provides visibility, traceability of food products, transparency, authenticity, and quality of agri-products.

The diffusion of digital technologies in Agri-Food supply chains results in enhanced efficiency and productivity as the technologies like big data and blockchain bring transparency to food supply chains. Also, it results in increased yield, reduced food wastage, taps changes in consumer patterns, and fulfilling the sustainable development goals. The cloud data acquisition-based supply chains are transformed from fragmented and ambiguous ones to integrated and transparent ones. At the same time implementation of digital technologies is quite challenging as well. Different implementation challenges for digital technologies faced by Agri-Food leaders and companies as mentioned in the literature are:

1. Training of existing staff and recruitment of a skilled workforce
2. Financial constraints
3. Lack of government support and policies
4. Lack of digital culture
5. Lack of infrastructure and internet-based networks
6. Lack of integration of technology platforms
7. Lack of coordination and collaboration
8. Unclear economic benefits by the implementation of digital technologies

Reverse Logistics

Reverse logistics related activities are crucial for creating closed-loop supply chains for the industry. Recall, return, recycling, review, and repair included in reverse logistics have significant environmental and economic impacts. Due to the dynamic and complex nature of reverse logistics activities, they are actively considered while calculating circular economy initiatives impact. Reverse logistics activities strongly correlate to green performance management by reducing food waste and loss, thereby necessitating close examination.

System Transition: A Way Forward

To begin with the circular agriculture system, more emphasis is needed on environmental and health concerns. More farmers and consumers are to be convinced about the possible health and environmental benefits of circular agriculture. For making circular agriculture a successful venture, there is a need to encourage the production of exportable agricultural commodities and liberal policies globally. For proper execution and business development, more emphasis has to put on better marketing strategy, managerial expertise, access to a world wide learned organization, and being in the position to receive funds for investment. More investment needs to be done in the public–private partnership (PPP) model to develop the necessary market infrastructure. Significant constraints and risks identifying with various new circular agricultural businesses are specified at the production and system level.

There are tedious and expensive registration measures for new products at the production level, an absence of information about new products among new customers, and tedious cycles to get the new circular model adopted. Winding up not so important cycle will help achieve minimum economic or environmental advantages at the system level. It may be a cumbersome task to bring the required changes in the mindset of producers and consumers.

In contrast, other linear processes involving waste streams and others in the food system can be continued to be used as it doesn't include external factors. Risk factors at the system level consist of organic waste, which contains toxic substances or pathogens and circulates in the food system, which needs to be addressed through suitable research and extension interventions. Along with these, it is to be noted that only technical or economic aspects such as recycling of nutrients or building the business can affect and create negative implications for other vulnerable groups to promote circularity. It is suggested for governments globally in general and developing countries in particular and their public and private accomplices to advance circular agriculture to improve various purposes, including better environmental monitoring, climate moderation, public health, and revenue generation at the same time.

The social, ecological, and financial measurements should be considered for designing circular initiatives, assuming a proper observing framework. Those social perspectives, such as comprehensiveness, value, youth, and gender, are not

adequately integrated into many circular ideas. Besides, it is prescribed to incorporate the private sector for the advancement of new activities. Likewise, it is prescribed to encourage circular initiatives to gain from existing activities and extra pilots. This is expected to additionally investigate the capability of the promising idea of circularity in farming and food in low and medium countries in particular. In developing economies, food wastage of food can be observed mainly during the food value chain's early levels, primarily responsible for financial, management, and technical constraints in harvesting, transportation, packaging, storage, cold chain, and processing facilities. Food waste issues can be tackled by making a massive investment in the early stages of the supply chain at the level of farmers through direct support in terms of technology, machinery, etc., and in the creation of lacking transportation, marketing, cold chain, modern storage, and processing infrastructure.

On the other hand, the wastage of food can be observed at later stages of the supply chain in developed countries. Consumer behavior plays a vital role in developed countries, which is not similar to developing countries. Many studies recognized failure to coordinate among various parties concerned in the supply chain as major contributory factors. Farmer-buyer agreements are often helpful to extend the extent of coordination. Furthermore, increasing perception among industries, retailers, and consumers and finding valuable benefits for food that gets wasted may reduce the number of losses and wastes in developed countries.

The unutilized fund, especially at the consumer level, is one of the most significant contributors to food waste generation. There are possibilities for minimizing and reusing the food waste at the consumer level by smart shopping in the sense of planning meals for the week and taking into account the food items in the refrigerator or in-store to avoid overbuying. This will reduce food waste and spoilage. Various old preserving techniques to preserve fresh foods have been developed over ancient times as there was no technology like refrigeration system. Pickling and sun-drying techniques have helped to preserve foods over a long time. The fresh food may be preserved to reduce spoilage. Around 40% of waste is generated from peeling the outer layers or removing the inside seeds. Food wastage can be avoided if the apples or cucumbers peels containing lots of nutrition are utilized. Even seeds from melon, watermelon, or pumpkin can be sun-dried and roasted to have these as nuts that contain various minerals and vitamins.

Perishable items like milk, fruits, or vegetables with a different life cycle need to be used smartly. A deep freezer is mainly for fish, meat, and other non-veg items. Keeping in other areas will spoil these items and cause more food waste. In most households, people throw away previous meals leftovers as they think it is harmful to consume previous meals causing infection. Right ways to preserve and use the previous meal leftovers for the next meal can save much food from going to the dustbins. Restaurants and hotels mostly throw away their leftovers, causing a huge pile of food wastes. Recent trends to give away leftover food to homeless people and beggars who cannot afford to buy food can reduce food waste. Health drinks from fruits help to prepare quick recipes saving time, effort and have a nutritious diet. The serving sizes on the plate need to be checked to avoid food waste.

Customers generally order more than their capacity in restaurants and hotels and throw away food. Governments in different countries like Singapore have put taxes on food waste, helping the hospitality industry keep a check on food waste. Local food banks can be promoted by different private agencies or government funding to establish different localities where supervisors can redirect avoidable food waste for distribution among various institutions or apply other solutions. Before buying in stores and markets, the date of expiry must be noted by customers for packaged foods. It is essential to avoid spoiled food from buying. Even if the food is purchased with a brief period of the lifecycle, it must be consumed to prevent spoilage and food waste. Developing and underdeveloped countries have inferior food product maintenance after harvesting, and rules and regulations must be developed to reduce this food waste. Though most food companies stock out

those lots that are nearing expiring dates, malpractices can be observed to resell the expired products with different labels and expiry dates. Strict measures by government agencies can keep a check on these malpractices.

A kitchen garden on a terrace is a prevalent scenario in metropolitan cities where the urban population is developing their small gardens over a terrace or small patch of land. Composting of food waste which is organic manure for plants provides natural nutrients for their growth. This reduces the waste load in landfills and is utilized very efficiently within the cycle for food production. Various Non-Governmental Organizations provide various terrace farming solutions for composting at their home. From plate leftovers like fish or meat, bones can be feed to stray dogs. Commercial and household food waste can be used to generate energy, which generally fills up the landfills. Municipal wastewater generated from organic waste in industrial areas such as food and beverage manufacturing, biodiesel production, electricity generation has found immense utilization of these resources. Non-eatable food waste may produce methane gas for kitchens in biogas plants that do not require complex setups and can be beneficial and cheap utilization of resources.

Conclusions

There is a high potential for circular agriculture globally and low and high-income countries to generate additional income and gainful employment. There are endless ways to reduce, reuse and recycle huge food wastes globally. Circular agriculture can save natural resources as well as the ecosystem and reduces wasteful expenditures on foods. Unnecessary health expenditures can be curtailed by improving the environment, thereby lesser health hazards to humankind. Considering more about our food wastes generated from each household, we can help make a specific transformation to preserve a portion of the world's most significant assets. Indeed, even minimal changes to how shopping, cooking, and consuming food help reducing the adverse effects on the environment and ecosystem in a big way. With little effort, food wastage may be reduced significantly. This would help accomplish different objectives simultaneously, viz. less ecological contamination, environment relief, improved public health, better revenue for farmers and other stakeholders, and finding new work opportunities in the circular Agri-Food sector.

Circular agriculture being a new concept, has many local practices and innovations followed by local people for generations globally. These practices and innovations are found to be economically feasible as most of this created additional income and gainful employment for the local population. The social benefits of circular agriculture can be observed in improved living conditions and new openings. The ecological advantages incorporate better waste administration, a diminished utilization of regular sources, lower fossil fuel byproducts, less natural contamination. Additionally, due to the utilization of natural composts, soil quality and soil biodiversity can improve.

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