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# Circularity in Agri-Food Value Chains in Developing Countries: A Case in Indonesia

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**Abstract**

The adoption of circular economy approaches in agri-food value chains in developing countries remains underexplored, particularly in contexts dominated by smallholder farmers. This paper aims to analyze existing circular practices and identify key barriers to circular transformation in developing country agri-food value chains, with a specific focus on Indonesia. Using a qualitative research design, the study draws on semi-structured interviews, with different value chain players, to empirically examine circularity within the cashew value chain in Indonesia. The findings reveal that while a range of circular practices are undertaken by individual actors across the value chain, these activities remain largely fragmented and weakly coordinated. Key barriers to further circular transformation include limited awareness, economic imperatives, constrained access to appropriate technologies, and insufficient institutional support. Notably, access to finance was not perceived as a major constraint. This study contributes to the literature by providing a multi-actor, value chain perspective on circularity in smallholder-based agri-food systems in developing countries. It offers novel empirical evidence that existing informal circular practices play an important role and should be preserved as value chains modernize. The findings further highlight the importance of stronger vertical and horizontal coordination to scale and integrate circular activities and support a more holistic sustainable transition.

**Keywords:** circular economy; agri-food; value chain; Indonesia; cashew sector; developing countries

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## 1. Introduction

The increasing demand for sustainable agri-food products requires a whole value chain approach. Agri-food systems are pivotal for global food security and livelihoods but are increasingly pressured by rising demand, resource inefficiency, and environmental degradation. The agriculture sector has limited resources (land, water, and labor, etc.) to produce more food and needs to utilize these resources more sustainably [1]. Agricultural development is also prone to social and environmental depredation, such as the overexploitation of workers, overly intensive soil use, loss of cultural/traditional practices, and excessive chemical use [2,3]. Mehmood [4] suggest that the circular economy (CE) approach provides a potential solution to these economic, social, and environmental challenges by enabling more self-sustaining production systems. The CE proposes a restorative and regenerative system designed to eliminate waste and keep materials in use indefinitely. CE principles promote resource efficiency, by-product valorization, and the closing of material loops.

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There is a growing interest in the CE concept from businesses, governments, academia, and the broader public (consumers). However, it is not yet well understood how businesses, and their production and consumption processes, could transition towards a CE. At the same time, there is a need for radical change in how resources are used and reused, and the role of different actors in the value chain in managing these resources [5]. The CE proposes a restorative and regenerative system designed to eliminate waste and keep materials in use indefinitely [6,7].

Agri-food value chains are trying to transform to a CE model for high-value markets in many developing countries [1]. More complex governance and value addition activities have evolved, with an emphasis not only on agri-food products but also on how food is produced and consumed [2]. However, the World Bank [8] suggests that smallholders are the key player in the value chains in developing countries, yet they have limited resources and bargaining power, and are typically trapped in a traditional value chain system supplying local markets with commodity products. The recent trend towards a focus on sustainable practices in agriculture presents further challenges to agri-food value chains and smallholders in particular. Value chain actors are required to refocus on "value" from the multi-functional perspectives of sustainability and circularity [9].

In contrast to the linear take–make–dispose model [5], the CE focuses on how to reduce, reuse, recycle, regenerate, and use waste as a source of alternative materials/products [10,11]. Linear systems can transform into circular economies when end-of-life products are reprocessed and used as an input resource in a forward supply chain [12]. Circular business models, with their restructured production processes, can provide a new source of value that can benefit businesses financially and also improve their reputation [5,9,13].

Since the CE can provide insights to improve value chain coordination and lead to more sustainable and circular practices, it has been acknowledged as critical to integrate it with sustainable agri-food value chain management [1,12]. Some studies have emerged on CE in the agriculture sector [12,14–18]; however, there is limited empirical research connecting the CE and its application in agriculture value chains. Zhang et al. [19] suggest that more research is needed in the primary sector as well as research in the context of developing countries. Furthermore, as more businesses seek to switch from the conventional linear model to a circular model [19], it is still debatable whether it offers any benefits for different value chain actors or instead just presents more challenges. Our research aims to fill this gap in the literature by analyzing the circularity in agri-food value chains in the context of developing countries and we have the following research questions: What are the current circular practices in the agri-food value chain? What are the barriers to circular transformation, with specific focus on Indonesia's cashew case as an example?

Indonesia's cashew nut sector is used as a case study to demonstrate the application of the framework forwarded by this paper. The cashew sector in Indonesia presents an intriguing opportunity to examine a value chain within the framework of developing countries. Agriculture is a very important sector for the Indonesian economy and the cashew sector has received significant governmental support through regulations and growth incentives as a high-value product [20,21]. Cashew planting was initiated in 1975 by the Forestry Department as part of afforestation programs for critical land and dry climatic condition areas [22]. Cashew crops have the potential to improve soil conditions in arid areas, thereby supporting sustainable agriculture [23]. Indonesia is an important Asian cashew producer and exporter [24–26], with export volume fluctuating but following an increasing trend over the last 20 years [20]. Nevertheless, approximately 99.8% of cashew nuts in Indonesia are cultivated by smallholder farmers, who are often face challenges related to sustainability practice [27,28].

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This research provides both theoretical contributions and practical implications. First, this study answers the call for further empirical research on circularity in the agriculture sector. Second, most of the available literature, theories, and frameworks are based on concepts that are applicable and relevant to developed countries, while this study is one of the first to provide exploratory empirical results in a developing country context. Third, there are several studies discussing circular approaches at the individual company level, while this study extends our knowledge of multi-actor value chain perspectives.

## 2. Literature Review

### *2.1. Circular Economy*

The origins of the CE concept link back to the longstanding idea of "closing the loop" for materials in the economy [29–31] and, in particular, the industrial ecology concept which emerged as a research topic in the early 1980s [32]. In general, these concepts build on the idea that there are potential environmental (and economic in some cases) benefits of increased reuse, refurbishment, remanufacture, repair, and recycling of materials and/or products.

The CE concept was popularized by McDonough and Braungart [33,34] with their "cradle-to-cradle" publications, and then by the Ellen McArthur Foundation (EMF). Table 1 summaries the EMF approach, which is based on three core principles (https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview, accessed on 2 June 2024): eliminate waste and pollution, circulate products and materials (at their highest value), and regenerate nature. The CE "... *is underpinned by a transition to renewable energy and materials. A circular economy decouples economic activity from the consumption of finite resources. It is a resilient system that is good for business, people and the environment."*

**Table 1.** CE principles.

| Source | Principle |
|---|---|
| Ellen MacArthur Foundation [35] | Design out waste<br>Build resilience through diversity<br>Rely on energy from renewable sources<br>Think in 'systems'<br>Waste is food |
| Ellen MacArthur Foundation [6] | Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows<br>Optimize resource yields by circulating products, components, and materials at the highest utility at all times in both technical and biological cycles<br>Foster system effectiveness by revealing and designing out negative externalities |

The CE is often represented graphically by a so-called butterfly diagram whose two "wings" highlight that biological and technical nutrients are differentiated and managed differently in the CE. Biological nutrients are those materials (e.g., timber and paper) or products (e.g., food items) that can degrade into simpler organic compounds through biological processes, and technical nutrients are durable materials (e.g., steel and plastic) or products (e.g., televisions and cars) used in industrial systems and which can (at least potentially) be recycled within industrial systems. Biological nutrients can be returned to the biosphere, where they will safely degrade, whilst the aim is to retain technical nutrients within industrial ecosystems [35].

The CE concept has been criticized for several reasons. Firstly, its application may not lead to reduced environmental impacts of economic systems due to rebound effects at different system levels (micro, meso, and macro). Secondly, it does not adequately address social equity aspects, including impacts on future generations [36,37]. Thirdly, it may not deliver economic benefits. Lastly, a focus on the CE may divert attention from other approaches that could be more effective in guiding societies to more sustainable futures, in particular, the need to radically reform economic systems. Korhonen et al. [38] therefore suggest that the CE is an "essentially contested concept". This is substantiated by Kirchherr et al. [36], who identify 114 definitions of the CE. The latter also note that the main aim of the CE is economic prosperity followed by environmental quality, whilst others interpret the CE as having a primary aim of environmental quality [39].

There is a disconnect between research on the management of circular initiatives, particularly at the micro-level, and research on the quantitative modeling of material flows and related environmental impacts associated with circular systems. The management research agenda has been largely addressed through the lens of green or sustainable supply chain management (e.g., [40–42] and, more recently, circular supply chain management [19]. However, the quantitative modeling of (circular) material flows and environmental impact modeling has been addressed through the lens of industrial ecology, and Life Cycle Assessment (LCA) studies. Zink and Geyer [43] noted this disjunct and redraw the typical material flow diagram found in industrial ecology and LCA studies to include the markets that mediate these flows in economic systems. They concluded that, "*it turns out that simply closing material loops is not enough to guarantee environmental improvement*". Therefore, a further criticism of the academic literature on the CE is the lack of attention to integrated studies on product circularity initiatives and the role of actors in potentially circular value chains alongside the assessment of environmental and social, as well as economic, outcomes.

For the purposes of this research, we define the key characteristics of a circular economy as the three core principles listed by the Ellen MacArthur Foundation plus two additional ones. A "*transition to renewable energy*" is described as underpinning the realization of a CE by the EMF [44], and the differentiation between technical and biological nutrients is fundamental to the CE concept articulated by both McDonough and Braungart [33,34] and the EMF [6,35]. Thus, the key circular characteristics used in this research are as follows:

1. Eliminate waste and pollution.
2. Circulate products and materials (at their highest value).
3. Regenerate nature.
4. Rely on energy from renewable sources.
5. Differentiate technical and biological nutrients.

### 2.2. Agri-Food Value Chain

The value chain approach has been increasingly employed as a key driver in the development of the agri-food industry. The concept can be used to illuminate the authority and power relationships between different actors (governance) and value-added activities [2,45]. Altenburg [46] argues that governance is broader than control as it also facilitates cooperation between agri-food value chain actors and establishes resources allocation [47]. Value chain governance includes the vertical and horizontal coordination of the supply of products and services to markets [48]. Vertical coordination is required to integrate and align the activities along the chain (e.g., between producers and traders, suppliers and processors) [49]. Horizontal coordination, on the other hand, refers to the relationships between chain actors at the same level (e.g., between farmers) [50]. Agri-food value chain governance has become more complex due to globalization and sustainability requirements [12].

Value addition is created at different stages and by different actors throughout the value chain [48] via product quality, safety, costs, delivery, and innovativeness. Value-added activities in agri-food chains can be divided into those focused on pre-harvest and post-harvest quality [51]. Pre-harvest quality refers to the state of ripening and storage (i.e., color, flavor, texture, color, and blemish), whereas post-harvest quality describes the finished product's processing (i.e., grading, slicing, ingredients, and packaging). Value can also be destroyed during the process, as the amount of consumable food decreases or quality is undermined [10]. The actors that create most of the value are not necessarily able to capture an equivalent share of the wealth arising from value-added activities [52].

The majority of agri-food value chain actors in developing countries adhere to traditional practices, with smallholders playing a crucial role as primary suppliers of raw materials. These smallholders typically find it difficult to integrate with the wider value chain and struggle to create high-value offerings because of their limited resources, skills, and market power [48,53]. As a result, these value chains suffer from high food loss during harvesting and storage [54], leading to governmental initiatives to support smallholder farmers with the aim of improving their production capabilities so they can supply modern markets. The government support includes various measures, such as training programs, financial assistance, incentives/subsidies, technology transfer, and the development of institutions like farmer groups [27,45]. Value chain practice transformation is also frequently pursued by government agencies as a strategy to enhance smallholders' farming practices to meet high-value markets [27,55].

### *2.3. Development of a Framework for Assessing Circular Agri-Food Value Chains in Developing Countries*

Another pressing challenge in the agri-food sectors in developing countries is the rising demand for sustainable practices. This necessitates that the actors strike a balance between their economic profit orientation and their social–environmental concerns [2,27,56]. The CE approach holds promise as a potential solution to address economic, social, and environmental challenges and promote self-sustaining systems [4].

CE strategies in agri-food systems emphasize waste valorization, nutrient and energy recovery, and the reuse of secondary materials [57]. Studies highlight the importance of maximizing value extraction from agricultural by-products by converting them into higher-value outputs such as biofertilizers, animal feed, biomaterials, and bioenergy, thereby enabling circular business models and improving resource efficiency [58,59].

Previous studies have identified barriers to realizing circularity and sustainable practices. For instance, Mor et al. [60] mentioned that adopting sustainable agri-food value chains and a circular economy requires participation from multiple stakeholders (including producers, businesses, governments, and consumers), which is a complex and challenging process. Miranda et al. [12] agreed, stating that farms and firms may have different levels of knowledge resources to identify business opportunities that may hinder governance activities. In addition to this, Mehmood et al. [4] identify three central CE barriers in agri-food supply chains: institutional, financial, and technological. They explain that limited governmental support and incentives, high cost of circular transformation, limited technological innovation, and inadequate infrastructure are critical challenges for a circular transition. Despoudi et al. [1] and Miranda et al. [12] support this claim as CE and sustainable value chain initiatives require adequate working capital and investment in education. Technology plays a crucial role in developing circular agri-food systems, and institutional support is needed to promote governance activities in the adoption of circular practices [61]. Empirical evidence is required to evaluate these barriers to a circular transition of agri-food value chains in a developing countries context.

Some empirical evidence from agricultural value chains demonstrates some level of effectiveness of these approaches. In Vietnam's rice sector, straw and husks are increasingly valorized for mushroom cultivation, biomass energy, and organic fertilizers, replacing residue burning and closing nutrient loops [62]. Similarly, Brazil's sugarcane sector integrates food and renewable energy production by valorizing by-products for bioethanol and bioelectricity, while recycling nutrient-rich residues back to fields [63]. These cases illustrate how CE practices can simultaneously enhance productivity, support renewable resource-based systems, and reduce environmental impacts.

However, there is still limited research focusing on the connection between circular initiatives and agri-food value chains, particularly in the developing countries context. The two approaches have contrasting perspectives: value chains are predominately viewed as linear business models in business, society, and research [5]. In developing countries in particular, the goal of value chain management is typically to grow business by establishing new relationships, hence, maximizing economic performance. Conversely, the CE focusses on closing the loop, enabling the recovery of value across the wider supply chain [19], thereby balancing economic gains with environmental impacts.

In summary, the CE has the potential to address some of the most pressing challenges faced by agri-food value chains, including limited agricultural land, population growth, and dietary changes [1,17]. Value chain actors in developing countries can utilize circular principles when they develop their practices within the constraints of limited natural resources while meeting the needs of a growing population and adhering to stakeholder pressure for sustainability.

Figure 1 presents the framework proposed in this study to enable circularity in agri-food value chains in Indonesia, which could be applicable in other developing countries. Firstly, current practices in developing countries can be assessed using a traditional value chain lens by evaluating the governance and value addition along the linear chain. The six primary barriers previously identified can then be assessed to understand the main obstacles to circular agri-food transformation. The final stage involves the application of the five core circular principles, in doing so, we provide a route map to convert the traditional value chain into a circular agri-food value chain.

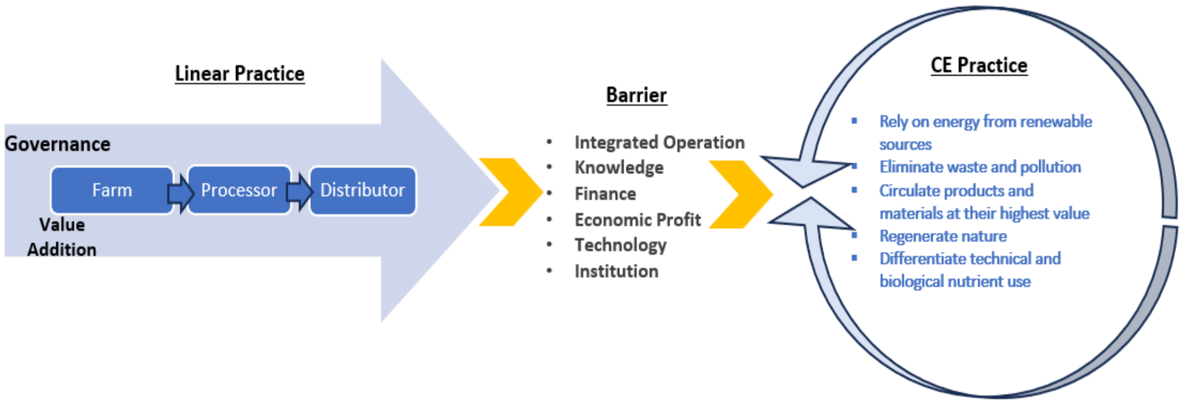


**Figure 1.** Circular agri-food value chain transition in developing countries, including Indonesia.

## 3. Methodology

This study focuses on the cashew sector in Madura Island in Indonesia. Madura Island is part of East Java Province in Indonesia, which plays a significant role in cashew production, covering a cultivation area of 30,167 ha [64,65]. This island contributes approximately 11% of Indonesia's national production [64], with an average productivity of around 0.76 tons per hectare [66]. The 'Cashew Belt' program was implemented on Madura

Island in 2014 to develop and intensify approximately 2660 ha of cashew plantations [64]. Sumenep Regency of Madura Island was chosen as the study area due to its status as a key production hub, contributing approximately 40% to East Java Province's total output. With 14,950 hectares of cashew area, it represents the second largest plantation area in the regency [67]. Additionally, 100% of cashew producers in this area are smallholders [28,64].

This study used qualitative methodology which allows further exploration and understanding of the phenomena relating to social or human problems [68]. Primary data were collected via semi-structured and face-to-face interviews. This method provides an opportunity for further explanations and additional space for the participants to share their views. The questionnaire was developed from the framework explained above, by focusing on cashew value chain players, current circular practices, and the barriers for circular transformation. The barrier-related questions specifically examine several key issues such as coordination and collaboration with other actors in the cashew value chain (such as collectors, farmer groups, and processors) in relation to cashew waste utilization; farmers' socio economic condition, skills, and technical capacity to re-use waste and to use technologies for processing; the financial costs and economic considerations involved in waste processing; and the support from farmer groups or local institutions. A total of 25 respondents participated in this study, which represent the cashew value chain actors and relevant governmental officers in 2024. The data were collected using purposive sampling, because it offers a unique perspective relevant to this study and allows for a deeper understanding of the phenomenon under investigation [69]. All respondents are actively involved in the cashew value chain/sector in Indonesia with at least two years of cashew sector experience. Data were collected from ten farmers, five intermediaries, two processors, one exporter, one head of the Cashew Farmers Association of East Java Province, two extension officers from the Agricultural and Plantation Agency, and four governmental officials of Sumenep Regency (Agricultural and Plantation Agency, Trade and Industrial Agency, and Cooperative and Small–Medium Enterprise Agency). Interviews were recorded and lasted between 45 and 60 min. In addition, photographs were taken to maintain the reliability and validity of the data.

Spiral analysis was used to analyze the qualitative data, which entails the classification of categories and subcategories The first phase involved organizing the data, including the storage of interview materials and transcription of audio recordings. The next phase focused on familiarization with the data through careful reading and the development of analytic memos. In the third phase, the data were described, coded, categorized, and interpreted, requiring a high level of analytical engagement. Coding was conducted to identify key themes and patterns, often based on the frequency and significance of recurring words and phrases [70]. Following this, interpretations were developed by comparing perspectives across data sources and drawing on the researcher's analytical judgment. In the final phase, the findings were synthesized and presented in visual formats, such as diagrams, to support interpretation and communication of the results.

## 4. Analysis

### *4.1. Cashew Value Chain Practice*

Figure 2 provides an overview of the current cashew value chain configuration in Sumenep Regency, Indonesia. The chain contains a multitude of small-scale farmers, several intermediaries, one major processor, and a handful of exporters. In general, cashew nuts are produced and marketed as raw produce, with the majority (75%) exported to neighboring countries. The circular economic principles are highlighted in the diagram, leading to further analyses in the following section.

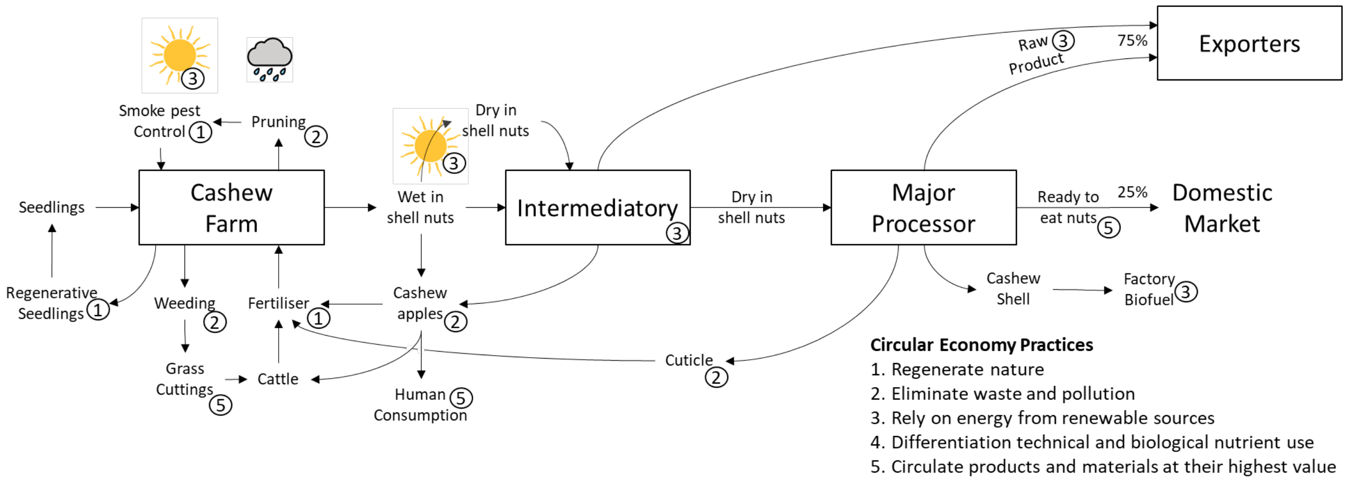


**Figure 2.** Sumenep cashew value chain practice.

The majority of cashew farms are family owned, with an average farm size of 0.35 hectares. Farmers mostly employ multiple cropping, which involves planting cashew trees alongside other seasonal crops (i.e., corn or paddy) with the cashew trees planted as hedgerows. The number of trees ranges from 5 to more than 100 trees (for larger farms). Productivity ranges from 5 kg to nearly 100 kg per tree, as many of the smallholders pay limited attention to their cashew trees as they focus on their other crops that provide higher and more regular income. Farmers used self-cultivation seeds to rejuvenate their cashew farm, and alternative seed sources may be sought from governmental seed grants. Cashew farming relies heavily on rainfall as there is no irrigation system available in the area. Herbicides are not commonly used for weed control because they poison and dry the surrounding grass, making it unusable for animal feed. Chemical fertilizer is rarely used for the cashew trees, rather manure from cattle is used as a fertilizer. Two methods are used by the respondents to control pests and disease in their cashew farms: smoking cashew trees and pesticides. Again, chemical pesticides are rarely used, while smoking cashew trees is commonly applied with caution from a safe distance to avoid burning the trees. In some cases, the burning material comes from pruning waste.

Pruning is carried out by selecting and cutting unwanted branches to maintain the tree's shape and improve productivity. It is undertaken primarily after the harvesting season. Cashew apples are harvested, and the nuts that are removed are known as 'wet-in-shell' nuts. Meanwhile, the outer casings (cashew apples) are used in various ways, such as manure, animal feed, and for human consumption as fruit. Some farmers sell 'wet-in-shell' nuts while many sell 'dry-in-shell' products after a drying process (sun exposure for 3–4 days).

In high-quality whole cashew fruit (maturely harvested), about 90% is cashew apple, and 10% is the cashew nut (the product going to consumers) (Table 2). However, the composition may vary depending on the size of the harvested cashew fruits. In many cases, farmers harvest immature cashew nuts, which affects both the number of nuts produced and their weight. While cashew apples can be used as animal feed or for human consumption, most are discarded in the field, where they naturally decompose and act as organic fertilizer. As a result, farmers often do not prioritize harvesting mature fruits of good quality.

**Table 2.** Cashew nuts and by-products.

| No. | Product | Total Weigh (Gram) | Key Products | Waste Utilization |
|---|---|---|---|---|
| 1 | Cashew fruit | 1 kg | 10% nuts (around 100 g, 16–18 nuts)<br>90% cashew apples (around 900 g | Local consumption, cattle feed, thrown away |
| 2 | Cashew nuts | 1 kg | 30% shelled nuts (around 300 g)<br>70% cashew shells (around 700 g) | Fuel source |

In fact, cashew apple waste can be utilized as an energy source in the form of bagasse, as well as in the production of fermented cultures used in probiotics. Additionally, it can be used for soil conditioning. Moreover, cashew apples are rich in vitamins and minerals, and the residue left after juice extraction can further assist in the fermentation process [71,72]. However, more research is needed to identify which activities would be most suitable for smallholders to engage in and what kind of businesses could be developed from cashew apples. Farmers would need potential buyers for such waste products, as well as fair pricing; otherwise, they are unlikely to be interested in such ventures, given that the cashew nuts already offer a good price. They may also consider shelling the cashew nuts for a potentially higher income.

Table 1 further shows that 1 kg of cashew nuts yields only around 300 g of edible kernels, while the remaining 700 g consist of cashew shells. This means only 30% of the cashew nut is used as a high-value food product. The leftover shells are typically sold to the limestone industry as fuel, and farmers also use them as an alternative energy source for traditional stoves. This further impacts the number of cashew nuts produced and the resulting waste. Cashew nut shell waste can be converted into charcoal briquettes with high calorific value and compressive strength [71,73].

Intermediaries buy either wet- or dry-in-shell nuts from farmers. Intermediaries are typically small-scale collators or wholesalers. Small-scale intermediaries are often farmers' relatives, friends, or traders who buy cashew products from farmers at the farm gate. Meanwhile, wholesalers are mostly well-known traders in the area.

Around 25% of raw cashew products are processed by the main processor, who is also the major wholesaler. The processing procedure starts with the un-shelling process. A mass of 1 kg of 'dry-in-shell' nuts produces around 300 g of 'shelled' nuts. Cashew shells, the waste from this process, are frequently sold to the local limestone business for biofuel as a wood replacement. Next, the process continues with cuticle removal to produce 'shelled' nuts for further food processing. This process also results in waste (cuticles), which is used as organic fertilizer on the farm and applied primarily in the rainy season. Finally, food processing activities are carried out using a range of procedures, including frying and roasting, as well as packaging, to serve the ready-to-eat nuts to the domestic market. The vast majority of the cashew nuts are exported in the form of dry-in-shell nuts to neighboring countries such as India and Vietnam. Gunny sacks (bags made from natural fibers) are commonly used for packaging. The exporters generally receive consolidated volumes of cashew products from wholesalers.

### *4.2. Identification of CE Principles in Cashew Value Chain*

Table 3 cross references the value chain activities with the CE principles for the main cashew value chain actors. The cashew farmers in Indonesia employ traditional production approaches, based on their experience, resulting in a wide range of circular value chain activities. Many of the circular activities are primarily performed at the farmer and processor echelons. The overall cashew production system demonstrates efficient resource use with very limited pollution or wastage.

**Table 3.** Cashew value chain circular practices.

| CE Principles | Farmers | Intermediaries | Key Processor | Exporter (Raw Material Exporter) |
|---|---|---|---|---|
| Eliminate waste and pollution | - Cashew apples are used for manure, livestock feed, and/or consumption<br>- Grass waste from weeding used for cattle feed<br>- Branches from pruning are burnt for pest and disease control | N/A | - Cuticles used as farm fertilizer<br>- Cashew shells used as biofuel | N/A |
| Circulate products and material at the highest value | - Unstandardized<br>raw material | Unstandardized raw material | Value-adding processes for domestic consumption (limited national standard) | Export standard products (raw material) |
| Regenerate nature | - Use of organic fertilizers<br>- Minimal use of chemical fertilizers<br>- Rejuvenation from current cashew trees | N/A | N/A | N/A |
| Rely on energy from renewable sources | - Sun exposure reliant at farm production<br>- Sun exposure reliant when drying cashew nuts<br>- Rainfall water reliant for watering trees<br>- Fertilizers sourced from cattle sewage<br>- Use of leaves and branches as the main material for pest and disease control | Use of sun exposure to dry cashew nuts | - Sun exposure to dry cashew nuts<br>- Woods material processing tool<br>- Manual/labor work<br>- Gunny sack as main cashew nuts packaging | Gunny sack as main cashew nuts packaging |
| Differentiate technical and biological nutrients | - Minimal technical nutrients<br>- Regenerative biological nutrients | N/A | N/A | N/A |

Note: N/A = No available practice found.

The application of traditional production techniques results in regenerating activities, a high reliance on renewable energy, and a clear differentiation of technical and biological nutrients. At the farm level, farmers use almost all natural-based inputs (i.e., rainfall, manure, pruning, and regenerative seedlings). At the processing stage, the processor uses sun exposure to dry cashew nuts and a wooden tool to un-shell the cashew nuts. However, the cashew value chain generates low levels of value addition or capture. The actors add very limited value throughout the chain, with most of the products exported as a raw commodity with limited processing, a lack of certification, or branding.

The results of this study suggest that there are several circular activities, underpinned by CE principles, integrated in the cashew value chain in Indonesia due to the use of traditional production systems. Cashew farmers and processors are involved in waste reduction, the use of regenerative principles, renewable resources, and biological nutrients (Table 4).

**Table 4.** Circular practice in Indonesia cashew value chains.

| CE Principles | Practice | Key CE Players |
|---|---|---|
| 1. Eliminate waste and pollution | *** | Farmers and processors |
| 2. Circulate products and material at the highest value | * | Processors and exporters |
| 3. Regenerate nature | *** | Farmers |
| 4. Rely on energy from renewable sources | *** | Farmers and processors |
| 5. Differentiate technical and biological nutrients | *** | Farmers |

Note: * Low, ** moderate, and *** high.

### *4.3. Identification of CE Barriers in Cashew Value Chain*

While the current practice in the cashew value chain in Indonesia appears to follow many circular principles, there are several barriers faced by the value chain actors (Table 5). The key barriers identified in this study are limited CE and sustainability knowledge, limited horizontal and vertical integration, and minimal value-adding activities. Meanwhile, financial constraints are not a concern for the majority of players.

**Table 5.** CE barriers in Indonesia cashew value chains.

| Barriers | Barriers Level | Description |
|---|---|---|
| Knowledge | *** | Limited CE and sustainability awareness |
| Profit orientation | *** | Minimal value-adding activities |
| Integrated activities | *** | Limited vertical and horizontal governance |
| Technology | ** | Traditional technology that supports CE practices |
| Institution | *** | Limited farmer groups and governmental incentives |
| Finance | * | Minimal CE investment |

Note: * Low, ** moderate, and *** high.

Across the value chain—from farmers to exporters—actors generally lack a clear understanding of the CE and sustainable practices. Most rely on instinct and traditional cultural methods rather than systematic approaches. Exporters, in particular, engage in few CE or sustainability initiatives, as their focus is mainly on exporting raw materials. More than 75% of cashew production is sold as raw material, with minimal processing or added value and low profit. According to a key processor, the price of raw (dried in-shell) cashew ranges from IDR 20,000 to IDR 23,000 per kilogram (approximately USD 1.20–USD 1.40), while shelled cashew nuts can sell for IDR 100,000 to IDR 150,000 per kilogram (around USD 6.00–USD 8.90). Moreover, the technology used—especially by farmers and processors—remains largely traditional and based on cultural practices. However, these low-tech methods result in relatively low financial costs. Additionally, many cashew farmers in the study area are not affiliated with farmer groups, reflecting a lack of coordination and integration both horizontally and vertically. Existing farmer groups mainly serve as channels for government support, such as the distribution of subsidized seeds and fertilizers, and act as intermediaries connecting farmers with extension workers—primarily to support the production of other crops like corn and rice.

## 5. Discussion

A key challenge facing developing countries is how they transition their agri-food value chains into a more circular fashion. This involves using fewer resources, reusing products, and recycling waste throughout the chain. While some studies have extensively discussed these issues, this study contributes by providing empirical evidence on current circular practice within the context of developing countries.

The cashew value chain players in Indonesia have limited knowledge of the importance of circular practice. The smallholders use traditional production approaches, which are advantageous in terms of alignment with circular principles, and they use or sell by-products and waste. However, they undertake this due to limited financial resources rather than specifically and intentionally avoiding the use of chemical fertilizers. Therefore, greater awareness is required in the future to intentionally maintain these circular practices. Governmental support, efficient value chain coordination, and training can enhance the adoption of circular activities [1,74].

Prior research suggests that moving towards circular food systems is costly [12], while this study demonstrates how traditional agriculture, still practiced in many developing countries, already includes many circular activities. However, the ability to create economic value in the cashew value chain is challenging. Most of the product is sold as a commodity (raw cashew nuts), with little value attributed to the circular practices used by smallholders. Furthermore, cashew producers receive minimal economic benefit from selling their by-products or waste, such as cashew apples or shells. Currently, the use of cashew shells is being explored as a substitute non-renewable sources for other industries [20]. Bastos and Tubino [75] discovered that cashew nuts shell liquid (CNSL) could provide a low-cost material for producing biodiesel, which is very advantageous due to its vegetal origin nature with minimal environmental impact. Brazil has developed successful valorization pathways for cashew apples, where they are not only processed into various food and beverage products at an industrial scale but also further valorized through the use of secondary by-products (cashew bagasse/pomace) [76]. With a reorganized mechanism in production and consumption processes, circular models have the potential to provide new sources of value [5].

There is currently a lack of integration between the farm-based cashew circular activities and downstream value chain actors in Indonesia. This situation is frequently observed in developing countries, where systemic integration in value chain practice remains limited [47,48]. However,, a key characteristic of industrial symbiosis in practice [19] is collaborative circular transformation. This lack of cooperation to develop circular value chains may be caused by cultural barriers in terms of attitudes and mindsets [1] and institutional practices that hamper the effectiveness of current value chain practices. The main reason is typically a lack of linkage between institutions, industry, and governments [60]. Ineffective institutional policies and a lack of legal regulations regarding waste collection and treatment often impede the transition from linear to circular value chains [4].

Limited technology adoption is apparent in the cashew value chain in Indonesia. Manual labor is mainly used on farms and in the processing stages. It is doubtful that the application of sophisticated technology would improve the circularity of the value chain. Technology application (i.e., machine use) often results in more waste and pollution [3], as it is often reliant on non-renewable resources and the use of technical nutrients. As a result, these efforts have the potential to degrade current circular practices, which are well-established under the current traditional system.

Regarding institutions, the Indonesian government provides limited CE regulation and standards and instead focuses primarily on economic profit enhancement for farmers. Governments are powerful and effective stakeholders when it comes to resolving conflicts of interest and encouraging resource circularity [19]. Therefore, despite limited institutional support, an effective and coordinated network between central, local, and extension workers has the capacity to connect with the cashew value chain actors and promote circular principles and the development of circular value chains.

Lastly, as mentioned earlier by Miranda et al. [12], moving towards circular food systems is often costly. However, this study suggests the opposite. The ability of the cashew value chain players to resolve their challenges locally while uncovering potential within their surroundings is crucial to minimizing financial investment. Smallholder farmers seize beneficial opportunities from local resources that are often considered waste, such as using livestock waste for manure, utilizing weed grass as livestock feed, and using pruned tree branches for smoking the trees (as a bio-pesticide). In the meantime, the cashew value chain not only address waste management but also presents an avenue for additional revenue, such as processors who sell cashew shells to factories for biofuel. In comparison, Vietnam and India have developed some valorization pathways for cashew shells, where they are processed into cashew nut shells liquid (CNSL) and used for industrial applications [77].

The aforementioned points further indicate that the primary challenge in enhancing circular practices in developing countries is to circulate products and materials at their highest value. In addition to this, financial barriers could be addressed by incorporating two additional elements: preserving beneficial cultural practice and engaging local business with a mutualism partnership to minimize financial investments, as depicted in Figure 3 below.

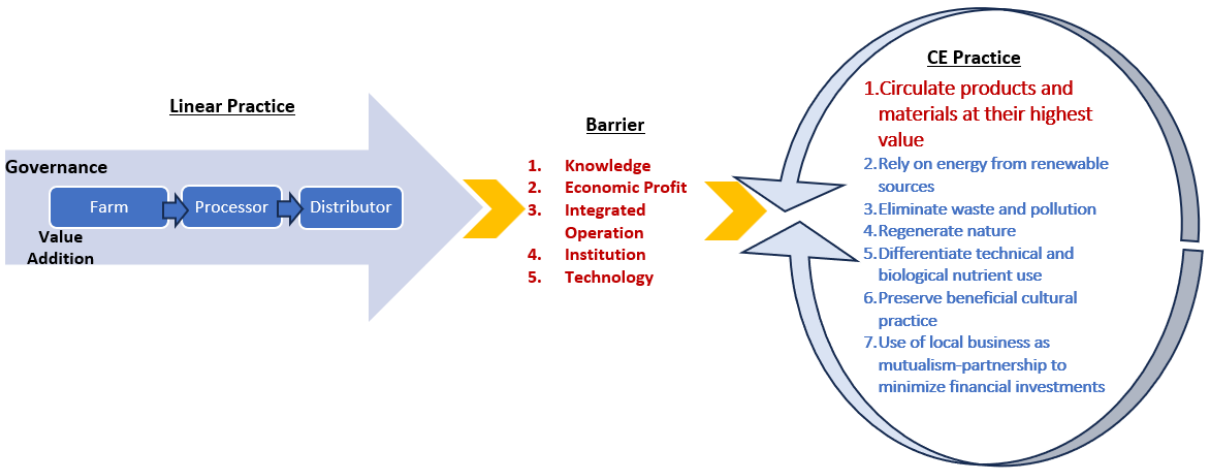


**Figure 3.** Improved framework for circular agri-food value chain transition in developing countries.

The development of circular practices should emphasize the preservation of beneficial cultural practices. Traditional systems in developing countries demonstrate the value and uniqueness of their traditional practices, which is surprising. As suggested by Hidayati et al. [27], it is important to preserve these culturally traditional and sustainable farm practices. Next, symbiotic mutualism from local business also emerges as a pivotal aspect of circularity, facilitating reduced financial requirements. Many emerging and developing countries are transforming their traditional agriculture practices towards supplying modern markets, following these industrialization processes [78]. However, local business/regional business could support the closed-loop circular economy within the regional boundary. Thus, finance should not necessarily be considered as a significant barrier to apply circular practices in agri-food value chains for developing countries.

## 6. Conclusions

The study provides novel empirical insights into the circularity in agri-food value chains in developing countries and Indonesia in particular. The findings highlight how traditional production systems incorporate a wide range of core circular principles that need to be preserved and potentially leveraged. Exporters in Indonesia and other developing countries have limited power to escape the raw commodity trap. Support mechanisms are required to increase the economic value of food exports by further processing and adding value to access higher-value international markets.

The theoretical contribution of this study lies in highlighting the importance of addressing key barriers specific to developing country contexts in order to advance value chains toward a CE system, where financial constraints are not always the primary limiting factor. This study identifies five critical barriers that require attention: limited CE and sustainability awareness, minimal value-adding activities, weak integration across value chain functions, insufficient institutional support for CE implementation, and technological solutions. The findings emphasize that technological interventions do not necessarily need to be sophisticated; rather, they must be locally adapted and aligned with existing preservation and production systems. The framework developed in this study can guide policymakers, practitioners, and value chain actors in developing countries in designing scalable and transferable strategies that address these barriers and strengthen sustainability, competitiveness, and resilience across diverse agro-industrial value chain settings.

Practically, a key general recommendation emerging from this is the need for collaboration and coordination between relevant actors (public and private), which are essential for a system change such as a CE transition. Value chain actors have to coordinate the sourcing of sustainable inputs as well as the collection, repair, reuse, and recycle of end-of-life materials. The activities within the chain need to prioritize waste valorization pathways; strengthen farmer–processor partnerships; develop business models that increase profitability from by-products; reinforce institutional coordination between local governments and private actors; and invest in appropriate processing technologies that enable full resource recovery. In addition to this, value chain governance is essential to coordinate the transition to a CE via the provision of incentives, especially for smallholder farmers, and value-adding activities and increasing institution support, by forming farmer groups, and the creation of broader networks to encourage new entrants to participate. To be noted, establishing circular value chain practices should also entail preserving sustainable practices and leveraging closed-loop activities.

The qualitative methodology used in this study limits transferability, especially given the narrow focus on the Indonesian cashew sector. However, the study does provide exploratory insights into this very complex phenomenon, leaving scope for further research to test the findings in different settings—agri-food sectors and countries. The traditional practices used in other developing countries will more than likely also be well-aligned with circular principles. How we nurture the sustainability of these value chains as they develop is a critical research question requiring further investigation.

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## References

1. Despoudi, S.; Sivarajah, U.; Dora, M. *From Linear to Circular Food Supply Chains: Achieving Sustainable Change*; Springer International Publishing: Cham, Switzerland, 2021; ISBN 978-3-030-72672-0.
2. Hidayati, D.R.; Garnevska, E.; Childerhouse, P. Sustainable Agrifood Value Chain—Transformation in Developing Countries. *Sustainability* **2021**, *13*, 12358. [CrossRef]
3. Zocca, R.O.; Gaspar, P.D.; da Silva, P.D.; Nunes, J.; de Andrade, L.P. Introduction to Sustainable Food Production. In *Sustainable Food Systems from Agriculture to Industry*; Elsevier: Amsterdam, The Netherlands, 2018; pp. 3–46. ISBN 978-0-12-811935-8.
4. Mehmood, A.; Ahmed, S.; Viza, E.; Bogush, A. Drivers and Barriers towards Circular Economy in Agri-food Supply Chain A Review. *Bus. Strategy Dev.* **2021**, *4*, 465–481. [CrossRef]
5. Hofstetter, J.S.; De Marchi, V.; Sarkis, J.; Govindan, K.; Klassen, R.; Ometto, A.R.; Spraul, K.S.; Bocken, N.; Ashton, W.S.; Sharma, S.; et al. From Sustainable Global Value Chains to Circular Economy—Different Silos, Different Perspectives, but Many Opportunities to Build Bridges. *Circ. Econ. Sustain.* **2021**, *1*, 21–47. [CrossRef] [PubMed]
6. Ellen MacArthur Foundation. *Delivering the Circular Economy: A Toolkit for Policymakers*; Ellen MacArthur Foundation: Cowes, UK, 2015; p. 177.
7. Groenewald, E.S.; Espinosa-Jaramillo, M.T.; Garg, A.; Pipalia, K.D.; Umasekar, V.; Groenewald, C.A. Circular Economy Strategies in Supply Chain Management: Towards Zero Waste. *Power Syst. Technol.* **2024**, *48*, 464–480. [CrossRef]
8. World Bank. *Worldbank_2018_Working with Smallholders: A Handbook for Firms Building Sustainable Supply Chains*; World Bank: Washington, DC, USA, 2019.
9. Liu, J.; Feng, Y.; Zhu, Q.; Sarkis, J. Green Supply Chain Management and the Circular Economy: Reviewing Theory for Advancement of Both Fields. *Int. J. Phys. Dist. Log. Manag.* **2018**, *48*, 794–817. [CrossRef]
10. Chiaraluce, G.; Bentivoglio, D.; Finco, A. Circular Economy for a Sustainable Agri-Food Supply Chain: A Review for Current Trends and Future Pathways. *Sustainability* **2021**, *13*, 9294. [CrossRef]
11. Wang, B.; Luo, W.; Zhang, A.; Tian, Z.; Li, Z. Blockchain-Enabled Circular Supply Chain Management: A System Architecture for Fast Fashion. *Comput. Ind.* **2020**, *123*, 103324. [CrossRef]
12. Miranda, B.V.; Monteiro, G.F.A.; Rodrigues, V.P. Circular Agri-Food Systems: A Governance Perspective for the Analysis of Sustainable Agri-Food Value Chains. *Technol. Forecast. Soc. Change* **2021**, *170*, 120878. [CrossRef]
13. Gong, Y.; Wang, Y.; Frei, R.; Wang, B.; Zhao, C. Blockchain Application in Circular Marine Plastic Debris Management. *Ind. Mark. Manag.* **2022**, *102*, 164–176. [CrossRef]
14. Fan, W.; Dong, X.; Wei, H.; Weng, B.; Liang, L.; Xu, Z.; Wang, X.; Wu, F.; Chen, Z.; Jin, Y.; et al. Is It True That the Longer the Extended Industrial Chain, the Better the Circular Agriculture? A Case Study of Circular Agriculture Industry Company in Fuqing, Fujian. *J. Clean. Prod.* **2018**, *189*, 718–728. [CrossRef]
15. Kapoor, R.; Ghosh, P.; Kumar, M.; Sengupta, S.; Gupta, A.; Kumar, S.S.; Vijay, V.; Kumar, V.; Kumar Vijay, V.; Pant, D. Valorization of Agricultural Waste for Biogas Based Circular Economy in India: A Research Outlook. *Bioresour. Technol.* **2020**, *304*, 123036. [CrossRef] [PubMed]
16. Kusumowardani, N.; Tjahjono, B.; Lazell, J.; Bek, D.; Theodorakopoulos, N.; Andrikopoulos, P.; Priadi, C.R. A Circular Capability Framework to Address Food Waste and Losses in the Agri-Food Supply Chain: The Antecedents, Principles and Outcomes of Circular Economy. *J. Bus. Res.* **2022**, *142*, 17–31. [CrossRef]
17. Silvestri, C.; Silvestri, L.; Piccarozzi, M.; Ruggieri, A. Toward a Framework for Selecting Indicators of Measuring Sustainability and Circular Economy in the Agri-Food Sector: A Systematic Literature Review. *Int. J. Life Cycle Assess.* **2022**, *29*, 1446–1484. [CrossRef]
18. Vrolijk, H.; Reijs, J.; Dijkshoorn-Dekker, M. *Towards Sustainable and Circular Farming in the Netherlands: Lessons from the Socio-Economic Perspective*; Wageningen University and Research: Wageningen, The Netherlands, 2020.
19. Zhang, A.; Wang, J.X.; Farooque, M.; Wang, Y.; Choi, T.-M. Multi-Dimensional Circular Supply Chain Management: A Comparative Review of the State-of-the-Art Practices and Research. *Transp. Res. Part E Logist. Transp. Rev.* **2021**, *155*, 102509. [CrossRef]
20. Directorate General of Estate Crops, Ministry of Agriculture. *Tree Crop Estate Statistics of Indonesia 2018–2020: Cashew Nuts*; Ministry of Agriculture of Indonesia: Jakarta, Indonesia, 2019.

21. President Republic Indonesia. *Regulation Presidential Regulation of Republic Indonesia No 44*; President of the Republic of Indonesia: Jakarta, Indonesia, 2016.
22. Directorate General of Plantation. *Technical Guide for Cashew Nuts Development*; Directorate General of Plantation: Jakarta, Indonesia, 2012.
23. United Nations. *Commodities at a Glance Special Issue on Cashew Nuts*; United Nations: Geneva, Switzerland, 2021; ISBN 978-92-1-005383-9.
24. ACi. *A Value Chain Analysis of the Cashew Sector in Ghana*; Technische Zusammenarbeit GmbH (GTZ); FAO: Rome, Italy, 2010.
25. CBI. *Exporting Cashew Nuts to Europe*; CBI: The Hague, The Netherlands, 2016.
26. Dendena, B.; Corsi, S. Cashew, from Seed to Market: A Review. *Agron. Sustain. Dev.* **2014**, *34*, 753–772. [CrossRef]
27. Hidayati, D.R.; Garnevska, E.; Childerhouse, P. Enabling Sustainable Agrifood Value Chain Transformation in Developing Countries. *J. Clean. Prod.* **2023**, *395*, 136300. [CrossRef]
28. Hidayati, D.R.; Garnevska, E.; Ramilan, T. Assessing Smallholders' Heterogeneity towards Sustainable Agrifood Value Chain in Developing Countries. *BFJ* **2023**, *125*, 4307–4334. [CrossRef]
29. Domenech, T.; Stegemann, J.A. Chapter 2: The Circular Economy: Concept, Tools and Implementation. In *Life Cycle Assessment: A Metric for The Circular Economy*; Royal Society of Chemistry: London, UK, 2021; pp. 27–53.
30. Ghisellini, P.; Cialani, C.; Ulgiati, S. A Review on Circular Economy: The Expected Transition to a Balanced Interplay of Environmental and Economic Systems. *J. Clean. Prod.* **2016**, *114*, 11–32. [CrossRef]
31. McLaren, S.J. Chapter 15: Linking Life Cycle Assessment to the Wider Circular Economy. In *Life Cycle Assessment: A Metric for The Circular Economy*; Royal Society of Chemistry: London, UK, 2021; pp. 358–374.
32. Graedel, T.E.; Lifset, R.J. Industrial Ecology's First Decade. In *Taking Stock of Industrial Ecology*; Clift, R., Druckman, A., Eds.; Springer: Cham, Switzerland, 2016; pp. 3–20.
33. McDonough, W.; Braungart, M. *The Upcycle: Beyond Sustainability—Designing for Abundance*; North Point Press: New York, NY, USA, 2013.
34. McDonough, W.; Braungart, M. *Cradle to Cradle: Remarking the Way We Make Things*; North Point Press: New York, NY, USA, 2002.
35. Ellen MacArthur Foundation. *Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition*; Ellen MacArthur Foundation: Cowes, UK, 2013.
36. Kirchherr, J.; Reike, D.; Hekkert, M. Conceptualizing the Circular Economy: An Analysis of 114 Definitions. *Resour. Conserv. Recycl.* **2017**, *127*, 221–232. [CrossRef]
37. Merli, R.; Preziosi, M.; Acampora, A. How Do Scholars Approach the Circular Economy? A Systematic Literature Review. *J. Clean. Prod.* **2018**, *178*, 703–722. [CrossRef]
38. Korhonen, J.; Nuur, C.; Feldmann, A.; Birkie, S.E. Circular Economy as an Essentially Contested Concept. *J. Clean. Prod.* **2018**, *175*, 544–552. [CrossRef]
39. Helander, H.; Petit-Boix, A.; Leipold, S.; Bringezu, S. How to Monitor Environmental Pressures of a Circular Economy: An Assessment of Indicators. *J. Ind. Ecol.* **2019**, *23*, 1278–1291. [CrossRef]
40. Ageron, B.; Gunasekaran, A.; Spalanzani, A. Sustainable Supply Management: An Empirical Study. *Int. J. Prod. Econ.* **2012**, *140*, 168–182. [CrossRef]
41. Seuring, S.; Müller, M. From a Literature Review to a Conceptual Framework for Sustainable Supply Chain Management. *J. Clean. Prod.* **2008**, *16*, 1699–1710. [CrossRef]
42. Srivastava, S.K. Green Supply-Chain Management: A State-of-the-Art Literature Review. *Int. J. Manag. Rev.* **2007**, *9*, 53–80. [CrossRef]
43. Zink, T.; Geyer, R. Circular Economy Rebound. *J. Ind. Ecol.* **2017**, *21*, 593–602. [CrossRef]
44. Ellen MacArthur Foundation. *Why Renewable Energy Infrastructure Needs to Be Built Using a Circular Economy Approach*; Ellen MacArthur Foundation: Cowes, UK, 2023.
45. Hidayati, D.R.; Garnevska, E.; Childerhouse, P. Transforming Developing Countries Agrifood Value Chains. *Int. J. Food Syst. Dyn.* **2021**, *12*, 358–374. [CrossRef]
46. Altenburg, T. Governance Patterns in Value Chains and Their Development Impact. *Eur. J. Dev. Res.* **2006**, *18*, 498–521. [CrossRef]
47. Gereffi, G.; Humphrey, J.; Sturgeon, T. The Governance of Global Value Chains. *Rev. Int. Political Econ.* **2005**, *12*, 78–104. [CrossRef]
48. Trienekens, J.H. Agricultural Value Chains in Developing Countries A Framework for Analysis. *Int. Food Agribus. Manag. Rev.* **2011**, *14*, 32.
49. Lazzarini, S.; Chaddad, F.; Cook, M. Integrating Supply Chain and Network Analyses: The Study of Netchains. *J. Chain. Netw. Sci.* **2001**, *1*, 7–22. [CrossRef]
50. Liu, Y.; Garnevska, E.; Shadbolt, N. The Role of Agriculture Cooperatives in Green Agri-Food Value Chains in China: Cases in Shandong Province. *Sustainability* **2025**, *17*, 7343. [CrossRef]
51. Collins, R. Value Chain Management and Postharvest Handling. In *Postharvest Handling*; Elsevier: Amsterdam, The Netherlands, 2014; pp. 123–145. ISBN 978-0-12-408137-6.

52. Kaplinsky, R.; Morris, M. *A Handbook for Value Chain Research*; FAO: Rome, Italy, 2000; p. 113.
53. Sjauw-Koen-Fa, A.R.; Blok, V.; Omta, O.S.W.F. Critical Success Factors for Smallholder Inclusion in High Value-Adding Supply Chains by Food & Agribusiness Multinational Enterprises. *Int. Food Agribus. Manag. Rev.* **2016**, *19*, 83–112.
54. FAO. Agrifood Market and Value Chains. In *Rural Development Report*; FAO: Rome, Italy, 2016.
55. Maspaitella, M.; Garnevska, E.; Siddique, M.I.; Shadbolt, N. Towards High Value Markets: A Case Study of Smallholder Vegetable Farmers in Indonesia. *Int. Food Agribus. Manag. Rev.* **2018**, *21*, 73–88. [CrossRef]
56. FAO. *Developing Sustainable Food Value Chains: Guiding Principles*; FAO: Rome, Italy, 2014; ISBN 978-92-5-108481-6.
57. Vlajic, J.V.; Mijailovic, R.; Bogdanova, M. Creating Loops with Value Recovery: Empirical Study of Fresh Food Supply Chains. *Prod. Plan. Control* **2018**, *29*, 522–538. [CrossRef]
58. Nattassha, R.; Handayati, Y.; Simatupang, T.M.; Siallagan, M. Understanding Circular Economy Implementation in the Agri-Food Supply Chain: The Case of an Indonesian Organic Fertiliser Producer. *Agric. Food Secur.* **2020**, *9*, 10. [CrossRef]
59. Tanveer, U.; Ishaq, S.; Gough, A. Circular Economy in Agri-Food Sector: Food Waste Management Perspective. In *Business Systems & Operations*; Environmental Footprints and Eco-design of Products and Processes; Springer: Singapore, 2021; pp. 55–75. ISBN 978-981-16-3791-9.
60. Mor, R.S.; Panghal, A.; Kumar, V. (Eds.) *Challenges and Opportunities of Circular Economy in Agri-Food Sector: Rethinking Waste*; Environmental Footprints and Eco-design of Products and Processes; Springer: Singapore, 2021; ISBN 978-981-16-3790-2.
61. Abbate, S.; Centobelli, P.; Cerchione, R.; Giardino, G.; Passaro, R. Coming out the Egg: Assessing the Benefits of Circular Economy Strategies in Agri-Food Industry. *J. Clean. Prod.* **2023**, *385*, 135665. [CrossRef]
62. UNDP. Joint Initiative to Upgrade Agricultural Circular Businesses in Viet Nam. Available online: https://www.undp.org/vietnam/press-releases/joint-initiative-upgrade-agricultural-circular-businesses-viet-nam (accessed on 19 December 2025).
63. Cherubin, M.R.; Bordonal, R.O.; Castioni, G.A.; Guimarães, E.M.; Lisboa, I.P.; Moraes, L.A.A.; Menandro, L.M.S.; Tenelli, S.; Cerri, C.E.P.; Karlen, D.L.; et al. Soil Health Response to Sugarcane Straw Removal in Brazil. *Ind. Crops Prod.* **2021**, *163*. [CrossRef]
64. Kementrian Pertanian. *Outlook Komoditas Perkebunan Jambu Mete*; Pusat Data dan Sistem Informasi Pertanian kementrian Pertanian: Jakarta, Indonesia, 2022; pp. 1–87.
65. Plantation Agency. *Strategic Plan of East Java Plantation Agency 2014-2019 (Rencana Strategis (RENSTRA) Dinas Perkebunan Provinsi Jawa Timur Tahun 2014–2019)*; Plantation Office of East Java Province: Surabaya, Indonesia, 2014.
66. Susanto, E.B. Eksplorasi Tanaman Jambu Mete (*Annacardium occidentale* L.) Pada Beberapa Daerah Sentra Di Pulau Madura). *J. Produksi Tanam.* **2018**, *6*, 1048–1057.
67. Statistics Indonesia Sumenep Regency. *Plantation Area in Sumenep Regency (Thousand Ha) in 2024*; BPS-Statistics Indonesia BPS-Statistics Indonesia Sumenep Regency: Sumenep, Indonesia, 2024.
68. Cresswell, J.W. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, 4th ed.; SAGE Publications, Inc.: Thousand Oaks, CA, USA, 2014.
69. Yin, R.K. *Case Study Research: Design and Methods*, 4th ed.; Sage: Thousand Oaks, CA, USA, 2009.
70. Zikmund, W.G.; Babin, B.J.; Car, J.C.; Griffin, M. Editing and Coding: Transforming Raw Data. In *Business Research Methods*; South Western Cengage Learning: Toronto, ON, Canada, 2010; pp. 461–484.
71. Aslam, N. Exploring the Potential of Cashew Waste for Food and Health Applications- A Review. *Future Foods* **2024**, *9*, 100319. [CrossRef]
72. Patade, M.A.; Gaikwad, S.T.; Pathare, M.; Nikhade, Y. Utilization of Cashew Nut Waste: Cashew Apple and Shell. *Int. J. Chem. Stud.* **2020**, *8*, 2076–2078. [CrossRef]
73. Pathaveerat, S. The Potential of Cashew Nut Shell Waste in Charcoal Briquettes after Producing Cashew Nut Shell Liquid through Cold Extraction. *Results Eng.* **2024**, *23*, 102579. [CrossRef]
74. Solomon, N.O.; Simpa, P.; Adenekan, O.A.; Obasi, S.C. Circular Economy Principles and Their Integration into Global Supply Chain Strategies. *Financ. Account. Res. J.* **2024**, *6*, 747–762. [CrossRef]
75. Bastos, F.; Tubino, M. The Use of the Liquid from Cashew Nut Shells as an Antioxidant in Biodiesel. *J. Braz. Chem. Soc.* **2017**, *28*, 747–755. [CrossRef]
76. Filgueiras, H.A.C.; Alves, R.E.; Mosca, J.L.; Menezes, J.B. Cashew Apple for Fresh Consumption: Research on Harvest and Postharvest Technology in Brazil. *Acta Hortic.* **1999**, *485*, 155–160. [CrossRef]

77. Darkunde, A.; Kolhe, S.; Somvanshi, S.; Nibe, R.L. Applications and Extraction of Cashew Nut Shell Liquid from Cashew Nut Shell. *Int. J. Adv. Res. Sci. Commun. Technol.* **2022**, *2*, 226–236.
78. Bowler, I. Sustainable Farming Systems. In *The Sustainability of Rural Systems*; Springer: Dordrecht, The Netherlands, 2002; pp. 169–187. ISBN 978-90-481-5978-9.