




## **Benchmarking Global Circular Food Supply Chain Models for Reducing Food Loss and Waste: Pathways for Islamic Value-Based Adaptation in Indonesia**



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### **ABSTRACT**

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*Circular Food Supply Chain, food loss and waste, prevention, redistribution, valorization, Pareto analysis, Iqtishad, Indonesia, SDG 12.3*

Food loss and waste (FLW) remains a major global challenge with significant economic, social, and environmental impacts, including 23-48 million tons wasted annually in Indonesia. This study benchmarks global Circular Food Supply Chain (CFSC) models and proposes an Islamic Circular Food Supply Chain (I-CFSC) adaptation grounded in Iqtishad to support Indonesia's transition toward SDG 12.3. A PRISMA-guided Systematic Literature Review (SLR) of 767 Scopus-indexed articles (2016-2025) is combined with bibliometric mapping, Pareto analysis, and expert-based Analytic Hierarchy Process (AHP) weighting. Dominant strategies by dimension are supply chain coordination for Prevention (23%), direct food donation for Redistribution (31%), and food upcycling and nutrient recovery for Valorization (33%). Pareto screening indicates that the top five models account for 77% (Prevention), 94% (Redistribution), and 89% (Valorization) of cumulative mentions. AHP synthesis shows the three strategies are judged nearly equivalent ( $A1 = 50.95$ ,  $A2 = 50.93$ ,  $A3 = 51.11$ ), with Valorization marginally highest. I-CFSC integrates circular interventions with Islamic economic ethics (Iqtishad) to strengthen operational legitimacy and guide context-specific pathways for reducing FLW in Indonesia.

## **1. INTRODUCTION**

Food loss and waste (FLW) represent one of the most pressing global challenges threatening food security, resource efficiency, and environmental stability. Recent data from the Food and Agriculture Organization (FAO) show that the proportion of food lost globally after harvest—across on-farm operations, transportation, storage, wholesale, and processing—reached 13.3% in 2023, increasing slightly from 13.0 percent in 2015 when global monitoring began [1]. Global assessments further indicate that one-third of all food produced for human consumption continues to be lost or wasted along the supply chain, contributing substantially to greenhouse gas emissions and environmental degradation.

In Indonesia, the situation is particularly alarming. Data from the Ministry of National Development Planning [2] show that food waste constitutes approximately 41.6% of total municipal waste—equivalent to 23–48 million tons annually—with an estimated economic loss exceeding IDR 551 trillion. This waste intensifies the national challenge of ensuring food availability and environmental sustainability.

The Circular Food Supply Chain (CFSC) framework has emerged as a transformative alternative to traditional linear food systems characterized by the “produce–consume–discard” paradigm [1]. CFSC emphasizes resource recovery, waste prevention, upcycling, redistribution, and closed-loop

flows, aligning with the core principles of the circular economy—reduce, reuse, recycle, and recover [3]. International experiences demonstrate significant benefits: Italy has advanced waste-to-energy valorization [4, 5], the US has strengthened redistribution networks through food donation policies and gleaning practices [6-9], and the Netherlands has integrated digital traceability for supply-chain transparency, especially on digital foodservice management [10]. These cases illustrate how circular strategies can simultaneously reduce FLW and improve environmental and economic performance.

Despite these promising developments, CFSC adoption in Indonesia remains limited. Studies highlight persistent structural barriers, including fragmented stakeholder coordination, insufficient technological readiness, limited policy enforcement, and low consumer awareness [11]. Furthermore, existing frameworks often lack cultural or value-based grounding, an essential element for context-specific adoption in Indonesia.

Given Indonesia's socio-religious landscape—where 87.2% of the population is Muslim [12]—integrating Islamic economic principles presents a culturally resonant pathway for strengthening CFSC implementation. The principle of Iqtishād, which emphasizes moderation, balance, and responsible resource use, provides an ethical foundation that aligns naturally with waste prevention and sustainability.

Qur’anic teachings explicitly discourage excessive consumption — “Eat and drink, but do not be excessive. Indeed, Allah does not like those who commit excess” (Surah Al-A’rāf 7:31)—while other verses and prophetic traditions encourage proportional spending, ecological responsibility, and the dignified distribution of resources. Instruments such as zakat, infāq, and sadaqah align closely with circular practices by promoting the redistribution of surplus food, reducing waste, and strengthening social justice. Contemporary literature also highlights that integrating Islamic values into consumption and production behaviors can accelerate sustainability transitions in Muslim-majority contexts [13, 14].

Within this ethical landscape, Iqtishād functions not merely as individual moral guidance but as a systemic ethic embedded across the entire food supply chain—from production and distribution to consumption and the management of organic residues. Such alignment enhances the legitimacy and societal acceptability of sustainable food-system innovations while offering a unique opportunity to contextualize CFSC principles within local cultural and religious values [15-17]. This systemic ethical perspective also corresponds with established notions of *maṣlahah* (public good), *ḥifẓ al-bi’ah* (environmental stewardship), and Islamic distributive justice [18, 19].

Moreover, embedding Iqtishād into CFSC implementation produces multidimensional impacts. Economically, it reduces losses associated with FLW and opens new markets for valorisation products. Socially, it reinforces solidarity and supports equitable food redistribution [20]. Environmentally, it reduces organic waste generation and lowers greenhouse gas emissions [21]. Culturally, it cultivates sustainable consumption awareness aligned with global sustainability trends [22]. In this way, the synergy between Iqtishād and CFSC forms an ethical-operational framework that transcends purely technical solutions, providing a religiously grounded foundation that supports Indonesia’s pursuit of SDG 12.3 by 2030.

Evolution of CFSC frameworks. CFSC extends circular economy logic to food systems by redesigning material, information, and value flows to prevent FLW, enable redistribution of edible surplus, and valorize unavoidable residues through closed-loop pathways. Recent CFSC studies increasingly integrate governance, digital traceability, and multi-actor coordination to operationalize circularity across upstream and downstream stages.

FLW intervention strategies. The literature typically clusters FLW mitigation into three complementary domains: (i) Prevention, focusing on coordination, logistics, postharvest practices, packaging, and demand planning to avoid waste generation; (ii) Redistribution, focusing on food donation systems, food banks, and enabling policies to channel edible surplus to beneficiaries; and (iii) Valorization, focusing on upcycling, nutrient recovery, bioenergy, composting, and other bioconversion routes that create value from inedible biomass. These domains are aligned with global policy agendas, including SDG 12.3, and provide an established analytical lens for benchmarking international practices.

Islamic economic ethics and sustainable consumption. In Muslim-majority contexts, Islamic economic ethics provides an additional normative layer that shapes consumption and production behavior. Iqtishad (moderation and proportionality) discourages israf (wastefulness) and supports responsible stewardship, while redistribution instruments (e.g., zakat, infaq, sadaqah) institutionalize social justice. Prior

studies suggest that embedding such values can improve public acceptance and strengthen governance arrangements for sustainability transitions, making value-based adaptation relevant for contextualizing CFSC in Indonesia.

To address persisting gaps, this study proposes an Islamic Circular Food Supply Chain (I-CFSC) model built upon global evidence and Islamic ethical principles. A Systematic Literature Review (SLR) is conducted to benchmark international CFSC practices within three widely recognized dimensions—Prevention, Redistribution, and Valorization. Subsequently, an Analytic Hierarchy Process (AHP) is used to evaluate the most suitable strategies for Indonesia based on economic viability, environmental impact, social benefits, operational flexibility, and alignment with Iqtishād. The resulting model offers a culturally embedded and analytically robust framework to support Indonesia’s transition toward a circular and ethically grounded food system capable of significantly reducing FLW.

## 2. METHODOLOGY

### 2.1 Research design

This study employs a SLR following the PRISMA 2020 protocol. The implementation of the PRISMA framework in this study ensures that the systematic review is conducted and reported with high methodological transparency and rigor (Figure 1). Accordingly, this review follows the PRISMA 2020 27-item checklist, its expanded reporting recommendations, the abstract checklist, and the updated flow diagrams [23, 24]. The review integrates bibliometric analysis, Pareto optimization, and AHP weighting to identify, classify, and prioritize global CFSC models addressing FLW. The combination of these methods enables both quantitative mapping and qualitative synthesis of best practices across *Prevention, Redistribution, and Valorization* dimensions of the circular food system.

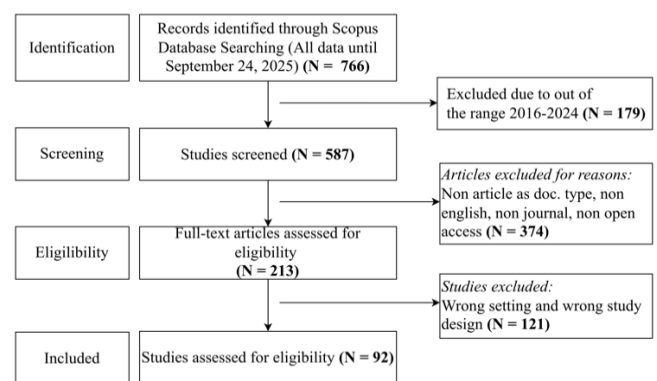


Figure 1. PRISMA methodology

### 2.2 Data source and search strategy

Scopus was selected as the primary database due to its comprehensive coverage of peer-reviewed journals. The search spanned publications from 2016 to September 2025, limited to open-access English-language journal articles. Search string: “Strategy” OR “Prevention” OR “Reduction” OR “Redistribution” OR “Food Donation” OR “Food Bank” OR “Islamic Perspective” OR “Valorization” OR “Circular Food Supply Chain” AND “Food Loss and Waste”. Search

fields were title, abstract, and keywords.

Inclusion criteria required complete English articles directly addressing CFSC and FLW variables. Exclusions applied to non-final publications, non-articles, and non-English texts. After applying these filters, 767 articles were identified for analysis (Table 1).

**Table 1.** Inclusion and exclusion criteria

Inclusion	Exclusion
Final, full-text journal articles English language	Non-final, abstracts only Non-English
Peer-reviewed journals	Books, reports, conference papers
High relevance to Circular Food Supply Chain (CFSC) and food loss and waste (FLW) variables	Peripheral or unrelated topics

### 2.3 Bibliometric and network mapping

Bibliometric analysis was employed as a systematic and rigorous approach to examine a large body of scientific literature, enabling the identification of developmental patterns within the field and the detection of emerging research themes [25]. Bibliometric network visualizations were generated using VOSviewer to map citation structures, co-authorship linkages, and keyword co-occurrence clusters [26]. This approach facilitated the identification of research clusters and temporal trends within the CFSC literature.

### 2.4 Pareto analysis

A Pareto analysis was conducted to identify, rank, and prioritize the vital indicators [27]. It is also used to sort and organize the critical success factors according to their level of criticality [28, 29]. Pareto analysis was applied to quantify the cumulative contribution of each CFSC model category (Prevention, Redistribution, Valorization). Following the 80/20 principle, the method identifies a small subset of dominant models responsible for most global impacts on FLW mitigation.

### 2.5 Expert weighting using Analytic Hierarchy Process

An expert-based AHP was employed to structure the decision hierarchy (criteria and alternatives) and to elicit pairwise comparisons using Saaty's 1-9 scale (1 = Equal Importance; 3 = Moderate; 5 = Strong; 7 = Very Strong; 9 = Extreme; with even numbers for intermediate judgments). Experts were selected purposively to represent complementary perspectives relevant to FLW reduction in Indonesia (academia, practitioners, and policy-related stakeholders). In total, nine experts provided judgments: three academics, two practitioners, two government representatives, and two Islamic institutional stakeholders. Each expert completed a pairwise comparison questionnaire covering: (i) criteria comparisons (social, economic, environmental, flexibility) and (ii) alternative comparisons (Prevention, Redistribution, Valorization) under each criterion. To obtain a group judgment matrix, individual comparison matrices were aggregated using the geometric mean at the cell level, which is standard for combining ratio-scale judgments. Priority vectors were derived using the normalized principal eigenvector approach, and consistency was evaluated using the Consistency Index (CI) and Consistency Ratio (CR), with CR < 0.10 considered

acceptable.

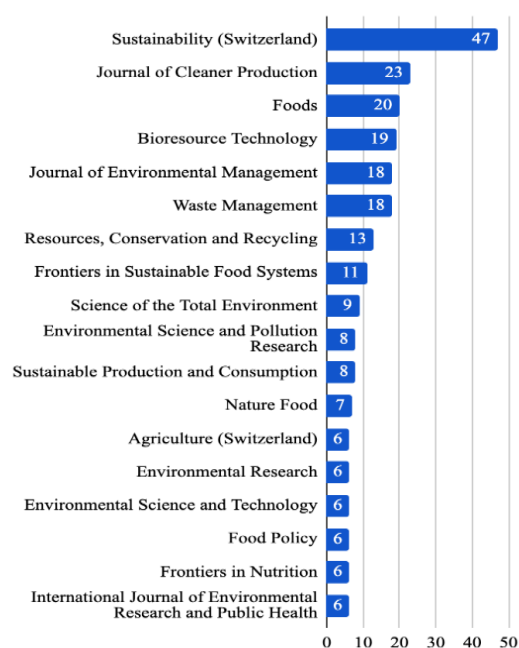
## 2.6 Islamic value-based adaptation: Integrating Iqtishād into the selected Circular Food Supply Chain strategy

To contextualize the prioritized CFSC strategy for Indonesia, the AHP results were examined through an Islamic value-based adaptation lens. The selected alternative was mapped against the principles of Iqtishād—moderation, proportionality, and responsible stewardship—derived from Qur’anic ethics and Islamic economic literature. To ensure relevance and applicability, this analysis was triangulated through focused consultations with academics, practitioners, policymakers, and religious institutions. Their insights validated the alignment between technical CFSC strategies and Islamic normative values, strengthening the interpretive basis of the proposed I-CFSC framework.

## 3. RESULTS AND DISCUSSION

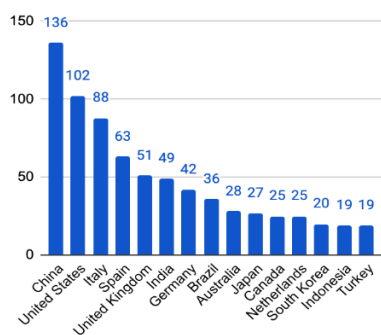
### 3.1 Bibliometric analysis

Figure 2 illustrates the distribution of scientific publications on FLW based on the journals that most frequently publish on this topic. It can be observed that Sustainability (Switzerland) is the most dominant journal with 47 publications, followed by the Journal of Cleaner Production (23), Foods (20), and Bioresource Technology (19). The dominance of these journals indicates that FLW issues are extensively examined within the contexts of sustainability, resource efficiency, and technological innovations in food waste processing. Moreover, journals such as Waste Management and Resources, Conservation and Recycling emphasize the relevance of this topic to circular management and waste valorization approaches. Meanwhile, the appearance of journals such as Frontiers in Sustainable Food Systems and Food Policy suggests that the discussion also extends to sustainable food systems and public policy dimensions, highlighting the multidisciplinary nature of research on FLW.

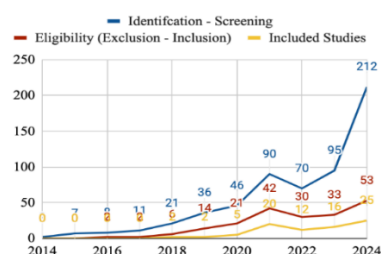


**Figure 2.** The leading journals in a specific field of research

Figure 3 presents the distribution of publications on FLW based on the country of origin of the research. China ranks first with 136 publications, followed by the United States (102) and Italy (88). The dominance of China and the United States reflects their strong attention to issues of food efficiency and sustainability within production and consumption systems, aligning with their national research capacities and policies in the fields of environment and food. European countries such as Italy, Spain, the United Kingdom, and Germany also demonstrate significant contributions, reflecting the European Union's strong commitment to the circular economy and food waste reduction. Meanwhile, the participation of developing countries such as India, Brazil, Indonesia, and Turkey indicates the growing global awareness of the urgency of FLW issues across diverse economic contexts, with a focus on improving supply chain efficiency and fostering sustainable food security.



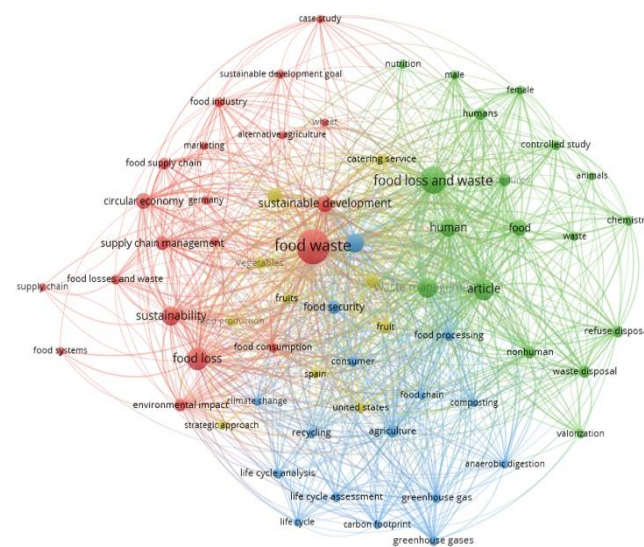
**Figure 3.** The most active countries in a specific field of research



**Figure 4.** Publication trends and volume in a specific field of research

Figure 4 illustrates the trend of research publications on FLW from 2014 to 2024 based on the stages of the systematic review process: identification–screening, eligibility (exclusion–inclusion), and included studies. A significant increase is observed, particularly at the identification–screening stage, which surged sharply from 95 articles in 2023 to 212 articles in 2024, indicating growing academic interest and research volume on this issue. The eligibility stage also shows a positive trend, rising from 33 to 53 articles, reflecting a more rigorous selection process alongside the continuous growth of relevant studies. Meanwhile, the number of included studies reaching 25 in 2024 demonstrates a more consolidated and mature body of research. Overall, this trend highlights a substantial acceleration of FLW research over the past decade, in line with the rising global urgency surrounding food security and the circular economy. The zero value in 2014 reflects that, under the study's Scopus query constraints and final inclusion window, no records meeting all filters were retained for that early year; thus the chart uses 2014 as a baseline reference with zero included studies.

Figure 5 presents a visualization map of keyword co-occurrence in research related to FLW, illustrating the interconnections among various thematic areas. Three main clusters are identified and closely linked. The red cluster focuses on issues of *circular economy*, *waste management*, and *supply chain sustainability*, highlighting how food waste management is integrated into circular economic systems through approaches such as valorization, resource recovery, and improved resource efficiency. The green cluster emphasizes *sustainability* and *environmental impact*, linking food waste to *climate change*, *carbon footprint*, and *greenhouse gas emissions*, thereby reflecting growing concern over ecological impacts and the need for environment-based mitigation policies. Meanwhile, the blue cluster relates to *food security*, *life cycle assessment*, and *consumer behavior*, underscoring the connection between food loss, consumption behavior, and global food security. Overall, this visualization reveals that research on FLW has evolved into a multidisciplinary field, integrating environmental, social, and economic dimensions within the broader framework of sustainability and the circular economy.



**Figure 5.** Bibliometric analysis

### 3.2 Model of preventive on food loss and waste

Table 2 presents various prevention models in FLW management, categorized by approach, key actors, and geographical research context. The most frequently discussed model is supply chain and coordination systems (22.92%), emphasizing the importance of cross-supply-chain coordination through logistics integration, lean management, and distribution optimization to prevent food loss across all stages from production to consumption. Next, sustainable production and postharvest practices (20.83%) highlight early-stage prevention through sustainable farming practices, mechanization, and resource efficiency, particularly in developing countries such as Iran, Kenya, and Nigeria. technological innovation also plays a vital role, as seen in packaging and preservation innovation (16.67%), which focuses on extending product shelf life and reducing food spoilage through advancements in packaging industries and cross-country research collaborations.

Collaborative efforts, represented by collaborative and community-based approaches (10.42%), demonstrate that the success of FLW prevention largely depends on synergy among

government bodies, communities, and the private sector. Meanwhile, digital and technological innovation (6.25%) indicates an emerging trend of utilizing digital technologies, AI, and IoT to detect and monitor food losses within the supply chain, though currently limited to a few countries such as Hungary and Italy. Other models—such as foodservice and operational efficiency, policy and governance frameworks, and behavioral and educational interventions—underscore the importance of operational efficiency, cross-sector policy integration, and consumer behavioral change in prevention strategies.

Interestingly, approaches based on market and regulatory reform and food processing and recovery practices remain relatively underexplored (4.17% and 2.08%, respectively), suggesting that market reform and industrial-level recovery innovations represent promising research gaps. Overall, these findings indicate that FLW prevention efforts are inherently multidimensional—combining technological, managerial, policy, and behavioral aspects—with a growing research trend toward systemic integration and digital innovation to enhance the sustainability of food supply chains.

Based on Table 2, it can be interpreted that prevention literature is dominated by system-level coordination and postharvest interventions, indicating that FLW prevention is treated primarily as an end-to-end supply chain coordination

problem rather than isolated operational fixes. The prominence of packaging and preservation innovation further shows that technological levers for shelf-life extension remain central, while the relatively lower frequency of digital/AI-enabled monitoring suggests an emerging but still underexplored research stream. In policy terms, these patterns imply that Indonesia's prevention agenda should prioritize coordination mechanisms (data sharing, cold-chain logistics, and contractual alignment), complemented by targeted technology adoption.

### 3.3 Model of redistribution on food loss and waste

Table 3 presents various food redistribution models developed in research on FLW, focusing on the main actors, research locations, and forms of implementation across different countries. The most dominant model is Direct Food Donation (31.25%), which emphasizes direct donation activities through logistical mechanisms, community involvement, and cross-sector collaboration among retailers, restaurants, hospitals, and local governments. This model is widely implemented in countries such as Indonesia, Australia, and the United States, indicating that philanthropy-based redistribution remains the primary approach to managing food surplus.

**Table 2.** Model of preventive on food loss and waste (FLW)

Model	Freq.	%	Key Actors	Location of Study	Refs.
Supply Chain and Coordination Systems	11	22.92%	Producers, retailers, logistics firms, policymakers	Brazil, Germany, Nigeria, China, Spain, Uganda, UK	[30-40]
Sustainable Production and Postharvest Practices	10	20.83%	Farmers, agricultural agencies, researchers, cooperatives	Iran, Chile, Kenya, Australia, China, Nigeria, South Africa, Spain	[41-50]
Packaging and Preservation Innovation	8	16.67%	Packaging industries, food manufacturers, researchers, policymakers	Japan, Germany, Brazil, Spain, Greece, Kenya, Global	[51-58]
Collaborative and Community-Based Approaches	5	10.42%	Governments, Non-Governmental Organizations (NGOs), academia, communities, private sector	Germany, Turkey, Costa Rica, Netherlands, Saudi Arabia	[59-63]
Digital and Technological Innovation	3	6.25%	Agritech firms, researchers, digital providers, producers	Hungaria, Italy	[64-66]
Foodservice and Operational Efficiency	3	6.25%	Hotels, restaurants, hospitals, catering services	UK, Netherlands, Indonesia	[10, 67, 68]
Policy and Governance Frameworks	3	6.25%	Governments, regulators, industries, NGOs, food agencies	US	[9, 69, 70]
Behavioral and Educational Interventions	2	4.17%	Consumers, educators, policymakers, social organizations, retailers	Romania, Germany	[71, 72]
Market and Regulatory Reform	2	4.17%	Regulators, associations, retailers, development agencies	Greece, US	[73, 74]
Food Processing and Recovery Practices	1	2.08%	Food processors, safety regulators, R&D institutions	UK	[75]

**Table 3.** Model of redistribution on FLW

Model Redistribution	Freq.	%	Key Actors	Location of Study	Ref.
Direct Food Donation	5	31.25%	Retailers, restaurants, hospitals, food banks, local government	Indonesia, Chile, Australia, US	[9, 45, 68, 76, 77]
Food Banks, Food Pantries, and Community Kitchens	4	25.00%	Government, NGOs, retail donors, social organizations	Spain, Brazil, Saudi Arabia	[63, 69, 78, 79]
Gleaning and Fresh Produce Recovery	3	18.75%	Farmers, food recovery organizations, regulators	US	[6-8]
Policy and Fiscal Incentives for Redistribution	2	12.50%	Government, tax authorities, social organizations, producers	Italy, Canada	[80, 81]
Digital and Information and Communication Technology (ICT)-Based Platforms and Innovation	1	6.25%	Consumers, NGOs, startups, regulators	Japan	[82]
Supply Chain Management and Anti-Food-Loss Marketing Strategies	1	6.25%	Farmers, retailers, consumers	Columbia	[83]

Following this, Food Banks, Food Pantries, and Community Kitchens rank second with 25% frequency, underscoring the importance of social institutions and inclusive policies in ensuring food and nutritional access for vulnerable groups. This model is particularly prominent in countries such as Spain and Brazil, where synergy between governments, NGOs, and retail donors plays a crucial role in establishing a sustainable redistribution ecosystem. Gleaning and Fresh Produce Recovery (18.75%) highlights efforts to recover fresh agricultural produce through local collaborations between farmers and social organizations—especially in the United States—as a means to enhance resource efficiency and reduce upstream food waste.

In addition, models based on Policy and Fiscal Incentives (12.5%) demonstrate that regulatory support, such as tax incentives and pro-redistribution policies, significantly enhances private sector participation, as observed in Italy and Canada. Meanwhile, digital innovation models such as ICT-Based Platforms and Innovation (6.25%) and Supply Chain Management and Anti-Food-Loss Marketing Strategies (6.25%) are emerging trends, focusing on the use of food-sharing technologies and sustainable marketing strategies to minimize losses along the supply chain.

Overall, these findings indicate that food redistribution practices are becoming increasingly diversified—shifting from traditional charity-based models toward more integrated, policy-driven systems supported by technological innovation—aligning with the global transition toward a circular economy and inclusive food security.

Based on Table 3, it can be interpreted that redistribution research is concentrated in direct food donation and institutional food banks/community kitchens, reflecting that most countries operationalize redistribution through structured philanthropy and intermediary organizations. The smaller presence of ICT-mediated food sharing platforms indicates

that digital coordination for redistribution is still developing, but it offers scalability by improving matching, traceability, and logistics efficiency. For Indonesia, the dominance of donation-based models suggests practical feasibility, but operational safeguards for food safety, halal compliance, and last-mile distribution remain critical design requirements.

### 3.4 Model of valorization on food loss and waste

Table 4 presents a comprehensive overview of various valorization models in FLW management, which aim to convert food waste into products of economic, social, and environmental value. The most prevalent model, Food Upcycling and Nutrient Recovery (33.33%), focuses on transforming surplus or substandard agricultural products into new food items or nutrient-rich functional ingredients within the framework of the circular economy. This model has been widely implemented in countries such as Brazil, Italy, and India, involving small and medium-sized enterprises (SMEs), food processing industries, and nutrition researchers. Its prominence reflects a paradigm shift from waste prevention toward sustainable product innovation and value creation.

Bioenergy and Composting Technologies (22.22%) constitute another significant category, representing the utilization of organic waste for renewable energy generation—such as biogas and biofertilizers—through processes like anaerobic digestion and thermal treatment. This model underscores the integration between the energy and environmental sectors, supported by local government initiatives and waste management industries. Similarly, Feed and Livestock Valorization (16.67%) highlights the conversion of food and agricultural residues into animal feed or aquaculture inputs, thereby contributing to cost reduction and decreased dependency on imported feed resources.

**Table 4.** Model of valorization on FLW

Model Valorization	Freq.	%	Key Actors	Location of Study	Ref.
Food Upcycling and Nutrient Recovery	12	33.33%	SMEs, food processors, retailers, consumers, nutrition researchers	Brazil, Global, Chile, Kenya, Italy, Turkey, India, Poland, Portugal, Australia, Egypt	[4, 5, 44, 76, 84-91]
Bioenergy and Composting Technologies	8	22.22%	Local governments, waste processors, renewable energy firms, researchers	Spain, Poland, Germany, France, Peru, India	[92-99]
Feed and Livestock Valorization	6	16.67%	Livestock producers, feed industries, agricultural ministries, researchers	Global, US, Mexico, Italy	[77, 100-104]
Biorefinery and Industrial Symbiosis	4	11.11%	Biotech firms, dairy and agro-industries, investors, regulators	Australia, Spain, Italy	[105-108]
Insect-Based Bioconversion and Protein Valorization	2	5.56%	Insect farmers, biotech institutes, environmental regulators	Global, Indonesia	[109, 110]
Agroecological Valorization and Soil Restoration	1	2.78%	Farmers, local authorities, environmental NGOs	Peru	[111]
Byproduct Recovery and Resource Valorization	1	2.78%	Agro-industries, regional policymakers, researchers	Italy	[112]
Circular Economy and Socioeconomic Valorization	1	2.78%	Farmers, cooperatives, local governments, financial institutions	Turkey	[113]
Waste Collection and Separation Systems	1	2.78%	Waste managers, governments, industrial producers, consumers	Italy	[114]

Moreover, Biorefinery and Industrial Symbiosis (11.11%) exemplifies a more advanced valorization pathway, in which food waste is converted into biofuels, bioplastics, and other bio-based materials through industrial integration and biotechnological innovation. Although less frequently discussed, emerging models such as Insect-Based Bioconversion, Agroecological Valorization, and Byproduct Recovery represent innovative directions in biological and agroecological waste utilization, including the use of insects such as the Black Soldier Fly for protein extraction and organic fertilizer production.

Interestingly, Circular Economy and Socioeconomic Valorization and Waste Collection and Separation Systems (each 2.78%) emphasize the social and infrastructural dimensions of valorization, such as local economic empowerment through agricultural recycling and the development of efficient waste separation systems. Collectively, these findings indicate that FLW valorization research has increasingly evolved toward resource transformation into value-added products, characterized by the integration of biotechnology, renewable energy, and community-based empowerment within a holistic and sustainable circular economy framework.

Based on Table 4, it can be interpreted that valorization studies increasingly prioritize upcycling and nutrient recovery, indicating a shift from waste treatment to value creation through new products and functional ingredients. Bioenergy/composting remains important as an infrastructure-oriented pathway, while feed and industrial symbiosis options represent resource-substitution routes with potential economic benefits. The diversity of valorization pathways implies that Indonesia can adopt a portfolio approach, selecting technology routes based on waste stream characteristics, local infrastructure, and SME capability.

### 3.5 Pareto analysis

Based on the Pareto analysis, several models were identified as potential strategies for preventing FLW, as shown in Table 5. Among the ten prevention models examined, five were found to account for the majority of the contributing factors, as indicated by their cumulative frequency in Figure 6. The Pareto analysis highlights supply chain and coordination systems as the most dominant preventive model for reducing FLW, emphasizing the systemic nature of the issue across production, distribution, and consumption stages. This finding aligns with a growing body of literature that underscores the

critical role of supply chain integration, coordination, and technological innovation in minimizing inefficiencies and losses.

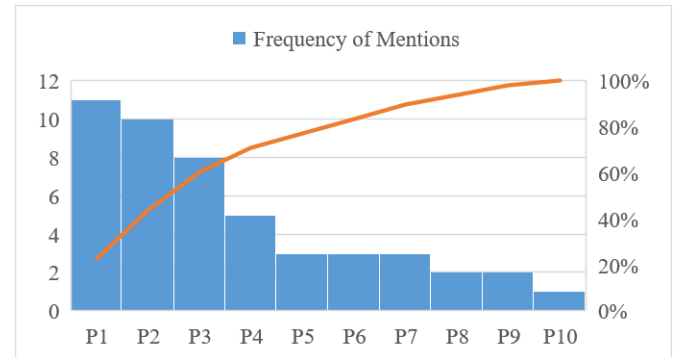


Figure 6. Pareto chart of prevention model

Dora et al. [30] developed a system-wide interdisciplinary framework for FLW mitigation within the circular economy paradigm, emphasizing zero-waste systems and triple bottom line principles (economic, environmental, and social). Their work demonstrates that preventive strategies must operate across the entire supply chain rather than focusing on isolated interventions. Similarly, Realpe et al. [31] identified systemic risk factors in Brazilian agrifood supply chains using root cause analysis, concluding that upstream–downstream coordination—such as logistics infrastructure, take-back agreements, and retail partnerships—plays a decisive role in preventing product losses.

In European contexts, Herzberg et al. [32] revealed that imbalances of power between producers and retailers in the German fruit and vegetable supply chain significantly contribute to food loss at the producer level. This study reinforces the need for governance mechanisms and equitable coordination frameworks to prevent waste generation driven by market inefficiencies. Abulude and Wahlen [33] further extended this perspective through a systematic review of Nigeria’s agrifood chains, identifying critical loss points between production and distribution that demand integrated policy and logistical solutions. Complementary studies in Brazil [34, 35] used principal component analysis and association rules to identify best practices in wholesale logistics—such as cold chain development, improved packaging, and workforce training—that substantially reduce FLW at the market level.

Table 5. Pareto calculation of prevention model

Model of Prevention	Prevention Code	Cumulative Mentions	% Cumulative Mentions
Supply Chain and Coordination Systems	P1	11	23%
Sustainable Production and Postharvest Practices	P2	21	44%
Packaging and Preservation Innovation	P3	29	60%
Collaborative and Community-Based Approaches	P4	34	71%
Digital and Technological Innovation	P5	37	77%
Foodservice and Operational Efficiency	P6	40	83%
Policy and Governance Frameworks	P7	43	90%
Behavioral and Educational Interventions	P8	45	94%
Market and Regulatory Reform	P9	47	98%
Food Processing and Recovery Practices	P10	48	100%

From a logistics perspective, Yan et al. [36] conducted a systematic review of loss drivers among logistics service providers (LSPs) in China, highlighting sustainable transportation, storage optimization, and digital monitoring as key enablers of waste reduction. In Germany, Rösler et al. [37] proposed 53 good practice recommendations for the food-processing industry, integrating lean management and quality control into preventive systems. Pérez-Mesa et al. [38] applied location optimization models (p-median, gravity p-median, and p-center) to enhance redistribution center efficiency for perishable goods in Southern Europe, further supporting the argument that logistics design and coordination are central to FLW prevention.

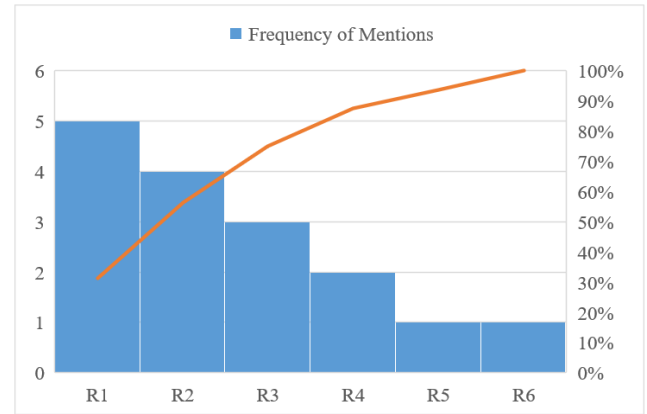
Finally, research in Uganda by Wesana et al. [39, 40] demonstrated that lean manufacturing and value stream mapping (VSM) can identify critical “hotspots” of food and nutritional loss within dairy value chains, revealing that 14% of losses occurred at the processing stage. Their studies emphasize the readiness of industry actors to implement integrated lean systems that support nutrition-sensitive agriculture.

Overall, these studies collectively validate the Pareto finding that Supply Chain and Coordination Systems represent the most strategic entry point for FLW prevention. The convergence of evidence across global contexts—from Europe and Latin America to Asia and Africa—demonstrates that improving coordination, logistics, and information flow not only reduces losses but also strengthens food security, supports circular economy transitions, and advances sustainability across the agrifood sector.

Based on the Pareto analysis, several models were identified as strategic approaches for food redistribution, as shown in Table 6. Among the six redistribution models analyzed, five accounted for the majority of the contributing factors, as indicated by their cumulative frequency in Figure 7. The Pareto analysis highlights direct food donation as the most dominant redistribution model, representing 31% of total mentions. This model underscores the importance of immediate redistribution from food surplus sources—such as restaurants, retailers, hospitals, and wholesale markets—to beneficiaries through structured donation mechanisms. The growing prominence of this model reflects a global shift from waste disposal toward redistributive practices that combine social responsibility, resource efficiency, and environmental sustainability.

Empirical evidence from various countries reinforces the centrality of direct food donation in addressing both food waste and food insecurity. In Indonesia, Subadra [68] introduced a sustainable culinary tourism model through the case of Aburi Sushi Bali, where restaurant food loss is minimized by redistributing unsold yet edible food to local communities. The study emphasizes the role of restaurants,

customers, and local governments in creating circular food systems in tourism-driven economies. Similarly, in Chile, Palleres et al. [76] developed a redistribution framework that transforms surplus food from wholesale markets into nutritious meals distributed free of charge to elderly beneficiaries through food banks. Their study demonstrates how collaborative networks among small food processors, local governments, and community organizations can unlock the social and environmental value of food surpluses while strengthening regional food security systems.



**Figure 7.** Pareto chart of redistribution model

In Australia, Somlai [45] analyzed business strategies for reducing food waste and found that food donation programs—coordinated between food industries, retailers, farmers, NGOs, and consumers—play a crucial role in achieving corporate sustainability goals while aligning with national waste reduction policies. Similarly, Cook et al. [77] conducted a qualitative study in Australian hospitals, illustrating how foodservice systems can divert edible surplus food from landfills through donation partnerships with local charities and food recovery organizations. These findings highlight that even highly regulated sectors such as healthcare can implement donation-based redistribution without compromising hygiene and food safety standards.

In the United States, Chen and Chen [9] identified donation, source reduction, and inter-organizational collaboration as key activities supported by government programs such as the Environmental Protection Agency (EPA) and the United States Department of Agriculture (USDA). Their study demonstrates that regulatory incentives, recognition systems, and policy alignment are essential to institutionalizing food donation practices at the national level. This reflects a mature redistribution ecosystem where public–private partnerships play a significant role in scaling up food donation initiatives.

**Table 6.** Pareto calculation of redistribution model

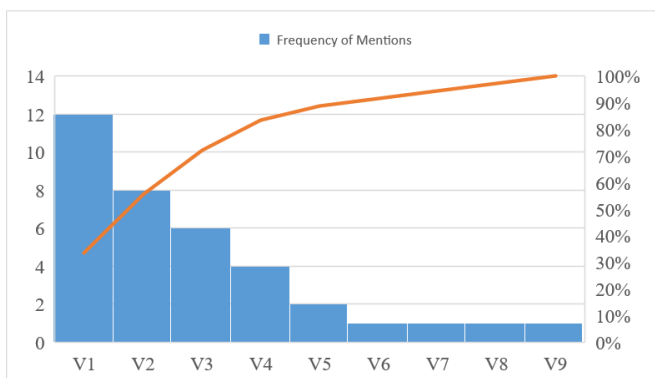
Model of Redistribution	Redistribution Code	Cumulative Mentions	% Cumulative Mentions
Direct Food Donation	R1	5	31%
Food Banks, Food Pantries, and Community Kitchens	R2	9	56%
Gleaning and Fresh Produce Recovery	R3	12	75%
Policy and Fiscal Incentives for Redistribution	R4	14	88%
Digital and ICT-Based Platforms and Innovation	R5	15	94%
Supply Chain Management and Anti-Food-Loss Marketing Strategies	R6	16	100%

**Table 7.** Pareto calculation of valorization model

Model of Valorization	Valorization Code	Cumulative Mentions	% Cumulative Mentions
Food Upcycling and Nutrient Recovery	V1	12	33%
Bioenergy and Composting Technologies	V2	20	56%
Feed and Livestock Valorization	V3	26	72%
Biorefinery and Industrial Symbiosis	V4	30	83%
Insect-Based Bioconversion and Protein Valorization	V5	32	89%
Agroecological Valorization and Soil Restoration	V6	33	92%
Byproduct Recovery and Resource Valorization	V7	34	94%
Circular Economy and Socioeconomic Valorization	V8	35	97%
Waste Collection and Separation Systems	V9	36	100%

Overall, these studies collectively validate the Pareto finding that direct Food Donation is the most strategic and widely adopted redistribution model globally. It serves as a socially equitable and environmentally beneficial solution by bridging the gap between food surplus and food insecurity. When adapted to the Indonesian context, this model offers substantial potential—especially when integrated with local food bank networks, digital food-sharing platforms, and municipal-level governance frameworks. By institutionalizing donation mechanisms, incentivizing participation from the food industry, and ensuring food safety and logistical efficiency, Indonesia can strengthen its redistribution ecosystem while aligning with the Sustainable Development Goals (SDG 2 – Zero Hunger and SDG 12.3 – Responsible Consumption and Production) within the circular economy framework.

Based on the Pareto analysis, several models were identified as strategic approaches for FLW valorization, as shown in Table 7. Among the nine valorization models examined, five accounted for the majority of the contributing factors, as indicated by their cumulative frequency in Figure 8. The analysis highlights Food Upcycling and Nutrient Recovery as the most dominant valorization model (33%), reflecting the global shift from waste management toward circular value creation by transforming agricultural surpluses and food by-products into new, nutritionally enhanced, and marketable products. This model exemplifies how innovation, biotechnology, and sustainable product development are being integrated into modern food systems to close the loop between production and consumption.



**Figure 8.** Pareto chart of valorization model

Recent empirical studies across multiple countries provide strong evidence supporting the dominance of the Food Upcycling and Nutrient Recovery model. In Brazil, Chagas et al. [84] demonstrated the transformation of discarded vegetables from the retail sector into nutrient-rich purees through collaboration among retailers, small processors, and

food authorities. The study emphasized that upcycling initiatives not only mitigate waste but also stimulate new business models for SMEs. Similarly, Palleres et al. [76] in Chile proposed an agri-food surplus valorization system where surplus fruits and vegetables from wholesale markets are processed into green and red concentrates for healthy and sustainable food production. This model integrated government agencies, local SMEs, and food banks, illustrating the socio-environmental value of converting food waste into functional food ingredients.

In Europe, multiple studies highlight how food upcycling bridges circular economy principles with innovation-driven gastronomy. In Italy, Cutroneo et al. [4] developed new sourdough bread prototypes fortified with chickpea and pea residues, while Serna-Barrera et al. [5] explored lactic acid fermentation of broccoli stems to enhance antioxidant potential and probiotic functionality. Both studies exemplify biotechnological pathways that convert side streams into high-value functional foods. Complementary research in Turkey by Koç and Atar Kayabaşı [86] revealed that pistachio hulls and grape seeds can be used to enrich bread with dietary fiber and antioxidants, further supporting the notion that food residues can contribute to the development of nutritionally improved bakery products.

Studies from Asia and Africa further emphasize the scalability and inclusivity of upcycling initiatives. In India, Kumari et al. [87] developed iron-enriched extruded snacks using jackfruit seed and mung bean flour, addressing both agricultural waste reduction and public health issues such as anemia. Likewise, Owino et al. [44] in Kenya discussed strategies for developing and scaling up fruit and vegetable upcycling models among smallholders and agro-processors, highlighting the need for supportive financing, policy incentives, and capacity building for SMEs in developing economies. In Poland, Markowska et al. [88] transformed outgraded vegetables like broccoli, cauliflower, and beans into nutritious pasta and patties for the HoReCa sector, while Araújo-Rodrigues et al. [89] in Portugal valorized carrot and cherry tomato by-products into frozen pulps and powders with preserved bioactive properties, aligning with circular economy goals.

Beyond traditional foods, upcycling has also penetrated the beverage and specialty product sectors. Krahe et al. [90] in Australia identified opportunities for upcycled tea production from visually rejected green tea leaves, showing that post-harvest reprocessing can yield semi-fermented tea products with high commercial value and phytochemical retention. Similarly, Sallam et al. [91] in Egypt demonstrated that green pea waste flour could substitute wheat flour in bakery applications without compromising sensory quality, illustrating scalable applications of waste-derived ingredients in mainstream food production.

Collectively, these studies validate the Pareto finding that Food Upcycling and Nutrient Recovery serve as the cornerstone of global valorization strategies. The convergence of evidence across regions—spanning Latin America, Europe, Asia, and Africa—underscores that upcycling-driven valorization not only reduces environmental burdens but also stimulates innovation, enhances nutrition, and fosters inclusive economic growth. For Indonesia, the implementation of this model offers considerable potential, particularly through the development of community-based food innovation hubs, SME-led circular processing units, and university–industry partnerships to commercialize upcycled products derived from agricultural surpluses and urban food waste streams. Integrating such initiatives within national policies on sustainable food systems and circular economy would position Indonesia to advance simultaneously toward waste reduction, value creation, and food security in alignment with Sustainable Development Goal 12.3.

### 3.6 Expert weighting using Analytic Hierarchy Process

Based on Table 8, the consistency test results of the AHP model indicate that all pairwise comparison matrices are within the acceptable consistency range, with CR values below the 10 percent threshold. At the main criteria level, the CR value of 8.6% demonstrates that the evaluation of the social, economic, environmental, and flexibility aspects was conducted logically and coherently, with no significant contradictions among the assigned weights. This level of consistency provides a strong foundation for relying on the derived criteria priorities in determining strategies for FLW management.

**Table 8.** Consistency ratio

Level	Definition	Consistency Ratio (CR)	Interpretation
Criteria	C	8.6%	Consistent
Sub-criteria	C1	3.6%	Consistent
Sub-criteria	C2	0.5%	Consistent
Sub-criteria	C3	0.0%	Consistent
Sub-criteria	C4	0.0%	Consistent

Furthermore, the consistency assessment at the sub-criteria level also shows excellent results, with CR values of 3.6% for C1, 0.5% for C2, and 0.0% for both C3 and C4. These low CR values reflect that the judgments across sub-criteria were made proportionally and systematically, indicating alignment and coherence among the evaluators or decision-makers. Therefore, the resulting weights across all hierarchical levels can be considered valid and reliable for the synthesis of alternative priorities. The high level of consistency achieved in this study confirms that the AHP model exhibits strong logical stability, making the results a credible basis for formulating sustainable FLW management strategies in Indonesia.

Table 9 shows the synthesis results of the AHP, indicating that the three strategic alternatives (A1: Prevention, A2: Redistribution, A3: Valorization) receive very close overall weights (A1 = 50.95, A2 = 50.93, A3 = 51.11). This suggests that experts view the three strategies as largely complementary rather than strongly rank-ordered. Therefore, while valorization is marginally highest, practical decision-making should interpret the outcome as a near-tie and prioritize an integrated portfolio approach across prevention,

redistribution, and valorization. A formal sensitivity analysis is recommended in future work to test the robustness of these near-equal priorities under plausible changes in criteria weights and expert judgments.

**Table 9.** Analytic Hierarchy Process (AHP) results

Criteria	Criteria Weight	A1	A2	A3
C1	4.18	3.02	3.03	3.07
C2	4.24	3.01	3.00	3.00
C3	4.46	3.00	3.00	3.00
C4	4.05	3.00	3.00	3.00
Alternative Weight		50.95	50.93	51.11
Rank		2.00	3.00	1.00

The preventive model (A1), with an alternative weight of 50.95%, ranked second. Although the difference is marginal, this model demonstrates strong relevance in minimizing waste generation through improved supply chain coordination, efficient logistics, and stakeholder integration. Meanwhile, the Redistribution model (A2) obtained the lowest weight of 50.93%, ranking third. Despite its social benefits in addressing food insecurity, redistribution is perceived as less sustainable in the long term compared to valorization and prevention measures.

At the criteria level, the environmental aspect (C3) received the highest importance weight (4.46), highlighting that sustainability and waste reduction are the primary considerations in decision-making. This was followed by the Economic (C2), Social (C1), and Flexibility (C4) criteria with weights of 4.24, 4.18, and 4.05, respectively. These results underscore that environmental sustainability remains the key driver in prioritizing strategies for FLW management in Indonesia. Overall, the AHP synthesis reveals a consistent and balanced evaluation framework, in which valorization emerges as the most preferred strategy for achieving sustainable and circular food systems.

The valorization model aligns most strongly with the Weaknesses–Opportunities (WO) quadrant analysis of Purnomo et al. [11], as it directly addresses weaknesses such as limited infrastructure and high implementation costs while leveraging existing policy and regulatory opportunities to improve food-system infrastructure, provide incentives, and enhance training for circular-economy practices.

This study is aligned with the findings of Widodo et al. [115], which emphasize that strategic interventions play a crucial role in the implementation of CFSC and are categorized into key domains such as technology, business, managerial capacity, and infrastructure. This is also consistent with the valorization model proposed in the present research, as its successful implementation similarly depends on these strategic elements to overcome existing barriers and effectively reduce FLW. Moreover, this alignment extends to the DPSIR framework, where valorization contributes directly to the Impact dimension by mitigating environmental pressures and lowering FLW across the supply chain [116].

### 3.7 Islamic value-based adaptation: Integrating Iqtishād into the selected Circular Food Supply Chain strategy

Table 10 shows the originality and operational contribution of I-CFSC. Unlike generic CFSC frameworks that mainly emphasize technical circular interventions, I-CFSC explicitly embeds Iqtishad as a governing ethic that shapes (i) decision rules for prevention (moderation-oriented demand planning,

loss monitoring, and coordination), (ii) redistribution governance (dignified, *tayyib* and *halal*-compliant donation protocols coordinated with Islamic institutions), and (iii) valorization stewardship (prioritizing environmentally responsible recovery routes and community benefit). This integration adds an operational layer by specifying ethical guardrails, actor roles, and compliance requirements that can be institutionalized through Indonesia's existing religious and social infrastructure.

Figure 9 presents the conceptual I-CFSC framework that operationalizes *Iqtishad* principles across the three core FLW strategies—Prevention, Redistribution, and Valorization—to systematically reduce FLW. In the Prevention stage (avoid FLW), *Iqtishad* is embedded through rules of moderation, demand planning, and coordination to minimize surplus generation at source. In the Redistribution stage (redirect edible surplus), the framework emphasizes *tayyib* and *halal* assurance, dignity-preserving distribution, and the involvement of *zakat*/*infaq* actors to channel safe, acceptable, and respectful food transfers to those in need. In the Valorization stage (recover unavoidable residues), *Iqtishad* guides resource recovery through stewardship, *hifz al-bi'ah* (environmental protection), and *maslahah* value to ensure residues are converted into beneficial outputs with minimal environmental harm. These stages are enabled by cross-cutting operational enablers—data and traceability, cold chains and logistics, policy and incentives, SME innovation, and religious and social institutions—which provide the infrastructure and governance needed to implement I-CFSC coherently across the entire system.

The integration of *Iqtishad* into CFSC framework is realized by aligning Qur'anic ethical principles with the three essential phases of the circular food cycle—Prevention, Redistribution,

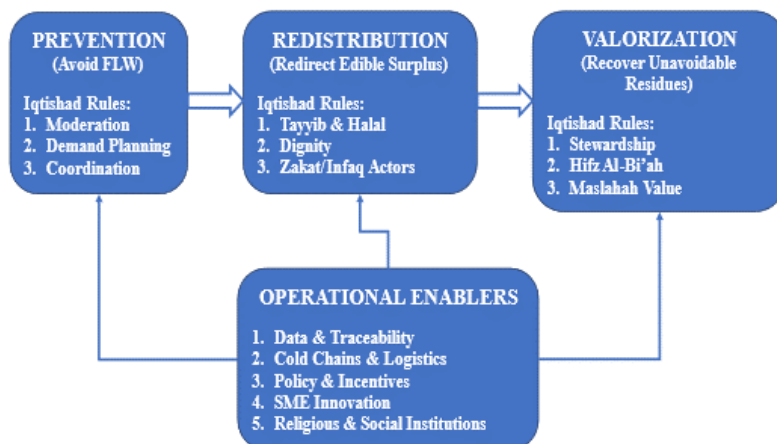
and Valorization. This ethical mapping reinforces the reduce–reuse–recycle–recovery logic of the circular economy while providing Islamic moral legitimacy, thereby enhancing the cultural relevance and social acceptance of CFSC implementation in Indonesia. In the Prevention phase, the Qur'anic prohibition of *israf* (wastefulness) and the call for moderation (*i'tidāl*) in QS Al-A'rāf 7:31 form the ethical foundation for reducing overconsumption, improving demand planning and smart labeling [117], strengthening cold-chain management, and coordinating upstream–downstream operations at critical loss points. These measures reflect the core principle of *Iqtishad*, which promotes proportional and efficient resource use [16, 21].

In the Redistribution phase, QS Al-Baqarah 2:267 emphasizes the provision of *tayyib* (nutritious and lawful) food, guiding the design of curated food banks, food-rescue systems that ensure safety, nutrition, and *halal* compliance, dynamic pricing and “ugly produce” initiatives [118], and the involvement of Islamic institutions—including MUI, BAZNAS, LAZ, and *pesantren*—in administering *zakat* and *infaq*-based food programs. This aligns redistribution practices with *maqāṣid al-sharī'ah*, ensuring dignity, fairness, and the preservation of life and property rather than the mere disposal of surplus.

The Valorization phase is grounded in the Islamic principles of stewardship (*khalīfah*, QS Al-Baqarah 2:30) and environmental preservation (*hifz al-bi'ah*) [119, 120]. In this phase, non-edible biowaste is not discarded wastefully [15], but transformed into valuable products such as organic compost for agroecology, Black Soldier Fly (BSF) larvae for animal feed [121]. Through these pathways, valorization generates *maṣlaḥah* (public benefit) while fulfilling Islamic ecological ethics.

**Table 10.** Originality and operational contribution of Islamic Circular Food Supply Chain (I-CFSC)

Aspect	Traditional Circular Food Supply Chain (CFSC)	I-CFSC (This Study)
Normative basis	Circular economy principles; predominantly technical/managerial framing.	Circular economy principles + <i>Iqtishad</i> as an explicit ethical governance layer (moderation, proportionality, stewardship).
Prevention design	Efficiency and coordination tools (forecasting, cold chain, packaging).	Adds moderation-oriented decision rules (anti- <i>israf</i> ), demand planning ethics, and accountability for loss hotspots.
Redistribution governance	Food donation and food bank models; safety protocols vary by context.	Adds <i>tayyib</i> / <i>halal</i> compliance, dignity principles, and institutional roles for <i>zakat</i> / <i>infaq</i> -based coordination.
Valorization priority rules	Technology route selection driven by feasibility and impact.	Stewardship-oriented prioritization ( <i>hifz al-bi'ah</i> ), community benefit ( <i>maslahah</i> ), and responsible recovery pathways.
Transferability	Generally transferable with infrastructural adjustments.	Transferable to Muslim-majority contexts but requires alignment with local religious institutions, governance, and food-system structure.



**Figure 9.** Conceptual I-CFSC framework embedding *Iqtishad* in prevention-redistribution-valorization

The AHP results further reinforce the significance of this phase: valorization emerges as the most effective FLW-reduction strategy, receiving the highest composite weight across social, economic, environmental, and flexibility dimensions. This empirical evidence supports integrating Islamic ethical reasoning—particularly *Iqtishād*—into the interpretation of the optimal strategy. Introducing *Iqtishād* after the AHP-based selection preserves methodological rigor while enhancing the sociocultural legitimacy of valorization. Islamic teachings prohibit *isrāf* and *tabdhīr* (QS Al-A‘rāf 7:31; QS Al-Furqan 25:67; QS Al-Isra’ 17:29), emphasizing the need to use food and natural resources moderately, responsibly, and without harm. These principles align closely with circular economy objectives that seek to sustain resource loops and minimize waste.

Within this ethical landscape, the prioritization of valorization closely aligns with the Qur’anic injunction in QS Al-Baqarah 2:267 to utilize the earth’s produce in a proper, dignified, and value-enhancing manner. Converting food residues into compost, BSF feed, bioenergy, and nutrient-rich by-products constitutes a morally grounded and tangible form of resource recovery. This reflects *Iqtishād*’s broader mandate to avoid wasteful disposal and optimize resource utility, consistent with prophetic traditions encouraging prudent expenditure and safeguarding surplus resources (HR Muslim; Ahmad). Consequently, valorization exemplifies *ḥikmah al-istihlāk* (wise consumption) and advances key *maqāsid al-sharī‘ah* objectives such as *maṣlaḥah* (public good), *ḥifz al-māl* (protection of wealth), and *ḥifz al-bi’ah* (environmental stewardship).

Moreover, situating *Iqtishād* within the valorization discourse highlights that CFSC implementation is not merely a technical intervention but a systemic ethical obligation across the food supply chain. Islamic ethics require moderation, efficiency, and ecological responsibility in production and consumption, while distributive ethics promote social justice for vulnerable groups through *zakat*, *infaq*, charitable food redistribution, and Sharia-compliant food banks. The ecological imperative to productively utilize organic waste for collective welfare [17] is also inherently embedded in valorization practices. Together, these principles strengthen valorization as a strategy that not only reduces FLW but simultaneously generates social, economic, and environmental value. Thus, the AHP-supported prioritization of valorization gains strong moral, theological, and sociocultural grounding within Islamic ethics, enhancing its public acceptability and reinforcing policy legitimacy for advancing sustainable and culturally attuned FLW-reduction pathways in Indonesia.

### 3.8 Limitations and future research

This study has several limitations. First, the evidence base was drawn from Scopus only; although Scopus offers broad coverage, relevant studies indexed in other databases (e.g., Web of Science, PubMed, Google Scholar, and regional repositories) may not be captured. Second, AHP results depend on expert judgments; therefore, the derived priorities may be influenced by subjectivity and the representativeness of the expert panel. Third, the proposed I-CFSC framework is conceptual and has not yet been empirically validated through field implementation or longitudinal measurement of FLW outcomes. Fourth, although I-CFSC is tailored to Indonesia, generalization to other Muslim-majority countries may require

adjustments to institutional settings, food system structure, and local interpretations of Islamic economic ethics. Future work should (i) extend the review to multiple databases, (ii) test robustness using sensitivity analysis and alternative multi-criteria methods, and (iii) validate I-CFSC through stakeholder interviews, pilot projects, and comparative studies across Muslim-majority contexts.

## 4. CONCLUSIONS

This study demonstrates that reducing FLW in Indonesia requires not only technical optimization but also sociocultural alignment with the ethical values that shape societal behavior. By benchmarking global CFSC strategies and prioritizing alternatives through the AHP, the research identifies valorization as the most effective intervention across social, economic, environmental, and flexibility dimensions. While prevention and redistribution remain integral components of the CFSC cycle, valorization offers superior capacity to generate new value from unavoidable organic residues, thereby addressing Indonesia’s systemic FLW challenges through both technological innovation and resource efficiency.

The integration of *Iqtishād*—the Islamic ethic of moderation, proportionality, and responsible stewardship—provides a normative foundation that strengthens the cultural legitimacy and societal relevance of CFSC implementation in Indonesia. Mapping Qur’anic values onto the prevent–redistribute–valorize cycle reveals that Islamic teachings inherently support FLW reduction through anti-*isrāf*, dignified redistribution, and ecological responsibility. Embedding these principles into the interpretation of AHP findings affirms that valorization is not only technically optimal but also theologically and morally coherent, embodying the objectives of *maṣlaḥah* (public welfare), *ḥifz al-māl* (protection of resources), and *ḥifz al-bi’ah* (environmental preservation).

By synthesizing empirical prioritization with Islamic ethical reasoning, this study introduces the I-CFSC framework—an approach that enhances social acceptance, strengthens policy legitimacy, and offers a culturally grounded pathway to FLW reduction in a predominantly Muslim society. The I-CFSC framework contributes conceptual novelty by demonstrating how circular economy principles can be indigenized through value-based adaptation, thereby making sustainability interventions more context-appropriate and durable. Future research may extend this framework through quantitative validation, stakeholder engagement studies, and pilot implementations across diverse food sectors in Indonesia. Taken together, the findings underscore that valorization, empowered by Islamic ethics, holds substantial promise as a transformative strategy for advancing national and global sustainability goals, including SDG 12.3, while reinforcing ethical stewardship of food resources.

## ACKNOWLEDGMENT

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