Strengthening APEC Cooperation in Circular Agriculture Development to Promote Inclusive and Sustainable Growth

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Strengthening APEC Cooperation in Circular Agriculture Development to Promote Inclusive and Sustainable Growth

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I. INTRODUCTION

Agricultural development has played a pivotal role in ensuring a steady supply of food for a growing population, ending extreme poverty, and boosting shared prosperity. Agriculture accounts for 4% of global gross domestic product (GDP), and in some of the least developed members, it can account for more than 25% of GDP.[1] However, this growth has come with significant trade-offs. The agribusiness sector has been responsible for about 25-30% of greenhouse gas emissions, 80% of deforestation, 90% of land degradation, 80% of losses in ecosystem services and biodiversity, 70% of fresh water use, over 80% of water pollution, and 89% of fisheries overexploited or at full capacity.[2]

In this context, circular agriculture (CA) practices had become one of essential solutions of developing and agriculture-based economies. In the global market, all of trade agreements emphasize on sustainable development, environmental protection, and response to climate change, which are prerequisites to promote economies to accelerate the transition to CA practices, "green" growth agriculture and low-emission food system.

The project "Strengthening APEC Cooperation in Circular Agriculture Development to Promote Inclusive and Sustainable Growth" aims to improve the capacity in circular agriculture not just in Viet Nam but for other APEC economies by facilitate knowledge sharing and exchange of best practices on circular agriculture (CA), particular in agri-food and fisheries sectors, to safeguard the quality of life through environmentally sound growth, to strengthen the dynamism of SMEs and small-scale producers as well as develop the integration to global market. This technical report will reiterate the importance of circular agriculture for sustainable development in Viet Nam and APEC economies. The report will provide a conceptual framework on CA, overview picture on status of CA in Viet Nam and APEC members with some key typical CA models, Highlight best practices, success factors, and innovative approaches that can be replicated or adapted in Viet Nam and other APEC economies and provide practical recommendations for policymakers, practitioners, and stakeholders interested in promoting circular agriculture in Viet Nam and other APEC economies.

II. CONCEPTUAL FRAMEWORK ON CIRCULAR AGRICULTURE

2.1. Definition of circular economy

The concept of circular economy (CE) was first officially used by D. W. Pearce and R.K. Turner in 1990. They pointed out that the traditional economy had been developed with no in-built tendency to recycle; the environment had been seen and treated as a repository for waste. They highlighted the necessity of viewing Earth as a closed system where the economy and environment are interconnected through

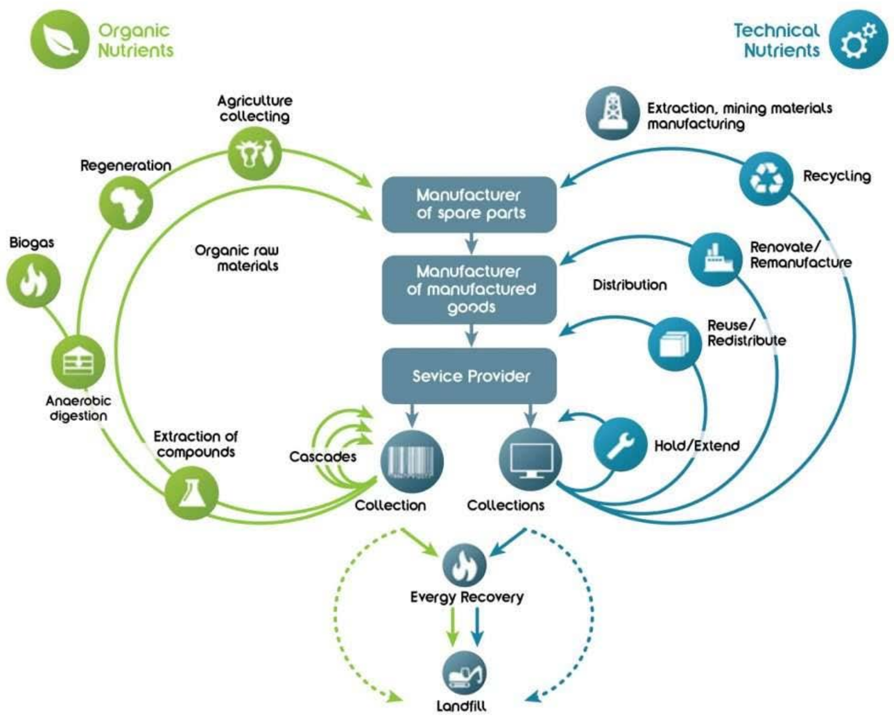
[1] https://www.worldbank.org/en/topic/agriculture/overview#1

[2] UNIDO (2020), Circular economy and agribusiness development

circular relationships, rather than linear interlinkages. They proposed a closed-loop of materials within the economy to achieve a win-win scenario for both economic development and environmental protection (Food & Business Knowledge Platform, 2019)[3].

In 2013, the Ellen MacArthur Foundation presented a widely accepted definition of CE as an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models.[4]

Figure 1 Circular Economy Flow: Organic and Technical Nutrient Cycles



Van Berkum et al. (2019) presents the concept of CE briefly as: "The economic counterpart of the ecological circularity concept – stands against the linear economic model of 'take-produce-consume-discard' and entails three economic activities, to be referred to as the 3Rs: reuse, recycle and reduce existing (used) materials and products. What was earlier considered as waste or surplus becomes a resource that is (re-valorised).

Thus, CE is a closed-loop production cycle where waste is returned and used as input for production, reducing negative environmental impacts, protecting ecosystems, and promoting human health. CE is driven by technological

[3] Circular Agriculture in Low and Middle Income Countries Discussion paper - October 16, 2019

[4] Ellen MacArthur Foundation, Towards the circular economy Vol. 1: an economic and business rationale for an accelerated transition (2013).

advancements amidst the Fourth Industrial Revolution, impacting various aspects of social life. The application of these technological achievements provides a significant opportunity for the development of CE.

Circular agriculture is based on ideas from the circular economy. According to Jurgilevich et al. (2016)[5], circular economy in the food system implies reducing the amount of waste generated in the food system, re-use of food, utilization of by-products and food waste, nutrient recycling, and changes in diet toward more diverse and more efficient food patterns. Avoidance of food waste and surplus is also a consumption issue related to consumer food competences and skills. The loop of nutrients related to the food system can, principally, be closed. The loop of matter can be partly closed relating to the reuse of food, and the utilization of by-products and waste. Minimization of food surplus and waste reduces the overall matter consumption in the economy, thus decreasing the flow of matter related to the linear economy. The measures must be implemented both at the producer and consumer levels and, finally, in waste management.

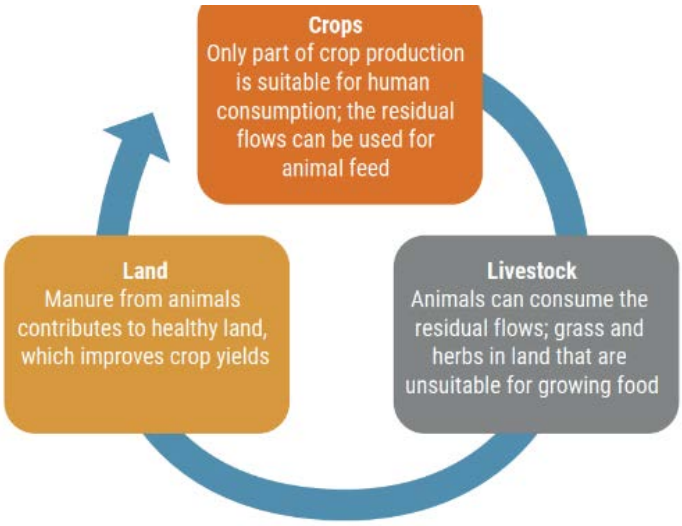
Agreeing with this definition, De Boer & van Ittersum (2018) offer a slight refinement: transitioning to a circular food system involves seeking practices and technologies that minimize the input of non-renewable resources, promote the use of regenerative resources, prevent the loss of natural resources (such as carbon (C), nitrogen (N), phosphorus (P), and water) from the food system, and encourage the reuse and recycling of inevitable resource losses in a way that adds the highest possible value to the food system.

According to Berkum and Dengerink (2019)[6], CE in agriculture is an ecologically intensive concept based on the principle of optimizing the use of all biomass. CE in agriculture aims to create a circular flow of materials and substances, while simultaneously reducing resource use and environmental emissions. According to van Bodegom et al. (2019), the concept of CE in agriculture was developed based on the idea of CE, using industrial ecology theories and principles to reduce resource consumption and environmental emissions by closing material and substance loops. The goal of CE in agriculture is to use no more land or resources than necessary. This can be achieved by producing within closed-loop resource cycles (WUR, 2018). In CE in agriculture, waste is considered a crucial input for the production of new products.

[5] Jurgilevich, A., Birge, T., Kentala-Lehtonen, J., Korhonen-Kurki, K., Pietikäinen, J., Saikku, L., & Schösler, H. (2016). Transition towards circular economy in the food system.

[6] Van Berkum, S., & Dengerink, J. (2019). Transition to sustainable food systems: the Dutch circular approach providing solutions to global challenges (No. 2019-082). Wageningen Economic Research.

Figure 2 Circular mixed-farming system



According to Helgason et al. (2021)[7], mixed crop-livestock and organic farming, agroforestry, and water recycling and wastewater reuse are key elements of circular agriculture. Circular agriculture is closely connected with the concept of mixed crop-livestock farming. Mixed farming that combines crop cultivation with animal husbandry offers additional opportunities to deepen circular agriculture. Mixed crop-livestock farms have lower costs, are less sensitive to market and price fluctuations and result in lower levels of nitrogen pollution. Such approaches can ensure more sustainable agricultural and rural development.

Organic farming is another key element of circular agriculture, striving to eliminate the dependence on chemical fertilizers, pesticides and plastics. Organic farming is also typically more labour intensive, thereby providing rural employment and development opportunities. Reduced use of pesticides and fertilizer also has gender implications. In many parts of the world, handling of pesticides is considered a male task, so pesticide-free organic farming can promote women's participation in agriculture (Meemken and Qaim, 2018). Despite growth, organic farming faces challenges such as resistance from vested interests, lack of information, weak infrastructure, and cultural biases. It also receives less research and investment compared to conventional farming, especially in developing members.

Agroforestry, defined as tree planting in combination with crops or pastures, is an integral element of circular agriculture. It enhances biodiversity and soil fertility by increasing organic matter. Agroforestry make agriculture more circular by reducing dependence on chemical fertilizers and pesticides. It is more accessible for female farmers with limited financial resources and limited access to credit, which can provide new opportunities for women's empowerment in the rural economy. In addition, agroforestry makes firewood and fodder available on the farm, reducing the time women spend on these tasks and empowering them.

The recycling and reuse of irrigation water is key element of circular agricultural water management. Using wastewater in agriculture could irrigate an additional 40

[7] Helgason, Kristinn & Iversen, Kenneth & Julca, Alex. (2021). Circular agriculture for sustainable rural development THE ENVIRONMENTAL IMPACT OF CONVENTIONAL AGRICULTURE. 10.13140/RG.2.2.11433.93282.

million hectares, or 15% of all irrigated land, reducing pollution and ensuring more water conservation and providing additional resources for recharging aquifers. Adequately treated wastewater provides valuable water and nutrients, contributing to food security and livelihoods. Livestock, for example, generate a substantial amount of wastewater, which is rich in organic matter and containing nutrients important to agriculture. Women are more impacted by inadequate wastewater treatment than men due to their higher household exposure to unsafe water.

Return-flow systems, which channel drainage and surplus irrigation back into the network, are also an integral element of circular agriculture. However, water recycling plants are energy-intensive and produce difficult-to-discard sludge. New technologies can mitigate this by developing beneficial sludge by-products and capturing biogas to offset energy use. These advances offer opportunities to close the water cycle, reduce carbon emissions, cut energy costs, and lower environmental contaminants.

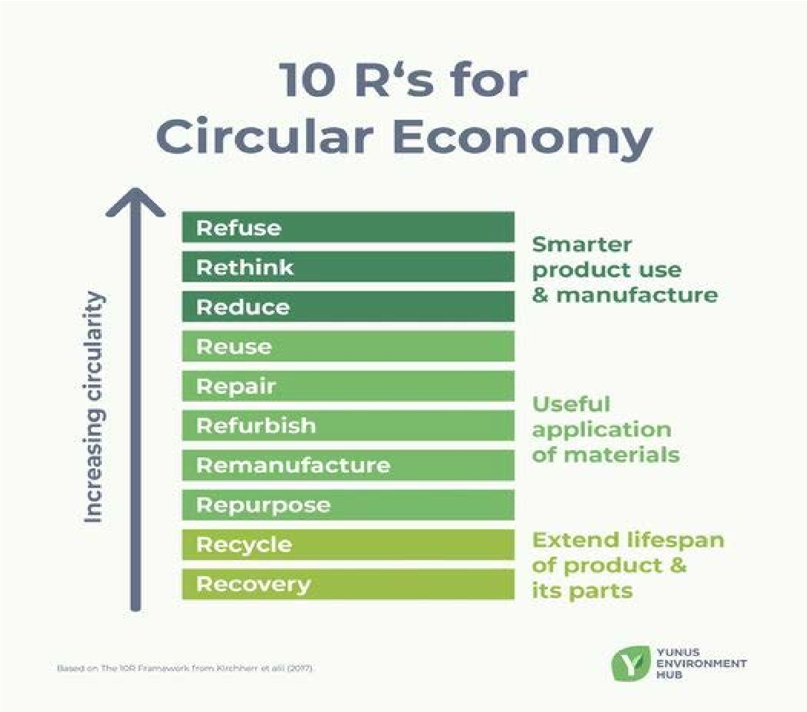
2.2. Principles of circular economy

CE operates on three basic principles (3R): Principle of Reduction (Reduce): minimizing the input of primary energy, raw materials, and waste through improving efficiency in production. Principle of Reuse (Re-use): products or components of products that are not waste are reused for the same purpose for which they were created. Principle of Recycling (Recycle): waste materials are recycled into products or materials. However, the 3R concept only focuses on three activities: reduction, reuse, and recycling, and does not address product design, materials, and production processes, among other aspects.

Therefore, based on the fundamental 3R principles, some organizations and researchers have expanded from 3R to 4R up to 10R with additional activities. According to Potting et al., 2017, the 10R principles include R0-Refuse – refusing, R1-Rethink – rethinking, R2-Reduce – reducing, R3-Reuse – reusing, R4-Repair – repairing, R5-Refurbish – refurbishing, R6-Remanufacture – remanufacturing, R7-Repurpose – repurposing for another use, R8-Recycle – recycling, and R9-Recover – recovering. Implementing higher-ranked principles achieves greater circularity.

The 10R principles provide the most comprehensive and holistic solutions to issues related to the Circular Economy (CE), addressing everything from product design to production processes and product handling, as well as consumer mindset. To achieve the goals of a fully circular economy by 2050, greater focus needs to be placed on the higher-ranked R principles, such as R0-Refuse, R1-Rethink, and R2-Reduce, rather than on R8-Recycle and R9-Recover (Karamanou, 2019; Rijksoverheid, 2018)."

Figure 3 10R principles for Circular Economy



2.3. Circular economy application in agriculture sector

According to Schmidt-Rivera et al. (2020), the application of Circular Economy (CE) in agriculture can be achieved through the following strategies: i) narrowing resource loops, ii) slowing resource loops, iii) closing resource loops, and iv) regenerating resource flows.

Narrowing resource loops refers to ecological efficiency solutions that help reduce the intensity of input use such as land, water, chemical fertilizers, labor, pesticides, and other production factors, as well as minimizing the negative impacts of agricultural activities on the environment per unit of product or service (Mendoza et al., 2017).

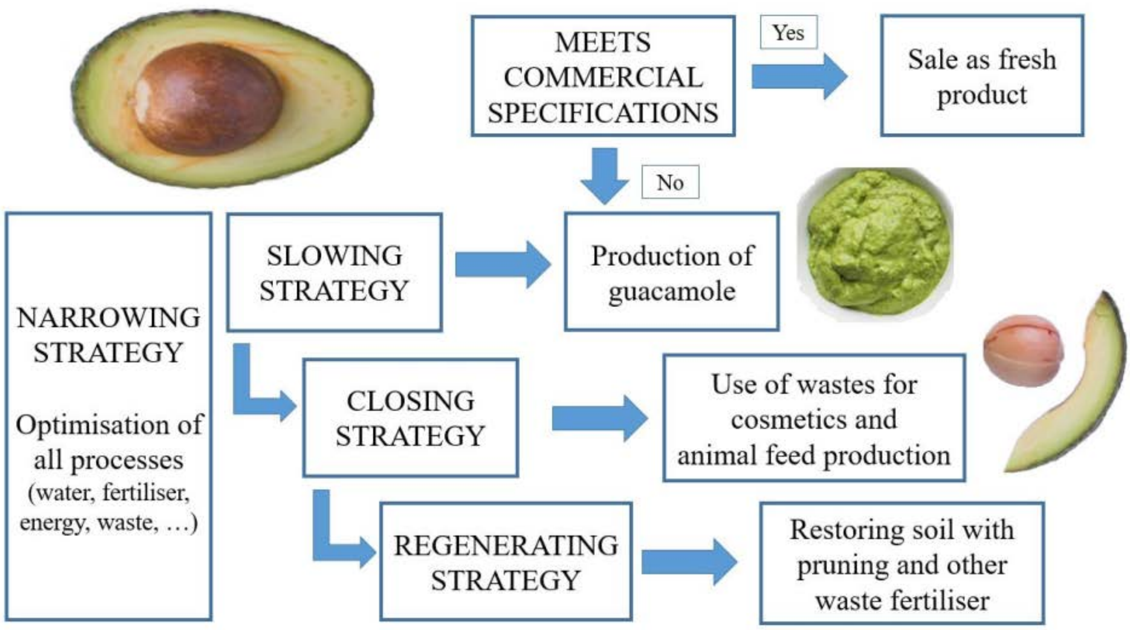
Slowing resource loops involves extending and enhancing the use of products to maintain their value over time (Bocken et al., 2016). A fundamental characteristic of agricultural products and food is that they change and cannot be restored after use, meaning they cannot be reused or repaired to extend their useful life. For example, once a tomato is cut in half, it cannot be repaired to reassemble the two halves into the original fruit. Therefore, the strategy of slowing resource loops in agriculture involves "a series of measures to extend the lifespan of agricultural products and food." Research and application of high-yield, high-quality crop varieties, post-harvest technologies, and preservation technologies to maintain the value of agricultural products are key elements in applying the CE model.

Closing resource loops aims to create new value through the reuse and recycling of used materials (Bocken et al., 2016). In agriculture, this includes activities such as generating energy from agricultural by-products, recovering nutrients from agricultural waste to make fertilizers, and producing high-value bio-compounds from agricultural biomass. In dealing with agricultural waste, the closing loop strategy prioritizes recovering both materials and energy compared to activities that only recover energy.

Finally, regenerating resource flows encompasses all actions to conserve and enhance natural capital (EMF, 2019a). This includes adopting manufacturing technologies, biotechnology, and developing new crop varieties that utilize by-products from main crops. In practice, research and activities related to the collection, recycling, and processing of agricultural by-products—such as producing household items from straw, banana stems, making organic fertilizer from straw, plant residues, cultivating mushrooms, and using materials that are environmentally friendly—are already being applied in Viet Nam, though on a relatively small scale, with most still being managed using traditional methods that impact the environment.

It is important to note that agricultural activities not only produce biological products (e.g., food, medicinal plants) but also involve the use of materials and technical equipment (e.g., machinery, tools, transportation vehicles). These can apply strategies for narrowing, slowing, closing, and regenerating resource loops. For example, the strategy of slowing resource loops must include all necessary activities to extend the lifespan of machinery and infrastructure. This strategy is particularly relevant to modern high-tech agricultural models that involve greenhouses, drip irrigation systems, and hydroponic vegetable cultivation (Colley et al., 2020; Velasco-Muñoz et al., 2018).

Figure 4 Development scheme for a set of CE strategies regarding the cultivation and commercialization of avocado



The image illustrates the implementation of the strategies of narrowing, slowing, closing, and regenerating in the cultivation and commercialization of avocados (Grupo La Caña, 2020). First, it is necessary to identify the avocados that meet market requirements to be sold as fresh fruit.

The slowing resource loops strategy involves using avocados with some defects that are not suitable for sale as fresh fruit to produce guacamole—a creamy sauce made from avocados. This strategy aims to extend the product's lifespan in the value chain, allowing the avocados to be consumed as food rather than being discarded. The closing resource loops strategy utilizes avocado seeds and skins for the cosmetics, pharmaceutical, or animal feed industries. The regenerating resource flows strategy involves using the remaining waste that cannot be reused for the aforementioned industries to produce organic fertilizer. The narrowing resource loops strategy is designed to optimize the entire production process, maximizing resource efficiency while minimizing waste and emissions. For example, the narrowing strategy might employ drip irrigation systems to save water during cultivation or install solar panels to meet the energy needs of the production facility.

III. RELEVANCE OF CIRCULAR AGRICULTURE IN ADDRESSING KEY CHALLENGES IN APEC ECONOMIES

3.1. Overview of APEC economies

The Asia-Pacific region is one of the most diverse, dynamic, and strategically important regions in the world. The Asia-Pacific is home to more than 4.3 billion people, accounting for approximately 60% of the global population. It encompasses a vast area stretching from East Asia to Oceania and parts of North and South America, including members along the Pacific Ocean. The region is defined not only by its geographic boundaries but also by its economic, cultural, and political importance on the global stage.

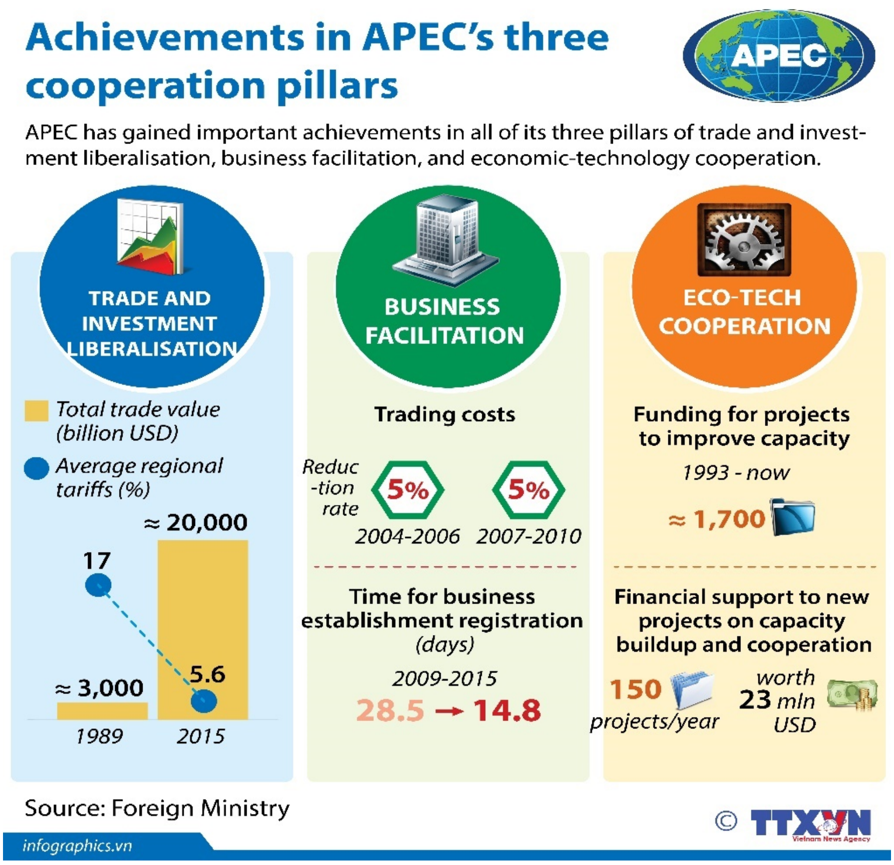
The Asia-Pacific Economic Cooperation (APEC) plays a crucial role in fostering economic growth, trade, and cooperation among its 21 member economies within the broader Asia-Pacific region. APEC is a regional economic forum established in 1989 to leverage the growing interdependence of the Asia-Pacific. APEC's 21 members aim to create greater prosperity for the people of the region by promoting balanced, inclusive, sustainable, innovative and secure growth and by accelerating regional economic integration.

APEC has 21 members, commonly referred to as "economies" rather than members due to the diverse governance structures of its members. These economies span both sides of the Pacific Ocean and include some of the world's largest economies (China, Japan, and the United States). APEC's primary goal is to support sustainable economic growth and prosperity in the region, and its focus extends into social, environmental and governance issues affecting the development of its member economies. These economies account for about 60% of global GDP and 47% of world trade, making APEC a significant platform for economic engagement.

APEC's mission is rooted in three pillars:

- Trade and Investment Liberalization: Reducing trade barriers and promoting open and free trade across the region.
- Business Facilitation: Improving the business environment by simplifying regulations and reducing the cost of doing business.
- Economic and Technical Cooperation: Fostering development and capacity building to bridge the economic disparity among member economies.

Figure 5 Achivements in APEC's three cooperation pilllars



APEC has launched a number of initiatives aimed at fostering economic growth, enhancing connectivity, and addressing emerging challenges, such as: Trade and Investment Liberalization, Economic Integration and Connectivity, Digital Economy and Innovation, Sustainable Development, Inclusive Growth, Health and Pandemic Response. For Sustainable Development, APEC promotes sustainable growth through initiatives on climate change, energy security, and sustainable agriculture. This includes transitioning toward low-carbon economies and promoting circular economy principles. Member economies collaborate on reducing greenhouse gas emissions, promoting the use of renewable energy, and transitioning to more sustainable agriculture and industrial practices.

3.2. Current challenges and Necessity for developing CE in APEC members

APEC economies face a number of pressing challenges that underscore the need for developing circular agriculture. These challenges are interconnected and affect not only economic growth but also environmental sustainability, food security, and social welfare. Key challenges need to be concerned:

(1) Environmental Degradation: Many APEC economies, especially those with large agricultural sectors like China, Indonesia, and Viet Nam, face severe environmental degradation such as soil degradation, water scarcity, deforestation and biodiversity loss. Overuse of chemical fertilizers and pesticides in conventional agriculture has led to loss of soil fertility and increased soil erosion. Meanwhile, intensive agriculture and climate change have worsened water shortages in members like Australia, Mexico, and parts of China. Meanwhile, the expansion of agricultural land at the expense of forests, especially in Southeast Asia and Latin America, is contributing to habitat destruction and loss of biodiversity. In addition, Agricultural runoff containing chemicals contributes to water pollution, particularly in regions like the Mekong Delta and the Yangtze River Basin.

(2) Climate Change: The Asia-Pacific region is particularly vulnerable to the effects of climate change, which poses a significant threat to agriculture with extreme weather events and rising temperatures as well as rising sea levels. Many APEC economies, including the Philippines, Viet Nam, and Japan, are frequently hit by typhoons, floods, and droughts that disrupt food production. Rising temperatures and changing rainfall patterns are already impacting crop yields in places like China, Thailand, and Australia. Rising sea levels threaten low-lying agricultural areas in coastal regions of Southeast Asia and Pacific Island members, exacerbating the risk to food production systems.

(3) Resource Depletion: The overuse and mismanagement of natural resources are critical issues of water depletion, fossil fuel dependency and overfishing. Agricultural water demand is rising, while freshwater resources are becoming scarcer in many APEC members, especially in arid regions like parts of China and Mexico. Conventional agriculture is heavily reliant on fossil fuels for machinery, transportation, and synthetic fertilizers, contributing to environmental degradation and economic vulnerability due to fluctuating oil prices. Additionally, APEC economies with large fisheries, such as Japan, Peru, and Indonesia, are facing the depletion of marine resources due to overfishing, threatening food security and livelihoods.

(4). Food Security Challenges

Food security is a growing concern across APEC economies due to population growth, rising demand, and limited arable land. As urban areas expand, agricultural land is shrinking, especially in members like China and Indonesia. APEC economies are highly integrated into global food supply chains, which can be disrupted by global trade tensions, pandemics, and other geopolitical issues. In addition, high levels of food waste and loss along the supply chain reduce the availability of food, while inefficient agricultural systems contribute to this problem.

(5) Economic Inequality and Rural Development

Many APEC economies, particularly in Southeast Asia and Latin America, have large rural populations dependent on agriculture for their livelihoods. *Smallholder farmers* often lack access to technology, infrastructure, and financing to adopt sustainable practice. *Economic inequality* between rural and urban areas is growing, leading to increased migration and the marginalization of rural communities.

(6) Pressure on Agricultural Productivity

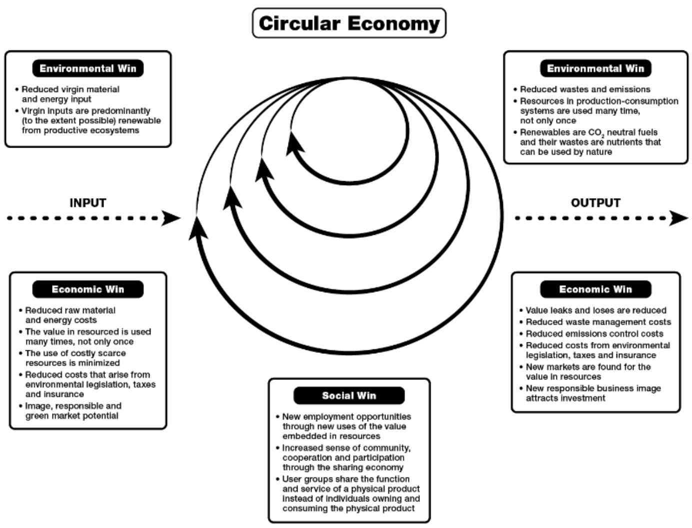
With growing populations and increased food demand, many APEC economies are under pressure to boost agricultural productivity. Traditional agricultural systems rely heavily on intensive farming methods that deplete natural resources, damage ecosystems, and reduce long-term productivity. The youth exodus from rural to urban areas is reducing the available agricultural workforce, making it difficult to sustain farming activities in many regions.

The development of circular agriculture in APEC economies is a necessity driven by environmental challenges, the need for economic efficiency, and food security. As APEC economies face pressures from climate change, resource scarcity, and increasing global demand for sustainable products, circular agriculture offers a pathway to resilient and sustainable agricultural systems. By reducing waste, enhancing resource efficiency, and promoting innovation, circular agriculture can help APEC economies achieve sustainable growth while supporting rural livelihoods and protecting the environment for future generations.

3.3. Benefits of CE for sustainable agricultural development in APEC economies

Circular Economy (CE) is a large-scale industrial ecosystem aimed at minimizing environmental footprints through effective adherence to maximum efficiency, using renewable resources, extending product service life, and designing for waste reduction (EMF, 2013). Korhonen et al. (2018) have highlighted the economic, social, and environmental benefits of CE in the illustration below.

Figure 6 Benefits of CE for sustainable development



Source: Korhonen and collegues, 2018

Economic Aspects: Implementing Circular Economy (CE) will help reduce input costs for materials and energy; maximize resource value through practices such as redesign, repair, reuse, and recycling; minimize the use of increasingly scarce resources; and reduce costs arising from environmental regulations, taxes, and insurance. The Ellen MacArthur Foundation estimates that applying CE to fast-moving consumer goods globally could save up to $700 billion in material costs.

Regarding outputs, CE models will help reduce damage and losses during production; lower waste management and emission control costs. CE also opens up new markets for resources that retain value after use. As environmentally friendly products and socially responsible goods become trends, businesses adopting CE models will attract more consumers, have greater opportunities to expand their customer base, and attract additional investment from organizations and individuals. According to the Ellen MacArthur Foundation, adopting CE could drive economic growth. For example, in Europe, if CE is developed, Europe's GDP could increase by up to 11% and 27% by 2030 and 2050, respectively, compared to 4% and 15% under the current scenario. An Accenture study estimates that CE models could provide an additional $4.5 trillion in global GDP by 2030.

In agriculture and food, CE models provide specific economic benefits, such as enhancing the value of agricultural products; reducing input costs for businesses; decreasing the costs associated with managing large volumes of waste during production; thereby increasing profitability. The Ellen MacArthur Foundation estimates that applying CE principles in the global food system could create up to $2.7 trillion in added value by 2050. The World Economic Forum estimates that CE in agriculture and food could generate an additional $2.3 trillion in economic value by 2030.

Environmental Aspects: CE helps reduce input materials and energy, increase the use of renewable materials in the production ecosystem, reduce waste and emissions, and convert renewable energy and waste into nutrients and reuse them in nature. It is estimated that implementing CE could reduce greenhouse gas emissions in the UK by up to 7.4 million tons annually and halve CO2 emissions in Europe by 2030.

In agriculture and food, cultivation and livestock are among the eight sectors primarily responsible for over 20% of greenhouse gas emissions, 95% of water use, and 88% of land use (CE, Ecofys & WBCSD). For example, Europe produces 1.3 billion tons of waste annually, with over 700 million tons being agricultural waste. Implementing CE measures in agriculture can address climate change, water resource issues, land use, reduce resource consumption, and cut waste and emissions. Some CE models have clearly demonstrated the ability to mitigate the environmental impacts of agricultural production, such as Agrocycle, CE at the household and farm levels. The Ellen MacArthur Foundation estimates that the world could cut food system emissions by half by 2050 through circular measures in agriculture.

Social Aspects: CE creates new job opportunities through the utilization of new resource values; contributes to raising community awareness, enhancing cooperation, and engaging stakeholders through shared economy models. CE helps reduce social costs related to environmental management, climate change adaptation, and improves public health.

In agriculture, promoting CE is an inevitable choice for sustainable agricultural development. Moreover, agriculture has unique advantages for developing a CE. The close link with the natural environment facilitates agriculture's easier access to recycling processes and the reuse of materials from natural ecosystems to establish CE models and promote sustainable development. According to Đỗ Kim Chung et al. (2009), sustainable agricultural development ensures a balance among economic, social, and environmental goals, meeting current agricultural needs without compromising the ability to meet future food requirements. Thus, CE ensures sustainability in agriculture by restoring, shifting towards renewable energy use, avoiding harmful chemicals that affect reuse, and minimizing waste through material, product, and system design. Pursuing CE means striving to harmonize economic, social, and environmental goals, meeting current agricultural needs without harming the ability to meet future food needs.

For APEC economies, the adoption of CE principles in agriculture is crucial for achieving sustainable agricultural development in APEC economies. Circular economy practices focus on resource efficiency, waste minimization, and the regeneration of natural systems—all key components for promoting sustainability in agricultural sectors that face increasing environmental and economic pressures. It is crucial for APEC economies to prioritize circular agriculture that brings following benefits:

(1) Environmental Sustainability

- Circular agriculture is centered on the efficient use of resources, particularly water, soil, and energy. Many APEC economies, such as China, the United States, and Southeast Asian members, are facing significant environmental pressures due to population growth, urbanization, and industrialization. Circular agriculture practices—such as nutrient recycling, composting, and reducing chemical inputs—can reduce the depletion of natural resources. Circular agriculture promotes the use of organic fertilizers and crop rotation to improve soil health, reducing reliance on chemical fertilizers that can degrade the soil over time. In addition, APEC economies with large agricultural sectors, like China, the U.S., and Australia, face water shortages. Circular practices like drip irrigation, rainwater harvesting, and recycling agricultural wastewater can significantly conserve water.

- APEC economies are some of the most vulnerable to the impacts of climate change, including rising temperatures, changing precipitation patterns, and extreme weather events. Circular agriculture helps mitigate climate change by (1) Reducing greenhouse gas emissions through lower reliance on synthetic inputs, promoting carbon sequestration in soil, and reducing methane emissions from livestock and (2) Adopting renewable energy systems, such as using biogas from agricultural waste, to lower carbon footprints.

- Many APEC economies are highly vulnerable to the effects of climate change, particularly island members and agricultural economies that are dependent on stable climate conditions. Circular agriculture provides strategies for adapting to climate change. Diversified farming systems help mitigate risks by reducing dependence on a single crop or livestock system. Resilient practices like agroforestry, crop rotation, and water-efficient farming can help APEC economies adapt to changing environmental conditions.

(2) Economic Efficiency

- In traditional linear agricultural models, there is significant waste—both of inputs (e.g., fertilizers, water) and outputs (e.g., food waste, crop residues). Circular agriculture focuses on closing the loop, turning waste into valuable inputs for other processes. By doing this, farmers can reduce costs and improve the efficiency of resource use.

+ Recycling nutrients: Animal manure, crop residues, and food waste can be converted into organic fertilizers, reducing the need for expensive synthetic fertilizers.

+ Reducing food loss: Improving post-harvest processes and utilizing by-products (e.g., using crop residues for animal feed) ensures that more of what is grown is used.

- Circular agriculture can make farms more resilient to economic shocks and supply chain disruptions. This is especially important for APEC economies with large rural populations or that rely heavily on agriculture for income. By diversifying farming practices and reducing dependence on external inputs, circular agriculture can help insulate farmers from price fluctuations in global markets for inputs like fertilizers and pesticides.

(3) Food Security

- Many APEC economies are facing the dual challenges of increasing food demand due to growing populations and land degradation caused by intensive farming. Circular agriculture supports sustainable food production by enhancing the long-term fertility of the land, ensuring that future generations can continue to produce food. By improving soil health and water efficiency, circular agriculture can maintain or increase agricultural yields, ensuring a stable food supply.

- Several APEC economies, particularly island members and smaller members, depend on imported food and fertilizers, making them vulnerable to global supply chain disruptions. Circular agriculture reduces reliance on imports by promoting local production and the use of local resources, such as organic fertilizers and recycled water. This increases the self-sufficiency of economies, reducing their vulnerability to external shocks.

(4) Meeting International Commitments and Goals

APEC economies are key players in international efforts to combat climate change and promote sustainability, such as the Paris Agreement and the Sustainable Development Goals (SDGs). Circular agriculture directly supports several of these goals, particularly: Goal 2: Zero Hunger – Circular agriculture ensures more sustainable food production systems; Goal 12: Responsible Consumption and Production – Promoting resource efficiency and reducing waste; Goal 13: Climate Action – Lowering emissions through sustainable farming practices. By investing in circular agriculture, APEC economies can advance their commitments to these global frameworks while also benefiting economically and environmentally.

(5) Supporting Smallholders and Rural Economies

APEC economies, particularly in Southeast Asia and parts of South America, rely heavily on smallholder farmers who are often most vulnerable to economic and environmental shocks. Circular agriculture provides smallholders with more sustainable farming models, helping them increase resilience to market volatility by reducing reliance on external inputs; enhance income through diversified farming practices that increase productivity and reduce waste and improve community development, as circular models often promote localized production, waste management, and the use of local resources.

(6) Innovation and Digital Agriculture

APEC economies are also global leaders in agricultural innovation, particularly with the rise of precision agriculture. Circular agriculture can integrate these innovations to enhance sustainability. Precision farming technologies allow farmers to reduce input waste (e.g., fertilizer, water) and optimize yields through better resource management. Digital tools can support circular practices by providing real-time data on soil health, water usage, and crop yields, enabling better decision-making.

(7) Enhancing Global Competitiveness

Circular agriculture can position APEC economies as leaders in sustainable agriculture, enhancing their competitiveness in global markets. As consumers and businesses increasingly prioritize sustainability in their supply chains, APEC economies that adopt circular agriculture practices may benefit from increased access to premium markets and trade partnerships. Eco-certification and sustainable labels could provide a competitive edge for agricultural exports from APEC economies.

3.4. Barriers of APEC economies in developing circular agriculture

Developing circular agriculture within APEC (Asia-Pacific Economic Cooperation) economies faces several barriers:

(1) Technological Barriers: Limited Access to Technology, High Technology Costs, Inadequate Infrastructure

Many APEC economies, especially developing ones, lack access to advanced technologies necessary for circular agriculture. Technologies for waste recycling, biogas production, energy recovery, and precision agriculture are often not readily available, limiting the ability of farmers to adopt efficient CA practices. The upfront cost of acquiring and maintaining circular agriculture technologies such as anaerobic digesters, composting machines, or water recycling systems is prohibitively high for small-scale farmers. This creates an economic barrier to entry, particularly in regions with lower income levels. Especially, many APEC members lack the infrastructure needed for implementing CA models at scale. This includes systems for waste collection, treatment facilities, and distribution networks for recycled resources like biofertilizers or biogas.

(2) ***Economic Barriers:*** High Initial Capital Requirements, Low Market Demand for Circular Products, Insufficient Financial Incentives

Circular agriculture often involves high initial investments, particularly for technologies and infrastructure. Smallholders and cooperatives often lack access to the capital necessary to make these investments, making it difficult for them to transition to CA models. Meanwhile, markets for circular agriculture outputs, such as bio-based fertilizers, organic food, or bioenergy, are not well-developed in many APEC economies. This limits the profitability of CA systems, reducing incentives for farmers to adopt them. Additionally, inadequate financial support, such as subsidies or incentives for adopting circular agriculture, makes it less attractive for farmers to invest in these systems. For example, the low purchase price of biomass electricity (e.g., bagasse-based energy) in Viet Nam discourages sugar mills from investing in co-generation technologies.

(3) ***Policy and Regulatory Barriers:*** Lack of Comprehensive Policy Frameworks, Regulatory Uncertainty,

Many APEC economies lack strong, cohesive policies that encourage the adoption of circular agriculture. Without regulatory support, there is little to drive the transition from linear to circular agricultural practices. Existing policies often focus on conventional agricultural methods and do not include incentives or guidelines for sustainable practices. Meanwhile, inconsistent or unclear regulations around waste management, renewable energy, and agricultural practices create uncertainty, making it difficult for businesses and farmers to invest in CA models.

(4) ***Cultural and Social Barriers:*** Resistance to Change, Limited Awareness and Education, Social and Gender Inequities

Traditional farming practices are deeply ingrained in many APEC economies, and farmers may be reluctant to adopt new methods that require significant changes to their operations. This resistance is often due to a lack of awareness of the long-term benefits of CA or fear of financial risk. Many farmers and local stakeholders are not fully aware of circular agriculture practices and their potential benefits. This lack of knowledge creates a barrier to adoption, as farmers may not understand how CA can increase productivity and sustainability. In addition, in some APEC economies, women and marginalized groups have limited access to resources, land, and training, which restricts their ability to participate in CA initiatives. Promoting gender inclusivity is crucial to overcoming these barriers.

(5) ***Environmental and Resource Barriers:*** Natural Resource Constraints, Climate Change and Extreme Weather and Biodiversity Loss

Some regions face constraints such as water scarcity, land degradation, and poor soil health, which make it challenging to implement circular agriculture models. For example, biogas production requires stable water and organic waste supplies, which are not always available in resource-constrained regions. APEC economies are increasingly affected by climate change, including more frequent droughts, floods, and temperature fluctuations. These unpredictable environmental conditions make it difficult to implement CA systems that rely on stable weather patterns, such as integrated crop-livestock systems or aquaculture. Additionally, circular agriculture depends on diverse ecosystems to thrive, but biodiversity loss in some APEC economies reduces the availability of natural pest controls, pollinators, and other ecosystem services essential for CA practices.

(6) Supply Chain and Market Barriers: Fragmented Agricultural Supply Chains, Lack of Integration with Other Sectors

Circular agriculture requires the integration of different actors across the supply chain, from waste producers to recyclers to end-users of products like biofertilizers or biogas. In many APEC economies, agricultural supply chains are fragmented, making it difficult to establish efficient systems for recycling agricultural by-products or distributing circular products. Especially, circular agriculture often involves sectors beyond farming, such as energy, waste management, and technology. In many cases, there is limited collaboration between these sectors, leading to inefficiencies and missed opportunities for synergy.

(7) Knowledge and Capacity Barriers: Limited Research and Development (R&D), Lack of Technical Expertise

Many APEC members do not invest enough in research and development for circular agriculture. Without sufficient R&D, it is difficult to develop locally adapted technologies, practices, and policies that support CA. In addition, circular agriculture requires specific technical knowledge, such as how to manage integrated farming systems or recycle waste into energy and fertilizers. A lack of training and technical assistance for farmers and businesses is a major barrier to the successful adoption of CA models.

IV. CURRENT STATUS OF CIRCULAR AGRICULTURE IN VIET NAM AND OTHER APEC ECONOMIES

1. General situation

Agricultural development across the Asia-Pacific Economic Cooperation (APEC) economies is highly diverse due to varying levels of economic development, natural resources, and technological capacities. APEC comprises developed economies like the United States, Japan, and Australia, alongside developing economies like Viet Nam, Indonesia, and Peru. This results in significant diversity in agricultural practices, productivity, and challenges. Developed economies have high-tech, mechanized farming systems, strong agricultural research and development (R&D), and more sustainable practices. Developing economies are often more reliant on traditional farming methods, smallholder farms, and have less access to advanced technologies, though this is changing rapidly.

In term of circular agriculture development, APEC economies are at different stages of adopting and implementing circular agriculture based on their unique economic, social, and environmental contexts. Several *leading APEC economies*, such as China, Japan, and Australia, are at the forefront of circular agricultural practices. These members have developed policies and technologies that support waste recycling, nutrient recovery, and resource efficiency in farming. *Emerging APEC economies*, like Viet Nam, Peru, and Mexico, are progressively integrating circular agriculture principles, although they face challenges such as limited resources, infrastructure gaps, and policy fragmentation.

Governments in APEC economies are increasingly developing policies and initiatives to support circular agriculture through developing action plan, standards in circular practices, incentives for farmers, promotion of research and innovation. Many governments offer subsidies and incentives to farmers adopting circular practices, such as waste recycling and organic farming. Economies like Japan and Australia heavily invest in research and innovation, focusing on improving circular agricultural technologies and practices. This includes developing more efficient nutrient recycling systems and exploring new methods for waste-to-energy conversion.

APEC economies have been making efforts to strengthen regional cooperation in promoting circular agriculture. APEC as a forum is promoting information-sharing and best practices among member economies. This includes joint research projects, cross-border collaboration in agricultural technology development, and capacity-building programs. The latest APEC summit took place in San Francisco in November 2023, with a focus on building a "Resilient and Sustainable Future for All." Key topics included advancing free and fair trade, fostering inclusive growth, and addressing climate change. The leaders adopted the "Golden Gate Declaration," which emphasizes these priorities while also promoting energy security and cooperation on environmental issues. The latest APEC summit in 2023 highlighted circular agriculture as a key approach to achieving sustainable food systems in the Asia-Pacific region. During the APEC summit, several workshops and initiatives focused on promoting circular agricultural practices across member economies. These discussions centered on how to integrate innovative technologies and policies to reduce resource input while increasing agricultural productivity. A particular emphasis was placed on sustainable food production systems that can adapt to climate change and environmental challenges. Circular agriculture promotes recycling organic matter, improving soil health, and conserving water, all while boosting local economies and reducing the environmental footprint of agriculture. Additionally, APEC leaders emphasized that adopting circular agriculture is crucial for achieving long-term food security and reducing the strain on finite natural resources as global populations grow. It is seen as a vital component of the region's overall goal of transforming agri-food systems into more resilient, inclusive, and sustainable frameworks.

Key circular agriculture practices in APEC members focus on enhancing resource efficiency, minimizing waste, and promoting environmental sustainability, specifically:

(1) Waste Recycling and Composting

- China, Japan, and Viet Nam lead in using agricultural waste (crop residues, livestock manure) to produce compost or biogas.
- Japan and China have extensive systems to collect agricultural waste and convert it into organic fertilizers, reducing reliance on chemical inputs.
- Mexico and Viet Nam are increasingly adopting composting, particularly for high-value crops like coffee and rice.

(2) Biogas and Energy Recovery

- China is a pioneer in biogas production, particularly in rural areas, where livestock waste is converted into energy. These biogas systems are widely used to provide renewable energy to rural households.
- Thailand and Viet Nam also use small-scale biogas systems to power farms, making productive use of animal waste.

(3) Precision Farming

- Australia and Japan use precision agriculture techniques to optimize the use of water, fertilizers, and pesticides. Drones, sensors, and AI technology are deployed to monitor crop health and minimize input waste.
- This practice enhances resource efficiency and supports nutrient recycling by ensuring that inputs like fertilizers are applied only where needed.

(4) Water Recycling and Conservation

- Australia, which faces significant water scarcity, leads in the use of recycled water in agriculture. Systems like drip irrigation and rainwater harvesting are common to reduce water use and improve efficiency.
- China and Mexico are also adopting water-saving technologies, especially in regions facing drought conditions.

(5) Nutrient Recovery

- Japan and Australia focus on nutrient recycling systems where organic waste is processed to recover valuable nutrients. This practice helps to replace synthetic fertilizers with organic alternatives.
- Livestock and aquaculture by-products are being used in crop production to close nutrient loops, particularly in China and Thailand.

(6) Agroforestry and Crop Diversification

- Indonesia and the Philippines use agroforestry, integrating trees and crops to enhance soil health, increase biodiversity, and recycle nutrients within the system.
- In Peru and Mexico, crop diversification and rotational systems are common, which helps to improve soil health and reduce pest and disease cycles.

(7) **Organic Farming**

- Organic farming practices that emphasize closed-loop nutrient cycling (using compost, organic matter, and animal waste) are growing in members like New Zealand, Australia, and Japan.
- Thailand and Viet Nam are also seeing increasing interest in organic farming, driven by consumer demand and government support.

(8) **Circular Aquaculture**

- China, Thailand, and Chile are promoting circular aquaculture practices, where waste products from fish farming are repurposed in integrated systems, such as using fish waste as fertilizer for plants in aquaponic systems.

(9) **Food Waste Reduction**

- Japan has developed advanced systems for minimizing food waste by redistributing surplus food and turning organic waste into compost or animal feed.
- Korea and China have programs to reduce food waste across the supply chain, with a focus on reusing and recycling food waste in agricultural systems.

(10) **Renewable Energy Integration**

- In China and Viet Nam, solar panels and wind turbines are increasingly being integrated into agricultural landscapes, reducing energy costs for farmers and promoting sustainable energy use.
- New Zealand and Australia are also exploring ways to integrate renewable energy into farms, with systems designed to use renewable energy in irrigation and farm machinery.

2. Current Status of Circular agriculture in Viet Nam

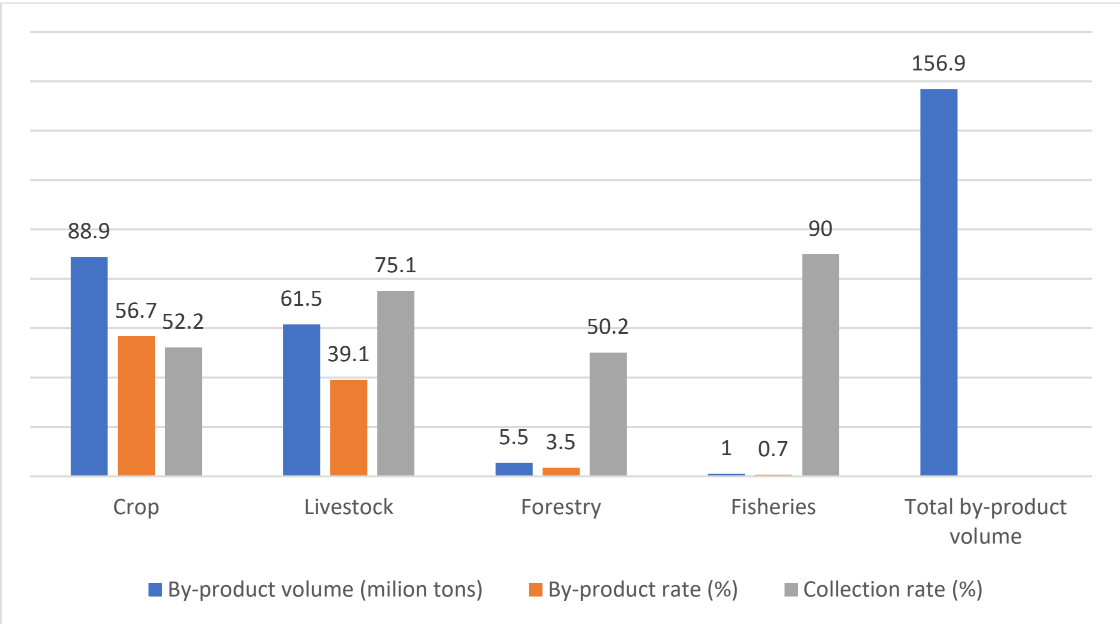
In Viet Nam, CA is being promoted by the Vietnamese government as a solution for sustainable agriculture. In recent times, circular economy contents have been integrated in the economy's socio-economic development strategies, policies and local development plans, programs and projects to implement circular economy. Viet Nam's active participation in bilateral and multilateral free trade agreements underscores its commitment to sustainable development, environmental protection, and adherence to emission standards.

Specifically, the Strategy for Sustainable Agriculture and Rural Development in the 2021-2030 period, with a vision to 2050, clearly mentions the transition to a circular economy as a key solution that contributes to the agricultural development towards increasing added value and sustainable development. This approach not only meets economic, social, and environmental objectives but also helps in coping with climate change. To affirm the role and importance of the circular economy, on June 7, 2022, the Prime Minister issued Decision No. 687/QD-TTg approving the Project on Circular Economy Development in Viet Nam. According to this Decision, the Ministry of

Agriculture and Rural Development (MARD) was tasked with perfecting institutions and policies to create a legal framework for the formation and development of circular economy models in agriculture and rural development; researching and implementing solutions to improve the capacity for recycling and reusing agricultural by-products. To implement the Decision No.687/QĐ-TTg, on June 19, 2024, MARD developed the scheme on Science Development and Application, Technology Transfer to Promote Circular Economy in Agriculture by 2030 and submited to the Prime Minister for approval and promulgation in the Decision 540/QD-TTg approving the scheme on Science Development and Application, Technology Transfer to Promote Circular Economy in Agriculture by 2030. Currently, the Ministry of Natural Resources and Environment (MONRE) has been developing and collecting comments on the draft Decision of the Prime Minister on the Action Plan to implement the circular economy by 2030. The Ministry of Planning and Investment (MPI) has been developing and collecting comments on the draft Decree on the pilot mechanism for developing a circular economy.

In Viet Nam, waste and by-products in agriculture sector have been considered renewable resources with an increasing rate of waste and by-product treatment. According to the General Statistics Office of Viet Nam (GSO), the total volume of by-products of the economy in 2020 was over 156.8 million tons, including: 88.9 million tons of post-harvest by-products from the cultivation and processing of agricultural products in the crop sector (accounting for 56.7%); 61.4 million tons of livestock and poultry manure from the livestock sector (accounting for 39.1%); 5.5 million tons from the forestry sector (accounting for 3.5%) and about 1 million tons from the fisheries sector (0.64%). The collection rate of by-products from crops is about 52%, in livestock it is 75%, in forestry it is 50.2% and in fisheries it is 90%.

Figure 7 Total by-products in Viet Nam



Source: GSO 2020

A number of successful CA models have been implemented in many localities, bringing high economic efficiency and added value. There are four popular CA models:

(1) Biogas production and utilization from livestock and crop waste and wastewater: This model converts animal manure from livestock and poultry farms, rice straw, and domestic wastewater into biogas, a renewable energy source. Biogas is used for cooking, heating, and lighting, while digestate, a byproduct of biogas production, serves as organic fertilizer. An example is the rice cultivation model using rice husks as fuel in Vinh Binh Commune, An Giang Province, with a capacity of 80,000 tons/year, producing 16,000 tons of rice husks. Half of the husks are used for drying rice, and the remainder is processed into husk briquettes for sale. This model reduces greenhouse gas emissions by 10.17 CO_2-e/ha/year, cuts energy costs by 30%, and increases profits by VND 400,000 per ton from selling husk briquettes, equivalent to VND 3.2 billion per year.

(2) CA model using crop byproducts as catalysts: Using crop by-products like straw and sawdust as substrates provides additional income and protects the environment. Farmers use straw to grow mushrooms, generating significant income. Straw can also be buried to retain fertilizers for the next crop, or treated with biological products to produce organic fertilizers, or used as feed for livestock. For example, one hectare of rice can produce 200m of mushroom substrate, yielding 250-300kg of fresh mushrooms after 25-30 days. which can be sold for 25,000-27,000 VND/kg, generating an additional VND 6-8 million per hectare. With a selling price of 25,000-27,000 VND/kg of fresh mushrooms, one hectare in this model can generate an additional income of VND 6 to 8 million for farmers, besides their earnings from rice. Moreover, rice straw can be used to produce ethanol. With the efficiency of bio-oil recovery, Viet Nam's straw resources have the potential to produce 31 million tons of bio-oil per year as an alternative fuel, and can also be upgraded to produce gasoline and diesel in the near future.

(3) Resource-saving model: This model focuses on reducing the use of chemical fertilizers, pesticides, veterinary drugs, and growth promoters in crop and livestock production to minimize negative environmental impact and protect human health. Alternatives include fruit bagging, selecting pest-resistant crop varieties, and using bio-fertilizers instead of chemical ones.

(4) Integrated models (e.g., garden-pond-barn models, rice-shrimp models, rice-fish models, agroforestry models, etc.): The garden-pond-barn model has been widely applied in Viet Nam since the 1980s and is considered the simplest form of CA. This model combines crop cultivation, fish farming in ponds, and raising livestock in cages, creating a closed-loop system that minimizes waste, maximizes resource use, and fully adheres to the principles of circular economy. Over time, the model has evolved into the garden-pond-livestock-biogas model and the garden-pond-livestock-forest model in mountainous provinces, and the garden-pond-lake model in central

provinces, enhancing agricultural productivity and reducing greenhouse gas emissions. The "rice-shrimp" and "rice-fish" models have been applied since the early 2000s in the Mekong Delta provinces. In the models, when shrimp or fish are raised in the rice field, their waste and leftover feed provide additional nutrients for the rice. Conversely, after harvesting the rice, releasing shrimp (or fish) into the field allows them to feed on the leftover straw and fallen grains. This model almost eliminates the need for pesticides and antibiotics, creating clean products and protecting the environment. The implementation of the "rice-shrimp" and "rice-fish" models has helped reduce diseases, decrease environmental pollution, produce safe products, and, most importantly, increase farmers' income by 5 to 10 times per hectare compared to growing rice alone.

These CA models highlight Viet Nam's commitment to sustainable agricultural practices, promoting economic efficiency, environmental protection, and climate resilience. Despite the achievements, the application of CA models in Viet Nam still faces a number of limitations:

(1) There is still a lack of awareness among state management agencies, businesses, and especially farmers about the need to transition to CA models. Although there has been a gradual shift towards sustainable and organic agricultural production, most agricultural entities still prioritize increasing output through higher inputs. Agriculture heavily relies on resource exploitation, growth stimulants, pesticides, and chemical fertilizers. The impact of CA models remains limited. Proper awareness of the importance, and requirements of the circular economy needs to be implemented from design to implementation for each industry and field. This understanding should be unified and agreed upon by leaders and management at all levels, down to each business and citizen.

(2) The policy framework for the scientific development, application, and technology transfer to promote the circular economy is not yet complete. Regulations related to the circular economy, particularly in agriculture, are under different laws and decrees, lacking guidance and standardization. There are no established regulations, criteria, or standards for identifying and evaluating technologies (biology, farming techniques, processing), and no prioritized list of technologies for CA models. In addition, there is no focal agency to oversee this issue, making implementation challenging. There is also a lack of regulations on corporate responsibilities for resource recovery from used products, as well as economic tools and policies such as natural resource taxes and environmental protection fees.

(3) The collection and processing rates of agricultural by-products to create added value are still low. The use of by-products remains simple and has not created high added value. The rate of factories using organic raw materials to produce organic fertilizer is still low, with only 43% of livestock waste and 33.2% of plant processing waste being utilized. In 2020, Viet Nam spent USD

952 million to import 3.8 million tons of fertilizer. Of the total 42.8 million tons of rice straw, only 56.3% is used for animal feed, mushroom cultivation, plant mulching, etc. A significant amount of straw is burned in the fields, causing air pollution and affecting human health and the environment. Experts estimate that if 158 million tons of agricultural by-products are well-exploited annually, there could be 40 million tons of organic fertilizer. The seafood by-product processing industry reached about USD 275 million in 2020, but fully exploiting nearly 1 million tons of seafood by-products with high technology could yield USD 4-5 billion from functional foods and cosmetics.

(4) High-tech circular economy models are not widely popular in Viet Nam and are only applied in limited fields and businesses. Developing the CE in the context of the 4.0 Industrial Revolution requires a knowledge economy and strong R&D capabilities. However, R&D activities in Vietnamese businesses are still limited. SMEs have difficulty investing in technological innovation. Agricultural enterprises are limited in recycling and reuse technology as well as capital and human resources. Many circular economy models are not closed or fully circular, lacking comprehensive design from the planning, investment, and construction stages.

(5) There is weak cohesion and participation among stakeholders in circular economy models, and a circular economy ecosystem in specific fields has not yet formed. There is a lack of connection between businesses in investing in technology, developing circular economy models in agriculture, and creating commercialized products. The connection between R&D organizations, universities, and businesses is also loose. The application of new digital technologies is limited to a few typical models and businesses with financial potential. However, these businesses have not created a significant spillover effect for SMEs and farming households. CA models are still sporadically deployed and have not yet formed an ecosystem that creates a high-value chain.

3. Current Status of Circular agriculture in some other APEC members

Circular agriculture is gaining momentum across APEC economies, driven by the need for sustainability, resource efficiency, and climate resilience. Each economy is at different stages of adopting circular agricultural practices, influenced by its unique environmental, economic, and social context. This section will provide a snapshot of the current status of circular agriculture in some key APEC agriculture-based APEC economies such as Australia, Japan, Korea, China, Chile, Mexico, Singapores, Thailand.

3.1. Australia

Australia has made significant strides in adopting circular agriculture practices, integrating these principles into various sectors to promote sustainability and resource efficiency.

Policy and Strategic Initiatives: The Australian government has recognized the importance of circularity in agriculture and integrated it into various policies, including waste management, resource recovery, and environmental sustainability. The Waste Policy Action Plan (2019)[8] and Australia's Agriculture Innovation Agenda [9]are two such frameworks promoting innovation in sustainable farming practices. Australia's strict biosecurity laws and practices also support circular agriculture by ensuring that recycling organic matter and using livestock feed from by-products are done in a way that minimizes disease and environmental risks

Collaboration and Knowledge Sharing: Australia has established research partnerships with universities and the private sector to advance circular agricultural practices. Initiatives like the Cooperative Research Centres (CRC) Program foster innovation in sustainable and circular farming techniques. Australia is also active in sharing knowledge and collaborating with other APEC economies to promote circular agriculture. Research and Standards Development: Australian institutions, such as the CSIRO, have been involved in developing standards and conducting research to support the adoption of circular economy practices across the Asia-Pacific region. This includes producing reports and organizing workshops to share best practices and innovations in circular agriculture. These initiatives demonstrate Australia's commitment to integrating circular agriculture into its farming practices, focusing on sustainability, resource efficiency, and resilience against environmental challenges. The success of these practices serves as a model for other economies looking to adopt similar approaches.

Key circular agriculture practices in Australia:

- Waste to Resource: In Australia's agricultural sector, considerable efforts are being made to transform organic waste, including crop residues, manure, and food processing by-products, into valuable resources. For instance, animal manure is used as organic fertilizer, reducing reliance on chemical inputs and enhancing soil health.
- Composting and Recycling: Farmers are increasingly adopting composting techniques, which recycle organic waste back into the soil, improving nutrient cycling and reducing landfill waste. Some regions also practice vermiculture (worm farming) to convert organic waste into rich compost for crops.
- Water Reuse and Efficiency: Given Australia's frequent droughts, water management is crucial. Circular agricultural systems often involve water reuse technologies, such as greywater recycling, and innovations like precision irrigation to minimize water waste.

Some key case studies of circular agriculture:

[8] https://www.agriculture.gov.au/sites/default/files/documents/national-waste-policy-action-plan-2019.pdf
[9] https://www.agriculture.gov.au/agriculture-land/farm-food-drought/innovation/national-ag-innovation-agenda

- Bega Cheese Ltd.: A prominent dairy company in Australia, Bega has embraced circularity by transforming by-products from cheese production into animal feed and bioenergy. This helps the company reduce waste and cut energy costs.
- Circular Cotton Farming: In the cotton industry, farmers are experimenting with using cover crops, crop rotation, and better water management to reduce waste and build healthier soil, which supports sustainable production in the long term.

3.2. Chile

Chile, a member known for its agricultural exports (fruits, wine, seafood, etc.), is integrating circular principles to reduce waste, recycle agricultural by-products, and improve the resilience of its farming systems in the face of environmental challenges like water scarcity and climate change. The member's experiences, particularly in wine production, organic farming, and water recycling, highlight the potential for circular practices to improve resource efficiency and reduce environmental impacts.

Policy and Strategic Initiatives: The Chilean government, through its Ministry of Agriculture and agencies like the Institute for Agricultural Development (INDAP), has been promoting sustainable agricultural practices, including circular agriculture, especially in rural and indigenous communities. The economy's policies like the Climate Change Adaptation Plan[10] for Agriculture include circular agriculture as a key tool for promoting sustainability and resilience. The government has also supported the development of organic farming and bio-inputs as part of the circular economy strategy. Chile's Strategy for Organic Waste Management (2021-2040) led by the Ministry of the Environment, aims to reduce organic waste through recycling and composting efforts, a key component of circular agriculture. Additionally, Chile's Circular Economy Roadmap by 2040, developed by the Ministry of Environment, focuses on promoting the circular economy across various sectors, including agriculture.

Key Practices in Circular Agriculture in Chile

- Waste-to-Energy and Biomass Recycling: Chile is a major producer of fruits and wine, both of which generate a significant amount of organic waste. Some wineries are increasingly converting grape pomace (the leftover grape skins, seeds, and stems) into biogas, bio-fertilizers, and compost. In the forestry sector, biomass from wood residues is often used to generate energy, supporting a circular system where waste is not discarded but utilized to produce renewable energy.
- Water Recycling and Conservation: Water scarcity is a major issue in Chile, particularly in the northern and, also, central regions. As a result, circular agriculture practices that focus on water recycling and efficiency are becoming

[10] https://www.greenclimate.fund/document/update-national-climate-change-adaptation-plan-nap-chile

essential. Drip irrigation, water recycling systems, and the reuse of treated wastewater are common practices in some agricultural areas.

- Organic Farming and Composting: Organic farming has seen a rise in Chile, supported by growing consumer demand for organic products both domestically and internationally. Chilean farmers use crop residues, manure, and food waste to produce compost, which is then applied to fields to enhance soil fertility and reduce the need for chemical fertilizers. This practice is especially common among smaller farmers.
- Agroecology and Traditional Knowledge: In rural and indigenous communities, agroecology plays a key role in promoting circular agriculture. Indigenous communities, especially in southern Chile, have long practiced forms of circular agriculture, using local resources efficiently and applying waste from one farming activity (such as animal manure) as inputs for another (like fertilizing crops).
- Bio-Fertilizers and Natural Pest Management: Chilean farmers are increasingly adopting the use of bio-fertilizers and natural pest control methods, which reduce the reliance on synthetic fertilizers and pesticides. Organic waste from farms is often used to produce these bio-inputs, closing the nutrient cycle. Additionally, the use of biological controls, such as beneficial insects and microbial products, is being promoted by both government and private sectors to manage pests in an environmentally friendly way.
- Circular Wine Production: Chile is one of the world's largest wine exporters, and the wine industry is leading the way in circular agriculture. Many vineyards are turning grape residues into compost, animal feed, or bioenergy.

Some key case studies of circular agriculture:

- Vallehermoso Farm: Located in the Maule Region, this farm uses composting to recycle organic waste into valuable soil amendments. By integrating composting into their practices, they’ve improved soil fertility and reduced dependency on synthetic fertilizers.
- AquaChile: This company, a major player in the aquaculture industry, has adopted water recycling practices in their fish farming operations. By treating and reusing water, they’ve reduced environmental impacts and conserved valuable water resources.
- Food Bank Network: Chile has developed a network of food banks that work to redistribute surplus food from farms and businesses to those in need. This practice not only reduces waste but also addresses food insecurity.
- Grape Marc Recycling: By-products from wine production, such as grape marc, are being converted into bioenergy and animal feed, reducing waste and creating additional revenue streams for wineries

3.3. China

The People's Republic of China achieved remarkable growth in agricultural production, but this has also led to declining quality of arable lands, soil degradation, eutrophication of surface water, and excessive nitrate in groundwater, amongst other problems that threaten long-term food security.[11] Circular agriculture practices have been increasingly adopted to address environmental concerns and improve resource efficiency.

Policy and Strategic Initiatives: The Chinese government has strongly promoted circular agriculture as part of its broader sustainability and rural development goals. The transformation to sustainable and low-carbon agriculture is one of the top priorities of the People's Republic of China. China's overarching policy framework for environmental protection and sustainable development is embodied in the concept of *Ecological Civilization* which promotes harmonious coexistence between humans and nature. Circular agriculture plays a central role in this framework, aiming to reduce environmental degradation, optimize resource use, and promote sustainability in the agricultural sector. The *Circular Economy Promotion Law* (2008) established a legal framework for the promotion of circular economic practices, including in the agricultural sector. *The Rural Revitalization Strategy* was developed in 2017 to emphasize the importance of developing rural areas. The strategy promotes sustainable and eco-friendly farming practices, including the adoption of circular agricultural systems. This is part of the government's effort to modernize agriculture, reduce rural poverty, and enhance food security while minimizing environmental impacts. Since then, the strategy has been expressed in numerous policies and reforms, including in the 2018-2022 Strategic Planning for Revitalization of Rural Areas, the 14th Five Year Plan covering 2021-2025, and the Rural Revitalization Promotion Law which continues to prioritize sustainable agriculture and circular agriculture. In February 2021, the State Council promulgated the *Guidance on Accelerating the Establishment of a Green Low-Carbon Circular Economic System*, which encourages the development of ecological farming and breeding and strengthens the certification and management of green food and organic agricultural products. It puts forward four key contents of the strategy: (i) developing eco-circular agriculture, (ii) increasing the utilization of livestock and poultry waste as resources, (iii) promoting the comprehensive use of crop straws, and (iv) strengthening the control of agricultural film pollution.

To encourage farmers to adopt circular agricultural practices, the Chinese government provides various subsidies and incentives to encourage the adoption of circular agricultural practices. Farmers receive financial support to set up biogas plants, use organic fertilizers, and adopt eco-friendly technologies. These subsidies make it easier for smallholder farmers to invest in sustainable infrastructure.

Along with many support policies, China has launched a number of initiatives such *"Zero-Waste Agriculture" projects* aimed at promoting full utilization of agricultural

[11] https://www.adb.org/sites/default/files/publication/843106/adb-brief-232-circular-agriculture-peoples-republic-china.pdf

resources and minimizing waste in rural areas. These projects are part of the government's broader "Zero-Waste City" initiative, which seeks to create a circular economy in various sectors.[12] China also has established several *eco-agriculture demonstration zones*, which serve as testing grounds for innovative circular farming methods. These zones encourage the adoption of eco-friendly technologies, resource recycling, and sustainable practices. Many of these zones are located in regions that face environmental challenges such as desertification, overuse of chemicals, or water shortages.

Key Practices in Circular Agriculture in China:

- Organic Fertilizers and Soil Health: The use of organic fertilizers is a critical aspect of circular agriculture in China. Farmers recycle livestock manure, crop residues, and food waste to produce compost and organic fertilizers. These inputs help improve soil fertility, restore nutrients, and reduce the dependence on chemical fertilizers that can degrade soil health and pollute water bodies.
- Livestock-Crop Integration: One common circular agricultural practice in China is the integration of livestock and crop farming. Livestock manure is composted and used to fertilize crops, while crop residues can be used as feed for livestock. This closed-loop system minimizes waste and improves resource efficiency. Regions with high livestock production, such as Inner Mongolia and Sichuan, have developed manure recycling systems that support local crop production.
- Biogas Production: Biogas plants, which convert animal waste and organic residues into renewable energy, are widely implemented in rural China. These systems provide energy for heating, cooking, and electricity, reducing rural reliance on fossil fuels. The remaining sludge from biogas production is used as organic fertilizer, creating a circular nutrient loop.
- Aquaponics and Aquaculture Integration: Aquaponics and integrated aquaculture are growing in China, particularly in regions with water scarcity. Fish farming waste, which is rich in nutrients, is used to fertilize plants in aquaponic systems. This reduces the need for synthetic fertilizers and creates a sustainable, symbiotic relationship between fish and crops.
- Water Recycling and Management: Efficient water use and recycling are critical for agricultural sustainability, especially in water-scarce regions of China. Precision irrigation systems, such as drip irrigation and sprinkler systems, are widely used to minimize water wastage by delivering water directly to plant roots. These systems are often integrated with nutrient recycling systems, reducing the overall need for external inputs
- Precision Agriculture and Smart Farming: China is heavily investing in smart agriculture to improve the efficiency of circular agriculture systems. Farmers

[12] https://www.sciencedirect.com/science/article/pii/S0956053X23002891

are increasingly using IoT-based systems and sensors to monitor soil moisture, nutrient levels, and crop health in real-time.

- Eco-Circulating Agriculture Parks: China has established several Eco-Circulating Agriculture Parks, which demonstrate the integration of multiple circular agriculture practices at a larger scale. These parks integrate livestock, crop farming, and aquaculture into a single system where waste from one component is used as input for another. For example, livestock manure is used to fertilize crops, while crop residues are used as feed for animals. Many of these parks utilize renewable energy systems, such as solar power and biogas, to reduce carbon emissions and create a more sustainable farming environment.

Some key case studies of circular agriculture:

- Precision Agriculture in Heilongjiang: Farmers in Heilongjiang Province have adopted precision agriculture technologies, such as GPS-guided machinery and data analytics. These technologies help optimize inputs like water and fertilizers, leading to more efficient and sustainable farming practices.
- Hebei Province – Livestock-Crop Integration: In Hebei Province, an integrated livestock and crop farming system has been established. Livestock waste is processed into organic fertilizer and used to fertilize local farms. This system has helped reduce chemical fertilizer use, improve soil health, and increase crop yields. The region’s focus on circular agriculture has also enhanced environmental sustainability and reduced water pollution.
- Jiangsu Province – Eco-Circulating Agriculture Park: In Jiangsu Province, an Eco-Circulating Agriculture Park has been established to demonstrate how circular agricultural systems can work on a large scale. The park integrates crop farming, livestock raising, and aquaculture into a closed-loop system. Organic waste from livestock is converted into energy and fertilizers, while aquaculture waste is used for crop irrigation. The park is a model for resource-efficient, eco-friendly farming.
- Hainan Province – Tropical Agriculture: Hainan Province, known for its tropical agriculture, has implemented circular agriculture techniques to manage the environmental impact of its farming practices. Farmers in the region use composting and biogas production to recycle organic waste from crops such as bananas and pineapples. The circular approach helps preserve soil quality, reduce chemical input, and promote biodiversity.

3.4. Japan

Japan, with its limited natural resources, has embraced circular agriculture to address its environmental challenges and improve food security. Japan has made significant progress in adopting circular agriculture practices, driven by its strong emphasis on sustainability, innovation, and resource efficiency.[13] The economy’s

[13] https://www.mdpi.com/2071-1050/16/2/596

approach to circular agriculture is marked by the integration of traditional farming techniques with modern technological innovations, aiming to create closed-loop systems that minimize waste and maximize resource use. The efforts in blend of traditional practices and modern technology, supported by strong government policies and community engagement make Japan a leader in sustainable agriculture, with practices that can serve as a model for other members seeking to implement circular agriculture.[14]

Policy and Strategic Initiatives: The Japanese government has actively promoted circular agriculture through various policies and programs. The government developed the Basic Plan for Food, Agriculture, and Rural Areas in 2020[15]. This plan promotes organic farming, efficient water use, and reducing agricultural waste. It aims to increase the organic farming area and promote sustainable farming techniques. The government also provides subsidies to farmers who adopt sustainable and circular practices, such as organic farming, renewable energy use, and waste recycling. Many local agricultural cooperatives in Japan facilitate the collective use of resources, such as shared machinery and knowledge-sharing platforms, to promote sustainable farming practices.

Research and Development: Japan invests heavily in research and development to improve circular agriculture practices. Institutions like the Japan Agricultural Research Organization (JARO) conduct studies on sustainable farming techniques, organic waste recycling, and resource-efficient technologies, providing valuable insights and innovations that are shared with the farming community.

Key Practices in Circular Agriculture in Japan:

- Eco-Friendly Fertilizer Use and Nutrient Cycling: Japanese farms frequently recycle organic waste, such as crop residues and animal manure, to create compost and organic fertilizers. This practice is common in both small-scale farms and large agricultural enterprises and is central to maintaining soil fertility without relying heavily on chemical inputs. For example, in regions like Hokkaido, large-scale dairy farms convert manure into compost and use it to fertilize pastures and crops, thereby closing the nutrient loop. In addition, Japanese farmers have Bokashi Composting method. This traditional Japanese method of composting involves fermenting organic waste using a mix of microorganisms. The resulting compost is rich in nutrients and enhances soil health, making it a popular technique among organic farmers in Japan.
- Water Recycling and Efficient Irrigation: In response to limited water resources, Japanese agriculture has increasingly adopted advanced irrigation systems, such as drip irrigation and micro-sprinklers, which significantly reduce water usage. Additionally, these systems often incorporate water recycling mechanisms to reuse runoff, particularly in greenhouse farming. In rice farming,

[14] https://eastasia.iclei.org/wp-content/uploads/2021/04/Circular-Food.pdf
[15] https://fas.usda.gov/data/japan-2020-basic-plan-food-agriculture-and-rural-areas

water is managed carefully through a series of irrigation channels and reservoirs, allowing for efficient water use and reducing waste. Techniques such as intermittent irrigation (aeration) are also used to reduce methane emissions and improve water efficiency

- Integration of Livestock and Crop Production: In Japan, livestock farming is often integrated with crop production, where waste from livestock, such as manure, is recycled as fertilizer for crops. This integration reduces the need for chemical fertilizers and helps maintain soil health. For instance, in the Kanto region, mixed farming systems are common where livestock waste is used to enrich the soil for vegetable production, creating a closed-loop system that benefits both livestock and crops.
- Urban-Rural Circular Systems: Japan has also promoted urban-rural collaborations where organic waste from cities is processed and used as fertilizer in rural areas. This reduces waste in urban centers and supports sustainable farming practices in rural regions.
- Technological Innovations and Smart Farming: Japan is a leader in incorporating technology into agriculture, with innovations like AI-driven systems that monitor and optimize crop growth, water usage, and waste management. These technologies contribute to circular agriculture by improving efficiency and reducing resource inputs. Especially, many Japanese greenhouses use closed-loop systems where water, nutrients, and energy are recycled within the system. These greenhouses often employ hydroponic or aquaponic techniques, where fish farming is combined with plant production, using fish waste to fertilize plants and plants to purify the water for the fish.

Some key case studies of circular agriculture:

- Eco-Farmers: Japan has designated certain farmers as "Eco-Farmers" who use organic methods and aim to recycle agricultural resources. These farmers often serve as models for sustainable practices in their regions.
- Toyama Prefecture: This region has become a leader in promoting sustainable circular agriculture, combining rice farming with fish cultivation (such as loach and carp) in the same paddies. This integrated approach boosts biodiversity and provides an additional source of income for farmers.
- Biogas Plant in Iwate Prefecture: This plant converts manure from local dairy farms into biogas, which is then used to generate electricity. The residue from the process is used as fertilizer, closing the nutrient loop.

3.5. Korea

Agriculture in Korea is a blend of centuries-old traditions and contemporary techniques adapted to a variety of environmental conditions, making it a model to adopt in the effort to future-proof food production against climate change. Korea has been actively pursuing circular agriculture practices as part of its broader commitment to sustainability and environmental conservation. Korea’s approach to circular agriculture is characterized by a strong focus on waste recycling, efficient resource use, and government support.

Policy and Strategic Initiatives: The Korean government has implemented various policies under its Green Growth Strategy to promote circular agriculture. These policies include subsidies for organic farming, incentives for waste recycling, and support for the adoption of renewable energy in agriculture. The Korean New Deal, announced in Korean on July 14 2020, plans to invest total 160 trillion won (114.1 trillion won worth of fiscal investment) to create 1,901,000 jobs by 2025. Korea's Green New Deal emphasizes sustainable development and eco-friendly practices across multiple sectors, including agriculture.[16] The Korean New Deal aims to transform the economy to make it greener, with more digital services and stronger safety nets, implemented through fiscal support for pump priming and improved regulations to promote the private sector. The plan promotes circular agriculture by supporting organic farming, reducing chemical inputs, and increasing the use of renewable energy in farming practices. In term of organic farming, Korea has set specific targets for expanding organic farming as part of its broader goal to promote sustainable agriculture. The government offers subsidies and technical support to farmers who adopt organic methods, which are a critical component of circular agriculture. The Korean government has also invested in biogas and biomass energy production through incentives and infrastructure development. This is aimed at converting agricultural waste, particularly from livestock farms, into renewable energy. The energy produced is used to power farms, and the residue is used as organic fertilizer. The Ministry of Agriculture, Food and Rural Affairs (MAFRA) runs programs to promote soil health and efficient nutrient management. This includes encouraging the use of compost and organic fertilizers produced from agricultural waste, contributing to the overall goals of circular agriculture.

Research and Development: Korea invests in research and development to improve agricultural sustainability. Universities and research institutions collaborate with farmers to develop and implement circular agriculture practices, focusing on innovations such as precision farming, waste recycling technologies, and sustainable soil management.

Key Practices in Circular Agriculture in Korea

- Organic Waste Recycling and Composting: Korea is known for its effective food waste recycling systems. Food waste from urban areas is collected, processed, and converted into animal feed or compost. Farmers in Korea commonly use composting to manage crop residues and animal manure. These organic wastes are composted and applied back to the fields, enhancing soil fertility and structure. The government supports these practices through subsidies and

[16] https://www.iea.org/policies/11514-korean-new-deal-digital-new-deal-green-new-deal-and-stronger-safety-net

technical assistance, encouraging farmers to adopt sustainable waste management strategies.

- Smart Farming Technologies: Korea has been at the forefront of integrating technology into agriculture. Smart farming systems, such as precision agriculture and IoT (Internet of Things), are used to optimize water and fertilizer use, reducing waste. Greenhouse farming, equipped with sensors and automated systems, is also widely adopted to enhance resource efficiency.
- Bioenergy from Manure: Some farms in Korea are using anaerobic digestion to convert livestock manure into biogas, which can be used for energy production. This not only reduces greenhouse gas emissions but also provides a renewable energy source for farming operations.
- Urban Agriculture and Vertical Farming: Urban farming initiatives are being developed in cities like Seoul. Seoul's food waste management system is a successful example of circular agriculture, where food is converted into fertilizers and used in urban farming projects. [17] Vertical farming techniques, which use minimal space and recycle water and nutrients, are being explored to enhance food security and sustainability in urban environments.

Some key case studies of circular agriculture:

- Eco-Friendly Farming Villages: In some rural areas, Korea has established eco-friendly farming villages that operate on circular agriculture principles. These villages use organic farming methods, recycle waste, and produce their own renewable energy. The success of these villages has demonstrated the viability of circular agriculture as a sustainable model for rural development.
- Jeju Island's Livestock and Crop Integration: Jeju Island is known for its integrated farming system that combines livestock and crop production. Livestock manure is used to fertilize tangerine orchards, reducing reliance on chemical fertilizers. This circular approach has improved soil health and reduced waste while boosting the local economy.
- Biogas Plant in Gyeonggi Province: A biogas plant in Gyeonggi Province is an example of successful circular agriculture. The plant converts livestock manure into biogas, which powers the local electricity grid. The leftover sludge is used as a high-quality organic fertilizer, which is then distributed to nearby farms.
- Seoul Urban Farm Initiative: In Seoul, urban farms have been established with a circular approach, where organic waste from households is composted and used to fertilize crops. This initiative has created a self-sustaining system, reducing food waste and promoting local food production.

[17] https://eastasia.iclei.org/wp-content/uploads/2021/04/Circular-Food.pdf

3.6. Peru

Peru has a diverse agricultural sector with a variety of crops and production systems. The member's agriculture includes staple crops like potatoes, maize, and quinoa, as well as cash crops such as coffee, cocoa, and asparagus. The sector plays a crucial role in the economy, contributing to both food security and export revenues. Given Peru's diverse geography, including the Amazon rainforest, Andean highlands, and coastal deserts, circular agricultural practices are seen as critical for maintaining biodiversity and ensuring sustainable agricultural production.

Policy and Strategic Initiatives: The Strategy on Climate Change (ENCC) 2015[18], developed by Peru's Ministry of Environment (MINAM), integrates circular agriculture as part of the member's response to the challenges posed by climate change, particularly in the agricultural sector. Peru's Agricultural Policy 2021 - 2030 provides a strategic framework for sustainable agricultural development, with a strong emphasis on sustainable and circular farming practices. It sets goals for improving resource use efficiency, reducing environmental impacts, and increasing agricultural resilience. Especially, Agroecology is also being promoted as a strategy for sustainable development, particularly among smallholder and indigenous farmers in the highlands and Amazonian regions. Peru has developed an Agroecology Plan that seeks to promote agroecological practices, which align closely with circular agriculture principles. Agroecology focuses on creating closed-loop systems that mimic natural ecosystems, enhancing soil health, reducing external inputs, and increasing biodiversity on farms. The government promotes agroecological zones and provides financial incentives for farmers who adopt agroecological practices, including crop rotation, organic fertilization, and the use of natural pest control methods. These practices are intended to create sustainable and circular farming systems that rely less on chemical inputs and fossil fuels. Additionally, Peru's Circular Economy Roadmap for Sustainable Development (2020-2030), spearheaded by MINAM, includes agriculture as a key sector for adopting circular economy practices. The roadmap outlines specific actions to reduce agricultural waste, improve resource efficiency, and create closed-loop systems where waste from one process is used as inputs for another.

Key Practices in Circular Agriculture in Peru

- Agroforestry and Biodiversity Conservation: Indigenous farmers in the Amazon use traditional knowledge in agroforestry, creating self-sustaining, circular systems where waste from crops and animals is used as organic fertilizer, and the forest ecosystem is maintained.
- Composting and Organic Fertilizer Production: The coffee and cocoa sectors have implemented composting techniques to recycle waste from processing (such as coffee pulp and cocoa husks), which is used to fertilize the crops, creating a closed-loop system that reduces waste and input costs.

[18] https://climate-laws.org/document/national-strategy-on-climate-change-to-2050-encc_94c4

- Water Management and Recycling: Water scarcity is a significant challenge, particularly in coastal areas where much of Peru's agro-export crops like avocados and asparagus are grown. Circular agriculture practices in water management include the use of drip irrigation and water recycling technologies. In the Andean highlands, traditional water management systems, known as amunas, are being revived. These systems capture and store rainwater, which is later used to irrigate crops, contributing to circularity in agriculture by efficiently using natural water resources.
- Waste-to-Energy Projects: Peru has started to explore biogas production and other waste-to-energy solutions in its agricultural sector. Organic waste from livestock farms and agro-industrial processing (such as sugarcane or rice husks) is used to generate biogas, which can be used for cooking, heating, or even powering farm equipment.
- Circular Systems in Indigenous Agriculture: Indigenous communities in the Andes and Amazon regions have long practiced circular agriculture, rooted in their traditional knowledge. They employ crop rotation, polyculture (growing multiple crops in the same field), and the recycling of organic materials to create self-sustaining farming systems.
- Organic Farming and Agroecology: Agroecology is a key part of Peru's circular agriculture experience. Farmers, particularly smallholders, are embracing organic farming techniques that focus on natural pest control, organic fertilization, and the sustainable management of ecosystems. The government and international organizations have promoted agroecology through training programs and grants, encouraging the adoption of sustainable practices that maintain circular cycles within farms.

Some key case studies of circular agriculture:

- Quechua people practice chakra farming, which involves rotating crops and integrating animals into farming cycles. Waste from animals is used to fertilize crops, and crop residues are used to feed the animals, closing the loop in their agricultural systems.
- Indigenous communities in the Andean highlands have been practicing agroecology for centuries, which naturally incorporates circular agricultural principles. These practices are based on deep knowledge of the local ecosystem and aim to create sustainable, self-sufficient farming systems. Farmers grow multiple crops in the same field, such as quinoa, potatoes, and corn. This practice enhances soil fertility, prevents pest outbreaks, and minimizes the need for external inputs.
- Coffee Production in Cajamarca and San Martín regions: Coffee pulp, a by-product of coffee processing, is composted to create organic fertilizer. Some coffee producers are using coffee waste to produce biogas. The coffee pulp is anaerobically digested to generate biogas, which is used for cooking or heating.

The remaining sludge from the process is further used as a bio-fertilizer for crops.

3.7. Singapore

Circular agriculture in Singapore is gaining momentum as part of the member's overall sustainability efforts. With just 1% of Singapore's land set aside for farming given the many competing land needs, the agri-food industry will need to significantly uplift its productivity in the coming years. Given its limited arable land, reliance on food imports, and focus on high-tech solutions, Singapore is positioning circular agriculture as a critical strategy to enhance food security, reduce waste, and improve sustainability in its agri-food systems. The member's approach to circular agriculture is innovative, leveraging technology and urban farming techniques to maximize resource efficiency and reduce waste.

Policy and Strategic Initiatives: The government's Green Plan 2030[19] launched in 2021, emphasizes sustainability across sectors, including agriculture. These include increasing local food production through innovative urban farming methods, reducing food waste, and improving resource efficiency in agriculture. The plan supports the growth of the agri-tech sector and encourages the adoption of circular practices across all levels of food production. Singapore's 30 by 30 initiative [20] aims to produce 30% of its nutritional needs locally by 2030. Circular agriculture plays a key role in this by minimizing resource inputs, reducing waste, and reusing by-products. The Government also aims to improve Singapore's overall recycling rate to 70% by 2030. The inaugural Zero Waste Masterplan21 was launched in 2019, and set an additional target to reduce the amount of waste sent to the landfill each day by 30% by 2030. This requires the recycling of food waste into useful resources like compost and animal feed.

Research and Innovation: Singapore is investing heavily in agri-tech to enhance circular agriculture practices. Technologies such as precision farming, automated systems for waste management, and AI-driven monitoring systems are used to optimize resource use and reduce waste. These innovations are crucial for maximizing agricultural output in a land-scarce environment. Singapore has become a hub for agri-tech innovations that support circular agriculture. Research institutions like the Singapore Food Agency (SFA) and Agri-Food & Veterinary Authority of Singapore (AVA) are heavily involved in advancing sustainable farming technologies. The development of urban farms and vertical farming systems is a key feature of Singapore's agriculture, with an emphasis on reducing inputs like water, fertilizers, and energy while recycling waste and other resources. The Singapore Institute of Food and Biotechnology Innovation (SIFBI) is exploring ways to use food waste for biofuel, animal feed, and other value-added products, contributing to the circular economy.

[19] https://www.greenplan.gov.sg/
[20] https://www.ourfoodfuture.gov.sg/30by30/
[21] https://www.mse.gov.sg/resources/zero-waste-masterplan.pdf

Private Sector and Start-Up Ecosystem: The Singapore government provides funding and incentives for businesses and startups involved in circular agriculture. Grants and subsidies are available for projects that focus on waste reduction, resource efficiency, and the development of sustainable farming technologies. Therefore, Singapore is home to a growing number of start-ups and companies focused on circular agriculture. Companies like Sustenir Agriculture, Insectta, and Comcrop are leading the way in adopting closed-loop systems where waste from one part of the system is reused as an input in another. Insect farming, particularly black soldier flies, is gaining traction as a sustainable method for converting food waste into insect protein for animal feed or fertilizer. Food waste recycling companies like Agrocorp International are developing methods to convert food by-products into value-added items such as energy, organic fertilizers, and animal feed.

Key Practices in Circular Agriculture in Singapore

- Aquaponics and Hydroponics Systems: Many urban farms in Singapore use hydroponic and aquaponic systems, which allow for water recycling and the efficient use of nutrients. Aquaponics, for example, combines fish farming with plant cultivation, where fish waste provides nutrients for plants, and plants help filter and clean the water for the fish. This closed-loop system exemplifies circular agriculture in an urban setting
- Vertical and Urban Farming Given its space constraints, Singapore has pioneered vertical farming, which allows for the efficient use of urban spaces for agriculture. Vertical farms in Singapore, such as those operated by companies like Sky Greens, use minimal land while maximizing output. These farms often integrate circular practices by recycling water and nutrients within the system, reducing waste and enhancing sustainability.
- Food Waste Recycling and Composting: (1) Food Waste Initiatives: Singapore has implemented extensive food waste recycling programs as part of its Zero Waste Masterplan. Organic waste from households, restaurants, and food processing facilities is collected and converted into compost or animal feed. The compost is then used in urban farms and gardens across the city, promoting circularity in food production. (2) Community Composting Projects: Several community-led initiatives in Singapore focus on composting food waste. These projects are often part of urban farming efforts, where residents are encouraged to compost their organic waste, which is then used to fertilize community gardens. These initiatives help reduce waste at the source and support local food production.
- Integration of Wastewater Recycling: Water conservation is essential in Singapore’s agricultural systems. Farms often recycle wastewater, which is treated and reused to irrigate crops. This practice is particularly important in hydroponic and aquaponic systems.

- Waste-to-Energy and Biogas Production: Some urban farms are integrating biogas systems that convert organic waste into energy, providing a renewable energy source to power farming operations.
- Insect Farming: Some companies transform food waste into high-protein animal feed or organic fertilizer. Black soldier flies, for instance, are efficient converters of organic waste into valuable proteins.

Some key case studies of circular agriculture:

- Urban Farm Integration: Citizen Farm in Singapore is a notable example of circular agriculture in an urban environment. The farm uses a closed-loop system where waste is minimized and resources are recycled. It integrates various urban farming methods, including aquaponics, mushroom cultivation on food waste, and composting. Citizen Farm serves as a model for sustainable urban agriculture and demonstrates how circular practices can be successfully implemented in a dense city environment.
- Companies like Insectta use food waste to breed black soldier flies, which not only help manage food waste but also produce protein feed for livestock and organic fertilizers for crops.
- Sky Greens, one of the pioneers in vertical farming, operates a circular farm where organic waste is composted, and energy is conserved through low-energy farming systems.

3.8. Thailand

Thailand has been actively adopting circular agriculture as part of its efforts to promote sustainable farming, enhance resource efficiency, and reduce environmental degradation. This shift is aligned with the member's Sufficiency Economy Philosophy (SEP) initiated by King Bhumibol Adulyadej in the late 1970s [22], which emphasizes sustainable development, moderation, and resilience. Circular agriculture in Thailand involves practices that recycle resources, reduce waste, and support environmental and economic sustainability in agriculture.

Policy and Strategic Initiatives: Thailand has integrated circular agriculture into development policies, with the government playing a significant role in promoting sustainability and environmental conservation in agriculture. The SEP underpins much of Thailand's sustainable development initiatives, encouraging farmers to focus on moderation, prudent resource management, and environmental protection. This philosophy directly supports the adoption of circular agriculture practices, emphasizing the need to reuse resources, reduce dependency on external inputs, and maintain ecological balance. Especially, the Thai Government determines to drive Thailand towards "Thailand 4.0"[23] by establishing the 20-Year Strategy (2017–2026) through a

[22] https://www.chaipat.or.th/eng/concepts-theories/sufficiency-economy-new-theory.html
[23] https://www.industry.go.th/web-upload/1xff0d34e409a13ef56eea54c52a291126/m_magazine/12668/373/file_download/b29e16008a87c72b354efebef853a428.pdf

roadmap consisting of six main strategies. This I strategy also promotes technology-driven agriculture with an emphasis on smart farming and eco-friendly practices. Circular agriculture aligns with the goals of Thailand 4.0, which seeks to modernize agriculture and make it more sustainable and resource-efficient.

Additionally, Thailand introduced the Bio-Circular-Green (BCG) Economy Model in 2021[24] as part of its strategy to enhance sustainability across sectors, including agriculture. The model promotes the bioeconomy, which includes using biological resources efficiently, circular economy, which focuses on recycling and reusing materials, and the green economy, which aims to reduce environmental impacts. Circular agriculture fits within this model as it promotes resource cycling, waste minimization, and sustainable farming practices.

The Thai government has been actively promoting circular agriculture through a variety of programs and initiatives. The government offers subsidies for organic farming, biogas production, and water management systems. These financial incentives help farmers transition to more sustainable and circular practices. Agricultural extension services and training programs educate farmers on circular agriculture practices, such as composting, organic farming, and integrated pest management. These programs aim to increase awareness and adoption of sustainable practices at the local level.

Key Practices in Circular Agriculture in Thailand:

- Organic Farming and Composting: Thailand has made significant strides in promoting organic farming, where farmers rely on natural inputs and recycle organic materials, such as crop residues and animal manure, as fertilizers. Composting is widely practiced to improve soil fertility and reduce the need for chemical fertilizers. Many farmers use compost made from rice husks, straw, and kitchen waste to enrich the soil.
- Rice Farming Systems: In Thailand's rice paddies, especially in the Central Plains, farmers often raise fish or ducks alongside their rice crops. These animals help control pests, reduce the need for chemical inputs, and provide additional food and income. Waste from the animals is naturally incorporated into the system as fertilizer.
- Community-Based Farming Models: Thailand has implemented community-based circular agriculture projects that promote sustainable farming practices at the local level. These projects, often supported by government and NGOs, aim to improve rural livelihoods while protecting the environment. These projects focus on integrated farming systems, water management, and agroforestry, all of which align with circular agriculture principles. They emphasize the reuse of resources, waste recycling, and minimizing chemical inputs to improve long-term sustainability. Many rural communities in Thailand have adopted organic farming practices as part of a circular economy. In these

[24] https://www.bcg.in.th/eng/background/

villages, farmers produce their own organic fertilizers and pesticides from local resources, reducing costs and environmental harm. Composting organic waste and recycling nutrients back into the soil are key practices in these model villages.

- Agroforestry and Multi-Cropping: In some regions, fruit farmers practice agroforestry, where fruit trees are planted alongside other crops or trees. This system promotes biodiversity, improves soil health, and helps create a balanced ecosystem that reduces the need for chemical inputs. Additionally, some fruit farms practice multi-cropping by growing multiple types of fruits together or incorporating other crops like herbs or vegetables. This practice enhances nutrient cycling, increases farm productivity, and reduces the risk of pests and diseases.
- Biodegradable Packaging: In response to global concerns about plastic waste, fruit exporters in Thailand are increasingly using biodegradable and eco-friendly packaging made from agricultural residues like rice husks, coconut fibers, and even fruit waste. This reduces the environmental impact of packaging and supports the member's circular economy goals.

Some key case studies of circular agriculture:

- Integrated farming in Chiang Mai: In northern Thailand, the Royal Project in Chiang Mai promotes integrated farming, organic agriculture, and water management practices. Farmers in the region have adopted crop-livestock integration and composting systems, helping them achieve sustainability and higher productivity.
- Pineapple Circular Agriculture in Prachuap Khiri Khan: Some pineapple processing facilities have started converting pineapple waste, such as peels and pulp, into biogas. This renewable energy source is used to power the plants or for cooking in local households. Pineapple pulp, which was previously discarded, is now used as a nutritious feed for livestock, further reducing waste and creating a closed-loop system.
- Durian Waste Recycling in Chanthaburi: Durian peels, which constitute a large portion of the fruit's waste, are now being composted and used as organic fertilizers for durian trees and other crops. Durian seeds are now processed into durian seed flour which is used in food processing, adding value to what was once an underutilized by-product. Some durian processing plants are exploring the conversion of durian peels into biogas. This renewable energy source powers local operations and contributes to sustainability efforts.

V. GOOD PRATICE MODELS OF CIRCULAR AGRICULTURE IN VIET NAM AND OTHER APEC ECONOMIES

1. Biomass Town Concept, Japan

Summary: Oki Town's food waste biomass project transforms food waste into biogas and organic fertilizers, promoting local farming. This circular model reduced greenhouse gas emissions and created economic benefits through community-driven stakeholder engagement.

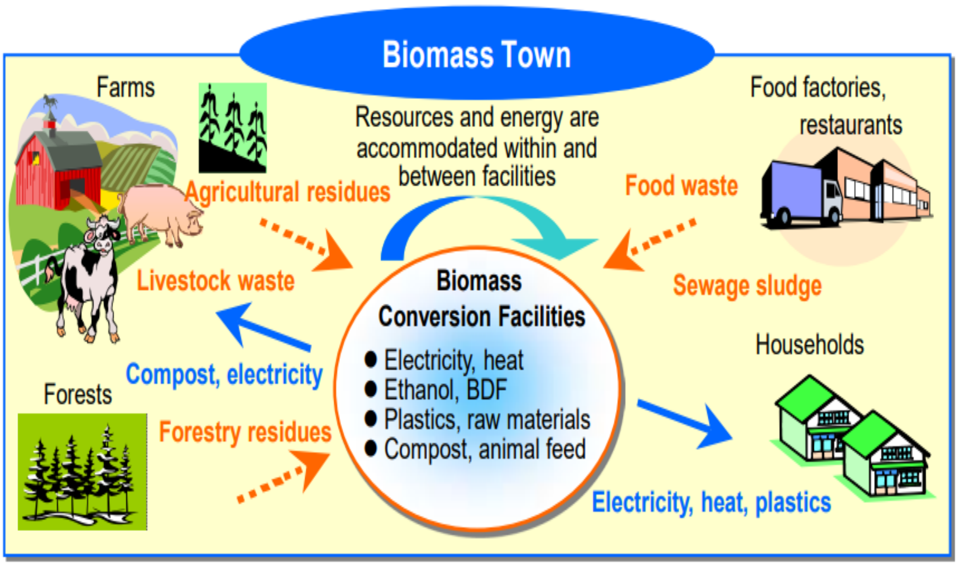
Innovation Approach: Integrating waste management and agriculture, food waste is converted into energy and fertilizers used in local farming. Residents, farmers, and businesses participate actively, promoting education and tourism around sustainable practices.

Benefits and Impacts: Economic gains come from reduced waste management costs and new revenue streams from biogas and crops, with a 149% increase in gross margin. Environmentally, emissions were cut by 105%, and social benefits include improved community involvement and educational opportunities.

Scale of Implementation: Implemented regionally in Oki Town, involving various stakeholders from waste collection to crop production. Scalable to other regions facing similar waste management challenges.

Lessons Learned: Localized approaches can optimize resources and ensure community involvement is crucial. Partnerships between governments, businesses, and residents enhance sustainability and regional development.

Figure 8 Concept of "Biomass town" in Japan



2. Wastes to profit in livestock industries, Australia

Summary: The initiative turns organic livestock waste into energy, bio-based materials, and fertilizers, leveraging advanced microbial technologies to support a sustainable livestock sector.

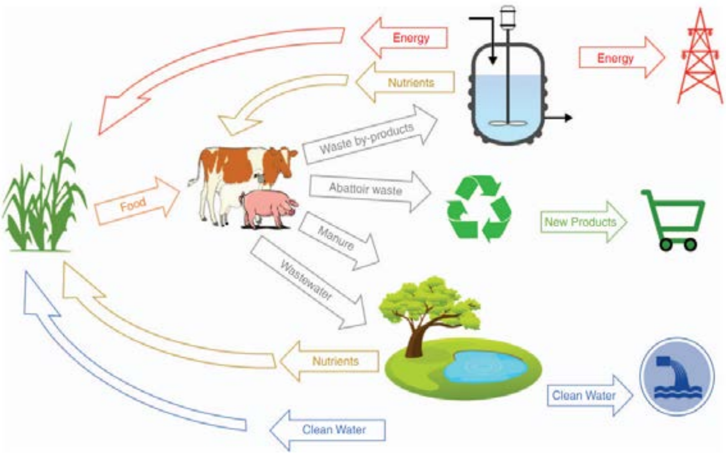
Innovation Approach: Technologies like anaerobic digestion and microbial transformation create biogas and animal feed, turning waste into valuable resources and reducing landfill reliance.

Benefits and Impacts: Economically, the model saves AU$200 million in waste disposal costs and generates AU$140 million in revenue. Environmentally, it reduces GHG emissions by using biogas and organic fertilizers, while socially, it creates jobs and meets consumer demand for sustainable practices.

Scale of Implementation: Applied across large-scale livestock operations in New Zealand, with potential for adaptation in other livestock industries globally.

Lessons Learned: Collaboration between industry, technology innovators, and policymakers is critical, as is educating stakeholders on the benefits of waste recovery.

Figure 9 A circular economy approach to livestock industry wastes in Australia



Source: Ramirez J., McCabe B., Jensen P.D., et al. (2021)

3. Circular Agriculture System based on the Integration of Maize and Cattle, Indonesia

Summary: An integrated model where maize residues feed cattle, and cattle manure fertilizes maize fields. The system, applied in West Kalimantan, increases productivity and income while aligning with circular economy principles.

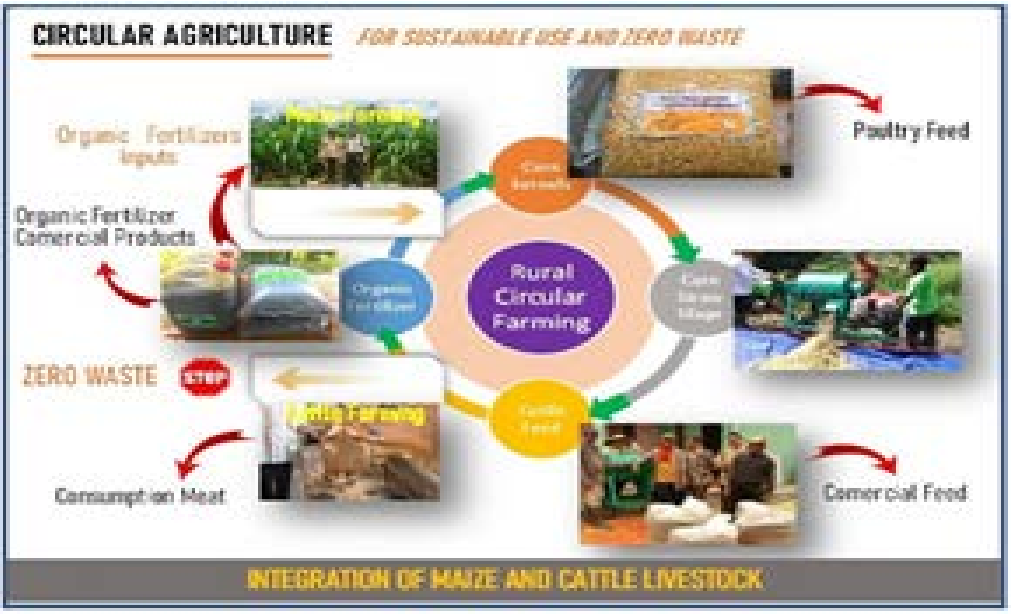
Innovation Approach: Zero-waste farming integrates crop and livestock sectors, with by-products recycled into animal feed and fertilizers, enhancing sustainability and productivity.

Benefits and Impacts: Farmers' incomes rose by 208%, and maize yield increased by 62%. The system reduces fertilizer and feed costs, promotes sustainable land use, and supports community resilience through capacity building.

Scale of Implementation: Implemented over 300 hectares, involving 558 farmers in West Kalimantan. Scalable to other regions with similar agro-climatic conditions.

Lessons Learned: Community participation and knowledge sharing are key to adoption. Strengthening local institutions enhances sustainability, while government support is essential for scalability.

Figure 10 Integration of maize and cattle livestock



4. Renewable Energy Development of Wood Pellets as an Implementation of a Circular Economy, Indonesia

Summary: Using Soft System Methodology, Indonesia optimizes biomass waste for renewable wood pellet energy production.

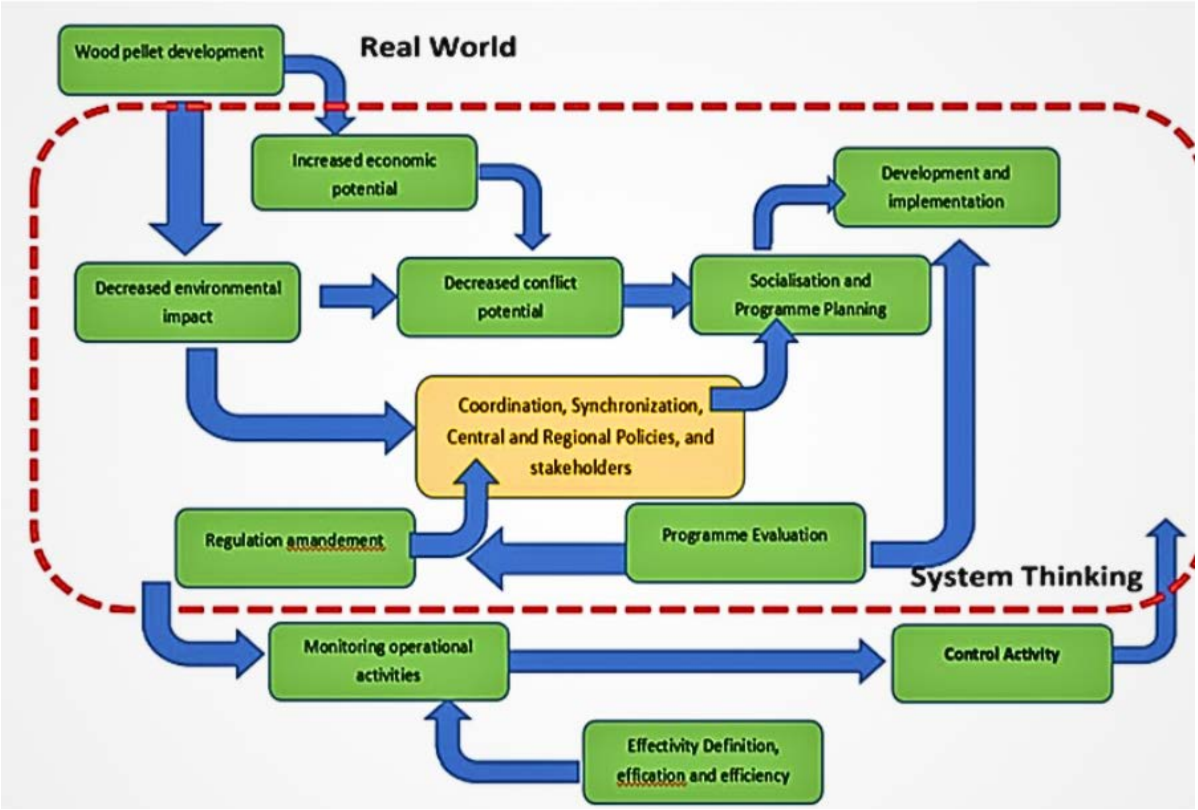
Innovative Approach: Stakeholders use CATWOE analysis for decision-making, engaging government and private sectors to enhance wood pellet production from biomass waste.

Benefits & Impact: Economic gains from reducing waste and creating renewable energy; environmental improvements by reducing landfill use and promoting recycling; socially, the model increases local job opportunities.

Scale of Implementation: Focused on small and medium enterprises, the model is adaptable to different regions.

Lessons Learned*: Systematic, stakeholder-focused methods ensure sustainability and scalability.*

Figure 11 Conceptual model for developing wood pellets as renewable energy



Source: Rimantho, D. (2024)

5. Recycling Practice in the Livestock Industry, Chinese Taipei

Summary: LonSen Farm in Chinese Taipei recycles pig manure into biogas and organic fertilizers, transforming a polluting farm into a net-zero carbon emitter.

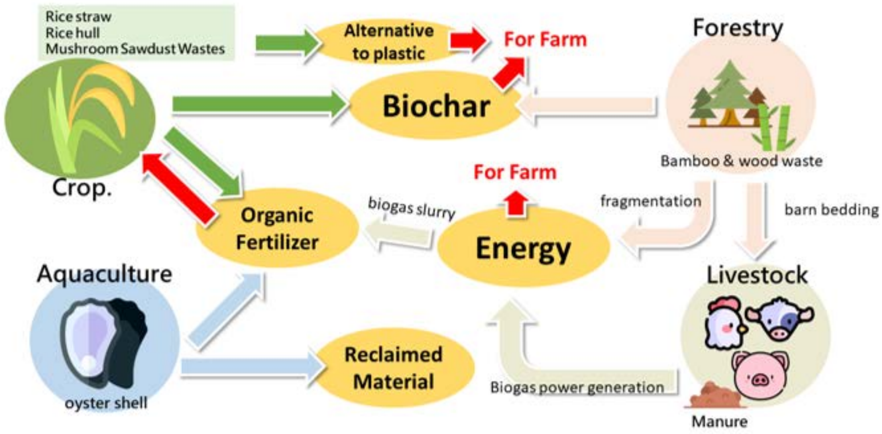
Innovative Approach: IoT-based systems and sustainable waste management practices drive this circular economy model.

Benefits & Impact: Economically, it reduces costs by transforming waste into resources. Environmentally, it reduces greenhouse emissions and reliance on fossil fuels. Socially, it fosters collaboration and community engagement.

Scale of Implementation: Implemented on a large scale, with potential for broader regional applications.

Lessons Learned: Combining technology with community collaboration achieves sustainable farming.

Figure 12 Agricultural by-products' circular model in Chinese Taipei



Source: Chinese Taipei Council of Agriculture

6. Agricultural By-Products for Energy in sugarcane sector, Son La, Viet Nam

Summary: Sugar companies in Sơn La, Thanh Hoa, and Nghe An have adopted circular production models, utilizing by-products from sugarcane processing, especially bagasse, to generate electricity and organic fertilizers. Companies like Nghe An Sugar Company (NASU) in Nghe An and Lam Son Sugar Joint Stock Company in Thanh Hóa use bagasse to produce electricity, fertilizers, and ash, contributing to both environmental sustainability and economic growth.

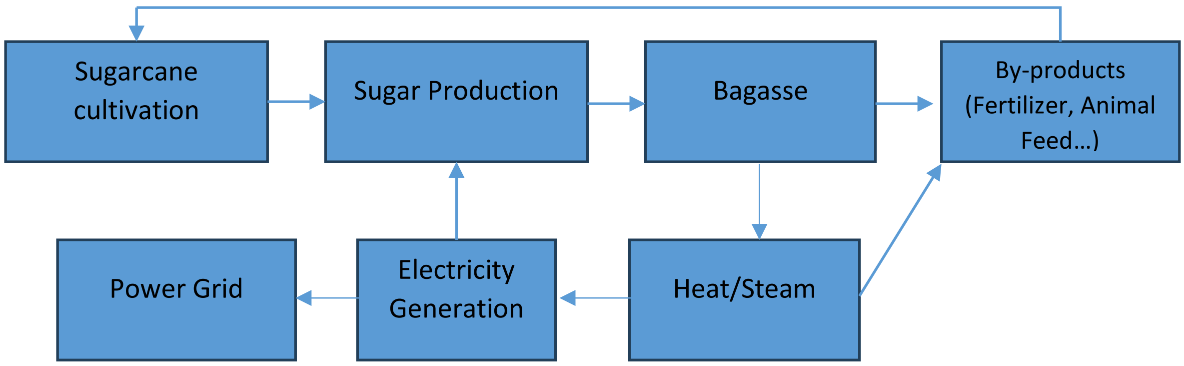
Innovative Approach: Viet Nam's sugar industry has adopted bagasse-based power generation, reducing costs and reliance on fossil fuels. Companies like Lam Sơn use bagasse to generate electricity for internal use and the grid, also earning carbon credits under the Clean Development Mechanism (CDM), boosting their competitive edge.

Benefits & Impact: (1) Economic: Bagasse offers a free and steady fuel supply, reducing raw material and transportation costs. Each ton of sugarcane can generate up to 100 kWh of electricity, with NASU generating VND 61.5 billion from electricity sales. This model enhances economic efficiency and opens investment opportunities in renewable energy. (2) Environmental: Bagasse-based electricity reduces reliance on fossil fuels, cuts CO_2 emissions, and minimizes waste. It improves waste management, supports natural resource conservation, and contributes to sustainable development. (3) Social: It creates jobs in rural areas, reduces pollution, and enhances public health.

Scale of Implementation: The model can be applied beyond sugar mills, including rice milling and coffee processing. However, Viet Nam's lower price for cogenerated electricity from bagasse limits wider adoption.

Lessons Learned: Bagasse has great potential as a biomass source, but policy adjustments and investments in technology are needed to fully realize its benefits and expand renewable energy production.

Figure 13 Schematic overview of the cicular sugar production



Source: Synthesis from the research team

7. Maize Biomass for Livestock Feed – Son La and Dak Lak, Viet Nam

Summary: The maize biomass model supports sustainable livestock feed production, using fast-growing maize that matures in 85-90 days. The entire plant is processed into silage or pellets for cattle, creating a circular system where dairy farm waste fertilizes the maize. Piloted across 8 hectares in Sơn La and Đắk Lắk, the model optimizes yields, improves soil health, and reduces CO2 emissions.

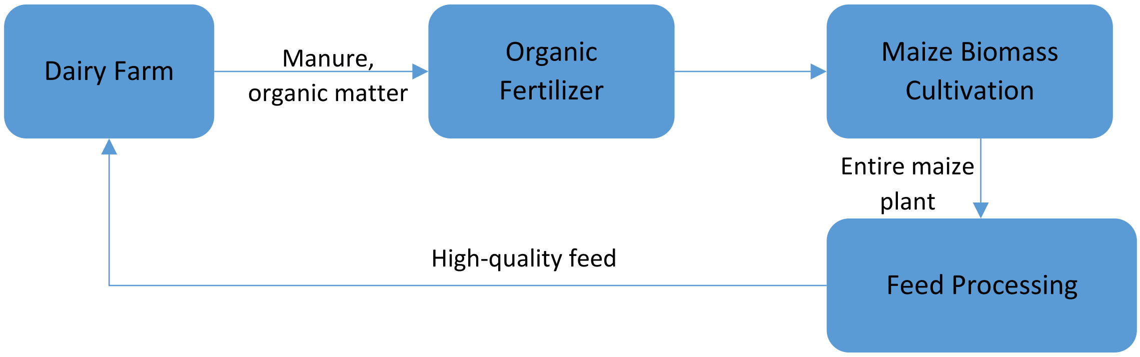
Innovative Approach: The model integrates maize cultivation with organic fertilizers from dairy farms, forming a closed-loop system. Dairy waste is repurposed to fertilize maize, which is then processed into livestock feed, reducing waste and boosting sustainability.

Benefits & Impact: Organic fertilizers cut chemical costs, increasing maize yields and lowering feed costs for dairy farms. Farmers can earn up to VND 18 million per hectare— VND 6 million more than traditional maize. The model reduces reliance on chemical fertilizers and cuts greenhouse gas emissions through efficient waste management. It supports rural livelihoods by diversifying crops, creating jobs, and improving food security.

Scale of Implementation: Adaptable for both small and large scales, especially in dairy farming regions like Mộc Châu, the model can be expanded to cover larger areas due to its short harvest cycle and high productivity.

Lessons Learned: Key insights include the benefits of integrating organic fertilizers, the economic viability of maize biomass, and the need for better pricing mechanisms to encourage wider adoption. Effective implementation requires adequate investment and scalability across regions.

Figure 14 Schematic overview of the Circular Economy Model for Biomass Maize Cultivation



Source: Synthesis from the research team

8. Combined crop and aquaculture farming (rice–shrimp model) – Mekong Delta, Viet Nam

Summary: Due to climate-induced saltwater intrusion in the Mekong Delta, farmers have adopted the "1 rice crop - 1 shrimp crop" model. During the dry season, saltwater is used to farm shrimp, while in the rainy season, stored rainwater is used for rice and freshwater shrimp cultivation. This model improves incomes, reduces farming costs, and supports environmental sustainability. It has been adopted across 190,000 hectares, producing 100,000 tons of shrimp annually.

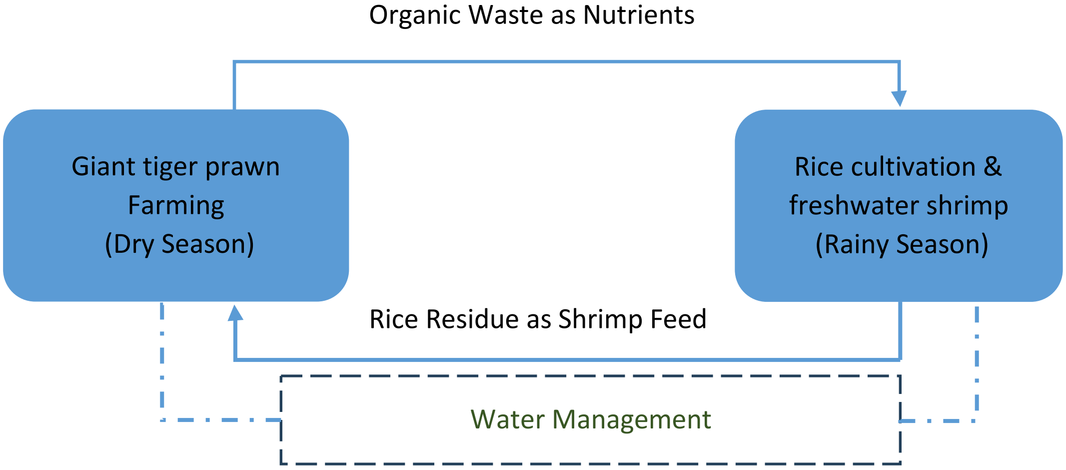
Innovative Approach: The model creates a symbiotic relationship where shrimp waste enriches soil for rice, and rice residues feed shrimp. This cycle reduces chemical inputs, production costs, and promotes resource efficiency. The model enhances resilience against environmental and market fluctuations.

Benefits & Impacts: Incomes have increased by 78%, with production costs halved. Organic rice and shrimp products meet international quality standards, securing stable market prices. The system reduces the need for chemicals and promotes biodiversity. It maintains soil fertility and minimizes water pollution. It also creates jobs, reduces rural-to-urban migration, and improves food security. It strengthens community collaboration and promotes sustainable practices.

Scale of Implementation: Applicable on both small and large scales, from household farms to cooperatives managing hundreds of hectares. Scaling up requires careful infrastructure and management.

Lessons Learned: Key factors for success include infrastructure investment, optimized cultivation techniques, market access, and climate resilience strategies like salt-tolerant shrimp varieties. Collaborative efforts between farmers and government support are critical for long-term sustainability.

Figure 15 Schematic overview of rice–shrimp model



Source: Synthesis from the research team

9. Clean Vegetable and Fish Farming Model (Aquaponics) - Viet Nam

Summary: Aquaponics combines fish farming and hydroponics in a closed-loop system where fish waste is converted into nutrients for plants, and the plants purify the water for fish. This sustainable method uses 90% less water than traditional farming, producing both vegetables and fish. Notable examples in Viet Nam include projects in Ho Chi Minh City, Long An, and Khánh Hòa, where farms provide clean food, support environmental protection, and create economic opportunities.

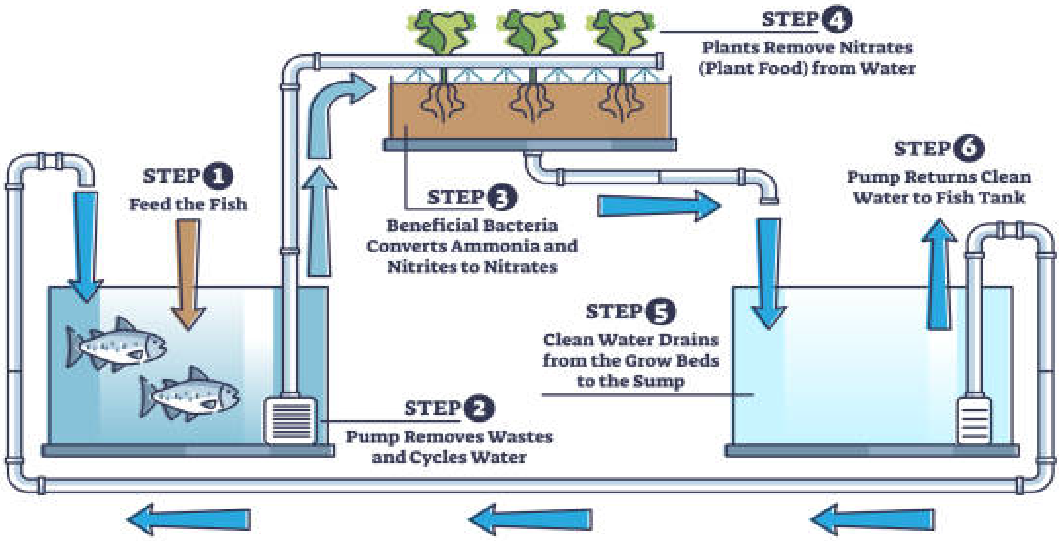
Innovative Approach: Aquaponics creates a self-sustaining ecosystem, recycling fish waste as plant nutrients while plants filter the water for fish. It maximizes resource efficiency, reducing water consumption and the need for chemical inputs. Dual production of fish and vegetables enhances food security, while its scalability allows it to adapt to urban, suburban, or large commercial farms.

Benefits & Impacts: Aquaponics generates dual revenue streams from fish and vegetables. For instance, pilot projects show fish biomass reaching 250-336 kg and vegetable yields of 2.24 kg/m², leading to enhanced revenue compared to single-crop systems. It minimizes water and fertilizer costs, leading to faster returns on investment, with significant output per square meter. The closed-loop system of Aquaponics reduces costs related to water treatment and fertilizers. For example, Nha Trang Aquaponics reuses 90% of water, minimizing operational costs and environmental impact. The closed-loop system cuts down on water use and pollution, promoting biodiversity and reducing reliance on synthetic chemicals. Aquaponics creates local jobs, promotes urban food security, and educates communities on sustainable farming.

Scale of Implementation: Aquaponics can be adapted for small household systems or scaled up for urban farms and large commercial operations, providing flexibility in different settings.

Lessons Learned: Key success factors include proper system design, choosing compatible fish and plant species, and engaging communities in education and operation. Scaling up requires careful resource management and ongoing research to ensure economic viability and sustainability.

Figure 16 Schematic overview of the Aquaponics model



Source: Synthesis from the research team

10. Collecting and Processing Crop Residues into Compost – Viet Nam

Summary: This model transforms crop residues like vegetable, flower waste, grass, and corn stalks into organic fertilizers. By using composting techniques, it reduces investment costs, boosts production efficiency, and protects the environment. In regions like Lam Dong, Binh Dinh, and Bac Kan, this model has been successfully implemented, with local cooperatives and businesses processing agricultural by-products into fertilizers, improving farm productivity and reducing reliance on chemical inputs.

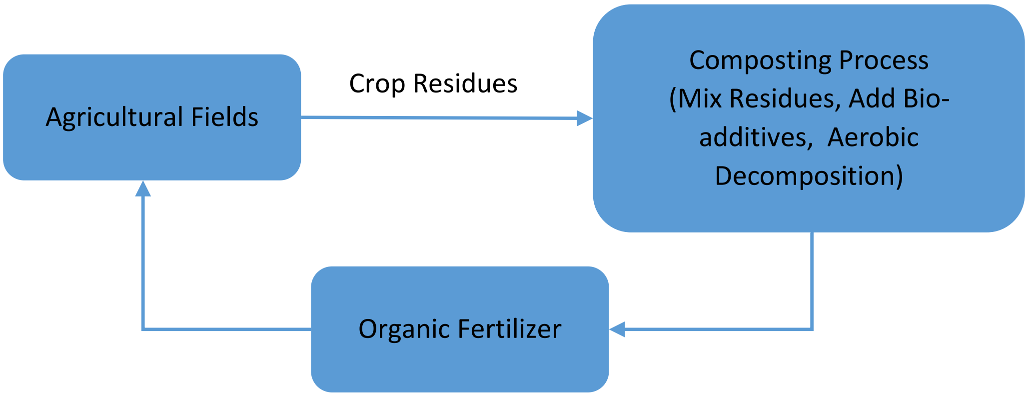
Innovative Approach: The model integrates modern composting techniques and sustainable practices to efficiently collect and process agricultural by-products. Using specialized machinery and bio-additives, it speeds up decomposition and improves the quality of organic fertilizers. Farmers receive comprehensive training to optimize the composting process, which minimizes waste, reduces chemical fertilizer dependence, and enhances soil health.

Benefits & Impacts: Farmers save on chemical fertilizers by using compost made from crop residues, which also boosts yields. For instance, Thiên Sinh Co., Ltd. in Lam Dong processes 30 m^3 of by-products monthly. This model yields profits ranging from 550,000 to VND 878,000 per ton of by-products. Converting agricultural waste into organic fertilizer reduces landfill waste, lowers pollution, and improves soil health by enhancing water retention and reducing erosion. The model empowers farmers through training and technical support, leading to increased income and improved crop yields. It also promotes community cooperation and strengthens local networks.

Scale of Implementation: The model, initially tested in pilot projects, is now expanding across Viet Nam, including Lam Dong, Bac Kan, and Nghệ An. Its adaptability and effectiveness are contributing to better waste management and sustainable farming practices of the economy.

Lessons Learned: Local adaptation and comprehensive farmer training are key to success. Engaging communities and fostering partnerships between stakeholders improve implementation. The model also demonstrates the synergy between economic growth and environmental sustainability, providing a win-win for farmers and the environment.

Figure 17 Schematic overview of the model for processing agricultural by-products into organic fertilizers



Source: Synthesis from the research team

11. Recirculating Aquaculture Systems (RAS)

Summary: Recirculating Aquaculture Systems (RAS) represent a sustainable innovation in Viet Nam's aquaculture, recycling water and controlling the aquatic environment to conserve resources and reduce disease risks. RAS is effective for various species, including shrimp, sturgeon, and eel, achieving high yields in farms across the economy.

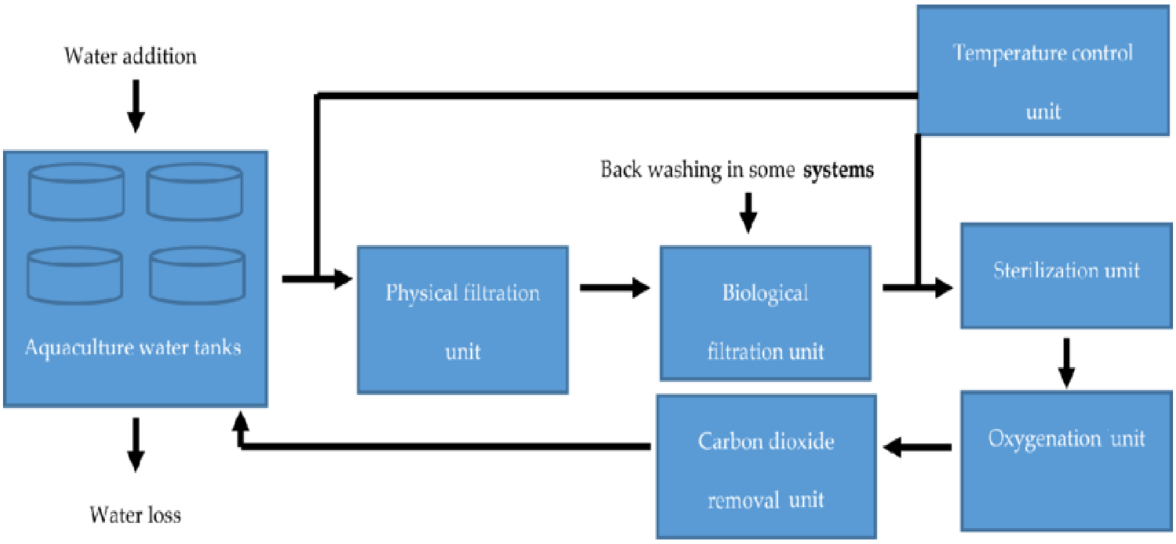
Innovative Approach: RAS operates as a closed-loop system that purifies water through advanced filtration, reducing waste and water use while enabling high-density aquaculture. Local adaptations, such as cost-effective components, address Viet Nam's specific conditions, making RAS more accessible and sustainable.

Benefits and Impacts: RAS reduces operational costs, enhances product quality, and minimizes environmental impact by conserving water and cutting wastewater discharge. It supports economic growth, creates jobs, and strengthens food security, particularly in urban markets. For example, eel farming in Tien Giang has achieved 30% savings in water and electricity costs.

Scale of Implementation: Initially limited to high-tech farms, RAS is expanding across Viet Nam, from large commercial shrimp farms to niche sturgeon and eel operations. Investments from local researchers and private stakeholders are accelerating its adoption.

Lessons Learned: Adapting RAS to local needs is crucial for affordability and performance. Training in system management, regular maintenance, and collaboration with research institutions are essential for success. Public-private partnerships play a key role in scaling RAS adoption.

Figure 18 Schematic overview of a recirculating aquaculture system



Source: Synthesis from the research team

12. Utilizing Rice Husks for Fuel - Viet Nam

Summary: Rice husks in Viet Nam have become a sustainable fuel source, addressing agricultural waste management and environmental pollution. With rice production at 43.5 million tons in 2023, an estimated 8.7 million tons of husks can pose disposal challenges. Converting these husks into fuel products, such as briquettes and gas, not only repurposes waste but also offers economic and environmental benefits. Technologies like rice husk pellets and gasification help mitigate issues related to greenhouse gas emissions while creating economic opportunities.

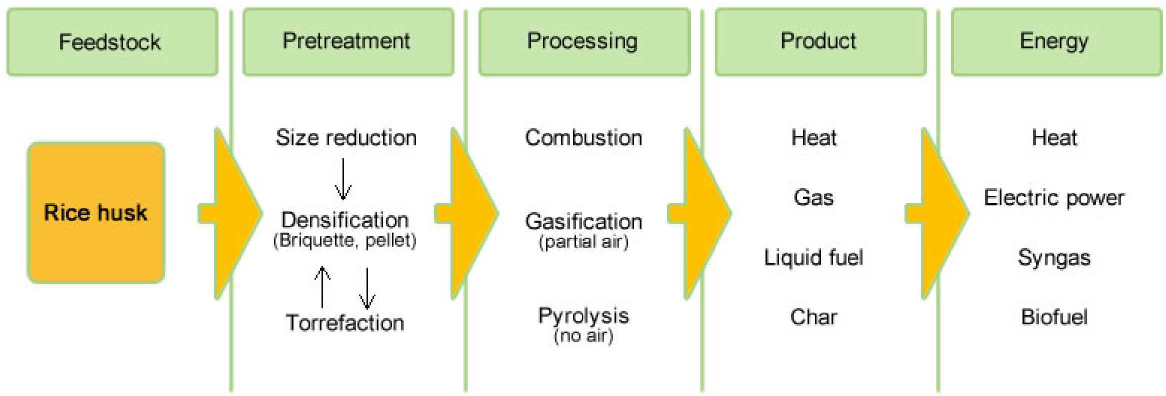
Innovative Approach: The model leverages two main technologies: rice husk pellet production and gasification. The pellet process compresses husks into high-density fuel, providing a cost-effective and transportable energy source. This approach has been widely adopted in the Mekong Delta region, showcasing its scalability. Gasification technology transforms husks into gas for industrial use, significantly reducing fossil fuel reliance and emissions, as evidenced by successful applications in rice mills like Vĩnh Bình.

Benefits and Impact: Economically, rice husk utilization reduces energy costs and creates new revenue streams. For instance, Vĩnh Bình Rice Processing Factory uses husks to replace oil-based energy, cutting energy costs by 30% while generating additional income through briquette sales. Environmentally, this model minimizes waste, lowers greenhouse gas emissions, and improves air quality by reducing reliance on fossil fuels. For instance, at the Vĩnh Bình Rice Processing Factory, switching from traditional fossil fuels to rice husk-based energy sources is projected to cut greenhouse gas emissions by 10.17 tons of CO2 equivalent per hectare per year. Socially, it creates jobs and enhances community health by reducing pollution and improving working conditions.

Scale of Implementation: The model is adaptable for both large-scale operations, like major rice processing facilities, and smaller rice mills or farms. Large-scale implementations benefit from economies of scale, while smaller operations can utilize husks for heating or onsite energy production. This flexibility allows broader adoption across different contexts and regions, promoting local economic development.

Lessons Learned: This model emphasizes the significance of integrated waste management in agriculture, demonstrating how byproducts can be repurposed for economic and environmental gain. The success at Vĩnh Bình highlights the importance of investing in technology and infrastructure for processing husks. Smaller operations can also benefit with the right tools and support. Finally, effective policies and community engagement are crucial for sustainable implementation, ensuring that local stakeholders are informed and trained to maximize benefits.

Figure 19 Schematic overview of energy from rice husk.



Source: IRRI

13. High-Value Aquatic By-Product Conversion Models

Summary: In Viet Nam, converting aquatic by-products into high-value products showcases significant potential for resource optimization and environmental impact reduction. Thuan An Co., Ltd. processes pangasius fish by-products into fish oil and fishmeal. Similarly, Dai Phat Manufacturing Trading Service Co., Ltd. collaborates with research institutions to process shrimp by-products into chitin and shrimp sauce. Viet Nam Food Joint Stock Company (VNF) adopts a zero-waste approach to convert shrimp by-products into chitosan, functional peptides, and organic fertilizers, contributing to environmental protection while creating high-value products. Together, these models enhance economic value while supporting sustainable solutions in Viet Nam's seafood processing industry.

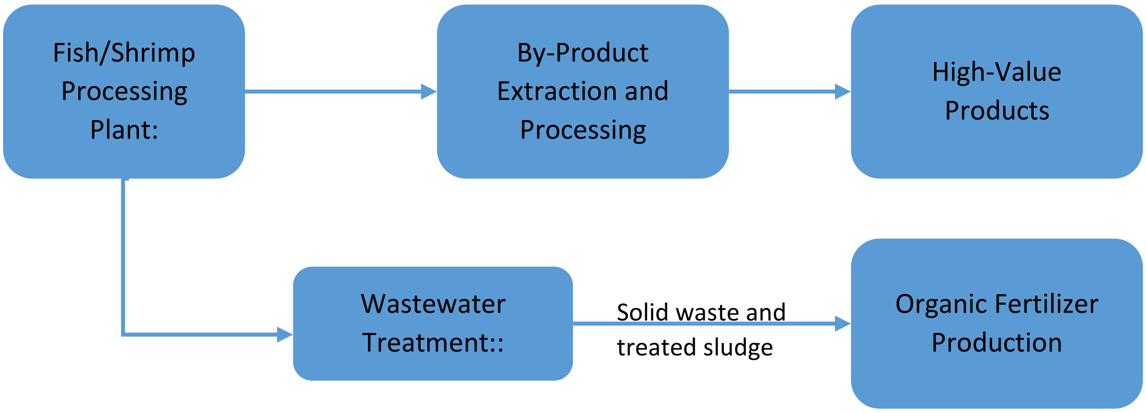
Innovative Approach: These models exemplify innovation by transforming waste into valuable resources using advanced biotechnology. Thuan An Co., Ltd. converts pangasius by-products into high-quality fish oil for biodiesel and collagen production, while Dai Phat Co., Ltd. extracts chitin from shrimp shells for diverse applications, including biodegradable packaging and medical products. VNF's zero-waste model fully utilizes shrimp by-products to create bioactive peptides, promoting a circular economy in seafood processing.

Benefits and Impacts: The processing models significantly boost revenue by turning waste into valuable products. Thuan An's fish oil production generates VND 19.5 trillion annually, while Dai Phat extracts chitin for lucrative applications in pharmaceuticals. Bioactive peptides from fish and shrimp by-products are also in high demand, tapping into global markets for health products.
These models effectively reduce waste and pollution, promoting sustainable seafood processing. By transforming by-products into valuable products, companies minimize environmental degradation. For example, Thuan An's operations are estimated to reduce CO_2 emissions by 22.9 tons per 100 tons of raw pangasius processed, contributing to climate change mitigation. The use of advanced technologies ensures that processing is environmentally friendly, conserving resources and reducing ecological pressures. The approach enhances the economic value of fisheries, creates job opportunities, and improves public health through high-value products. Efficient processing leads to reduced waste and emissions, while companies like VNF demonstrate a commitment to environmental sustainability. Technological advancements in processing foster research and improve competitiveness in biotechnology.

Scale of Implementation: In Viet Nam, fishery by-product processing occurs on various scales. Small-scale operations utilize basic technologies for local markets, while medium-sized companies leverage advanced processing for regional impact. Large-scale implementations, like those of Thuan An and VNF, involve extensive facilities producing high-value products for domestic and international markets, contributing significantly to economic growth and environmental sustainability.

Lessons Learned from Practices: Economic viability is crucial for the success of fishery by-product processing. Companies understand market demands and ensure sustainable operations. Technology adaptation enhances efficiency and product quality, while effective market integration enables broader reach. Emphasizing environmental responsibility minimizes ecological impact, and supportive policies can facilitate growth. Continuous improvement through regular evaluations and feedback ensures sustained competitiveness and relevance in the industry.

Figure 20 schematic overview of the seafood by-product processing model



Source: Synthesis from the research team

14. Integrated grapefruit cultivation with cattle raising – Viet Nam

Summary: Hop Farm, located in Luong Son district, Hoa Binh province, Viet Nam, utilizes a circular production system that integrates grapefruit cultivation with cattle raising. This innovative approach optimizes resource use and reduces waste, yielding significant economic, environmental, and social benefits.

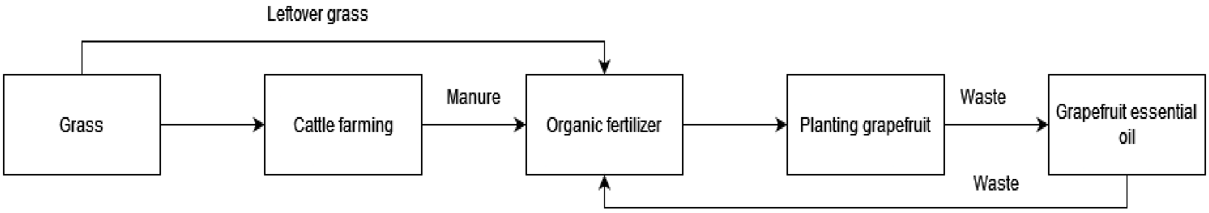
Innovative Approach: Hop Farm integrates both biological and technical cycles within its circular economy model. Manure from livestock is composted with leftover grass to create organic fertilizer, reducing reliance on chemical fertilizers. Grapefruit waste, including peels, is distilled to produce essential oils, with the residue repurposed into organic detergents and fertilizers for grapefruit trees.

Benefits and Impacts: The farm saves approximately VND 50-60 million annually by producing organic fertilizer in-house. It projects an annual grapefruit yield of 150-200 tons, enhancing productivity and revenue through value-added products like essential oils. The closed-loop system reduces waste, improves soil health, and promotes resource efficiency. Organic fertilizers enhance soil quality while minimizing pollution. Hop Farm improves community quality of life by meeting food safety standards and creating jobs in agriculture and waste management.

Scale of Implementation: The farm plans to expand operations by increasing cattle and pig numbers and aims to produce 100-150 tons of organic fertilizer annually while targeting a grapefruit output of 150-200 tons in five years. This model can be replicated throughout the member.

Lessons Learned: Hop Farm's success demonstrates the importance of integrating farming and animal husbandry in a closed ecosystem. Investing in sustainable practices and technology boosts productivity and environmental stewardship. To further promote circular agriculture, government actions could include tax incentives, training programs, research support, and financial assistance for small businesses.

Figure 21 Schematic overview of the circular farm



Source: Synthesis from the research team

15. Circular livestock farming model - Viet Nam

Summary: T&T 159 Hoa Binh, located in Hoa Binh province, Viet Nam, is a pioneering company implementing a circular livestock farming model. All production processes are integrated and waste-free; by-products are reused in other processes, resulting in safe, high-quality products and minimizing environmental impact. The company also creates biological bedding from agricultural waste like tree bark, sawdust, and dry leaves, which is enriched with beneficial microorganisms

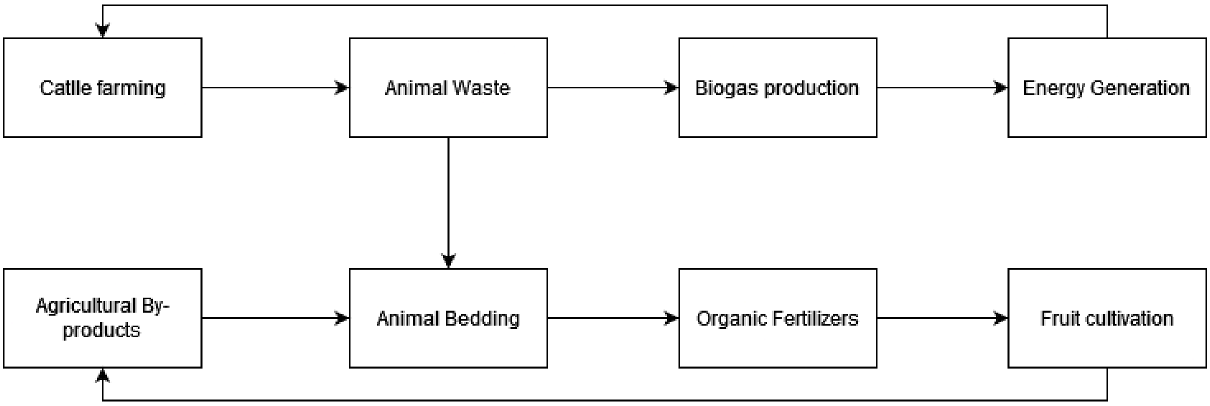
Innovative Approach: The company manages 5,000 buffaloes and cows with a scientifically planned fattening process, featuring dedicated areas for different livestock functions. By integrating and reusing by-products, T&T 159 minimizes waste and environmental impact. It also creates biological bedding from agricultural waste, enriching it with beneficial microorganisms to decompose manure into nutrient-rich fertilizer while providing a comfortable environment for livestock.

Benefits and Impact: The farm supplies around 800 commercial buffaloes and cows monthly, primarily to restaurants, and produces approximately 100 tons of organic microbial fertilizer daily, valued at VND 300 to 500 million, sustaining operations. The circular model significantly reduces pollution and enhances resource efficiency. Biogas systems capture methane, mitigating climate change. Organic fertilizers enhance soil structure and increase water retention, reducing chemical fertilizer reliance. **Waste Reduction** is made through converting waste into biogas and organic fertilizers minimizes disposal needs. In addition, healthier livestock lead to better productivity and reduced veterinary costs. Enhanced air quality improves the quality of life for nearby communities, promoting the adoption of sustainable practices among local farmers.

Scale of Implementation: The T&T 159 model shows great scalability potential due to its resource efficiency and economic success. Its closed-loop system can be adapted to various agricultural settings, making it a strong candidate for replication in other regions.

Lessons Learned: T&T 159's approach emphasizes optimizing resources and reducing waste by converting by-products into valuable materials. Its closed-loop production effectively reuses waste, producing high-value products while mitigating environmental impacts. The use of agricultural waste for bedding improves livestock conditions and fertilizer quality, offering insights applicable to other agricultural models.

Figure 22 Schematic overview of the circular farm



Source: Synthesis from the research team

16. Sustainable pig farming through the Circular Organic Agriculture Model – Viet Nam

Summary: Nguyen Khoi Farm, established in Yen Lap district, Phu Tho province, Viet Nam, focuses on sustainable pig farming through the Circular Organic Agriculture Model (COAM). Launched in 2017 and supported by a $25,000 grant from the World Bank in 2019, COAM promotes sustainable livestock practices while addressing climate change challenges.

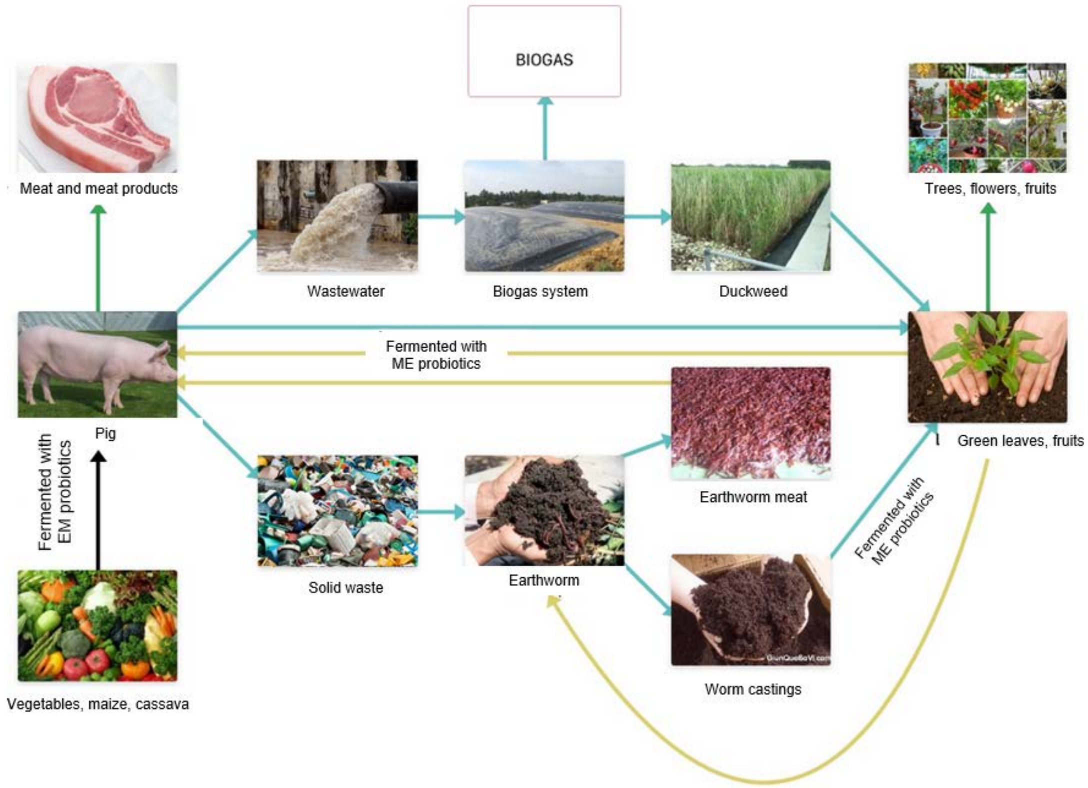
Innovative Approach: Nguyen Khoi Farm’s COAM efficiently conserves nutrients in a closed-loop system. Waste is processed into solid and liquid forms: Liquid Waste - Directed to a biogas tank and filter bed for aquatic plants, which is then reused for crop irrigation; Biogas- Used as alternative fuel; Solid Waste- Fermented with effective microorganisms (EM) to feed earthworms, whose manure enriches crops, while earthworm meat supplements livestock feed.

Benefits and Impact: COAM reduces operational costs by 28% in feed through organic waste repurposing and lowers chemical fertilizer expenses by 40% via earthworm manure. The farm also cuts water usage by 50% by treating wastewater for irrigation, achieving cost efficiency and sustainability. Overall, product diversification under COAM increases revenue by at least 150%, providing resilience against market fluctuations. In term of environmental aspects, the model minimizes pollution by transforming waste into resources, generating renewable energy, and enhancing soil quality through organic fertilizers. Efficient water management reduces contamination and optimizes usage. The model lowers costs, boosts profitability, and improves community health through effective waste management. It creates local jobs in waste management and biogas production, fostering resilience and supporting sustainable agriculture.

Scale of Implementation: The success of the COAM at Nguyen Khoi Farm aligns with Viet Nam's shift toward organic agriculture. Its results warrant pilot applications at other farms, providing a foundation for broader replication in the livestock community.

Lessons Learned: Nguyen Khoi Farm exemplifies how waste can become valuable resources, promoting sustainability through renewable energy, efficient water management, and organic fertilizer use. This model underscores the need for innovative agricultural practices to ensure long-term sustainability.

Figure 23 Schematic overview of Nguyen Khoi Farm



Source: https://nguyenkhoifarm.com

17. Wood by-product as a renewable energy source – Viet Nam

Summary: Phu Tai Company, located in Binh Dinh province, Viet Nam, has implemented a circular production model by repurposing wood by-products from its processing activities. These by-products are converted into energy pellets and fuel for boilers, significantly reducing energy costs and boosting profits by 2-3%, while contributing to environmental sustainability through reduced CO2 emissions.

Innovative Approach: Phu Tai's circular economy model focuses on transforming wood waste into renewable energy sources. Wood by-products are processed into energy pellets, replacing coal and oil as fuel for boilers. Wood scraps are directly used as fuel, minimizing the company's reliance on fossil fuels and making effective use of waste.

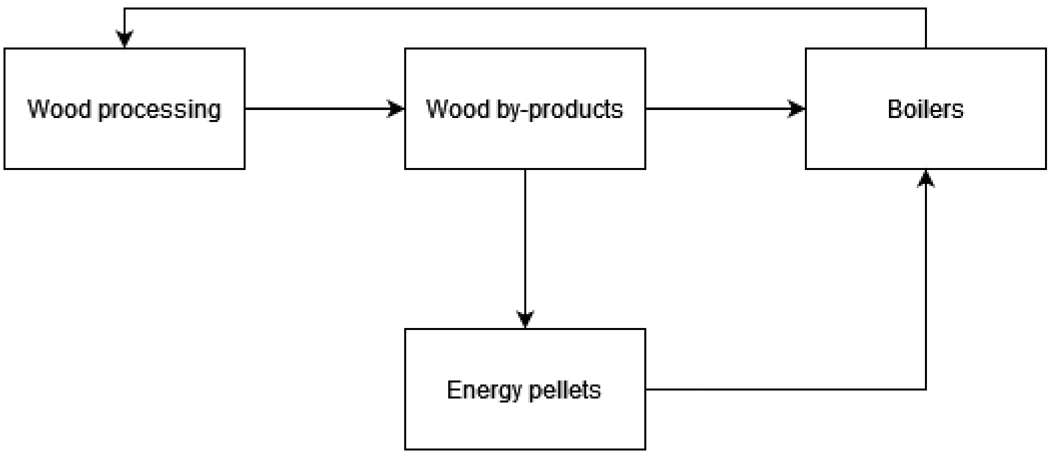
Benefits and Impact: This model has saved Phu Tai VND hundreds of billions of annually, reducing energy costs and boosting profitability by up to 3%. Additionally, repurposing wood by-products into engineered wood products like MDF and particleboard maximizes material use and generates additional revenue streams. The shift to renewable energy has reduced the company's carbon footprint, supporting Viet

Nam's goal of net-zero emissions by 2050. This waste minimization contributes to a cleaner environment. The circular model creates job opportunities in green energy while improving air quality through CO_2 emission reductions. Phu Tai's approach promotes sustainable practices in the community and sets an example for other businesses to follow.

Scale of Implementation: With over 5,800 companies and 340 craft villages in the wood industry in Viet Nam, the potential for scaling Phu Tai's circular model is significant, especially given the large volume of wood by-products available for repurposing.

Lessons Learned: Phu Tai's success demonstrates the economic and environmental benefits of adopting circular economy principles. Integrating circular practices can drive cost savings and profitability. Investing in technology to convert waste into valuable products enhances resource efficiency. Raising awareness of circular models is essential to scaling sustainable practices across industries.

Figure 24 . Schematic overview of circular production system in Phu Tai company



Source: Synthesis from the research team

18. Circular economy model and eco-tourism

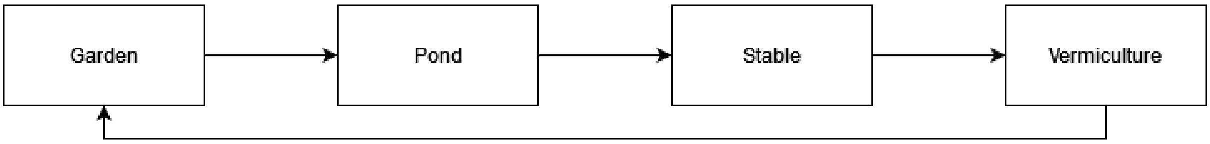
Summary: The Sun & Wind Farm in Ninh Thuan, Viet Nam, showcases a circular economy model that integrates sustainable agriculture with eco-tourism. Spanning nearly 100 hectares, the farm employs a self-sustaining system that minimizes waste and maximizes productivity, using modern techniques in crop cultivation, aquaculture, livestock management, and vermiculture. It serves as a model for sustainable practices in agriculture.

Innovative Approach: The farm modernizes the traditional "garden-pond-stable" system by adding vermiculture. Key components include a Global GAP-certified garden, a recirculating aquaculture pond, a closed-loop livestock stable, and vermiculture producing organic compost from waste. Eco-tourism further enhances the farm's sustainability by engaging visitors in these practices.

Benefits and Impact: Recycling waste cuts costs, and eco-tourism diversifies income. Certifications like OCOP 4-star and Global GAP improve market value. Recycling organic waste reduces environmental impact, while water efficiency and biodiversity support soil health. The farm creates jobs, provides sustainable agriculture training, and raises environmental awareness through eco-tourism.

Lessons Learned: The farm highlights the importance of recycling waste into resources, engaging communities, and continuous improvement. Scaling up requires government incentives, educational support, partnerships, and certifications to encourage broader adoption of sustainable agricultural models.

Figure 25 Schematic overview of the circular farm



Source: Synthesis from the research team

19. Combined goat farming with black pepper cultivation - Viet Nam

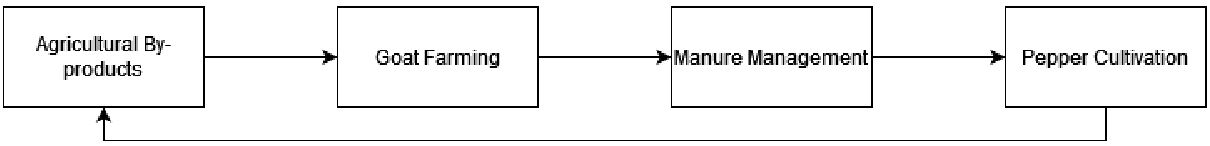
Summary: In Bu Dop district, Binh Phuoc province, Viet Nam, farmers have combined goat farming with black pepper cultivation in a circular economy model. Goat manure is used as organic fertilizer for pepper plants, while goats are fed with agricultural by-products. This approach addresses sustainability challenges in pepper farming, helping farmers cope with price fluctuations and environmental concerns.

Innovative Approach: The model integrates goat farming with pepper cultivation, recycling agricultural waste as goat feed and using goat manure as fertilizer. This circular system minimizes the need for external inputs, reduces waste, and improves soil health, offering a sustainable solution for both livestock and crop production.

Benefits and Impact: Farmers reduce fertilizer costs by up to 30%, while goat farming provides additional income, helping offset losses from fluctuating pepper prices. Goat farming has become a vital source of income in Binh Phuoc, benefiting over 500 farmers and expanding the local economy. The use of organic manure reduces reliance on synthetic fertilizers, improving soil fertility and reducing pollution. The model creates jobs, empowers marginalized communities, and fosters cooperation through local cooperatives.

Lessons Learned: Integrating livestock with crop production creates a sustainable farming cycle that reduces costs and waste, while diversifying income sources. To scale, governments should.

Figure 26 Schematic overview of the circular farm



Source: Synthesis from the research team

20. Wood processing by-products for valuable biomass pellets

Summary: Netma Joint Stock Company in Yen Bai, Viet Nam, turned wood processing by-products from waste into valuable biomass pellets. This innovative circular economy model reduces pollution while meeting growing global demand for biomass fuel.

Innovative Approach: Netma Yen Bai optimized biomass pellet production by implementing advanced drying technology and efficient production processes. The model involved a comprehensive overhaul of the production process, starting from the selection, classification, and treatment of raw materials, to the final stages of pellet formation and quality control. One of the critical innovations was the introduction of an automated drying system, which allowed for precise control of material moisture levels—ranging between 6% and 10%—to ensure consistent pellet quality.

Benefits and Impact: The company now produces 39,000 tons of bio-pellets annually, with expected revenue surpassing VND 100 billion. Utilizing wood by-products has reduced costs, enhanced profitability, and met strict export standards. The model reduces waste and pollution by converting by-products into renewable energy, supporting global climate efforts. Job creation and training improved local livelihoods and skills, promoting community development.

Lessons Learned: Investing in technology and workforce training can transform waste into valuable products, boost productivity, and create economic opportunities. Government support for technology and training in rural areas, along with stronger environmental policies, can help scale similar models across Viet Nam.

Figure 27 Schematic overview of a circular system

Source: Synthesis from the research team

VI. KEY TAKEAWAYS AND SUCCESS FACTORS FOR THE IMPLEMENTATION OF CIRCULAR AGRICULTURE IN VIET NAM AND OTHER APEC ECONOMIES

Circular agriculture is emerging as a critical strategy for sustainable development across APEC members, with Viet Nam making notable progress despite challenges. Key practices such as waste recycling, water conservation, and nutrient cycling are driving resource efficiency and environmental sustainability. From the stocktaking and analysis of status of circular agriculture in Viet Nam and other APEC economies, it can be extracted some key takeaways for the implementation of circular agriculture in Viet Nam and other APEC economies:

Firstly, circular agriculture is being implemented at different levels across APEC members, with developed economies such as Japan, Australia, and China leading the way. Developed members such as Japan, Australia, and China have established more advanced circular agriculture systems, integrating practices like waste recycling, nutrient recovery, and resource-efficient farming. Meanwhile, developing economies like Viet Nam, Mexico, and Peru are progressively integrating these principles, but they face challenges such as limited access to technology, infrastructure gaps, and insufficient policy frameworks. Many economies like Viet Nam are working on embedding circular agriculture into development strategies.

Secondly, many Key Circular Agriculture Practices have been developed recently. Circular agriculture in APEC members revolves around waste recycling, composting, energy recovery, precision farming, and water conservation. Members like China and Japan have extensive systems for waste recycling and nutrient recovery, while Viet Nam is increasingly adopting composting for crops like coffee and rice. Many economies, such as China and Thailand, are utilizing livestock waste to produce biogas, which is then used to generate energy for farming activities. Australia, a water-scarce economy, is leading efforts in water-saving technologies such as drip irrigation and rainwater harvesting. Similar practices are being adopted in regions facing water shortages across APEC.

Thirdly, policies and initiatives across APEC members play a vital role in promoting circular agriculture. Governments are offering subsidies and incentives for waste recycling, promoting research, and facilitating regional cooperation in circular agriculture. Many APEC economies, including Viet Nam, have integrated circular agriculture into their strategies, promoting the transition to sustainable agriculture through incentives, financial support, and policy initiatives. APEC is actively promoting cooperation among member economies to share best practices and technological innovations. Workshops and joint research projects enhance capacity building and information exchange. The recent APEC summit emphasized circular agriculture as a key strategy for achieving sustainable food systems in the region, addressing climate change, and enhancing economic resilience.

Insite of many progress, APEC members face several barriers to developing circular agriculture, including: (1) Technological Barriers (Limited Access to Technology, High Technology Costs, Inadequate Infrastructure); (2) Economic Barriers (High Initial Capital Requirements, Low Market Demand for Circular Products, Insufficient Financial Incentives); (3) Policy and Regulatory Barriers (Lack of Comprehensive Policy Frameworks, Regulatory Uncertainty); (4) Cultural and Social Barriers (Resistance to Change, Limited Awareness and Education, Social and Gender Inequities); (5) Environmental and Resource Barriers (Natural Resource Constraints, Climate Change and Extreme Weather and Biodiversity Loss); (6) Supply Chain and Market Barriers (Fragmented Agricultural Supply Chains, Lack of Integration with Other Sectors); (7) Knowledge and Capacity Barriers (Limited Research and Development (R&D), Lack of Technical Expertise).

From the stocktaking of different CE models in agriculture across Viet Nam and other APEC members, it can be seen some key success factors to the implementation of CE in agriculture. These factors demonstrate that a combination of supportive policies, technological innovation, community engagement, and market demand are essential for the successful implementation of circular agriculture in Viet Nam and APEC members. The holistic integration of these elements is critical for fostering sustainable agricultural practices and enhancing resilience in the face of environmental challenges.

(1) **Government Policies and Support:** A strong and clear policy framework is essential for promoting circular agriculture (CA). Governments in APEC economies are increasingly developing action plans and policies that support CA, including financial incentives, research funding, and technical assistance for farmers. Especially, members like Viet Nam have integrated circular economy principles into their socio-economic development strategies, emphasizing the transition to sustainable agricultural practices.

(2) **Research and Development:** Continuous investment in agricultural research and development is crucial. Members such as Japan and Australia are heavily investing in R&D to improve circular agricultural technologies and practices. In addition, providing training and technical assistance to farmers helps in the adoption of innovative practices, enhancing their understanding of CA principles and their benefits.

(3) **Cross-Sector Collaboration:** Successful implementation of CA requires collaboration among many cross-sectors such as agriculture, waste management, and energy sectors. Many APEC economies are establishing partnerships that facilitate the integration of different sectors to promote resource efficiency. The development of Public-Private Partnerships with the collaborations between governments, private sector actors, and civil society organizations enhance knowledge sharing, technology transfer, and resource mobilization. In addition, learning from successful CA models within and outside the region can provide valuable insights and strategies for effective implementation. Members like Australia, Japan, China, Singapore offer successful examples that can be adapted to local contexts

(4) **Community and Stakeholder Engagement:** Engaging local communities and stakeholders in the planning and implementation of CA initiatives fosters ownership and increases the likelihood of success. Models like Japan's Biomass Town project highlight the importance of community involvement in promoting sustainable practices. In addition, tailoring CA models to meet the needs of smallholder farmers is crucial, as they often face unique challenges.

(5) **Technological Adoption:** The adoption of precision farming technologies, such as drones and IoT, helps optimize resource use (water, fertilizers, and pesticides), reduce waste, and enhance overall productivity. Implementing technologies for converting agricultural waste into energy (e.g., biogas) is a significant step towards achieving circular agriculture

(6) **Market Demand and Consumer Awareness:** Increasing consumer awareness of sustainability and demand for eco-friendly products drive the adoption of circular agriculture. APEC economies can benefit from accessing premium markets through sustainable practices. Additionally, establishing

certifications for sustainable products can provide a competitive edge in both local and international markets.

APEC members can transition towards more circular agricultural systems, enhancing sustainability, resilience, and economic viability in the face of global environmental challenges. Some key recommendations for this transition are as following:

(1) **Strengthen Policy Frameworks:** Viet Nam and APEC governments should create and implement comprehensive policies that promote circular agriculture, integrating it into agricultural strategies. This includes establishing clear regulations that incentivize sustainable practices and provide support for farmers adopting circular methods. It is crucial to encourage standardization. New technologies and circular economy infrastructure require standardization to ensure common protocols across economies and businesses and especially to maintain quality across highly globalized supply chains. It is also significant to introduce more subsidies, grants, and low-interest loans for farmers investing in circular agriculture technologies, such as biogas production and precision farming tools.

(2) **Enhance Research and Development:** It is significant to increase funding for research and development in circular agriculture technologies and practices and encourage partnerships between universities, research institutions, and agricultural enterprises to foster innovation. Knowledge Sharing can be promoted by creating platforms for knowledge exchange and sharing of best practices among APEC members, enabling farmers and stakeholders to learn from successful circular agriculture initiatives.

(3) **Foster Cross-Sector Collaboration:** It is essential to encourage Multi-Sector Partnerships to facilitate collaboration between agriculture, waste management, energy, and technology sectors. Public-private partnerships are strengthened to share resources and expertise in implementing circular agriculture systems. In addition, it is necessary to involve local communities in the planning and execution of circular agriculture projects, ensuring that initiatives align with local needs and practices.

(4) **Increase Awareness and Capacity Building:** Develop training programs and workshops for farmers, policymakers, and agricultural workers to increase understanding of circular agriculture practices and their benefits and Conduct campaigns to educate consumers about the advantages of sustainable agricultural products, fostering demand for eco-friendly goods.

(5) **Promote the application of technological Solutions:** Encourage the use of advanced technologies like drones, IoT, and AI to optimize resource use, monitor crop health, and reduce waste. Provide training and support for farmers to integrate these technologies into their practices.

(6) **Support Smallholder Farmers:** It is significant to design programs that specifically address the needs and challenges of smallholder farmers, ensuring they have access to resources and support for adopting circular agriculture practices. In addition, state agencies should have concrete action plan to help

smallholder farmers connect with markets for their products, including providing assistance in meeting certification and quality standards.

(7) **Encourage International Cooperation**: Viet Nam and APEC members should actively engage in regional collaborations focused on sustainable agriculture, sharing best practices, technologies, and research findings and make effort to align with Global Goals to ensure that circular agriculture strategies align with international commitments, such as the Sustainable Development Goals (SDGs) and the Paris Agreement, reinforcing the importance of sustainability in agriculture.

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