Incentivizing Food Loss and Waste Technology in Indonesia

Ministry of National Development Planning/Bappenas Republic of Indonesia

Koalisi Sistem Pangan Lestari
Bagian dari Food and Land Use Coalition (FOLU)

P4G
Pioneering Green Partnerships, Investing in Impact

ibcsd

EMBASSY OF DENMARK
Jakarta

CONTENTS

ABBREVIATIONS

Bappenas : Badan Pembangunan Nasional (Ministry of National Development Planning)

BCR : Biochar Carbon Removal

BPOM : Badan Pengawas Obat dan Makanan (National Agency of Drug and Food Control)

BRIN : Badan Riset dan Inovasi Nasional (National Research and Innovation Agency)

BRIDA : Badan Riset dan Inovasi Daerah (Regional Research and Innovation Agency)

BSF : Black Soldier Fly

CAGR : Compound Annual Growth Rate

CO2: Carbon Dioxide

CSI : Carbon Standard Institute (CSI)

CSR: Corporate Social Responsibility

EU : European Union

FLW : Food Loss and Waste

GDP : Gross Domestic Product

GR : Government Regulation

GW : Gigawatt

MoEF: Ministry of Environment and Forestry

MoF : Ministry of Finance

OJK : Otoritas Jasa Keuangan (Financial Services Authority)

RPJPN : Rencana Pembangunan Jangka Panjang Nasional (National Long-Term Development Plan)

SMEs : Small and medium-sized enterprises

US : United States

VAT : Value Added Tax

OVERVIEW

On Oct. 30, 2024, P4G hosted a policy dialogue on "Incentivizing Food Loss and Waste Reduction Technology" in partnership with the Ministry of National Development Planning (Bappenas), the Embassy of Denmark in Indonesia, the Indonesia Business Council for Sustainable Development (IBCSD) and World Resources Institute's (WRI) Food and Land Use Coalition team.

The dialogue highlighted the urgent need for acknowledging the potential of technology in supporting sustainable solutions in food loss and waste (FLW) reduction. About 50 key stakeholders from across sectors gathered to exchange insights, discuss challenges and explore actionable policy recommendations that would support Indonesia's Circular Economy Roadmap and the Roadmap for Managing Food Loss and Waste. This proceeding summarizes the conclusions of the meeting and incorporates additional secondary data that will be shared with a larger audience.

Key discussions centered around three essential themes:

1. Standardizing definitions and metrics for FLW reduction in Indonesia.
2. Creating incentives for FLW reduction technologies.
3. Strengthening Indonesia's innovation strategy for FLW technological solutions.

The following are key recommendations to accelerate the adoption of FLW reduction technology in Indonesia:

1. Recognize FLW as a critical issue through regulation and require a holistic approach to achieve a sustainable food system.
2. Incentivize the progress of FLW technologies from research and development to commercialization.
3. Enhance digitalization and promote an integrated traceability system with data sharing across the food supply.
4. Establish public-private consortiums to bolster the bioeconomy.

FOOD LOSS AND WASTE TECHNOLOGY TRENDS: GLOBALLY AND IN INDONESIA

FLW is a growing global crisis, threatening food security, economic stability and environmental sustainability. Nearly one-third of all food produced (about 1.3 billion tons) is lost or wasted annually, costing the global economy approximately$1 trillion[1] . Meanwhile, 783 million people face hunger and one-third of the world's population struggles with food insecurity, highlighting a stark contradiction. FLW is responsible for 8%-10% of global greenhouse gas emissions — nearly five times the emissions from the aviation industry. It also depletes water, land and energy resources.

When categorizing the causes of FLW, two pathways of direct causes and indirect causes need to be considered:

Table 1 | Direct and Indirect Causes of FLW[2]

Direct causes	1. Lack of good handling practices (GHP) 2. Excessive production 3. Poor harvesting techniques 4. Suboptimal storage space 5. Technological limitations 6. Poor packaging and containers 7. Misinterpretation of expiration and best-before dates 8. Excessive portions and consumer behavior
Indirect causes	1. Lack of information and education for food workers and consumers about food loss and waste. 2. Lack of food waste regulation 3. Infrastructure limitations 4. Market quality standards and consumer preferences 5. Market competition and consumer purchasing power limitations

Although FLW is generated at all five stages of the food supply chain — production; post-harvest and storage; processing and packaging; distribution and marketing; and consumption — the causes of FLW vary by region. In developing nations, nearly 44% of food loss occurs during post-harvest and processing due to poor storage, transportation and financial constraints. In contrast, developed countries see about 40% of waste at the consumer level, driven by over-purchasing, improper storage and confusion over labels[3]. Alarmingly, 40% of all farm-grown food remains uneaten, with reports estimating global food waste at 2.5 billion tons annually — almost double previous figures[4].

Addressing FLW requires significant investment in infrastructure, education and technology. The Food and Agriculture Organization of the United Nations estimates that approximately $40 billion per year is needed over the next few decades to reduce waste at every stage of the supply chain[5]. Storage and transportation infrastructure improvements, particularly in developing countries, are crucial to reducing post-harvest losses. More efficient food distribution systems can help prevent waste before it reaches consumers, ensuring surplus food is redirected rather than discarded. Equally important is increasing awareness and education on food management, encouraging behavioral changes that promote responsible consumption and reducing unnecessary waste.

At the same time, FLW reduction presents a significant economic opportunity. Cutting consumer waste by 20%-25% by 2030 could save $120 billion to $300 billion annually[6], and every $1 invested in reducing waste yields a $14 return[7]. Technological innovation, such as food storage, packaging and monitoring innovations, plays a key role in minimizing waste. Real-time IoT sensor monitoring ensures temperature and humidity control during transportation, reducing spoilage before food reaches consumers. Dynamic pricing models allow retailers to adjust prices based on expiration dates, increasing sales of products that might otherwise be discarded.

Startups like Wasteless use AI-powered pricing to optimize food costs. They have helped divert 750 tons of waste from landfills — equivalent to 50 truckloads — by implementing smart markdown strategies[8]. Meanwhile, Hazel Technologies has developed freshness-extending sachets that help preserve produce longer, extending its shelf life by 20%-30% and keeping fruits and vegetables fresh for up to three weeks longer, with some products lasting as long as 12 months[9]

Currently, $0.1 billion per year — less than 1% of tracked agricultural investment — is allocated to FLW solutions, restricting the scale and impact of necessary interventions.[10] On the private sector financing side, investment in FLW solutions is also not growing to match the need.

Startups in this space raised $15.6 billion globally in 2023, a 49.2% decline from the $30.5 billion raised in 2022. The decline was both in dollar terms and as an overall portion of global venture capital funding, where the agrifood-tech sector represented 5.5% of all venture capital dollars in 2023 compared to 7.6% in 2021. This drop is attributed to several reasons, including the overvaluation of startups between 2018 and 2021, the lack of exits and the lack of government support.

While all global regions experienced a downturn, the U.S. was particularly hard hit. At $5.1 billion, African investment levels in 2023 were higher compared to 2021 levels ($626 million), but Asian startups only raised $3.8 billion in 2023 compared to $16.3 billion in 2021. Investment in upstream solutions was greater than in downstream startups.

Based on these trends and the insights from the workshop in Indonesia, this paper reviews FLW technologies from P4G startups and includes the recommendations that were discussed that can help scale this sector in Indonesia.

Food Loss and Waste in Indonesia

Indonesia is the second largest FLW producer globally. The country wastes approximately 115-184 kilograms of food per person per year[11], which totals about $39 billion in economic losses. This is the equivalent of 4%-5% of Indonesia's GDP. All the food wasted could meet the nutritional needs of 61 million to 125 million people a year. Badan Pembangunan Nasional (Bappenas) projections estimate that FLW will increase to around 336.76 kilograms of food per capita per year in a business-as-usual scenario.

Acknowledging the issue, Indonesia has enacted several targets to reduce FLW. For instance, the National Long-Term Development Plan (RPJPN 2025-2045) outlines that Indonesia aims to tackle the food crisis by achieving food security by 2045 and reducing FLW by 50% by 2030[4]. To further support these objectives, the country has also developed the National Roadmap for Food Loss and Waste (the FLW roadmap), which focuses on enhancing national food security through policy and strategy development, capacity building and education, improved coordination and collaboration, as well as technology and infrastructure improvements. Additionally, it includes considerations to implement systems of incentives and disincentives for FLW.

Other documents, such as The Strategic National Pathways for Food System Transformation in Indonesia[12], have also identified FLW as a critical target in several key priorities:

- Priority 1 focuses on eradicating hunger, improving dietary quality and supporting food sources from coastal and ocean areas.
- Priority 2 emphasizes the necessity of reducing FLW through technological innovations that improve food handling efficiency, leading to increased production and lower greenhouse gas emissions.
- Priority 3 is centered on supporting business strategies, such as empowering farmers by enhancing their technology and innovation skills, particularly in digital transformation, while also stressing the importance of strengthening resilient local food systems and promoting research and innovation in sustainable farming practices[13].

Several regulations highlight technology as one of the key drivers to reduce FLW. The FLW roadmap underscores the significance of supporting innovation and technology as a national target (Strategy 4) and emphasizes the importance of improving infrastructure and technology development strategy by promoting research for new technologies and collaboration with start-ups and tech companies during the periods of 2021-2025 and 2026-2030. [14]

However, when discussing FLW, Indonesia currently lacks a national definition that addresses these issues in the context of enhancing food security and environmental protection. There are three legal frameworks that tackle "food management" and "food as waste." Law 18/2012 outlines food management, emphasizing that it should satisfy basic human needs and deliver equitable, sustainable benefits grounded in food sovereignty, self-sufficiency and security. Article 5 further details critical aspects of food management, including planning, availability, affordability and consumption[15]. Law 18/2008 focuses on waste management[16], and Law 32/2009 addresses environmental protection[17], both categorizing FLW as organic waste that requires proper collection and management to ensure environmental sustainability.

The current law designates two ministries in charge of FLW — namely the Ministry of Environment and the Ministry of Agriculture — but misses the opportunity to create an interministerial link to

support sustainable food system, which includes both efficient food waste management and food security. This hampers the development of FLW technology, since the two definitions disregard FLW as a potential input for production in circular economy and consider it the end output of a linear process. Moreover, the research and technology budget allocated to Indonesian Research and Innovation Agency (BRIN) is less than 1% of the national budget[18], which restricts the advancement of technologies aimed at addressing FLW, circular economy and food security.

3. EMERGING TECHNOLOGIES, OPPORTUNITIES AND CHALLENGES IN INDONESIA

There are various FLW technologies emerging in Indonesia along the food value chain. The following sections will briefly explain the type of technology and share the challenges faced by each to scale in Indonesia.

VALUE CHAIN	TYPE OF TECHNOLOGY	EXAMPLES IN INDONESIA
Production or post-harvest	Edible coating, black soldier fly (BSF), Biochar	BIKI, Foodcycle Farm, Magalarva
In transit	Freezer-equipped delivery trucks	Lalamove
Food processing	Food handling, food upcycling	BIKI, RE:harvest, Great Giant Pineapple
Retail	Food rescue	Surplus, Garda Pangan
Consumption	Waste management collection, traceability	Jangjo, BIKI traceability

Edible Coating Technology

Technology description

Edible coatings represent a transformative solution to FLW challenges, providing a biodegradable and sustainable alternative to conventional packaging. These coatings regulate gas exchange, control moisture transfer and oxidation, help preserve food and extend the shelf life of perishable goods. This solution reduces food waste and provides opportunities for producers and retailers to minimize income losses. The global edible coatings market reflects the rapid advancements in this field. It is valued at approximately $3.2 billion in 2023[19] and is projected to grow at a compound annual growth rate of 7.5%-9.0%[20], reaching $4.2 billion by 2028 and an estimated $5.65 billion by 2032[21]. This growth is driven by consumer demand for biodegradable materials and innovations in food preservation technologies. Companies such as Apeel which raised $640 million[22] for plant-based coatings; Mori with $85.7 million invested in silk-based food protection; and Saveggy, which secured $1.87 million for plant-based packaging, exemplify the global momentum toward sustainable solutions.

Examples in Indonesia

In Indonesia, edible coatings have begun to be adopted as a practical solution for waste management challenges in urban areas and as a support mechanism for farmers facing growing pressures from increasing agricultural demand. Indonesia's diverse agricultural output, including high-value crops such as chilies and mangoes, faces significant challenges related to short shelf life and postharvest losses. Edible coatings made from natural ingredients such as polysaccharides, proteins and lipids are biodegradable and align with global sustainability goals, presenting Indonesia with an opportunity to position itself as a leader in sustainable food packaging. An example of a startup working on this is BIKI, which produces edible coating technologies using chitosan, a type of sugar substance taken from the skeleton or shell of a sea animal. BIKI, an Indonesian food tech company, addresses the country's significant food loss

challenges through practical solutions. One of its key interventions is Chitasil Edible Coating, a technology designed to extend the shelf life of fruits and vegetables between 8 and 40 days depending on the type of produce. This solution targets inefficiencies in post-harvest handling, where much of Indonesia's 5.7 million tons of annual food loss occurs.

The extended shelf life provided by Chitasil enables farmers and retailers to reduce spoilage, optimize inventory turnover and minimize revenue loss. Furthermore, the edible coating contributes to environmental sustainability by curbing methane emissions from decomposing organic waste in landfills, aligning with Indonesia's broader climate action goals.

In addition to technological innovation, BIKI offers good handling practices (GHP) training and promotes food traceability systems to encourage sustainable consumer behavior. These efforts are complemented by BIKI's policy advocacy, which includes recommending standardized methods for calculating FLW, as well as regulations for fruit and vegetable labeling.

Challenges and recommendations

Indonesia's regulatory framework complements this innovation, with policies such as Law 86/2019 on food safety emphasizing the need for protective packaging that maintains food quality and prevents contamination[23]. Similarly, the Indonesian Food and Drug Authority Regulation 11/2019[24] and Government Regulation 28/2004 provide guidelines for food additives and agricultural practices, creating a foundation for safely implementing edible coatings[25]. However, despite these regulations, no specific policies exclusively address and further support research and advancement of edible coating technology. This gap underscores the need for increased research and development investment to unlock these solutions' full potential.

Organic Waste Management (Collection)

Technology description

Efficient organic waste management relies on technology-enabled collection services. These services connect users and haulers, charging fees for curbside pickup, drop-off center use or specialized commercial collection from businesses and large-scale generators. After collection, waste is processed through methods tailored to specific needs, such as incineration, mechanical-biological treatment or composting.

Examples in Indonesia

FoodCycle and Jangjo are two organizations working within Indonesia's food waste management ecosystem. Both employ innovative approaches to tackle organic waste challenges.

FoodCycle operates as a food rescue and donation platform, redistributing surplus food to underprivileged communities to minimize food waste and address hunger. The platform partners with hotels, restaurants and retailers to recover edible food that would otherwise be discarded. It also transforms inedible food waste into animal feed using black soldier fly (BSF) larvae, supporting both waste reduction and resource recovery. However, FoodCycle faces financial challenges in covering logistics costs such as transportation and handling, which can limit its ability to scale operations.

Jangjo specializes in sustainable waste management solutions, focusing on empowering communities to sort and process waste effectively. It collaborates with businesses and residential communities to implement tailored waste management systems, including organic waste processing. Like FoodCycle, Jangjo utilizes BSF technology to convert food waste into high-protein animal feed. However, it encounters similar hurdles with logistics, particularly the high costs of collecting, transporting and processing food waste from multiple sources.

Challenges and recommendations

Historically, waste management in the country relied heavily on "end-of-pipe" solutions, where waste was treated as a byproduct with little regard for its potential value. This approach resulted in significant inefficiencies and an overreliance on natural resources. However, a shift began with the introduction of Law 18/2008, which emphasized waste reduction and recycling within a circular-economy framework[26].

Over the years, the Indonesian government has implemented several policies to enhance waste management systems. Regulations like the Presidential Regulation 97/2017[27] and the Ministry of Environment and Forestry Regulation 75/2019 aimed to reduce waste at its source and promote sustainable waste processing[28].

However, despite these efforts, significant challenges persist. The national budget allocated to waste management remains minimal, comprising just 0.51% of the total budget in 2022[29]. Waste management funding in Indonesia relies heavily on local government budgets, as waste fees are not typically levied at the city or regional levels. The fees collected from residents usually cover only the transportation of waste from its source to temporary storage sites, not the actual cost of waste treatment. This limited funding hinders the development and implementation of advanced technologies and infrastructure. Many areas still rely on outdated landfill systems, with open dumping and controlled landfills being standard practices. These methods fail to maximize the value of organic waste and pose environmental risks.

The existence of startups such as FoodCycle Farm and Jangjo exemplifies the transformative potential of innovative food waste management practices and underscores the pressing need for public private partnership to provide logistical and financial support to scale these efforts. The application of the Ministry of Finance Regulation 26/2021 could address these challenges by providing financial incentives for infrastructure development and operational costs, including transportation. The regulation offers an opportunity to expand food waste management[30] efforts. It provides a pathway for regional governments to secure funding for sustainable waste management initiatives by tying financial support to environmental performance. Regions that demonstrate effective waste management as part of their ecology-based programs can qualify for budget support, creating a powerful incentive for local governments to integrate food waste management into their broader environmental strategies.

The regulation also provides mechanisms to enhance infrastructure and promote innovation in waste processing. This can encourage investment beyond traditional landfill and composting methods by allocating incentives for developing facilities such as food waste processing plants or advanced storage technologies. Article 7, paragraph 2, notes that such funds can support public education campaigns and raise awareness about food waste management at the household level. Meanwhile, Article 11 opens the path for private companies to access these incentives, creating opportunities for public-private partnerships and accelerating the adoption of innovative food waste processing technologies.

Additionally, there is a need to combine the zero-waste targets outlined in Presidential Regulation 97/2017 and the Ministry of Finance Regulation 26/2021 to establish a comprehensive framework for extending food waste management initiatives. These policies highlight the potential to shift from basic waste processing systems to more advanced, value-driven approaches. For instance, integrating FLW management into ecological performance metrics could encourage regions to adopt technologies such as biodigesters, which convert organic waste into energy, or black soldier fly systems, which turn food waste into high-protein animal feed using valorization methods described in the next section.

Valorization Technologies

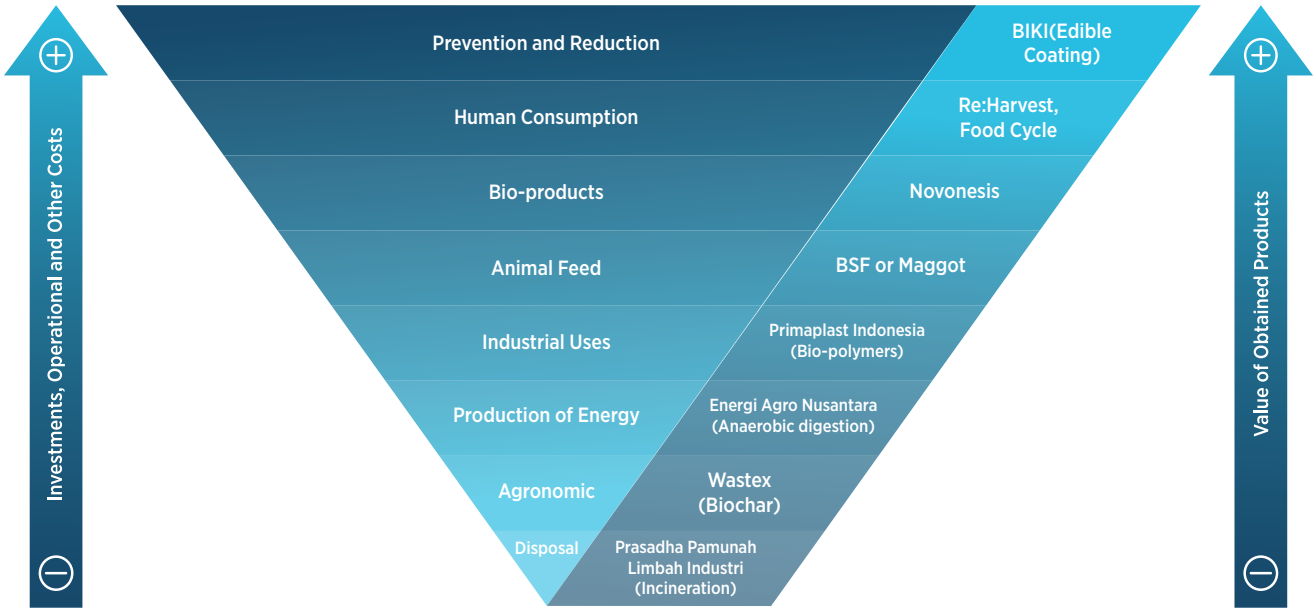
Technology description

Food waste valorization includes a range of innovative technologies that transform organic waste into valuable resources, such as high-value products and renewable energy. These methods, which are becoming increasingly important for sustainability, include hydrothermal carbonization, green extraction, enzymatic fermentation, biofuel and ethanol production, pyrolysis, anaerobic digestion, composting and animal feed production.

The viability of these techniques stems from the fact that food waste streams from the food industry are rich in nutrients and bioactive compounds, offering significant potential for resource recovery and economic benefits.

Food valorization techniques have different investment needs as they move up the ladder of higher-value output, as shown in the figure below[31].

Hierarchy of food by-product valorization and examples in Indonesia



Source: Adapted from the Guide for the Selection of Valorization Options of By-catches[42]

Examples in Indonesia

Indonesia has a range of valorization technologies that turn organic waste into higher-value products, including waste-to-energy and waste-to-feed methods. The country is actively promoting these techniques, particularly waste-to-energy solutions, to convert organic waste into biomass energy.

BIOMASS SUPPLY POTENTIAL UP TO 2040		
BIOMASS SUPPLY POTENTIAL FOR POWER GENERATION (MILLION TONS)		
BIOMASS TYPE	**ANNUAL POTENTIAL (MILLION TONS)**	**ENERGY VALUE (MILLION TONS)**
Crops	75	25
Forest residues	25	5.7
Residues from agro-industry	12	3.5
Residues from wood-industry	7	1.8
Animal waste	8	1.6
Other	10	1.8
Total	137	39.4

Source: Mahidin et al. (2020) in ERIA Research Project Report 2022 No. 01

Indonesia is also making significant strides in converting organic waste into valuable resources, particularly using the BSF method, which can reduce organic waste by 60%-70% and transform it into animal feed[32]. Numerous companies in Indonesia, including Margalarva and Maggot Indonesia, are involved in BSF initiatives. Although there are currently no specific regulations governing the use of BSF, the Indonesian government is actively encouraging communities and businesses to participate in programs aimed at meeting the national target of reducing organic waste by 40 million tons of carbon dioxide emissions by 2030[33].

Another emerging valorization technique includes biochar technology which presents significant potential for biomass conversion in Indonesia. As a type of negative emission technology, biochar carbon removal effectively removes carbon dioxide from the atmosphere and securely stores it to prevent its release back into the environment. This carbon-rich material is produced by pyrolyzing organic biomass — such as wood, agricultural residues or waste — in an oxygen-free environment, contributing to climate change mitigation efforts. The national capacity for converting agricultural biomass into biochar is estimated at around 10.7 million tons, which could produce approximately 3.1 million tons of biochar[34].

The global revenue outlook for biochar is projected to range from $614.7 million to $1.35 billion between 2024 and 2030, with an anticipated compound annual growth rate of 13.9% during that period[35]. Combining biochar production with carbon offset credit generation creates opportunities to develop an industry that offers local ecological benefits and global climate advantages while enhancing the profitability of biochar production. According to MSCI Carbon Markets, corporate use of voluntary credits from biochar projects surged from less than 1,000 tons in 2020 to 34,000 tons of carbon dioxide equivalent in 2022 and reached 65,000 tons in 2023[36].

One company working on biochar technology is WasteX, which offers a comprehensive waste-to-biochar solution, delivering innovative and

cost-effective biochar production technology to agricultural producers, small and medium-sized enterprises and mills. The startup also promotes the adoption of biochar among smallholders, highlighting its financial, operational, agricultural and environmental (carbon removal) benefits for all.

In addition to selling biochar production equipment, WasteX enables farmers to earn carbon credit revenue based on the total biochar generated, connecting production directly to the voluntary carbon market. The platform offers an app that helps farmers calculate the budget they can receive from the carbon generated by their biochar.

So far, WasteX has produced 38 tons of biochar and is in the process of registering with a carbon market platform called Carbon Future. To validate their carbon generation efforts, they have received certification from the Carbon Standard Institute (CSI) and are aiming for a target price of $50 per ton. Currently, carbon prices in the artisan market range from $100 to $200 per ton of carbon dioxide equivalent.

While WasteX focuses on biochar production and carbon market integration, other initiatives are exploring different ways to maximize the value of organic waste. One emerging approach is food waste and by-product valorization, which, though gaining traction, remains in its early stages in Indonesia. An example is the food upcycling technology developed by South Korean company RE:harvest. The startup is collaborating with PT Multi Bintang Indonesia to convert by-products from the brewing process into high-protein products, showcasing another innovative solution in the circular economy.

Since food upcycling technology is very nascent in Indonesia, there are no regulations that support its development, which is hindering smooth technology transfer.

Another example is Adakarbon, a nonprofit organization that focuses on community-based biochar production through farmer training and grassroots implementation. Unlike technology-centric models, Adakarbon works directly with smallholder farmers to transform agricultural residues into biochar for soil improvement and climate mitigation. This approach addresses food loss at the production stage, where large quantities of biomass are typically discarded or burned, and instead channels these residues into a circular system that enhances productivity and soil health. In addition to its ongoing fieldwork, Adakarbon is developing a “biochar bank” concept — a community-level exchange mechanism where farmers can trade biochar for inputs or participate in carbon credit schemes. The model aims to democratize access to climate finance by redistributing carbon revenues to rural producers who generate biochar, ensuring that smallholders are recognized and rewarded as contributors to both FLW reduction and emission mitigation. By linking agronomic valorization, food system resilience and grassroots access to carbon markets, Adakarbon offers a replicable model to advance Indonesia’s circular bioeconomy goals.

Challenges and recommendations

While Indonesia is seeing the emergence of new technologies in the valorization process, to advance to higher-value-added valorization technologies, the country must invest in its national research system, emphasize a bio-based economy and foster collaboration among researchers, entrepreneurs and funders. Additionally, supportive regulations are needed to facilitate effective sorting methods, select appropriate technologies based on the composition of food waste, enforce higher biosecurity standards and encourage joint efforts among stakeholders to boost investment, expand markets for value-added products, develop marketing strategies and raise public awareness about the potential benefits of food waste valorization[37].

The box below highlights technologies and strategies championed by the Republic of Korea and Denmark that were highlighted at the workshop.

The Republic of Korea and Denmark's public-private partnership approach to valorization technology

In 2005, the Republic of Korea implemented a policy prohibiting food waste from being sent to landfills. This practice identified "food upcycling" as a key development area under "food technology" by the Ministry of Agriculture. This move laid the groundwork for a comprehensive strategy to manage food waste sustainably.

By 2010, the country introduced an innovative volume-based food waste fee system, which operated on a pay-as-you-throw basis to encourage residents to minimize food waste. Further advancements in waste management included automated waste collection systems in urban areas, featuring bins with integrated scales and RFID technology.

The Republic of Korea also prioritized investment in infrastructure to support these initiatives. A dedicated research and development center was established, backed by government policy, to focus on food upcycling as a core technology. Additionally, significant investments were made in constructing biogas facilities, such as the Daejeon Bioenergy Center, to convert food waste into renewable energy, supplying green energy to thousands of households.

To further support FLW technologies, the country was the first to establish a food upcycling research and development center in Naju. The government facilitated funding by setting up government-led venture capital firms (Korea Venture Investment Corporation and the Korea Fund of Funds) where the Ministry of Industry and other departments became limited partners. They also introduced a regulatory sandbox program for startups, exempting them from certain regulations to encourage innovative green business models.

Similarly, the government of Denmark established a National Bioeconomy Panel under the Ministry of the Environment and the Ministry of Industry, Business and Financial Affairs. The panel aims to develop new and sustainable value chains within the bioeconomy. Made up of companies, researchers, nonprofit groups and key organizations, the panel has issued various recommendations and fact sheets related to the bioeconomy and biomass. Its focus includes renewable biological resources and the transformation of these resources, along with their waste, into products like food, feed, biomaterials and bioenergy. Research and innovation play a crucial role in defining and carrying out initiatives that promote optimal food use throughout the supply chain, emphasizing the best uses for surplus food and maximizing the value of edible resources.

Food Rescue Apps and Food Donation Models

Technology description

Food rescue apps connect consumers with discounted surplus food from supermarkets and restaurants. Users browse the app to see available items (individual groceries or full meals), place orders and pay online, then collect their purchases at a designated time. Retailers easily list their excess inventory via the app, much like posting a photo and description on social media.

A food bank is a nonprofit organization that collects surplus food from various sources (farmers, manufacturers, retailers and restaurants) and distributes it to those in need, typically through a network of partner charities and community organizations. While a traditional food bank isn't designed as a for-profit business model, several models can incorporate food bank principles or operate around them. These include generating revenue by charging a fee for removing unsold food, upcycling the rejected produce into value-added products or integrating donation-based model as revenue streams.

Examples in Indonesia

Indonesia currently has food rescue apps and food bank services, with startups like Surplus and FoodCycle Farm operating in this space. These food rescue and food bank models generate revenue in different ways:

- Surplus offers a commission-based model by partnering with hotels and retailers to offer discounted products.
- FoodCycle and FoodCycle Farm use both donation-based models and a commodity exchange model with the hotel, restaurant and catering industry.

However, both models require users to cover delivery logistics, which poses challenges in gaining traction and generating revenue.

Challenges and recommendations

Indonesia lacks clear regulations regarding food safety standards and distribution, along with liability protection clauses that would provide assurance to retailers, hotels and others interested in collaborating with food banks or rescue apps. Additionally, misinterpretation of date labeling contributes to food waste, as expiration dates are often confused with food safety deadlines. This ambiguity further leads to restrictions on the sale or donation of food past its labeled quality date, reducing consumer confidence in the safety of food collected from food banks and rescue efforts.

Moreover, there is no clear regulation offering liability protection for food banks or a framework to address logistics costs related to food handling, which often incurs additional taxes that raise expenses for food rescue operators.

There is a pressing need for a comprehensive framework and regulations addressing food donation and rescue that consider not only logistics but also enhance the sustainability of business models. Implementing dual labeling regulations to distinguish between food safety ("use by") and food quality ("best before") dates could clarify consumption deadlines for consumers and help reduce avoidable food waste. Additionally, introducing liability protection, removing the value-added tax on donated food and monetizing impact reporting could improve operational costs for food donation and rescue apps.

The box below explores the potential use of impact reporting to support food donation and rescue apps.

Surplus and the potential of impact reporting

Surplus, a food rescue app in Indonesia, collaborates with a marketplace that includes more than 5,000 partners and 1 million users. The app provides impact reports to hotels, which includes the amount of food collected and the emission avoided, and to retailers participating in the program. These reports have a significant positive influence on partners, helping them improve operational systems for tracking, planning, and inventory management. As a result, partners see reduced costs and improved efficiency, leading to stronger financial performance. This aligns with research from World Resources Institute, which found that food waste initiatives implemented by hotels can save more than 4 cents for every dollar spent on goods sold.

The impact reports have supported carbon offset activities by Ascott Hotels by providing data on food waste diversion and its contribution to carbon dioxide emissions reductions. In this way, hotels and retailers can recoup lost revenue from donated food by earning carbon credit revenue.

Given this example, impact reporting could serve as a key tool for the Indonesian government to monitor FLW while offering mutually beneficial solutions for participating businesses. Indonesia could consider making impact reporting for FLW either a voluntary or mandatory practice, following the example of initiatives in other countries.

Traceability System

Technology description

Effective FLW monitoring relies heavily on traceability technologies. Solutions such as QR codes, blockchain, AI, IoT, and RFID, or combinations of these, capture crucial data on location, temperature, and handling practices throughout the supply chain. This data helps identify vulnerabilities, reduce spoilage and improve efficiency. The resulting insights optimize procurement and inventory management, which is especially beneficial for developing nations where 14% to 21% of fruit and vegetable production is lost during processing.

Examples in Indonesia

BIKI is in the process of developing a traceability system that will span from packing houses to distribution, retail and ultimately the consumer. This system will generate data showing the journey of food treated with BIKI's edible coatings and calculate the total loss by the time it reaches the end consumer. The traceability app is directed at consumers and enables them to view the shelf life of the products they purchase, while also providing access to potential recipes for various foods they have at home, helping reduce overall FLW at the end of the chain.

The traceability system will store data of the commodities' origin, the journey, the shelf life and the carbon emissions. The QR code-based BIKI system will also integrate machine learning to predict total food loss from packing houses to end consumers. In the future, BIKI plans to enhance the traceability system with blockchain technology to further validate the amount of food loss avoided, which is in line with the Indonesian government's strategy to improve technological infrastructure in the food supply chain as part of the country's FLW strategy. Additionally, the system will support the collection of reliable data based on the FLW protocol and other reporting systems and help with carbon credit validation processes.

Challenges and recommendations

Currently, Indonesia has regulations for a direct traceability system to support product recall, including the Ministry of Agriculture Regulation 53/2018 on the quality and safety of fresh food and plants[38], and the National Agency of Drug and Food Control Regulation 21/2021 on implementing a safety and quality assurance system for processed foods at distribution facilities[39].

Regulations specifically requiring a traceability system are found in the Ministry of Marine Affairs and Fisheries Regulation No. 29/2021 on the National Fish Logistics and Traceability System[40]. In general, the food agro-industry has not fully implemented a traceability system. Where one does exist, it is typically conventional and static, not a real-time system or one connected to all actors involved.

In its current food loss and waste strategy, Indonesia aims to enhance data collection for FLW through technology infrastructure, as highlighted in Strategy 4 of the FLW roadmap. The strategy outlines the adoption of an integrated information system using blockchain technology to monitor FLW across the food supply chain between 2026 and 2030. However, literature points out that distributed ledger technologies like blockchain and IoT face challenges such as scalability, network security, cost, privacy, information storage, energy consumption, latency and lack of interoperability with other systems[41]. These factors should be considered by Indonesia when selecting the most suitable technology.

SUMMARY AND RECOMMENDATIONS

The discussion and current context emphasize the critical need to address FLW in Indonesia, which costs the country anywhere from $13 billion to $33.8 billion annually and significantly affects the environment and the economy. It highlights the potential of various technologies to mitigate FLW and promote a circular economy.

The key findings are as follows:

1. **Indonesia has many sectoral regulations to support FLW. However, there is no law that holistically addresses FLW.** Laws on food management (Law 18/2012), waste management (Law 18/2008) and environmental protection and management (Law 32/2009) place responsibility for FLW under two different ministries. The definitions cited in these laws undermine FLW as a potential input to support resilient food and agriculture systems and as a circular economy industry. As of July 2025, the revision of the food management law (Law 18/2012) is being processed in the House of Representatives (DPR), with indications that FLW will be included.
2. **There is a lack of ministerial involvement across all value chains related to FLW technology.** The FLW roadmap emphasizes the role of technology and its stakeholders but doesn't integrate the roles of the Ministry of Industry and the National Agency for Research and Innovation. It is crucial for both ministries to increase their capacity for supporting technologies and to advance higher-value waste-to-valorization activities. Additionally, the Indonesian Research and Innovation Agency (BRIN) plays a vital role in supporting commercialization strategies through technology incubation, fostering industrial partnerships and developing key areas in science and technology.
3. **The current state of digitalization of FLW monitoring and data sharing is still lacking**, with many different players, including the government and private sectors, providing data independently through systems that do not interact with each other. There are currently no mandates to support FLW data collection in Indonesia, while the regulations for traceability systems exist only to support product recalls.
4. **The enabling environment for supporting and commercializing FLW technologies is currently constrained**. In addition to (BRIN) facing limited budget support, there is also no explicit mandate for the agency to facilitate the commercialization process. At present, the regulations from BRIN only address commercialization strategies up to the industrial matchmaking stage, but do not provide support for a funding strategy. There is a need to explore feasible pathways of commercialization between stakeholders.
5. **Public and private sector actors in the FLW space lack coordination and a clear strategy** to advance FLW technology and circular economy based on bioeconomy. There are currently no consortiums or space for all actors to co-create regulations based on the advancement of the technologies.
6. **Collaboration between Indonesia and other countries in supporting research and technology transfer is insufficient**, causing international private sector entities in the industry to encounter significant operational bottlenecks within Indonesia in terms of licensing and standards, limiting smooth technology transfer.

Based on the discussions and context in Indonesia, the recommendations for supporting FLW technology in Indonesia are as follows:

1. **Recognize FLW as a critical area through regulation and require a holistic approach to achieve a sustainable food system.**
   Indonesia's strategic pathways for food system transformation should recognize FLW as a critical area requiring a holistic approach to achieve a sustainable food system that addresses both food security and environmental sustainability. The draft presidential regulation on FLW was initially a strategic regulation instrument to recognize this issue. However, as of 2025, this presidential regulation draft has been cancelled.
2. **Incentivize the progress of FLW technologies from research and development to commercialization.**
   To incentivize the progress of FLW technologies, it is essential to cultivate a vibrant research and startup ecosystem with the involvement of both the National Research Agency, the Ministry of Industry and the investors. Indonesia can draw lessons from the Republic of Korea's experience in supporting the incubation of FLW technologies by establishing a food tech research center in Naju and creating supportive environments, such as regulatory exemptions through a regulatory sandbox and the establishment of a government-led fund of funds. Additionally, collaborating early with the Ministry of Industry to provide standards for technology, particularly in the food upcycling sector, can streamline processes for offering incentives like green industry certification.
3. **Enhance digitalization and promote an integrated traceability system with data sharing across the food supply chain.**
   This is crucial for encouraging the adoption of circular economy principles and ensuring that progress is directly linked to greenhouse gas emission reductions, facilitating accurate tracking and reporting. Supporting the early adoption of traceability systems with affordable and suitable technology is key to defining the data and measures necessary for establishing incentives and disincentives.
4. **Establish public-private consortiums to bolster the bioeconomy.**
   Establishing public-private consortiums to bolster the bioeconomy is critical for fostering a thriving industry. Additionally, promoting government-to-government collaboration on research and technology transfer in FLW can provide valuable leverage for the industry.

Sectoral Recommendations for FLW Technologies

TYPES OF TECHNOLOGY	KEY INCENTIVES	TARGETED REGULATIONS AND INITIATIVES	RELEVANT INSTITUTIONS
Edible coating technology	Promotion and research support for edible coating technologies	Revision of UU 18 year 2012 on food: There is a plan that FLW will be included in the revision of UU 18	1. National Food Agency 2. Research and Innovation Agency (BRIN) 3. Ministry of Industry
Organic waste management	Regulation on retribution fees Carbon-based revenue from waste and agriculture sector	Ministry of Environment (KLH/BPLH) to provide regulation on the reduction of organic waste through systematic collection, penalties and retribution fees Ministry of Environment Regulation No. 21 year 2022 on carbon pricing implementation Ministry of Environment to release roadmap on waste sector carbon roadmap	1. Ministry of Environment
Food upcycling and valorization	Research funding for valorization technologies Biosafety regulation Public-private partnerships to support bioeconomy	Revision of UU 18 Year 2012 to include funding on research for FLW technology and supporting public-private partnerships to support bioeconomy	1. Indonesia National Food Agency 2. National Agency for Research and Innovation (BRIN) and Regional Innovation Research Agency (BRIDA) 3. Ministry of Finance 4. Ministry of Industry 5. Indonesia Biosafety Clearinghouse 6. Ministry of Agriculture 7. Agency for Food and Drugs Control

Sectoral Recommendations for FLW Technologies Cont.

TYPES OF TECHNOLOGY	KEY INCENTIVES	TARGETED REGULATIONS AND INITIATIVES	RELEVANT INSTITUTIONS
Food rescue apps and food donations	Additional guidelines for labeling expired dates and "best before" dates Regulations to provide liability protection to food banking provider VAT exemption for logistic providers Include food donation as one of the CSR activities that can be tax deductible for food retailers Voluntary and mandatory impact monitoring for food and hotels	Revision in PerBPOM 31/2013 for dual labelling Law 36/2008 about income tax and concurrently the Ministry of Finance Regulation No. 2/PMK.03/2010 to include food donation for CSR activities and support tax reduction. Tax deduction regulations need to be coordinated with MoF Revision of UU 18 Year 2012 to include FLW and provide general guidelines on food banks, subsequently the Indonesian National Food Agency to release derivative regulations to support technical regulations for food bank and food donation Government of Indonesia to release voluntary and mandatory impact reporting for hotels and retailers Ministry of Environment to release roadmap on waste sector carbon roadmap	1. Indonesia National Food Agency 2. Indonesian Food and Drug Control Agency (BPOM) 3. Ministry of Finance 4. Financial Services Authority (OJK) 5. Local government
Traceability systems	Pilot project on traceability for FLW using QR codes Regulations on traceability system	Revision of UU 18 Year 2012 on food to provide general guidelines on the monitoring process for FLW	1. Indonesia National Food Agency

POLICY DIALOGUE SPEAKERS	
Irfan Martino – Bappenas	Agung Saputra – Surplus
Nita Yulianis – Bapanas	Fierra Setyawan – IBCSD (KSPL's core partner)
Indah Budiani – IBCSD (KSPL's core partner)	Jinhee Hwang – ASEIC
Romauli Panggabean – WRI Indonesia (Koalisi Sistem Pangan Lestari/KSPL's core partner)	Alex Min – RE:harvest
Muhammad Hafid – BIKI	Joanne Looi – Novonesis
Nadia Fausta – Embassy of Denmark	Dian Yuanita – IBCSD (KSPL's core partner) (Moderator)
Astrid Paramita – FoodCycle	Hanny Chrysolite – Systemiq (KSPL's core partner) (Moderator)
R. Hery Sulistio Hermawan – DPKP DIY	Rendy Aditya – Parongpong RAW Lab (KSPL's core partner)
POLICY DIALOGUE ATTENDEES	
Direktorat Pangan dan Pertanian Bappenas	Koalisi Rakyat untuk Kedaulatan Pangan (KRKP) (KSPL's core partner)
UNDP	Systemiq (KSPL's core partner)
PISAgro	CDP
Green Growth Institute (GGGI)	Yayasan Humanis dan Inovasi Sosial (KSPL's core partner)
Great Giant Food	Waste4Change
Center for Indonesian Policy Studies	ADB
Badan Pengawas Obat dan Makanan	Persatuan Hotel dan Restoran Indonesia
Global Alliance for Improved Nutrition (GAIN) (KSPL's core partner)	Badan Riset dan Inovasi Nasional
Bappeda Kota Semarang	Dietplastik Indonesia

ENDNOTES

1. UNFCCC secretariat (UN Climate Change). (2024, September 28). Food loss and waste account for 8-10% of annual global greenhouse gas emissions; cost USD 1 trillion annually. https://unfccc.int/news/food-loss-and-waste-account-for-8-10-of-annual-global-greenhouse-gas-emissions-cost-usd-1-trillion

2. World Resources Institute Indonesia & Koalisi Sistem Pangan Lestari. (2023). *Systems Thinking for a Sustainable Food System Booklet Series: Reducing Food Lost and Waste.* (4, 1–5). https://wri-indonesia.org/sites/default/files/2024-02/KSPL%20Booklet_04%20Reducing%20Food%20Lost%20and%20Waste.pdf

3. Ishangulyyev, R., Kim, S., & Lee, S. (2019). Understanding Food Loss and Waste—Why are we losing and wasting food? *Foods*, *8*(8), 297. https://doi.org/10.3390/foods8080297

4. WWF. (2016). Driven to waste: Global food loss on farms. https://wwf.panda.org/discover/our_focus/food_practice/food_loss_and_waste/driven_to_waste_global_food_loss_on_farms/

5. Abiad, M. G., & Meho, L. I. (2018). Food loss and food waste research in the Arab world: a systematic review. *Food Security*, *10*(2), https://doi.org/10.1007/s12571-018-0782-7

6. Goodwin, L. (n.d.). The global benefits of reducing food loss and waste, and how to do it. *World Resources Institute*. https://www.wri.org/insights/reducing-food-loss-and-food-waste

7. Ramsey, B. (2024, October 26). The hidden costs of food waste: Eye-opening statistics and solutions for businesses. *Environment+Energy Leader*. https://www.environmentenergyleader.com/stories/the-hidden-costs-of-food-waste-eye-opening-statistics-and-solutions-for-businesses,48408

8. Mestey, M. (2024, November 20). Reducing food waste: Oded Omer of wasteless AI on how they are helping to eliminate food waste. *Medium*. https://medium.com/authority-magazine/reducing-food-waste-oded-omer-of-wasteless-ai-on-how-they-are-helping-to-eliminate-food-waste-8588134d718e

9. Masiwa, D. (2024, June 18). New tech keeps produce fresh longer. *Food for Mzansi*. https://www.foodformzansi.co.za/new-tech-keeps-produce-fresh-longer/

10. CPI [Daniela Chiriac, Harsha Vishnumolakala, Paul Rosane]. (2023). Landscape of Climate Finance for Agrifood Systems*. Climate Policy Initiative*

11. https://lcdi-indonesia.id/wp-content/uploads/2021/07/Report-Kajian-FLW-ENG.pdf

12. Government of Indonesia & National Development Planning Agency. (2021). *INDONESIA STRATEGIC NATIONAL PATHWAY FOR FOOD SYSTEMS TRANSFORMATION*. https://summitdialogues.org/wp-content/uploads/2021/09/Pathway_version_1.0english_Indonesia_15.09.2021.pdf

13. Government of Indonesia. (2024). *National Long-Term Development Plan (RPJPN 2025-2045)*.

14. Isdarmadji, N. Q. (n.d.). *Kemenko Pangan Alokasikan Rp139,4 Triliun untuk Swasembada Pangan di 2025*. Kementerian Pendayagunaan Aparatur Negara Dan Reformasi Birokrasi. https://www.menpan.go.id/site/berita-terkini/berita-daerah/kemenko-pangan-alokasikan-rp139-4-triliun-untuk-swasembada-pangan-di-2025

15. Government of Indonesia. (2012). *Government Regulation No. 18/2012 on concerning food*.

16. Government of Indonesia. (2008). *Law No. 18/2008 on solid waste management.*

17. Government of Indonesia. (2008). *Law No. 18/2008 on solid waste management.*

18. Hidayat, A., & Maulana, M. R. (2022, February 4). Anggaran Riset Disebut Menyusut di Era BRIN. *Tempo*. https://www.tempo.co/politik/anggaran-riset-disebut-menyusut-di-era-brin-840875

19. Edible Films and Coatings Global Market Report 2025. (2025). In https://www.thebusinessresearchcompany.com/report/edible-films-and-coatings-global-market-report. Retrieved January 2, 2025'

20. Maximize Market Research Pvt Ltd. (2024, July 10*). Edible Films and Coating Market - Industry Analysis & forecast.* MAXIMIZE MARKET RESEARCH. https://www.maximizemarketresearch.com/market-report/edible-films-and-coating-market/145932/

21. Edible films and coating market size, share & trends analysis report by material type (protein, polysaccharides, lipids, composites), by application, by region, and segment forecasts, 2022 - 2028. (n.d.). https://www.grandviewresearch.com/industry-analysis/edible-films-coating-market-report

22. Top Food Preservation Coatings startups. (n.d.). https://tracxn.com/d/trending-business-models/startups-in-food-preservation-coatings/__TCo9kznibXt-rWGQA3iRLZePt7watcJjAFaVpBVywYw/companies#t-1-apeel. Retrieved January 3, 2025

23. Government of Indonesia. (2019*). Presidential Regulation No. 86/2019 on food safety.*

24. Government of Indonesia. (2019). *Indonesia Food and Drug Authority Regulation No. 11/2019 on food additives.*

25. Government of Indonesia. (2004). *Government Regulation No. 28/2004 on food safety, quality and nutrition*

26. Government of Indonesia. (2008). *Law No. 18/2008 on waste management*.

27. Government of Indonesia. (2017). *Presidential Regulation No. 97/2017 on national policy and strategy for management of domestic waste and domestic waste equivalents.*

28. Government of Indonesia. (2019). *Ministry of Environment and Forestry No.75/2019 on roadmap for waste reduction by producers.*

29. Kemendagri lakukan public expose atas kajian perhitungan biaya penanganan sampah dan penerapan skema retribusi untuk Kota Denpasar. (2022, September). [*Press release*]. Retrieved January 10, 2025.

30. Government of Indonesia. (2021). *Ministry of Finance Regulation No.26/2021 on state budget funding support for waste management in the regions.*

31. European Parliament Council. (2008). *Directive 2008/98/EC of The European Parliament and of the Council of 19 November 2008 on waste and repealing certain directives.* Brussels, Belgium.

32. Prabowo, M. A., Prasetya, A., & Purnomo, C. W. (2024, December 7). Reduksi Limbah Organik dengan black soldier fly (BSF). https://proceeding.uns.ac.id/semnasfp/article/view/694

33. Indonesia. (2022). *Enhanced NDC - Republic of Indonesia*. https://unfccc.int/sites/default/files/NDC/2022-09/23.09.2022_Enhanced%20NDC%20Indonesia.pdf

34. Ariningsih, E., Ashari, N., Mardiharini, M., Sujianto, N., Irawan, N., Rahayu, H. S., Saleh, Y., Slameto, N., Suharyon, N., & Septanti, K. S. (2024). The potential utilisation of rice biomass for biochar to support sustainable rice farming development in Indonesia. *BIO Web of Conferences*, *119*, 05001. https://doi.org/10.1051/bioconf/202411905001

35. BioChar market size, share & trends analysis report by technology (gasification, pyrolysis), by application (agriculture, others), by region (North America, Asia Pacific), and segment forecasts, 2024 - 2030. (n.d.). https://www.grandviewresearch.com/industry-analysis/biochar-market

36. Outlook for the global biochar market. (n.d.). MSCI. https://www.msci.com/www/blog-posts/outlook-for-the-global-biochar/04633228838

37. European Parliament Council. (2008). *Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain directives.* Brussels, Belgium.

38. Government of Indonesia. (2018). *Ministry of Agriculture Regulation No. 53/2018 on the safety and quality of fresh food of plant origin*.

39. Government of Indonesia. (2021). *National Agency of Drug and Food Regulation No. 21/2021 on the implementation of the safety and quality assurance system for processed food in circulation facilities.*

40. Government of Indonesia. (2021). *Ministry of Marine Affairs and Fisheries Regulation No.29/2021on the National Fish Traceability and Logistics System.*

41. Nurgazina, J., Pakdeetrakulwong, U., Moser, T., & Reiner, G. (2021). Distributed ledger technology applications in food supply chains: A review of challenges and future research directions. *Sustainability*, *13*(8), 4206. https://doi.org/10.3390/su13084206

42. Iñarra, B., Bald, C., Cebrián, M., Antelo, L. T., Franco-Uría, A., Vázquez, J. A., Pérez-Martín, R. I., & Zufía, J. (2018). Guide for the selection of valorisation options of by-catches https://www.azti.es/wp-content/uploads/2022/02/AZTI_guia_discardless.pdf

Ministry of National
Development Planning/Bappenas
Republic of Indonesia

Koalisi
Sistem Pangan Lestari
Bagian dari Food and Land Use Coalition (FOLU)

P4G
Pioneering Green Partnerships,
Investing in Impact

ibcsd

EMBASSY OF DENMARK
Jakarta