Ministry of National Development Planning/Bappenas Republic of Indonesia

LOW CARBON DEVELOPMENT INDONESIA

PAGE PARTNERSHIP FOR ACTION ON GREEN ECONOMY

STUDY REPORT

FOOD LOSS AND WASTE REGIONAL

WEST JAVA, CENTRAL JAVA, BALI

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STUDY REPORT

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Tables of Contents

STUDY REPORT

FOOD LOSS AND WASTE REGIONAL

WEST JAVA, CENTRAL JAVA, BALI

List of Tables

STUDY REPORT

FOOD LOSS AND WASTE REGIONAL

WEST JAVA, CENTRAL JAVA, BALI

List of Figure

STUDY REPORT

FOOD LOSS AND WASTE REGIONAL

WEST JAVA, CENTRAL JAVA, BALI

List of Abbreviations

ASA	:	Healthy Child Intake / *Asupan Sehat Anak*
BAPPENAS	:	Ministry of National Development Planning / *Badan Perencanaan Pembangunan Nasional*
Budikdamber	:	Fish Farming in Buckets / *Budidaya Ikan Dalam Ember*
Botram	:	Support for Marginalized Parents and Community / *Bantuan Orang Tua dan Masyarakat yang Termaginalkan*
BPS	:	Central Bureau of Statistics / *Badan Pusat Statistik*
BSF	:	Black Soldier Fly
CPO	:	Crude Palm Oil
DKPP	:	Food Security and Livestock Agency / *Dinas Ketahanan Pangan dan Peternakan Provinsi Jawa Barat*
DISHANPAN	:	Food Security Agency / *Dinas Ketahanan Pangan Provinsi Jawa Tengah*
DISTANPANGAN	:	The Agriculture and Food Security Agency in Bali / *Dinas Pertanian dan Ketahanan Pangan Provinsi Bali*
DTPH	:	Food Crops and Horticulture Agency / *Dinas Tanaman Pangan dan Hortikultura Jawa Barat*
FAO	:	Food and Agricultural Organization
FOI	:	Food Bank of Indonesia
FBS	:	Food Balance Sheets / *Neraca Bahan Makanan*
FL	:	Food Loss / *Susut Pangan*
FW	:	Food Waste / Sisa Makanan
FSC	:	Food Supply Chain
FLW	:	Food Loss and Waste / *Susut Pangan dan Sisa Makanan*
Garang Asem	:	Love Food Movement / *Gerakan Sayang Pangan*
GDP	:	Gross Domestic Product
GHG	:	Greenhouse Gas / *Gas Rumah Kaca*
GKG	:	Dry Milled Paddy / *Gabah Kering Giling*
GSP	:	Save Food Movement / *Gerakan Selamatkan Pangan*
HH	:	Household / *Rumah Tangga*
HORECA	:	Hotel, Restaurant, and Cafe
JAMKRIDA	:	Regional Credit Guarantee / *PT Penjaminan Kredit Daerah*
LCDI	:	Low Carbon Development Initiatives
MUFPP	:	Milan Urban Food Policy Pact
MoA	:	Ministry of Agriculture / *Kementerian Pertanian*
NFA	:	National Food Agency / *Badan Pangan Nasional*
NGO	:	Non-governmental Organization
PN	:	National Priority / Prioritas Nasional

Executive Summary

Introduction

In support of the global development goals, which have been integrated into the National Medium-Term Development Plan (RPJMN) 2020-2024, the Indonesian Government has firmly committed to addressing food waste through various national policy measures and initiatives. One such initiative involves a comprehensive national study on Food Loss and Waste (FLW) to ascertain baseline data on FLW for identifying the necessary policies and strategies for responsible FLW management. This effort is part of the broader strategy to support low-carbon development and the transition to a circular economy.

Indonesia is estimated to generate 115-184 kg of food loss and waste per capita annually, with significant contributions from households and the commercial sector, including restaurants and hotels. High levels of food waste can lead to substantial economic challenges, contribute to greenhouse gas (GHG) emissions, and intensify resource inefficiencies. There is an urgent need for transformative actions that ensure food security while reducing food waste generation and GHG emissions within the food systems. To address these concerns, a Regional Food Loss and Waste study has been conducted to obtain the latest data on food waste generation at the regional level, particularly in West Java, Central Java, and Bali. The three provinces were selected for further study on food loss & waste due to being three out of seven provinces that have signed a Memorandum of Understanding (MoU) with the Ministry of National Development Planning (Bappenas) to implement low-carbon development[1]. Moreover, these provinces have the highest population density and more comprehensive reference data compared to the other four provinces. The data from this study can be the basis for relevant stakeholders in understanding waste management situations in their respective regions and enabling data-driven decision-making.

The methodology for this study involved a literature review, secondary data collection from online sources and relevant agencies, and primary data collection through waste sampling. The calculation of food loss was based on secondary data, specifically, the Food Balance Sheets (FBS), obtained from the Provincial Food Security Agencies in each province, namely the Food Security and Livestock Agency in West Java, Food Security Agency in Central Java, and The Agriculture and Food Security Agency in Bali. Meanwhile, the calculation of food waste was based on both FBS and waste generation and composition measured by taking waste samples at each provinces, adhering to the guidelines specified in the SNI 19-3964-1994 regarding The Method of Sampling and Measuring Municipal Waste Generation and Composition. The

[1] Low Carbon Development has been one of the six National Priority Agendas outlined in the National Medium-Term Development Plan (RPJMN) 2020-2024. This low-carbon development encompasses five main policies: (1) Transition towards Renewable Energy and energy efficiency; (2) Forest protection, peat moratorium, and enhanced reforestation efforts; (3) Industrial and household waste management; (4) Agricultural productivity enhancement; and (5) Institutional and governance improvements. Available in: https://lcdi-indonesia.id/2020/05/12/pembahasan-finalisasi-logframe-pelaksanaan-perencanaan-pembangunan-rendah-karbon-pprk-terus-berjalan-ditengah-pandemi-covid-19/

waste generation and composition data then analysed proportionally according to source of the waste to be able to scale up into food waste provincial data.

Food Loss and Waste in 3 Provinces

The quantity of FLW generation in three provinces is shown in **Table 1** as follows.

Table 1 Food Loss and Waste (FLW) Generation in 3 Provinces in 2021

Food Supply Chain	Total (Tonnes/Year)		
	West Java	Central Java	Bali
Production Loss	1,748,495	1,690,386	300,650
Post-Harvest and Storage Loss	1,232,302	1,173,806	180,225
Processing and Packaging Loss	229,783	198,157	16,412
Distribution and Market Waste	1,393,522	921,566	153,766
Consumption Waste	2,113,301	2,053,417	232,796
Total FLW	6,717,403	6,037,333	887,224
FLW (kg/capita/year)	137.70	164.31	201.08

Based on the food supply chain, the highest FLW generation among the 3 regencies occurred in the consumption stage for West Java and Central Java, and in the production stage for Bali. Meanwhile, based on the food categories, cereals, vegetables, and fruits are the three categories with high amount of FLW in the three provinces. The highest in West Java and Central Java is cereals, while in Bali is fruits.

This trend can be attributed to the specific characteristics of each food category. Horticultural products, for example, are prone to spoilage without adequate treatment and technology. Cereal products, such as rice, experience food loss due to the limited technologies available, which results in a significant quantity of grains being scattered throughout the food supply chain stages, especially in production (harvesting). On the other hand, the preference for specific visual standards in products can lead to food waste during the consumption stage. Consumers often choose not to purchase ugly products, even with good nutritional quality.

In the context of Bali, there has been a growing trend in orange production since 2018, driven by orange cultivation clusters in Bali, as encouraged by the Ministry of Agriculture. Additionally, the COVID-19 pandemic has posed challenges in marketing and selling vegetable and fruit products produced in Bali. It is important to note that fruits are also a component of religious offerings, and after religious ceremonies, they are often left unconsumed and subsequently discarded.

Existing FLW Management

Food waste in general in the three provinces is collected mixed with other waste, as there are barely source-segregation in place. But when it is in place, food waste is usually processed into compost or used for Black Soldier Fly (BSF) cultivation. Additionally, some initiatives involve repurposing food waste as animal feed or pet food, returning potentially discarded food products (such as those with defects, substandard quality, or unsellable items) to their suppliers, or distributing them to those in need. Similar efforts have been done to manage food loss in which agricultural products that are not suitable for sale or consumption are reprocessed as animal feed and organic fertilizer. The National Food Agency has also launched the "Save Food Movement (*Gerakan Selamatkan Pangan*)" as a part of its preventive and reduction efforts to address excess and potential food waste. This movement comprises three main activities: food donations, a food rescue platform, and awareness campaigns, including the "Stop Wasting Food (*Stop Boros Pangan*)" campaign.

Specific regulations related to Food Loss and Waste (FLW) management are not yet in place, but each province in this study has established its local regulations regarding waste management, which includes the management of food waste as a part of organics. For example, West Java Regional Regulation No.12/2010 stated that organic waste should be processed into compost or BSF cultivation. Meanwhile, Central Java Governor's Regulation No. 11/2019 mentions biodigestion systems in the community level (RT/RW) as a solution to organic waste. On the other hand, Bali Governor's Regulation No.47/2019 suggests to use organic waste to produce liquid fertiliser, waste charcoal/briquettes, and other products in alignment with technological advancements.

Recommendations

Following the completion of the national FLW study, the central government is currently in the process of drafting specific regulations regarding the reduction and management of FLW, as well as improving the standardization of food product labelling, with the expectation that these regulations can be adapted to derivative regulations at the regional level.

In parallel, responsible FLW management is associated with the reduction of greenhouse gas emissions, regulated both nationally and within regional jurisdiction. At national level, the reduction of GHG is regulated under Presidential Regulation No.61/2011, repealed with the enactment of Presidential Regulation No.98/2021 concerning The Implementation of Carbon Economic Value for Achieving National Determined Contribution (NDC) Targets and Controlling Greenhouse Gas Emissions in National Development. According to this regulation, NDC target for greenhouse gas emission reduction is set at 29 – 41% by 2030 compared to the baseline emission of 2,869 million tons CO_2eq[2]. Furthermore, low-carbon development is also one of the national priority programs outlined in the Medium-Term National Development Plan (RPJMN) 2020-2024[3].

At the regional level, low-carbon development policies are implemented through the Regional Low-Carbon Development Plan (RPRKD), focusing on five priority sectors: circular waste streams management and energy, circular industry development, sustainable energy development, low-carbon marine and coastal areas, and sustainable land restoration. Among the three pilot provinces studied, West Java has formulated its RPRKD. The emission reduction target is set at 9.94% by 2030, with the agricultural sector capable of achieving a reduction of 10.96% and the waste sector achieving a reduction of 22.74% from the Business as Usual (BaU) scenario after mitigation actions[4].

Meanwhile, in Central Java, there is Governor Regulation 43/2012 regarding RAD-GRK for the period 2010-2020, which refers to Presidential Regulation 61/2011 with a target of reducing greenhouse gas emissions in the agricultural sector by 4.37% and waste management by 22.27%[5]. The Central Java government also promotes the Climate Village Program (ProKlim) regulated under Governor Regulation 51/2019, with one of its components being mitigation efforts including waste management and low GHG emission agricultural land handling[6]. Additionally, the RPRKD document for Central Java has been prepared and is currently under review by Bappenas[7].

[2] Presidential Regulation Number 98 of 2021 regarding The Implementation of Carbon Economic Value for Achieving National Determined Contribution (NDC) Targets and Controlling Greenhouse Gas Emissions in National Development.
[3] Presidential Regulation Number 18 of 2020 regarding Medium-Term National Development Plan (RPJMN) 2020-2024.
[4] Bappenas, UNPage, and West Java Government (2022). *West Java Regional Low-Carbon Development Plan (RPRKD).*
[5] Central Java Governor Regulation Number 43 of 2012 regarding Regional Greenhouse Gas Action Plan (RAD-GRK) 2010-2020.
[6] Central Java Governor Regulation Number 51 of 2019 regarding Climate Village Program.
[7] Radio Republik Indonesia (2023): https://rri.co.id/index.php/iptek/199723/terapkan-circular-ekonomi-jateng-susun-pembangunan-rendah-karbon

For Bali itself, Governor Regulation 49/2012 addresses RAD-GRK[8]. Furthermore, in late 2021, the Bali provincial government, together with Bappenas, issued the economic roadmap "Kerthi Bali Economy towards a New Era for Bali," one of its six major strategies being "Green Bali". Several recommendations regarding waste management in this document include developing food and waste management and a food bank system. The strategies outlined are projected to reduce Bali's emissions by approximately 40-80% by 2045 compared to the Business-as-Usual scenario[9].

In addition to regulation, other initiatives, such as voluntary agreements and behaviour change campaigns, have the potential to make an impact on reducing FLW. Therefore, recommendation of options which need to be considered for developing policies, guidelines and programs at the regional level for the three provinces, with detail as follows.

1. **Preventing food loss and waste, or the productive utilisation of surplus food**. This includes supporting the procurement and enhancement of essential infrastructure facilities to facilitate food loss and waste (FLW) prevention and management and conducting training and regular monitoring for those involved in FLW prevention and management.
2. **Effective food management follows the hierarchy of food recovery hierarchy**. Efforts to reduce and utilise food waste should be accompanied by data collection at the city or regency level and ongoing reinforcement and monitoring. The collected data consists of Food Balance Sheets used as a reference for calculating food loss and the completion of the SIPSN as a national integrated platform for waste data, including food waste. This data is regularly collected, typically every 6 months or once a year.

In addition to the aforementioned recommendations, there are several considerations based on the existing conditions in each province.

West Java

1. In the West Java RPRKD, low-carbon programs have been formulated for each priority sector, including waste management, agriculture, and animal husbandry, accompanied by delineating roles for respective stakeholders[10]. Stakeholder mapping is crucial to ensure and enhance the participation of each stakeholder following their respective mandates. Additionally, the sustainability of program implementation is supported by factors such as funding sources and regular monitoring and evaluation.
2. It is also important to integrate policy strategy recommendations to reduce FLW in supporting the implementation of low-carbon development policies, such as increasing budget allocations or funding support to enhance the quantity and quality of agricultural products and reduce food loss as well as raising consumer or public awareness regarding the importance of preventing food waste[11].

Central Java

1. Align with Climate Village Program (ProKlim) regulated under Governor Regulation 51/2019, with one of its components being mitigation efforts including waste management and agricultural land handling

[8] Bali Governor Regulation Number 49 of 2012 regarding Regional Greenhouse Gas Action Plan (RAD-GRK)
[9] Bappenas and Bali Government (2021). *Economic Roadmap Kerthi Bali Economy towards a New Era for Bali: Green, Strong, and Prosperous.*
[10] Bappenas, UNPage, and West Java Government (2022). *West Java Regional Low-Carbon Development Plan (RPRKD).*
[11] UNPage (2023). *Executive Summary: Policy Reform to Reduce Food Loss & Waste and Support the Implementation of Low Carbon Development Policies in West Java Province-Indonesia.*

with low GHG emission[12], existing climate villages or villages intending to implement ProKlim can be encouraged to integrate food loss and waste reduction initiatives into their climate mitigation efforts.

2. Considering Governor Regulation 43/2012 regarding the RAD-GRK concerning mitigation in the agricultural sector, the activities outlined are also expected to reduce food loss. As stated in this regulation, farmers' acceptance of the proposed mitigation options is one crucial factor that needs to be assessed[13]. It is important to educate farmers about the importance of climate mitigation, provide regular training for the transition of farming and animal husbandry patterns, and offer incentives to encourage this transition.

   One of the main activities regarding climate mitigation in the agriculture sector is using local feed sources for livestock[14]. Black Soldier Fly (BSF) larvae are a potential livestock feed source due to their efficiency in converting food waste into high-quality protein biomass. This reduces environmental impact and offers cost-effectiveness, as BSF larvae utilize inexpensive food waste, minimizing reliance on costly feed ingredients.

Bali

1. Following the economic roadmap "Kerthi Bali Economy towards a New Era for Bali", it is necessary to demonstrate direct commitment to developing food & waste management and optimizing the food bank in Bali, in alignment with the ongoing national FLW and food bank regulation being drafted.

   The Bali government can draw numerous lessons from waste management efforts within the ongoing pilot project model areas to gradually scale up across the entire province of Bali. It can be initiated to optimise food banks by providing a legal framework for food bank activities or similar initiatives that utilize surplus food. Additionally, the modernization efforts in agriculture towards organic farming[15], as outlined in the economic roadmap, must consider the significant strengthening of farmers and the importance of reducing food loss for environmental preservation.

2. Bali is renowned for its cultural traditions, with the local population often prioritizing adherence to customary rules over other regulations. Therefore, reinforcing the role of traditional villages (*desa adat*) is essential to accelerate the responsible implementation of FLW management.

[12] Central Java Governor Regulation Number 51 of 2019 regarding Climate Village Program.
[13] Central Java Governor Regulation Number 43 of 2012 regarding Regional Greenhouse Gas Action Plan (RAD-GRK) 2010-2020.
[14] Central Java Governor Regulation Number 43 of 2012 regarding Regional Greenhouse Gas Action Plan (RAD-GRK) 2010-2020.
[15] Bappenas and Bali Government (2021). *Economic Roadmap Kerthi Bali Economy towards a New Era for Bali: Green, Strong, and Prosperous.*

1 INTRODUCTION

Chapter 1 Introduction

Background

As a country that participates in agreeing on the global development agenda, Indonesia has a responsibility to support global targets in terms of sustainability that have been set out in the Sustainable Development Goals (SDGs). This commitment is demonstrated by the mainstreaming of SDGs goals, targets, and indicators in the National Medium-Term Development Plan (RPJMN) 2020-2024, together with the Low Carbon Development Initiatives (LCDI), where development must consider the value of sustainability and low emissions. Low Carbon Development has become a priority in the 2020-2024 RPJMN, especially in the National Priority Agenda (PN) 6 Building the Environment, Improving Disaster Resilience, and Climate Change. Low Carbon Development has several strategic actions in the 2020-2024 planning: a. Sustainable energy development; b. Waste management; c. Green industry development; d. Sustainable land restoration; e. Blue carbon.

In Indonesia, the agriculture, forestry, and fisheries sectors account for 12.7% of GDP and represent almost a third of total employment[16]. At least 52% of Indonesia's greenhouse gas (GHG) emissions are from the food sector and land use related to deforestation and fire haze[17]. Indonesia is also estimated to generate food loss and waste of 115-184 kg per capita per year, where food waste from households and the commercial sector, such as restaurants and hotels, is generated[18]. High levels of food loss and waste (FLW) will cause significant problems in the economic sector, contribute to GHG emissions, and exacerbate inefficiencies in using natural resources. Thus, to support the achievement of SDGs and LCDI, there is an urgent need for transformative actions that ensure food security while reducing FLW generation and GHG emissions within the food systems.

The Government of Indonesia has published a national FLW baseline study in 2021. The study is an important supporting data for policy development related to waste management and circular economy. However, in regional level, a comprehensive baseline data and information on food loss and waste generation is not yet available. To address these concerns, a Regional Food Loss and Waste study has been conducted with aim to obtain the latest data on FLW generation, particularly in West Java, Central Java, and Bali. The data from this study can be used as the basis for relevant stakeholders in their respective regions as a source to enable data-driven decision and policy making.

Scope of the Study

Area

The study covers three provinces: West Java, Central Java, and Bali Province.

Food Supply Chain

The food supply chain in this study consist of 5 stages, which are (1) Production, (2) Post-harvest and storage, (3) Processing and packaging; (4) Distribution and market; and (5) Consumption.

[16] World Bank and OECD (2019). *National Account Data Files*.
[17] Bappenas. (2019). *Low Carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia – A report of the Indonesian Ministry of Development Planning (BAPPENAS)*. Jakarta.
[18] Bappenas, WRI, Waste4Change and UK-FCDO (2021). *Study of Food Loss and Waste in Indonesia*. Jakarta.

Definition of Food Loss and Waste

Food loss (FL) and food waste (FW) definitions used in this study refer to the definition released by FAO[19], without incorporating the loss of food quality. The scope of FLW in the five stages of food supply chain is shown in Figure 1 and the detail definition of food loss and food waste is as follows:

- **Food Loss:** is the decrease in the quantity of food resulting from decisions and actions by food suppliers in the chain, excluding retailers, food service providers and consumers.
- **Food Waste:** refers to the decrease in the quantity of food resulting from decisions and actions by retailers, food service providers and consumers.

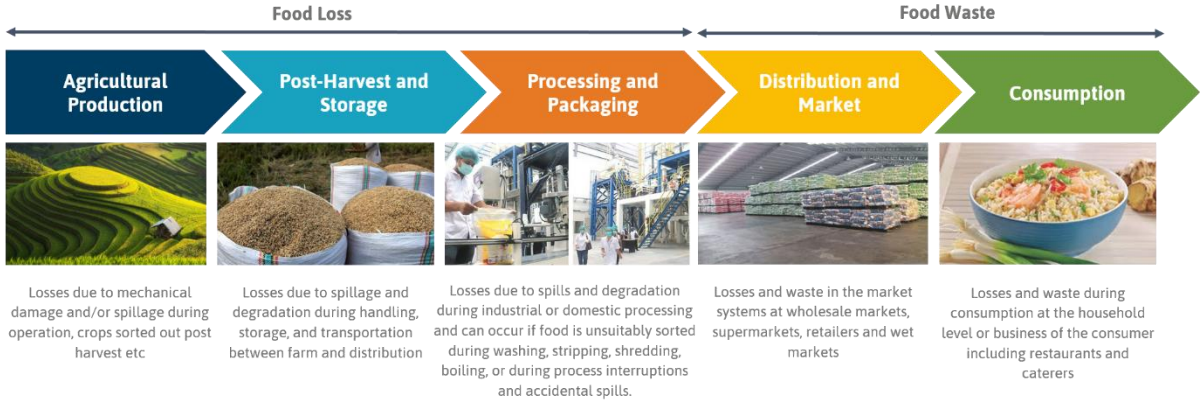


Figure 1. Food Loss and Food Waste Scope in Food Supply Chain[20]

The FLW stage discussed in this study do not include the pre-harvest food loss stage or FLW generations that occur during the food import-export process[21].

Food Commodity

To analyse the FLW generation, food category and commodity are referred to the Food Balance Sheet (FBS) from the National Food Agency (NFA) of the Ministry of Agriculture (MoA) as well as the Regional Food Security Agency in West Java, Central Java, and Bali Province. Food commodity categories used in this study are shown in **Table 2.** FLW discussed in this study does not include processed food products other than those listed in the Table 2.

Table 2. Food Commodity Category based on Food Balance Sheet

Food Category	Food Commodity
1. Cereals	Unhusked Rice, Rice, Maize, Fresh Maize, Wheat, Wheat Flour
2. Starchy food	Sweet Potatoes, Cassava, Cassava/Manioc, Cassava/Tapioca, Sago Flour
3. Sugar	White Sugar, Other Sugar

[19] FAO (2011). *Global food losses and food waste – Extent, causes, and prevention*. Rome.
[20] Bappenas, WRI, Waste4Change and UK-FCDO (2021). *Study of Food Loss and Waste in Indonesia*. Jakarta.
[21] Bappenas, WRI, Waste4Change and UK-FCDO (2021). *Study of Food Loss and Waste in Indonesia*. Jakarta.

Food Category	Food Commodity
4. Pulses Nut and Oil Seeds	Groundnuts in Shell, Groundnuts Shelled, Soybeans, Mungbean, Coconut Fresh, Copra
5. Fruits	Avocados, Oranges, Lanzon, Durians, Waterapples, Rose Apple, Mangoes, Pineapples, Papayas, Bananas, Rambutans, Salacia, Sapodilla, Melon, Watermelon, Star Fruit, Mangosteen, Jackfruit, Marquisa, Soursop, BreadFruit, Apple, Grape, Strawberry, Cantaloupe, Lemon, Pomelo, Date Fruit, Fig, Pear, Apricot/Cherry/Nectarine, Raspberry and Blackberry, Kiwi, Persimmon, Longan, Lychee, Dragon Fruit
6. Vegetables	Shallot (Onion), Cucumber, Kidney Beans, String Beans, Potatoes, Cabbage, Tomatoes, Carrots, Chilli, Bird's Eye Chilli, Eggplant, Mustard Greens, Spring Onion, Swamp Cabbage, Radish, Chayote, Greenbeans, Spinach, Garlic, Cauliflower, Mushroom, Melinjo, Twisted Cluster Bean, Jengkol, Bell Pepper, Snow Pea, Lettuce, Asparagus, Celery, Other (Luffa, Winged Bean, Pare, Pakis)
7. Meat	Beef, Buffalo Meat, Mutton, Lamb, Horse Meat/Other, Pork, Local Chicken Meat, Improved Chicken Meat, Duck Meat, Quail Meat, Offal All Kinds
8. Eggs	Local Hen Eggs, Improved Hen Eggs, Ducks Eggs, Quail Eggs
9. Milk	Cow's milk, Imported milk
10. Fish	Skipjack/Little Tuna, Giant Seaperch, Sharks, Pomfret, Anchovies, Indian Oil Sardinella, Indian Mackerels, Narrow Bard/King Mackerels, Milk Fish, Mullets, Mozambique, Tilapia, Common Carp, Catfish, Pangasius spp, Nile tilapia, Groupers, Giant Gourami, Shrimps, Swimming and Mud Crab, Clams, Cuttlefish, Squids and Octopus, Sea Weeds, Giant Trevally, Siganus, Caesionidae, Scad, Cobia, Java Barb, Others
11. Oil and Fats	Peanut Oil, Coconut Oils, Palm Oils, Cooking Oils, Corn Oils, Olive Oils, Sesame Oils, Soybean Oils, Cattle Fats, Buffalo Fats, Goat Fats, Sheep Fats, Pig Fats

2 METHODOLOGY

Chapter 2 Methodology

Data Collection

Secondary Data Collection

Food Balance Sheet

This study uses the Foods Balance Sheet (FBS) from each provinces' Provincial Food Security Agency, which are the Food Security and Livestock Agency in West Java, Food Security Agency in Central Java, and Agriculture and Food Security Agency in Bali. FBS contains information on food quantities per commodities in three provinces that will be used to calculate the FLW generation, especially in the stage of production, post-harvest and storage, processing and packaging, and distribution and market. The main aim is to calculate the amount of FLW in year 2021, however, FBS data for year 2021 was not yet available during the study. Thus, FBS collected is range between 2016-2020. The FBS data availability for each provinces is shown in **Table 3** below.

Table 3. FBS Data Availability in 3 Provinces

No	Province	Year					
		2016	2017	2018	2019	2020	2021
1.	West Java						
2.	Central Java						
3.	Bali						

Municipal Waste Generation Data

To calculate food waste, secondary data of municipal waste generation and composition in each city/regency within the three focused provinces were collected. There are two main sources of data, with details as follows.

1) Local government data
   This data was collected from local Environmental Agency, Regional Planning and Development Agency, or from National Waste Management Information System (SIPSN). The data collected varies from 2017 to 2021. While it's acknowledged that the accuracy and consistency of this data may vary across different administrative regions due to individual collection methodologies and limited monitoring budget, SIPSN remains the most comprehensive and integrated source available at present.

2) Waste4change's data
   These are the list of Waste4change's previous study that used to complete this study:
   - Waste4change & Bappenas FLW National Study: Waste Sampling Result in Bandung City and Tabanan Regency (Nov-Dec 2020)
   - Waste4change's Project in Subang Regency (Jan 2021)
   - Waste4change's Project in Karawang Regency, Purwakarta Regency, Bandung City (Aug 2021)

- Waste4change, Bappenas, & GIZ DKTI Project: Bogor Regency, Cirebon City, Denpasar City (Sep-Oct 2021)

Secondary data collected from municipalities then listed for each provinces to be able to identify cities and regencies with and without food waste data. Cities/regencies with no or insufficient secondary data were then prioritised for waste sampling.

Primary Data Collection

Primary data collection for this study is in the form of waste generation and composition sampling in three focused provinces. The detail are as follows.

Selection of Cities/Regencies

For each province, two cities/regencies were sampled. Three parameters were used to select cities/regencies representing each province, which are 1) the city/regency does not have complete food waste generation data, 2) population density is the most similar to province's, compared to others that have no/incomplete food waste generation data, and 3) expenditure per capita is the most similar to province's, compared to others that have no/incomplete food waste generation data. This was to ensure that the areas chosen were as representative as possible. In addition, the selection also consider recommendation from each province's Environmental Agency. The selected areas for waste sampling are:

1) **West Java:** Cianjur Regency, Cirebon Regency
2) **Central Java:** Pekalongan Regency, Purbalingga Regency
3) **Bali:** Buleleng Regency, Karangasem Regency

Sources of Waste Sample

Household

Households and the number of residents in the household are recruited to participate in the study at this stage. Residents were informed that the study looked at waste to ensure they did not dispose of or incinerate it during data collection. However, residents were not informed that the study was looking specifically at food waste to minimise potential impact on behaviour. Waste was collected daily over 8 days. In each regency, 100 households were surveyed, divided evenly into three household areas based on income (high, middle and low). Selection of area of households is based on recommendation of local Environmental Agencies.

Non-household

1) **Restaurants**
   For each regency, one restaurant is sampled. Recommendations from the local Environmental Agencies determined the restaurants sampled, to ensure the selected restaurants is representative. Due to the study was conducted during COVID-19 pandemic, many restaurants have had fewer visitors. To avoid underestimation calculation, each restaurant's average capacity in normal days was noted, along with the maximum capacity of the restaurants.
2) **Traditional Markets**
   For each regency, one traditional market is sampled. Recommendations from the local Environmental Agencies determined the traditional market sampled, to ensure the selected restaurants is representative. In general, the traditional markets chosen were the primary wholesale market (the biggest market in the regency) with many stores. While the wholesale market is more extensive than other markets in the regency, it can still represent other markets because of the wide variety of shops; it is also the primary market that residents visit.

Waste Sampling Methodology

The waste sampling method can be seen in **Figure 2**. The same method was used for all waste sources sampled. The sampling starts with sample of waste collected from each source and then weighed. This sample was then placed into a sampling box and was compressed by being stepped on three times. The volume of waste was then measured. The sample was then mixed until blended and divided into quadrants. One quadrant was sorted into the following groups: food waste, garden waste, plastics, metals, textiles, rubber, glass, paper, cardboard and beverage cartons, and other (diapers, hazardous waste, etc.) (see **Figure 3**). Each group was then individually weighed and measured by volume. Total waste with each composition was measured at each sampling site every day for 8 days, and it will be expressed as a percentage composition and an arising per person per day.

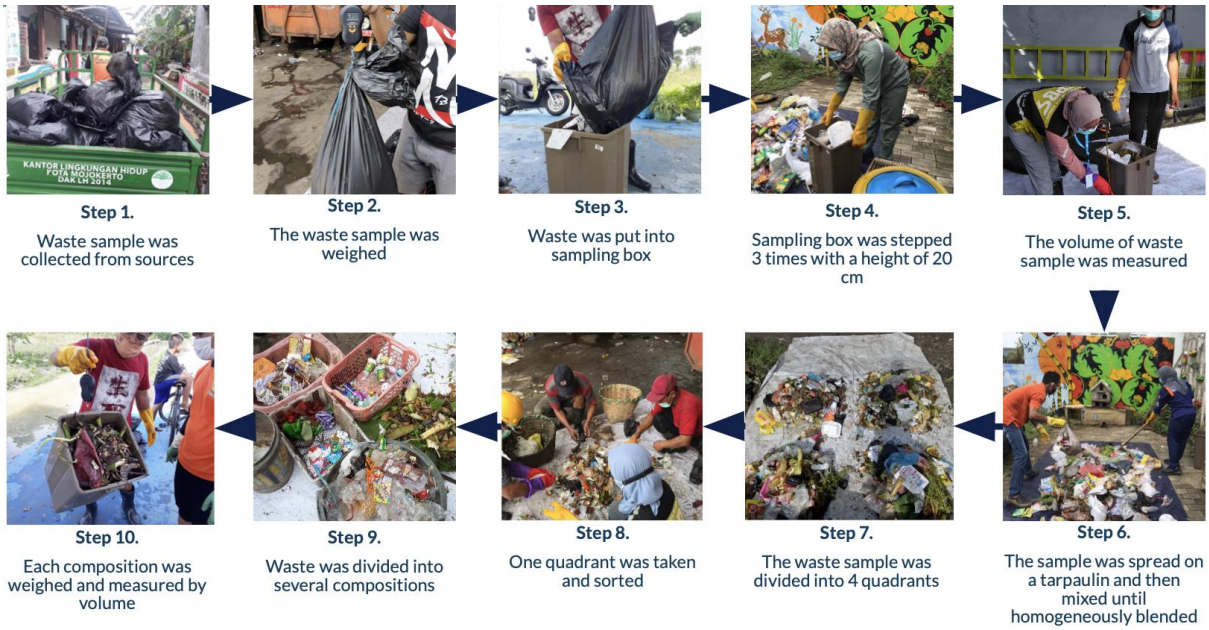


Figure 2. Waste Sampling Methodology

Figure 3. Waste Composition Categories

Food waste in the waste composition is divided into two types, which are:

1) **Edible food waste,** which is anything that originally intended to be eaten but thrown away. For example, a banana that got too overripe to eat and was tossed in the trash is considered food waste.
2) **Inedible food waste,** which is the part of the food that discarded because it cannot or not commonly consumed, for example thorns, bones, banana peels, etc.

Data Analysis

Calculation of FLW Generation

This study estimated FLW generation using the FBS data from the Provincial Food Security Agency in West Java, Central Java, and Bali. FBS represents a comprehensive overview of the food supply chain in a country for some specific period[22]. Therefore, FBS is used to analyse the flow and quantity of FLW in the food supply chain. The main aim of the calculation is to calculate the amount of FLW in year 2021. However, since FBS data for year 2021 is not yet available during the study, FLW for stage 1-4 for year 2016-2020 based on NBM 2016-2020 was calculated first. Historical FLW generation stage 1-4 in 2016-2020 then extrapolated using five methods: linear regression, exponential, polynomial, logarithmic, and power series. Amongst five projection methods, the data for FLW 2021 was selected based on their proximity to the existing data pattern and an R-value close to 1.

The calculation using FBS used an input-output system, where the losses in production to distribution and market were calculated based on the loss factor per commodity from FAO and FBS, while the losses in the consumption stage are calculated by combined FBS data with food waste amount calculated from waste sampling result. **Figure 4** shows the calculation of the FLW generation carried out in this study.

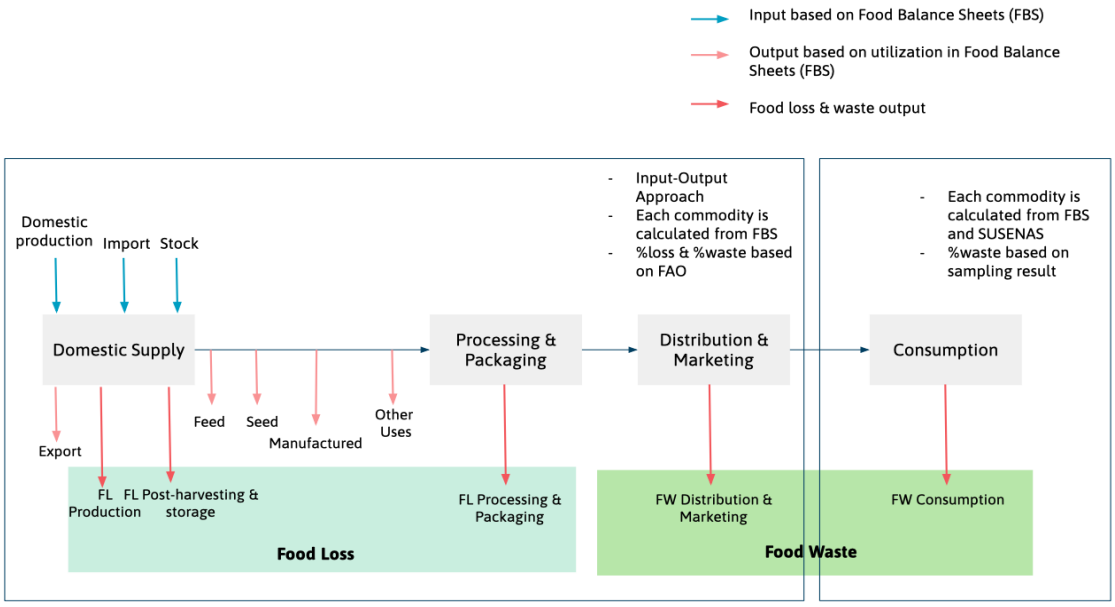


Figure 4. FLW Calculation Flow Figure from FLW Study in Indonesia[23]

[22] FAO (2001). *The State of Food and Agriculture – Economic Impacts of Transboundary Plant Pests and Animal Diseases*. Rome
[23] Bappenas, WRI, Waste4Change and UK-FCDO (2021). *Study of Food Loss and Waste in Indonesia*. Jakarta.

The calculation process to discover the food loss generation in generation in production, post-harvest and storage, processing and packaging stage as well as food waste generation in the distribution and market stage are explained in **Figure 5** and **Table 4** as follows.

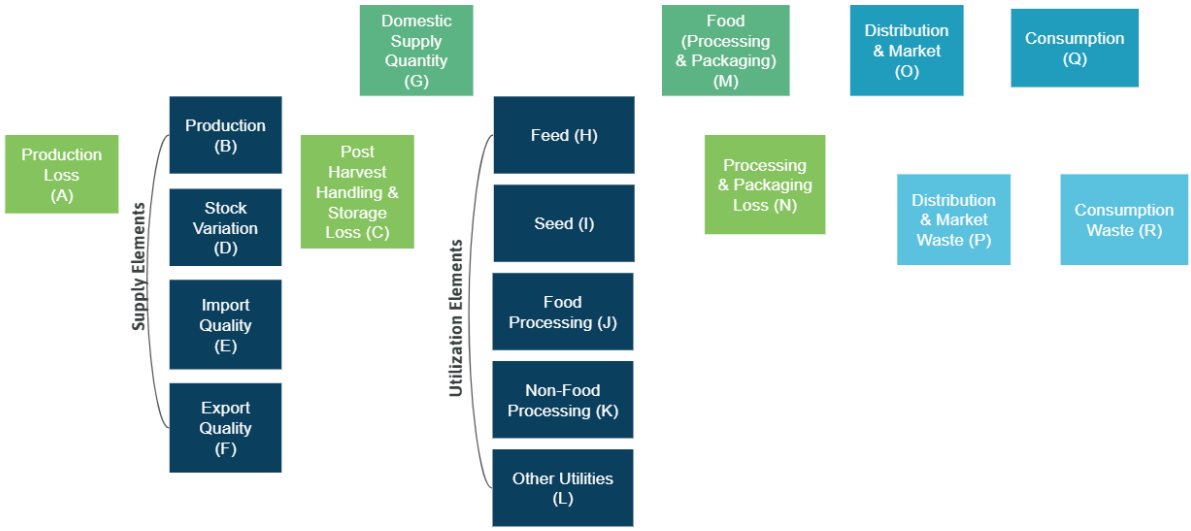


Figure 5. Food Loss and Waste (Stage 1-4) Calculation Flow in Food Balance Sheet

Table 4. Detail Components of Food Loss and Waste Calculation Flow in Food Balance Sheet

Stage	Information
Production Loss (A)	Food loss generated at the harvesting stage is calculated using this formula: A = (%PL : (1-%PL)) x B
Production (B)	Total food production before being transferred to the commodity processing stage
Post-harvest and storage loss (C)	Food loss that is generated at the post-harvest and storage stage is calculated using this formula: C = % PHSL x B
Stock variation (D)	Changes in government food supplies
Import quantity (E)	Total commodities that come into the country/region
Export quantity (F)	Total commodities that are transported abroad/regions
Domestic supply (G)	The total domestic food supply, calculated using this formula G = B – C – D + E – F
Feed (H)	The number of commodities used as animal feed
Seed (I)	The number of commodities used as seeds/seedlings for re-production
Food processing (J)	The number of commodities available for human consumption which undergo further processing
Non-food processing (K)	The number of available commodities subjected to further processing to be utilised as industrial needs
Other utilities (L)	Commodities are used for the food supply of tourists, refugees, schools/dormitories/Islamic boarding schools, public and private stocks, as well as the use of non-food industries whose numbers are not available due to unavailable data.
Food (Processing & Packaging) (M)	Food available for consumption or processed into food derivatives, distributed to markets and consumers. The food value is obtained from the calculation:

Stage	Information
	M = G - (H + I + J + K + L)
Processing and Packaging Loss (N)	Food loss generated at the processing and packaging stage is calculated using this formula: N = % PPL x M
Distribution and Market (O)	The total food supply at the distribution and markets stage is obtained using this formula: O = M - N
Distribution and Market Waste (P)	Food waste generated at the distribution and market stage is calculated using this formula: P = % DMW x O
Consumption (Q)	The total food supply at the consumption stage is obtained using this formula: Q = O – P
Consumption Waste (R)	Food loss generated at consumption is calculated using this formula: R = % CW x Q

According to FBS, some commodities are processed from fresh/primary products into derivative products. The form change proportion of those products is obtained using a conversion factor for each food product. The conversion factors used in this study refer to the conversion factors from FAO[24] and NFA[25] , which are listed in **Table 5**.

Table 5. Conversion Factor of Food Products

Category		Conversion Factor	Source
Input	Output		
Paddy	Rice	64.02%	NFA, 2019
Wheat	Wheat flour	0.78	FAO, 2011
Peanuts with shells	Peanuts without shells	60%	NFA, 2019
CPO	Palm cooking oil	68.28%	

The conversion factors did not include fresh and non-processing commodities, which are not listed in **Table 5**. In this study, FLW percentage from production to distribution and market stage (stage 1-4 FSC) using references from FAO[26] percentage for South and Southeast Asia Region and National Food Agency (NFA) from Ministry of Agriculture (MoA)[27] listed on Indonesia FBS Guidance. These two sources are selected based on their proximity to the percentage loss in the field. **Table 6** shows the FLW percentage used in this study.

Table 6. FLW Weight Percentage in Each Food Supply Chain Stage

Category	Production	Post-harvest & Storage	Processing & Packaging	Distribution & Market	Source
Cereals	6%	7%	3.50%	2%	FAO, 2011
Oilseeds	7%	12%	8%	2%	

[24] FAO (2011). *Global food losses and food waste – Extent, causes, and prevention*. Rome.
[25] NFA (2019). *Guidelines For the Preparation of Food Material Balances*. Jakarta
[26] FAO (2011). *Global food losses and food waste – Extent, causes, and prevention*. Rome.
[27] NFA (2019). *Guidelines For the Preparation of Food Material Balances*. Jakarta

Category	Production	Post-harvest & Storage	Processing & Packaging	Distribution & Market	Source
Vegetable and fruit	15%	9%	25%	10%	
Meat	5.1%	0.3%	5%	7%	
Fish and seafood	8.2%	6%	9%	15%	
Milk	3.5%	6%	2%	10%	
Egg	8%	-	0.10%	3%	
Sweet potato	0.74%	2.34%	1.23%	1.35%	NFA, 2019
Cassava *(Ubi Kayu)*	0.52%	1.64%	0.86%	0.95%	
Cassava *(Gaplek)*	0.09%	0.28%	0.15%	0.16%	
Cassava/ Tapioca	0.09%	0.28%	0.14%	0.16%	
Sago flour	0.09%	0.28%	0.15%	0.16%	

FAO: Food and Agriculture Organization UN **NFA:** National Food Agency of Indonesia

For food waste in the consumption stage, the calculation was conducted by combining data from FBS with waste sampling calculated data, with steps as follows applied for each province.

1) Food waste generation result from households is divided into two: result from fieldwork area and non-fieldwork area. For fieldwork area, household food waste sampling result for each income (kg/capita/year) is multiplied with number of regency's population, proportionally with the proportion of income in the regency, to obtain total household food waste in a regency. The result of total household food waste from two regencies within one province then added to obtain 'household food waste generation from fieldwork area'. For non-fieldwork area, the kg/capita/year from two regencies within one province is averaged then multiplied with the number of the population in the non-fieldwork area (all other regencies in the province except two that were sampled). This will result in 'household food waste generation from non-fieldwork area' (tons/year). Both data from fieldwork and non-fieldwork then added to obtain the province's total food waste generation from household (tons/year).
2) Waste sampling result from restaurants and traditional markets of 6 sampled regencies in 3 provinces is averaged in kg/unit/year and then the average result is multiplied with number of restaurants and traditional market in each province to obtain the total amount of food waste generated from restaurants or traditional market within one province (tons/year). The cross-province data is used due to small number of samples in each province; based on expert judgement, a cross province average amount will provide more reliable estimation of food waste in non-household sources.
3) The total amount of food waste from households, restaurants, and traditional market are added to generate total amount of food waste in one province (tons/year).
4) The amount of food waste in consumption stage of each province (tons/year) is obtained by deduct the total amount of food waste in one province with the amount of food waste in distribution and market stage in one province obtained from FBS calculation.

3 FOOD LOSS & WASTE ANALYSIS

Chapter 3 Food Loss and Waste Analysis

FBS Analysis: Historical Data of FLW

West Java

The amount of FLW generation in West Java during 2016-2020 was calculated to be able to project and extrapolate data for FLW generation in 2021; the result is shown in **Table 7.** The result shows that in West Java production loss tends to decrease overtime, while losses and waste in other stages is fluctuating during 2016-2020.

Table 7. FLW Stage 1-4 Generation in West Java in 2016-2021

Year	Production Loss (tons/year)	Post-Harvest Handling and Storage Loss (tons/year)	Processing and Packaging Loss (tons/year)	Distribution and Market Waste (tons/year)
2016	2,366,261	1,756,005	265,133	1,287,623
2017	2,231,858	1,653,452	265,517	1,217,143
2018	2,891,417	2,032,064	235,951	1,545,231
2019	2,253,161	1,555,381	225,471	1,452,128
2020	1,828,167	1,307,594	251,901	1,330,922
2021*	1,748,495	1,232,302	229,783	1,393,522

*Based on the projection analysis results with extrapolation and expert judgment approach

Central Java

The amount of FLW generation in Central Java during 2018-2020 was calculated to be able to project and extrapolate data for FLW generation in 2021; the result is shown in **Table 8.** The result shows that in Central Java FLW in all stages from production to distribution and market tend to decrease over the years.

Table 8 FLW Stage 1-4 Generation in Central Java in 2018-2021

Year	Production Loss (tons/year)	Post-Harvest Handling and Storage Loss (tons/year)	Processing and Packaging Loss (tons/year)	Distribution and Market Waste (tons/year)
2018	2,536,488	1,765,063	230,816	1,344,683
2019	1,796,162	1,369,898	198,747	881,842
2020	1,791,692	1,359,272	198,474	843,732
2021*	1,690,386	1,173,806	198,157	921,566

*Based on the projection analysis results with extrapolation and expert judgment approach

Bali

The amount of FLW generation in Bali during 2016-2020 was calculated to be able to project and extrapolate data for FLW generation in 2021; the result is shown in **Table 9.** The result shows that in Bali FLW in all stages from production to distribution and market tend to fluctuating over the years.

Table 9 FLW Stage 1-4 Generation in Bali in 2016-2021

Year	Production Loss (tons/year)	Post-Harvest Handling and Storage Loss (tons/year)	Processing and Packaging Loss (tons/year)	Distribution and Market Waste (tons/year)
2016	199,544	130,220	17,412	98,685
2017	266,697	164,999	19,105	133,476
2018	250,813	158,723	19,767	124,766
2019	274,169	171,356	20,244	138,093
2020	303,380	181,937	18,470	161,189
2021*	300,650	180,225	16,412	153,766

*Based on the projection analysis results with extrapolation and expert judgment approach

Waste Sampling Result Analysis: Food Waste per Source

Households

The result of household sampling to identify food waste generation in the three provinces is shown in **Table 10**. Findings summary from **Table 10** are as follows:

1) **The proportion of food waste in households is varied between three provinces, with West Java range between 44.03% - 64.29%, Central Java range between 26.70% - 62.28%, and Bali range between 17.75% - 39.16%.** The two highest household food waste proportion of the three provinces are the low-income households in Cirebon Regency, West Java with 64.29% and the middle-income households in Purbalingga Regency, Central Java with 62.28%. The low-income residents in the sampled area in Cirebon Regency located far from the city and thus often cooks at home, which may contribute to the high proportion of food waste in the area. Meanwhile, some of the middle-income residents in the sampled area in Purbalingga Regency work as food sellers, which may affect the amount of food waste generated.
2) **The amount of food waste generation per capita increases with the income of the residents**: this means food waste generation is highest in the high-income households and lowest in the low-income households. This applies for all the fieldwork areas surveyed in the three provinces, except in Purbalingga Regency, Central Java where it is the middle-income household that has the highest food waste per capita. This might be affected by the fact that in the middle-income household area sampled in Purbalingga, some of the residents work as food sellers.
3) **The average amount of household food waste per capita for West Java is 60.35 kg/capita/year, for Central Java is 48.16 kg/capita/year, and for Bali is 25.80 kg/capita/year.** For each province, this average household food waste per capita from fieldwork areas will be used to calculate other areas in the same provinces that were not surveyed; or also called as non-fieldwork areas.

Table 10 Household (HH) Food Waste Calculation for Fieldwork Areas

Regency	Population**	Income	%Population per Income**	HH Waste* (kg/cap/year)	%Food waste*	HH Food Waste (kg/cap/year)	Total HH Food Waste (tons/year)	HH Food Waste (kg/cap/year)	Average HH Food Waste (kg/cap/year)
West Java									
Cianjur	2,506,680	High	13.73%	177	53.51%	95	132,338	52.79	60.35
		Mid	31.05%	137	51.22%	70			
		Low	55.22%	70	46.96%	33			
Cirebon	2,290,970	High	25.00%	175	49.80%	87	155,570	67.91	
		Mid	30.00%	189	44.03%	83			
		Low	45.00%	73	64.29%	47			
Central Java									
Pekalongan	968,821	High	35.70%	105	39.75%	42	33,827	34.64	46.16
		Mid	60.50%	117	26.70%	31			
		Low	3.80%	74	30.40%	23			
Purbalingga	998,561	High	14.00%	107	42.98%	46	58,138	57.69	
		Mid	59.00%	108	55.28%	60			
		Low	27.00%	95	62.28%	59			
Bali									
Buleleng	687,200	High	20.00%	73	31.70%	23	15,797	19.58	25.80
		Mid	40.00%	88	22.12%	20			
		Low	40.00%	85	21.15%	18			
Karangasem	492,402	High	29.33%	109	39.16%	43	16,029	32.01	
		Mid	44.51%	91	34.12%	31			
		Low	26.16%	123	17.75%	22			

*Waste sampling result, **Secondary data

The composition of food waste based on waste sampling is shown in **Table 11** and **Figure 6.** The result shows that generally, **inedible food waste accounted for the majority (around two-thirds) of overall household food waste generated in the three provinces.** This trend can be attributed to home cooking practices and the disposal of fruit peels. Large fruits such as durian or jackfruit in Southeast Asia contribute significantly to producing inedible waste[28]. It is only in high income households in Bali that has a higher proportion of edible than inedible food waste. This can occur due to the understanding that "more is better than less" in some segments of society, leading to excess food serving or purchases. This pattern is also evident during celebrations. Such celebratory events typically display social status, where higher social status is often associated with more significant food portions or grander ceremonial arrangements. Consequently, it is expected to witness a surplus of leftover food after these events. It is also notable that there are considerable differences between provinces. The reasons for these differences are outside the scope of the current study, which is purely quantitative; however, field notes and observations on the material being sorted have been reproduced in **Appendix 1**.

[28] UNEP (2021). *Food Waste Index Report 2021*. Nairobi

Table 11 Edible-Inedible Proportion of Household Food Waste for Fieldwork Areas

Regency	Income	Food Waste (kg/cap/year)	%Edible*	%Inedible*	Edible FW (kg/cap/year)	Inedible FW (kg/cap/year)
West Java						
Cianjur	High	95	43%	57%	40.88	53.85
	Mid	70	32%	68%	22.24	47.68
	Low	33	46%	54%	14.93	17.81
Cirebon	High	87	9%	91%	7.52	79.73
	Mid	83	28%	72%	23.61	59.63
	Low	47	23%	77%	10.75	36.19
Central Java						
Pekalongan	High	42	27%	73%	11.29	30.50
	Mid	31	30%	70%	9.31	21.88
	Low	23	40%	60%	9.06	13.46
Purbalingga	High	46	46%	54%	21.37	24.60
	Mid	60	17%	83%	10.21	49.71
	Low	59	20%	80%	11.57	47.31
Bali						
Buleleng	High	23	68%	32%	15.73	7.30
	Mid	20	40%	60%	7.78	11.76
	Low	18	41%	59%	7.27	10.64
Karangasem	High	43	52%	48%	22.23	20.36
	Mid	31	43%	57%	13.47	17.54
	Low	22	48%	52%	10.50	11.33

*Waste sampling result

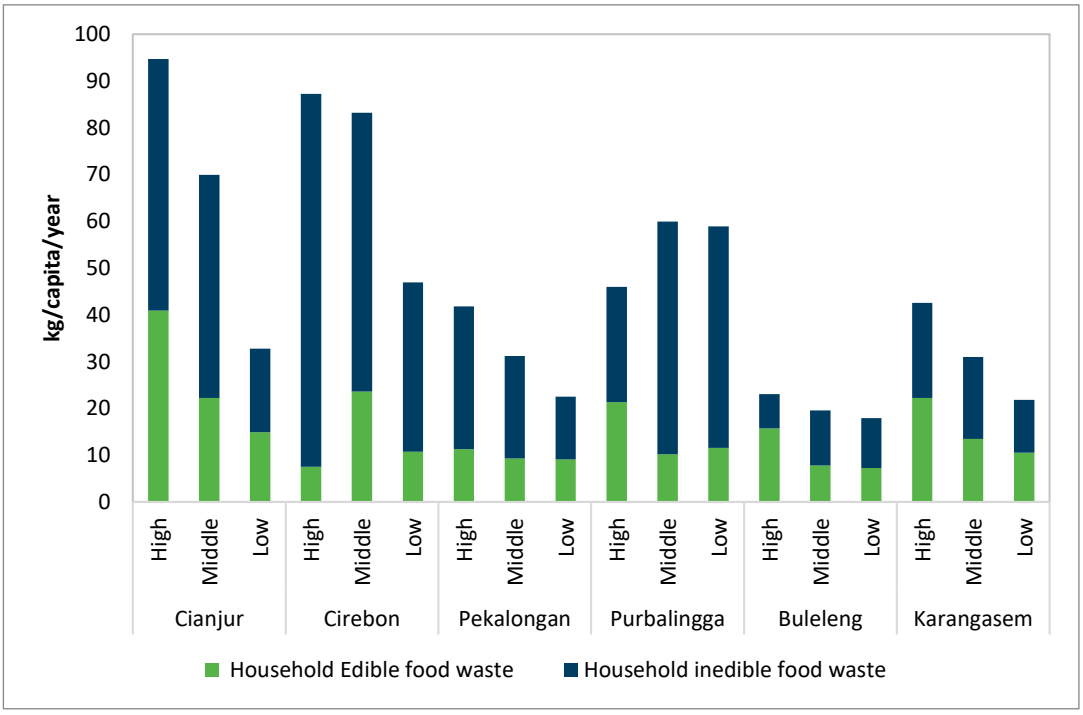


Figure 6 Household Food Waste in Fieldwork Areas

Restaurants and Traditional Markets

Waste was collected and sorted from one restaurant and one traditional market in each regency. The results show high levels of variation in the arisings and composition of the waste – this could be due to differences between areas, differences in size or random variation (sampling error). Since it is impossible to quantify the error margin with one case (and thus impossible to generalise from such results), the average arising for restaurants and traditional markets was calculated based on all six cases.

For restaurants, an attempt was made to model restaurant waste, considering each restaurant's seating capacity. This model, however, gave a food waste result that was not significantly different to the data above (9,715 kg per restaurant per year) while relying on more potentially unsound assumptions (e.g. that the average size of a restaurant in 81 seats – this is remarkably similar to the sample average of 80.66 seats and could be a case of circular reasoning). The model was therefore rejected in favour of the simpler approach. A model based on seating capacity could be developed in future but would require: 1) large-scale sampling to measure the average number of seats in restaurants in different provinces across Indonesia, 2) larger waste analysis sample, and 3) modelling (e.g. linear regression) to establish whether seating capacity is, in fact, a valid estimator of waste. This is by no means obvious, as the field notes (see **Appendix 2**) make it clear that actual customer numbers may not always be closely correlated with seating.

Table 12 shows food waste from restaurants in each regency, with average amount of food waste from six samples over three provinces is 9,675 kg/unit/year. Meanwhile, **Table 13** shows food waste from traditional market in each regency, with average amount of food waste from six samples over three provinces is 531,826 kg/unit/year. This average amount will be used to calculate food waste from both sources in non-fieldwork areas and in provincial level. Both restaurants and traditional markets have 95% confidence interval around this average estimate.[29] It can be seen that, due to the small sample size and significant variation between cases, the margin of error around the average estimates is substantial; this is an area that would benefit from additional research.

Table 12 Food Waste from Restaurants in Each Regency

Area	Name	Waste per restaurant (kg/unit/year)*	Food waste per restaurant (kg/unit/year)*	Number of restaurants in each regency**	Food waste all restaurants in each regency (tons/year)
West Java	Cianjur	32,500	30,514	255	2,467
	Cirebon	4,380	2,605	282	2,728
Central Java	Pekalongan	2,190	1,302	21	203
	Purbalingga	3,154	2,405	75	726
Bali	Buleleng	34,361	19,242	200	1,935
	Karangasem	2,854	1,983	146	1,413
Average		13,240	9,675		
95% confidence range of average		2,937 – 23,852	1,963 – 19,229		

*Sampling result, **Secondary data

[29] These were estimated using resampling (100,000 runs) as modelling using the normal distribution produced intervals with lower bounds below zero. The script used to generate the intervals is included in appendix 4.

Table 13 Food Waste from Traditional Market in Each Regency

Area	Name	Waste per market (kg/unit/year)*	Food waste per market (kg/unit/year)*	Number of markets in each regency**	Food waste all markets in each regency (tons/year)
West Java	Cianjur	1,560,240	1,466,782	24	12,764
	Cirebon	401,500	337,742	30	15,955
Central Java	Pekalongan	26,258	9,490	18	9,573
	Purbalingga	82,125	76,738	76	40,419
Bali	Buleleng	513,595	334,967	69	36,696
	Karangasem	1,112,155	965,239	41	21,805
Average		615,979	531,826		
95% confidence range of average		198,015 – 1,064,766	184,416 – 952,136		

*Sampling result, **Secondary data

Using the average food waste amount of 9,675 kg/unit/year for restaurants and 531,826 kg/unit/year for traditional market, food waste in provincial level was calculated and the result is shown in **Table 14.**

Table 14 Food Waste from Restaurants and Traditional Market in Provincial Level

Area	Number of Restaurants	Total amount of restaurants food waste (tons/year)	Number of Traditional Markets	Total amount of traditional markets food waste (tons/year)
West Java	10,076	97,488	878	466,943
Central Java	4,169	40,336	2,328	1,238,091
Bali	3,868	37,424	436	231,876

All Sources (Household, Restaurant, and Traditional Market)

West Java

The result of food waste analysis in West Java is shown in **Table 15.** It shows that the total food waste is estimated at 3,506,823 tons/year, which equals to 71.89 kg/capita/year or 0.20 kg/capita/day. This total amount of food waste then deducted with the amount of food waste in distribution and market stage from FBS analysis of 1,393,522 tons/year, resulting in food waste in consumption stage of 2,113,301 tons/year. The food waste based on supply chain in West Java is shown in **Table 16.**

Table 15 Food Waste in Waste Java in 2021 based on Waste Sampling

Area	Population**	Household food waste* (tons/year)	Restaurant food waste* (tons/year)	Market food waste* (tons/year)	Total food waste (tons/year)
Fieldwork areas	4,797,650	287,909	5,196	28,719	321,823
Non-fieldwork areas	43,984,770	2,654,483	92,293	438,225	3,185,001
Total	48,782,420	2,942,392	97,488	466,943	3,506,823

*Calculation based on waste sampling, **Secondary data

Table 16 Food Waste in West Java in 2021 based on Food Supply Chain

Total Food Waste	Distribution and Market Waste (tons/year)	Consumption Waste (tons/year)
3,506,823	1,393,522	2,113,301

Central Java

The result of food waste analysis in Central Java is shown in **Table 17.** It shows that the total food waste is estimated at 2,974,983 tons/year, which equals to 80.97 kg/capita/year or 0.22 kg/capita/day. This total amount of food waste then deducted with the amount of food waste in distribution and market stage from FBS analysis of 921,566 tons/year, resulting in food waste in consumption stage of 2,053,417 tons/year. The food waste based on supply chain in Central Java is shown in **Table 18.**

Table 17 Food Waste in Central Java in 2021 based on Waste Sampling

Area	Population**	Household food waste* (tons/year)	Restaurant food waste* (tons/year)	Market food waste* (tons/year)	Total food waste (tons/year)
Fieldwork area	1,984,298	91,964	929	49,992	142,885
Non-fieldwork area	34,758,203	1,604,591	39,407	1,188,100	2,832,098
Total	36,742,501	1,696,556	40,336	1,238,091	2,974,983

*Calculation based on waste sampling, **Secondary data

Table 18 Food Waste in Central Java in 2021 based on Food Supply Chain

Total Food Waste	Distribution and Market Waste (tons/year)	Consumption Waste (tons/year)
2,974,983	921,566	2,053,417

Bali

The result of food waste analysis in Bali is shown in **Table 19.** It shows that the total food waste is estimated at 379,937 tons/year, which equals to 87.09 kg/capita/year or 0.24 kg/capita/day. This total amount of food waste then deducted with the amount of food waste in distribution and market stage from FBS analysis of 153,766 tons/year, resulting in food waste in consumption stage of 226,171 tons/year. The food waste based on supply chain in Central Java is shown in **Table 20.**

Table 19 Food Waste in Bali in 2021 based on Waste Sampling

Area	Population**	Household food waste* (tons/year)	Restaurant food waste* (tons/year)	Market food waste* (tons/year)	Total food waste (tons/year)
Fieldwork area	1,307,400	31,826	3,348	58,501	93,674
Non-fieldwork area	3,055,200	78,811	34,076	173,375	286,263
Total	4,362,600	110,637	37,424	231,876	379,937

*Calculation based on waste sampling, **Secondary data

Table 20 Food Waste in Bali in 2021 based on Food Supply Chain

Total Food Waste	Distribution and Market Waste (tons/year)	Consumption Waste (tons/year)
379,937	153,766	226,171

4 FOOD LOSS AND WASTE IN 3 PROVINCES IN INDONESIA

Chapter 4 Food Loss and Waste in 3 Provinces

West Java

In 2021, FLW generation in West Java reached 6,717,403 tons/year or equivalent to 137.7 kg/capita/year, which is still in the range of Indonesia's FLW generation results in 2000-2019 with 115-184 kg/capita/year. FLW generation in West Java consist of 65.81 kg/capita/year of food loss and 71.89 kg/capita/year of food waste. Based on the food supply chain, the highest FLW generation occurred in the consumption stage, with 2,113,301 tonnes/year or 31.46% of the total FLW proportion in West Java. The detail result of FLW in West Java is shown in **Table 21.** In general, West Java's food waste generation is higher at 52.21% than food loss at 47.79% (see **Figure 7**).

Table 21 FLW Generation in West Java in 2021

Stage	West Java Population in 2021*	FLW Generation in 2021	
		tons/year	kg/capita/year
Production Loss	48,782,420	1,748,495	35.84
Post-harvest Handling and Storage Loss		1,232,302	25.26
Processing and Packaging Loss		229,783	4.71
Distribution and Market Waste		1,393,522	28.57
Consumption Waste		2,113,301	43.32
Total		**6,717,403**	**137.7**

*Secondary data from West Java Central Bureau of Statistics (BPS Jawa Barat, 2022)

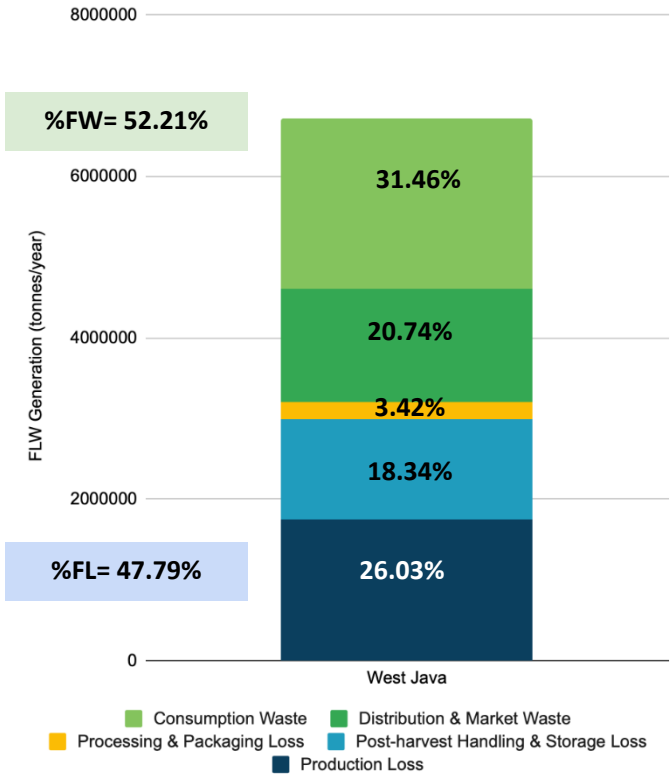


Figure 7 FLW generation in West Java (%)

Based on the food categories, the highest FLW generation came from cereals, which dominated 30.09% of total FLW with 2,021,271 tonnes/year. This was followed closely by fruits at 24.37% (1,637,180 tonnes/year) and vegetables at 21.84% (1,467,368 tonnes/year), respectively. Data figure 7 consists of mixed data for both domestic consumption, and exports in each sub-commodity. The composition of FLW in West Java based on food categories is shown in **Figure 8.**

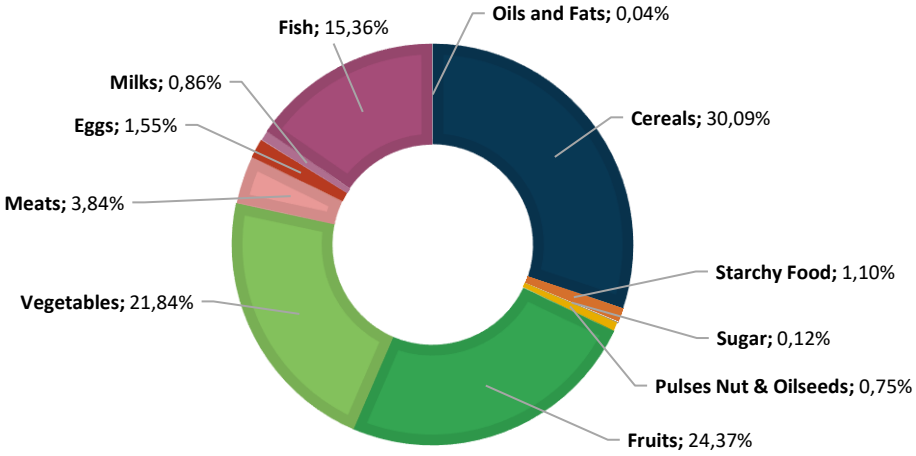


Figure 8. Composition of FLW Generation in West Java (%)

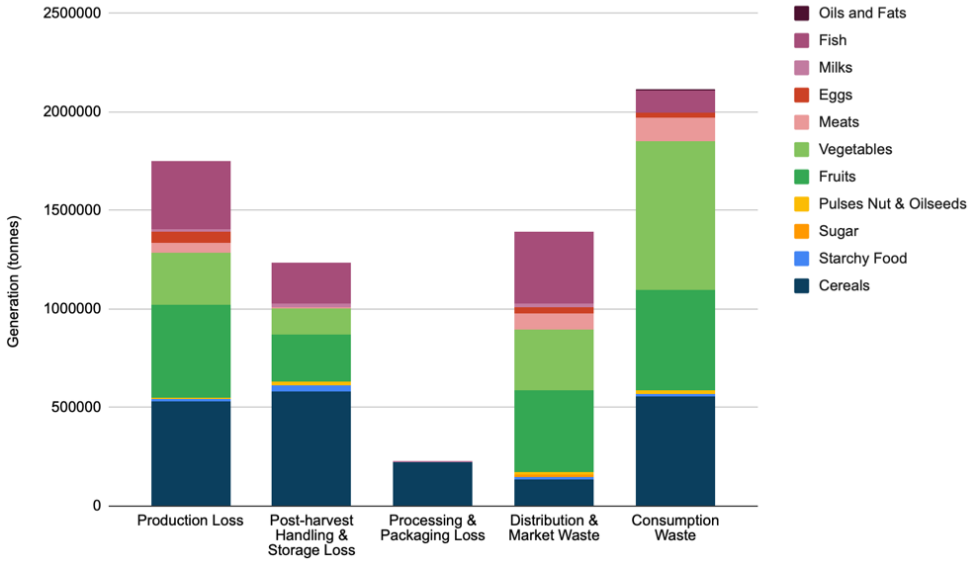


Figure 9. Composition of West Java's FLW generation in Food Supply Chain (tons/year)

When mapping FLW generation in food supply chain as in **Figure 9**, it shows that the cereal category is mainly lost during the first two stages in the food chain (i.e. production, post-harvest handling and storage) compared to other food categories, while fruits and vegetables (which are categorised as horticulture sector) are mainly wasted in the distribution and market, and consumption stage. This trend happens due to the characteristics of each food category, in which horticulture products tend to be easily spoiled without proper treatment and technologies, such as the use of cold chain technology along the supply chain. On the other hand, the perception of specific visual standards for horticulture products can contribute to food waste in the distribution and market stage as well as consumption stage, as customers

tend not to buy or consume ugly products, even though the nutrition quality is excellent and sufficient. For cereals products such as paddy, food loss often occurred due to limited technologies, which affected the large amount of scattered grains during production (harvesting), post-harvest, and storage stages[30].

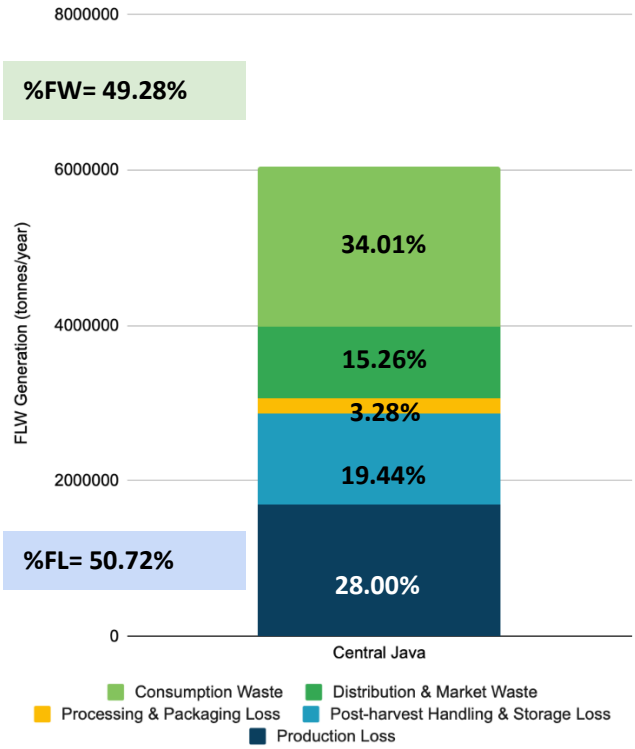
Central Java

In 2021, FLW generation in Central Java reached 6,037,333 tons/year or equivalent to 164.31 kg/capita/year, which is still in the range of Indonesia's FLW generation results in 2000-2019 with 115-184 kg/capita/year. Based on the food supply chain, the highest FLW generation occurred in the consumption stage, with 2,053,417 tonnes/year or 34.01% of the total FLW proportion in Central Java. The detail result of FLW in Central Java is shown in **Table 22.** In general, Central Java's food loss generation is higher at 50.72% than food waste at 49.28% (see **Figure 10**).

Table 22 FLW Generation in Central Java in 2021

Stage	Central Java Population in 2021*	FLW Generation in 2021	
		tons/year	kg/capita/year
Production Loss	36,742,501	1,690,386	46.01
Post-harvest Handling and Storage Loss		1,173,806	31.95
Processing and Packaging Loss		198,157	5.39
Distribution and Market Waste		921,566	25.08
Consumption Waste		2,053,417	55.89
Total		**6,037,333**	**164.31**

*Secondary data from Central Java Central Bureau of Statistics (BPS Jawa Tengah, 2022)



[30] Bappenas, WRI, Waste4Change and UK-FCDO (2021). *Study of Food Loss and Waste in Indonesia*. Jakarta.

Figure 10. FLW Generation in Central Java (%)

Based on the food categories, the highest FLW generation came from cereals, which dominated 39.28% of total FLW with 2,371,594 tonnes/year. This was followed closely by fruits at 28.61% (1,726,995 tonnes/year) and vegetables at 22.42% (1,353,750 tonnes/year), respectively. The composition of FLW in Central Java based on food categories is shown in **Figure 11.**

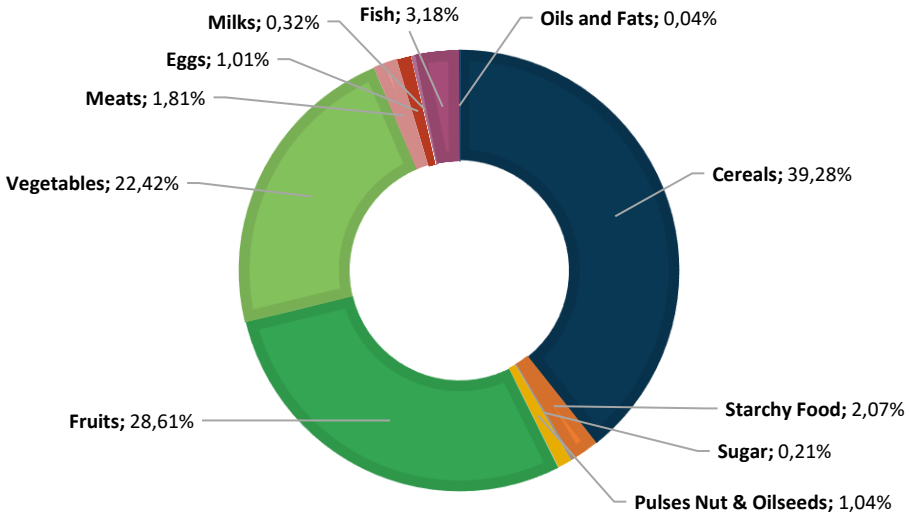


Figure 11. Composition of FLW Generation in Central Java (%)

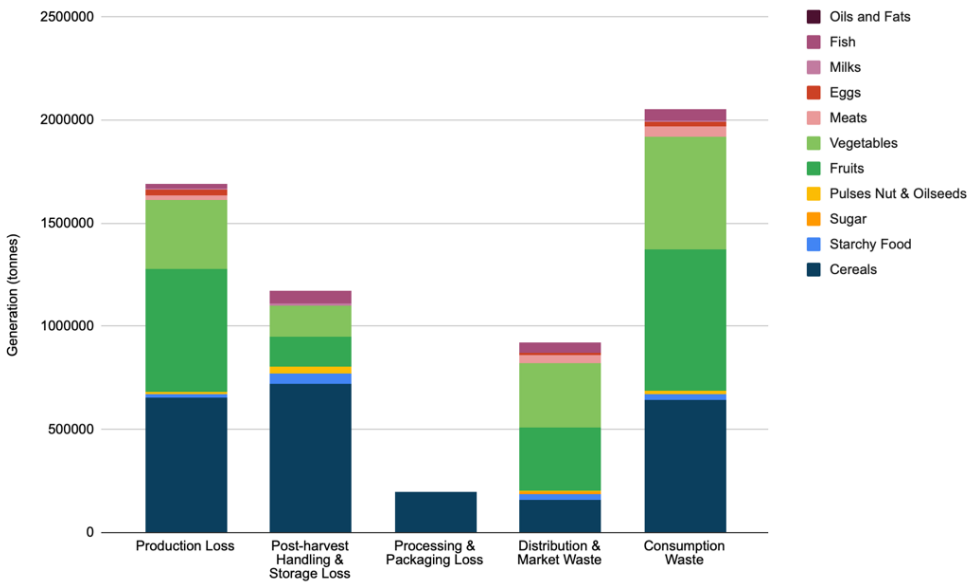


Figure 12. Composition of Central Java's FLW generation in Food Supply Chain (tons/year)

When mapping FLW generation in food supply chain as in **Figure 12,** it shows that the highest loss in the cereals category mainly occurred in the first two stages of supply chain. The cereals commodity with the highest loss is paddy, as it is also the most produced commodity amongst others in the cereals category. This is proven by the fact that Central Java Province in 2019 was ranked first out of Indonesia's 10 largest rice-producing provinces. Central Java Province has a land area of around 1,678,479 hectares, producing

approximately 9,655,653 tons of dry milled paddy (GKG) or the equivalent of 5,539,448 rice. Meanwhile, for fruits and vegetables that also generates high FLW, the amount of losses happen most in the two later stages of supply chain. This might happen due to the perception of specific visual standards for horticulture products, as customers tend not to buy or consume ugly products, even though the nutrition quality is excellent and sufficient[31].

Bali

In 2021, FLW generation in Bali reached 877,224 tons/year or equivalent to 201.08 kg/capita/year, which is higher than the range of Indonesia's FLW generation results in 2000-2019 with 115-184 kg/capita/year. Based on the food supply chain, the highest FLW generation occurred in the production stage, with 300,650 tonnes/year or 34.27% of the total FLW proportion in Bali. The detail result of FLW in Bali is shown in **Table 23.** In general, Bali's food loss generation is higher at 56.69% than food waste at 43.31% (see **Figure 13**). Based on this data, the fact that per capita of FLW in Bali is higher than the average in Indonesia might be affected by inefficient process happening in the food production stage. However, a further inspection and analysis might need to prove the numbers founded in this study.

Table 23 FLW Generation in Bali in 2021

Stage	Bali Population in 2021*	FLW Generation in 2021	
		tons/year	kg/capita/year
Production Loss	4,362,600	300,650	68.92
Post-harvest Handling and Storage Loss		180.225	41.31
Processing and Packaging Loss		16,412	3.76
Distribution and Market Waste		153,766	35.25
Consumption Waste		226,171	51.84
Total		**877,224**	**201.08**

*Secondary data from Bali Central Bureau of Statistics (BPS Bali, 2022)

[31] MoA (2019). *Annual Report of Directorate General of Food Crops 2019.*

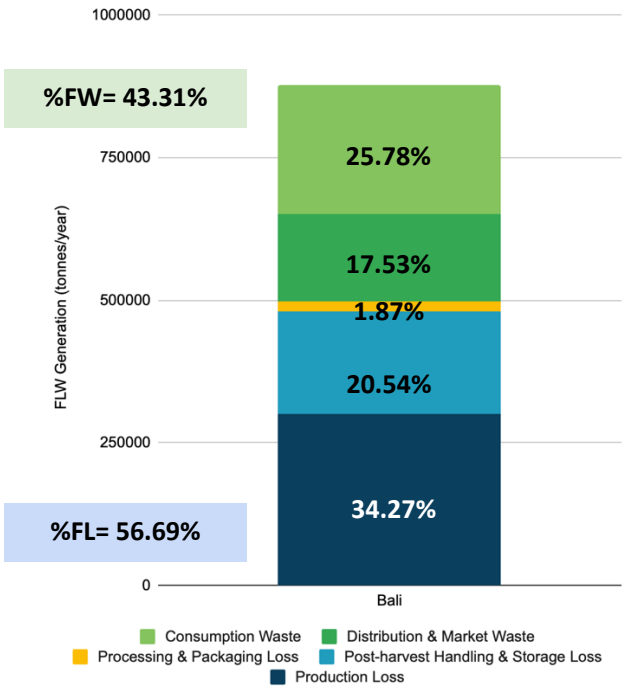


Figure 13. FLW Generation in Bali (%)

Based on the food categories, the highest FLW generation came from the fruits category with 497,315 tonnes/year, which took over half of the total FLW percentage with 56.69%. Furthermore, the second and third rank of highest FLW generation is cereals at 20.22% (177,374 tonnes/year) and vegetables at 13.04% (114,388 tonnes/year). This means the horticulture products sector, which consists of vegetables and fruits, dominated the FLW generation in Bali in 2021. The composition of FLW in Bali based on food categories is shown in **Figure 14.**

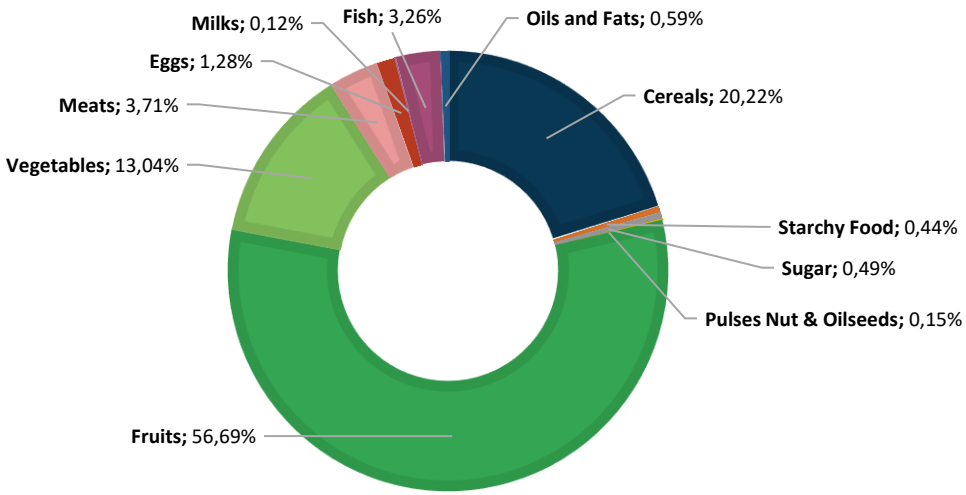


Figure 14. Composition FLW generation in Bali (%)

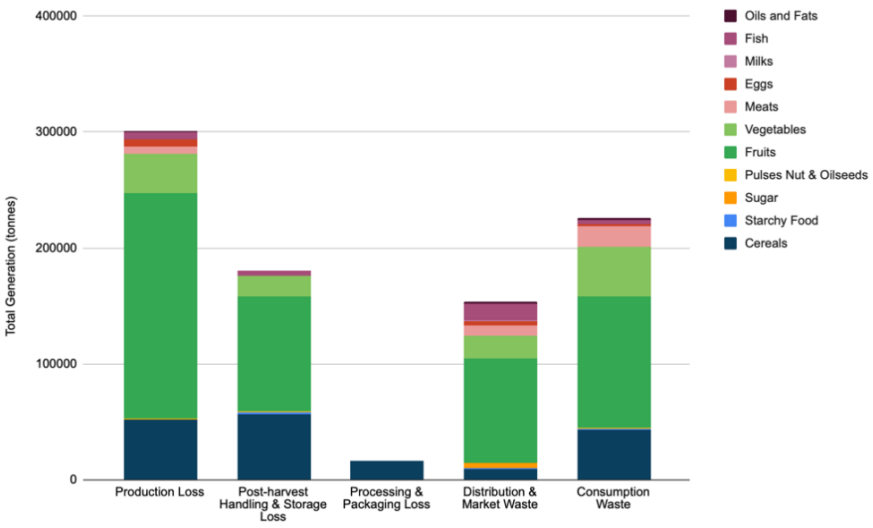


Figure 15. Composition of Bali's FLW generation in Food Supply Chain (tons/year)

When mapping FLW generation in food supply chain as in **Figure 15**, the highest loss in the fruit category mainly occurred in the production stage. Fruit commodities with the highest loss are oranges and bananas, as both commodities were recorded to be the most produced amongst others in the fruit category. In 2017–2018, the most cultivated fruit commodity in Bali was bananas[32], while in 2019, siamese orange took first place with the highest production[33]. The Ministry of Agriculture encouraged the development of orange cultivation clusters in three areas in Bali, namely Bangli, Badung, and Gianyar[34], which caused the inclining trend in orange production in Bali since 2018 and affected the higher food loss percentage in Bali compared to West Java and Central Java. Moreover, due to the COVID-19 pandemic, around 200 thousand families working in the agricultural sector in Bali were affected, and 50% were directly affected during the seven months of the pandemic. There were difficulties in marketing and selling vegetable and fruit (horticulture) products produced in Bali due to the decline of hotels, restaurants, and supermarkets. Most Bali residents only focus on staple foods such as oil, rice, and fish, affecting the decrease in horticulture products[35]. Furthermore, 60% of Siamese orange production was marketed outside Bali, mainly to Semarang, Surabaya, and Jakarta[36] , resulting in a lower food waste percentage.

[32] Agriculture and Food Security Agency in Bali (2020). *Food Balance Sheet Report 2020*. Bali.
[33] BPS (2019). *Bali Province Horticultural Statistics Report.*
[34] Bisnis.com. (2018). The Ministry of Agriculture Encourages Citrus Cultivation Clusters in Bali. Available in: https://ekonomi.bisnis.com/read/20180905/99/835558/kementan-dorong-klaster-budi-daya-jeruk-di-bali
[35] Mongabay (2020). Petani Jeruk dan Kopi Kintamani Menyemangati Diri di Tengah Pandemi. Available in: https://www.mongabay.co.id/2020/10/11/petani-jeruk-dan-kopi-kintamani-menyemangati-diri-di-tengah-pandemi/
[36] Tribun News. (2021), Jeruk Siam is now the Primadona of Farmers in Gianyar, 60% of the Harvest is Sold Out of Bali. Available in: https://bali.tribunnews.com/2021/12/23/jeruk-siam-kini-jadi-primadona-petani-di-gianyar-sebanyak-60-dari-hasil-panen-dijual-keluar-bali

5 EXISTING FLW MANAGEMENT PROGRAM

Chapter 5 Existing FLW Management Program

Several efforts have been undertaken to address the issue of food loss and waste in Indonesia. Generally, food waste is collected from the source to TPS 3R or other material recovery facilities to be processed into compost or Black Soldier Fly (BSF) cultivation. Some initiatives also involve utilising food waste as animal feed or pet food, returning potentially discarded food products (such as those that are defective, substandard, or unsellable) to suppliers, or distributing them to those in need. Similar efforts have been done to manage food loss in which agricultural products that are not suitable for sale or consumption are reprocessed as animal feed and organic fertilizer [37].

In 2022, the National Food Agency initiated the "Save Food Movement (***Gerakan Selamatkan Pangan***)" as part of the preventive and reduction efforts targeting excess and potential food waste. This movement encompasses three primary activities as follows:

1. Provision, collection, sorting, processing, and distribution of food through food donations
2. The establishment of a digital platform for food rescue
3. Public awareness, education, and advocacy campaigns, including "Stop Wasting Food (Stop *Boros Pangan*)" and "Smart Shopping (*Belanja Bijak*)."

Initially launched in the Jabodetabek area, this program has been expanded to 12 other provinces, including those within the scope of this study, which are West Java, Central Java, and Bali[38].

Specific regulations related to Food Loss and Waste (FLW) management are not yet in place, but each province in this study has established its local regulations regarding waste management, which includes the management of food waste as a part of organics. For example, West Java Regional Regulation No.12/2010 on Waste Management stated that organic waste should be processed into compost or BSF cultivation. Meanwhile, Central Java Governor's Regulation No. 11/2019 on the Regional Policies and Strategies for Waste Management of Household and Household-like Waste in 2018-2025 mentions biodigester systems in the community level (RT/RW) as a solution to organic waste. On the other hand, Bali Governor's Regulation No.47/2019 on Source-Based Waste Management suggests to use organic waste to produce liquid fertiliser, waste charcoal/briquettes, and other products in alignment with technological advancements.

The following are some examples of additional programs implemented in West Java, Central Java, and Bali.

West Java

In West Java, Strategic Plan of Food Crops and Horticulture Agency (DTPH) West Java 2018-2023 notes that the utilization of combine harvesters is able to reduce post-harvest waste from 10% to 3% (DTPH, 2019). **Combined harvesters** has been used to reduce post-harvest waste in various regions of West Java, such as Sumedang, Subang, and Karawang Regency. Combine harvester serves a triple function as a harvesting tool, rice grain separator, and field plough[39]. Meanwhile, food waste management is regulated in West Java Regional Regulation No.12/2010 on Waste Management, which has undergone several amendments outlined in West Java Regional Regulation No. 1/2016. The regulation prescribes criminal sanctions for

[37] Bappenas, WRI, Waste4Change and UK-FCDO (2021). *Study of Food Loss and Waste in Indonesia*. Jakarta.
[38] NFA (2023). Available in: https://badanpangan.go.id/blog/post/peringati-hari-kesadaran-pemborosan-pangan-nfa-mantapkan-gerakan-selamatkan-pangan-bersama-stakeholder-terkait
[39] UNPAGE (2021). *Ringkasan Eksekutif Reformasi Kebijakan untuk Mengurangi Food Loss & Waste dan Mendukung Implementasi Kebijakan Pembangunan Rendah Karbon di Provinsi Jawa Barat-Indonesia*.

waste disposal in the environment or improper locations, with a maximum imprisonment of 6 months or a fine for up to IDR 50 million.

In Bandung, **Surplus Indonesia** provides an anti-food waste platform in the form of an application that connects food and beverage businesses with consumers, enabling the rapid sale of surplus products during specific hours (happy hour) at half price. Surplus has expanded its coverage area to include Jabodetabek, Bandung, Yogyakarta, Malang, and Bali[40]. In addition, the waste management program in Bandung City using maggot in collaboration with the **Paguyuban Pegiat Maggot** can be relied upon to be facilitated by the Government in absorbing food waste. With only modest facilities, this association can process up to 20 tons of food waste[41].

Food Bank Bandung Foundation has a program that collects food waste and turns it into BSF and compost. In addition, Food Bank Bandung also has a community-based entrepreneurship program, Budikdamber (Fish Farming in Buckets) and Aquaponic to help reduce food loss and food waste in Bandung. Food assistance programs such as ASA (Healthy Child Intake), Ngebul Kitchen and Botram are also some programs to improve community welfare[42].

Bandung city produces 1,500 tons of waste every day. The survey was conducted on 61 industry players to see how leftover food is treated in the food and beverage industry. This survey looks at how to dispose of leftover food based on the characteristics of food producers. Cafes/restaurants contributed the most to the disposal of leftover food, at 67%, followed by hotels at 15%, and the rest was spread across the food manufacturing, catering and bakery sectors. 35% of respondents said the leftover food was distributed for free, while 28% said it was thrown away, 26% stored in the refrigerator: and 5% became animal feed or composted. The rest were used as discounted food[43].

Central Java

Central Java government has enacted Regional Regulation of Central Java No.3/2023 regarding Marketing System Governance for Agricultural, Fisheries, and Micro, Small, and Medium Enterprises' Products which outlines efforts directed at enhancing the utilization of local products by the Regional Government. The increased utilization of local products can contribute in reducing the occurrence of unsold harvests that might be disposed as food loss. Meanwhile, in addition to Central Java Governor's Regulation No.11/2019 on Regional Policies and Strategies for Waste Management of Household and Household-like Waste in 2018-2025, there is Central Java Regional Regulation No.4/2023 regarding environmental protection and management, including solid waste. This regulation includes criminal provisions, with a maximum imprisonment of 6 months or a fine of up to IDR 50 million, for violations such as improper disposal of waste in undesignated locations and waste management practices that lead to environmental pollution and/or degradation.

In order to reduce food waste, as a member of the Milan Urban Food Policy Pact (MUFPP), the Semarang City Government in Central Java has signified its commitment by initiating the "Love Food Movement (*Gerakan Sayang Pangan*, abbreviated as ***Garang Asem***)" aimed to prevent and reduce food waste through extensive awareness and education campaigns engaging various stakeholders, including private entities

[40] Surplus Indonesia (2023).Available in: https://www.surplus.id/
[41] Bandung Bergerak.id (2023).Paguyuban Pengiat Maggot Membutuhkan Regulasi untuk Mengolah Sampah Organik Bandung Raya.Available in: https://bandungbergerak.id/article/detail/158834/paguyuban-pegiat-maggot-membutuhkan-regulasi-untuk-mengelola-sampah-organik-bandung-raya
[42] Food Bank Bandung (2023). Available in: https://foodbankbandung.org/tentang-kami/
[43] Katoling Parahyangan University (2023) https://unpar.ac.id/riset-unpar-26-pelaku-industri-miliki-program-pengolahan-sisa-makanan/

and communities[44]. Furthermore, there is the "**Cempaka Program**" (Collaborative Efforts to Prevent Stunting with Business Entities in Semarang City or *Cegah Stunting Bersama Pengusaha di Kota Semarang*), a collaboration between the government and business owners, mainly hotels and the Indonesian Association of Culinary Service Providers (*Perkumpulan Penyelenggara Jasa Boga Indonesia* or PPJI). This program aims to ensure that surplus food from hotels is distributed to those in need; given that hotel food typically adheres to high standards and provides excellent nutritional value, it is a valuable resource for consumption[45]. As of August 2023, there are 1,022 stunting cases in Semarang City, down from 1,340 cases in February 2023. Within 6 months, stunting cases in Semarang City decreased by 218 cases[46]. Collaborative steps have also been taken with the Food Bank of Indonesia (FOI) and support from PT Penjaminan Kredit Daerah (Jamkrida), which has provided box trucks to distribute the surplus food[47].

Meanwhile, in Solo City, the "**Bread Rescue**" program is implemented by **FoodCycle**. FoodCycle is an NGO to break the cycle of hunger among underprivileged communities by redistributing surplus food, reprocessing imperfect food products, and recycling food waste. FoodCycle Donation Boxes (FoodCycle Point) are available at 21 locations, including various facilities such as supermarkets across Indonesia[48].Since its inception in 2019, the Bread Rescue program in collaboration with one of the bread companies, Holland Bakery, has distributed 319,571 pcs of bread equivalent to 23 tons to beneficiaries[49]. It is worth noting that Solo has also signed the Milan Pact, underscoring its commitment to sustainable urban food policies[50].

Bali

Regarding Food Loss, there is Bali Governor Regulation No.99/2018 regarding the Marketing and Utilization of Local Bali Agricultural, Fisheries, and Industrial Products. The regulation aims to facilitate the absorption of Bali's local products by mandating businesses such as hotels, restaurants, catering services, and supermarkets to purchase and sell local Bali products (with specified percentages as outlined in this regulation). Although not explicitly stated in the regulation, these efforts can also contribute to reducing the likelihood of unsold harvests or agricultural products, thus minimizing food loss.

Moreover, food waste management is included in the regulation previously mentioned, Bali Governor Regulation No.47/2019 regarding Source-Based Waste Management. According to chapter Guidance and Monitoring in the regulation, several sanctions may be imposed on parties violating this regulation, including (1) administrative sanctions by the government and (2) customary sanctions (*Sanksi Adat*) by the traditional village (*Desa Adat*). In additon, Bali Regional Regulation No.5/2011 on Waste Management stated a maximum imprisonment of 6 months or a fine of up to IDR 50 million for those who violate certain prohibitions, such as improper disposal of waste in non-designated locations.

Many accommodations generate significant food waste in Bali, a popular tourist destination. Several food waste management initiatives have been undertaken by the facilities, such as Desa Potato Head, including converting food waste into animal feed, compost, and recycled ornaments. Grand Hyatt has also made an

[44] NFA (2023).Available in: https://badanpangan.go.id/blog/post/nfa-apresiasi-upaya-pencegahan-food-waste-melalui-gerakan-sayang-pangan-kota-semarang
[45] Semarang City Government (2023).Available in: https://semarangkota.go.id/p/5185/entaskan_stunting,_bersama_pengusaha,_mbak_ita_luncurkan_cempaka
[46]https://semarangkota.go.id/p/5185/entaskan_stunting,_bersama_pengusaha,_mbak_ita_luncurkan_cempaka
[47] NFA (2023). Available in: https://badanpangan.go.id/blog/post/nfa-apresiasi-upaya-pencegahan-food-waste-melalui-gerakan-sayang-pangan-kota-semarang
[48] FoodCycle Indonesia (2023). Available in: https://foodcycle.id/about/
[49] https://foodcycle.id/foodcycle-hadiri-webinar-holland-bakery-we-care-for-social-responsibility/
[50] Mongabay (2022). Available in: https://www.mongabay.co.id/2022/02/28/sisa-makanan-jadi-limbah-dominan-ini-cara-mengolahnya/

effort to process their food waste into compost. Fairfield by Marriott, Four Points by Sheraton and several bakeries have partnered with **Surplus Indonesia** to distribute their surplus food at more affordable prices[51]. There is also **Scholars of Sustenance (SOS)**, an organization in Bali that distribute surplus food from HORECA, catering, and supermarket to those in need. SOS has partnered with a total of 60+ businesses in Bali. Other than in Bali and Jakarta, Indonesia, SOS also operates in Thailand and Philippines. The NGO has rescued a total of 890 tons surplus food in Indonesia since 2017[52]. Similarly, **FoodBank**, a food distribution Initiative operating in India, Kenya, and Indonesia (particularly Bali) also accept donation in form of non-perishable food[53].

Inspired by local wisdom, the traditional village or Desa Adat Cemenggaon in Gianyar has created a biopore infiltration hole called "***Teba Modern***". In traditional Balinese architecture, every house has a *teba,* the rear part of the house designated for cultivating plants and housing livestock. The local Waste Management Authority (Badan Pengelola Sampah) has modernised the *teba* by constructing covered holes, 80 cm wide and 2 m deep, made of concrete or bricks in every household. These holes can be discreetly placed behind stone tiles on the road to prevent odours and preserve aesthetics. In addition to *teba modern* initiative for organic waste, the village also operates a waste bank to collect valuable inorganic waste. Through these programs, the village has successfully reduced more than 80% of waste sent from household to the landfill, decreasing waste generation from 4 kg per household to only 0.5 kg of residual waste sent to the landfill[54].

Permaculture, originally from Permanent Agriculture techniques, has already been implemented primarily in Badung Regency, such as The Kul Kul Farm, Jiwa Garden, and Jiwa Damai. Permaculture offers an alternative to destructive chemical farming in which agricultural ecosystems grow in a manner that promotes sustainability, regeneration, and self-sufficiency. This agricultural approach prevents food loss and waste due to the efficient utilisation of crops and post-consumption utilisation.

In addition, the Education Center of **Eco-Enzyme Nusantara (EEN)** in Bali was inaugurated in October 2023. This educational centre includes an eco-enzyme bank and educational facilities dedicated to waste management, primarily organic waste. The EEN Bali community actively produces eco-enzymes derived from organic materials, specifically fruit and vegetable waste. Aside from eco-enzyme, there is social enterprise such as **Urban Compost Bali** that provides pickup and composting services for food waste. Similar to Urban Compost Bali, **Magi Farm** provides food waste collection service which later processed with BSF[55]. The food waste management service had processed 5 tons of food waste in September 2023[56]. There is also a consulting agency specialising in sustainable solutions for hotels and restaurants in Bali named **Eco Horeca**.

Furthermore, other initiatives have been done by the Bali Government to prevent or manage food waste from various sectors. The Marine and Fisheries Agency (Diskelkan Bali) has directed surplus fish catches and fish processing by-products to be utilised to produce fish flour or fishmeal. The Industry and Trade Agency (Disperindag Bali) had conducted awareness campaigns on utilising tofu residue in cake baking and the comprehensive use of coconut, thus striving for zero waste. As of this year, The Environmental Agency in Bali (DKLH Bali) has introduced the **Model Area** program, a pilot project involving training and capacity building in villages to separate their food waste. Subsequently, this food waste is further processed into

[51] Surplus Indonesia (2023). Available in: https://www.surplus.id/
[52] SOS (2023). Available in: https://www.scholarsofsustenance.org/
[53] FoodBank (2023).Available in: https://foodbank.co/
[54] Daniera, D. (2023). Sistem Pengelolaan Sampah Kolektif ala Desa Adat Cemenggaon Bali, Ada Komposter dengan Kearifan Lokal. Liputan6. Available in: https://www.liputan6.com/lifestyle/read/5281684/sistem-pengelolaan-sampah-kolektif-ala-desa-adat-cemenggaon-bali-ada-komposter-dengan-kearifan-lokal?page=3
[55] MagiFarm (2023). Available in: https://magifarm.id/#
[56] MagiFarm (2023). Available in: https://www.instagram.com/reel/CzcncxISYLd/?utm_source=ig_web_button_share_sheet&igsh=MzRlODBiNWFlZA==

compost using Osaki method or utilised as BSF maggot feed. Currently, the on-going program has reduced 10-20% waste to landfill[57]. DKLH hopes that in the future, this pilot project can be implemented in more villages or traditional villages in Bali, becoming a sustainable initiative to reduce waste, especially food waste that ends up in landfills.

[57] Environmental Agency of Bali (2023). Data on the Implementation of Source-Based Waste Management for the Osaki System Technology Transfer Program.

6 CONCLUSION & RECOMMENDATION

Chapter 6 Conclusions and Recommendations

Conclusions

The highest per capita FLW between three provinces is founded in Bali at 201.08 kg/capita/year, followed by Central Java at 164.31 kg/capita/year, and West Java at 137.70 kg/capita/year. This also means between three provinces Bali has the highest in food loss per capita (113.99 kg/capita/year) and the highest food waste per capita (87.09 kg/capita/year). The same applies for West Java. As the lowest FLW per capita, it has the lowest food loss per capita (65.81 kg/capita/year) and the lowest food waste per capita (71.89 kg/capita/year). It should be noted that the scope discussed does not include the pre-harvest food loss stage, the quantity of food loss from processed food products other than those listed in the FBS, or loss that occurs during the food import-export process. Thus, when looking from the food supply chain, processing and packaging stage has the lowest of FLW. Meanwhile, production and consumption stage are the two stages with the highest FLW in three provinces. On the other hand, when looking from the type of commodities, three main commodities with the highest FLW in three provinces are (1) cereals, (2) fruits, and (3) vegetables. While cereals is the highest both in West Java and Central Java, in Bali the highest is fruits.

In managing FLW, regulations in the three provinces have highlighted how FLW as part of organic waste should be treated; with treatment varies from composting to BSF to biodigester. Align with the regulation, there are several programs/initiatives in place in three provinces, conducted by local government or NGOs, collaborate with various parties such as HORECA industry. However, as municipal waste in the three provinces barely implement source segregation, food waste still has difficulties to be recovered as most of the waste is collected mixed with other waste and will goes to the landfill.

Recommendations

These are general recommendations that analysed based on FLW generation and a brief overview of FLW management regulations and practices in the three provinces. Following the completion of the national FLW study, the central government is currently in the process of drafting specific regulations regarding the reduction and management of FLW, as well as improving the standardization of food product labelling, with the expectation that these regulations can be adapted to derivative regulations at the regional level.

In parallel, responsible FLW management is associated with the reduction of greenhouse gas emissions, regulated both nationally and within regional jurisdiction. At national level, the reduction of GHG is regulated under Presidential Regulation No.61/2011, repealed with the enactment of Presidential Regulation No.98/2021 concerning The Implementation of Carbon Economic Value for Achieving Nationally Determined Contribution Targets and Controlling Greenhouse Gas Emissions in National Development. According to this regulation, the National Determined Contribution (NDC) target for greenhouse gas emission reduction is set at 29 – 41% by 2030 compared to the baseline emission of 2,869 million tons CO_2eq[58]. Furthermore, low-carbon development is also one of the national priority programs outlined in the Medium-Term National Development Plan (RPJMN) 2020-2024[59].

[58] Presidential Regulation Number 98 of 2021 regarding The Implementation of Carbon Economic Value for Achieving National Determined Contribution (NDC) Targets and Controlling Greenhouse Gas Emissions in National Development.
[59] Presidential Regulation Number 18 of 2020 regarding Medium-Term National Development Plan (RPJMN) 2020-2024.

At the regional level, low-carbon development policies are implemented through the Regional Low-Carbon Development Plan (RPRKD), focusing on five priority sectors: circular waste streams management and energy, circular industry development, sustainable energy development, low-carbon marine and coastal areas, and sustainable land restoration. Among the three pilot provinces studied, West Java has formulated its RPRKD. This document represents a transformation from the Regional Greenhouse Gas Action Plan (RAD-GRK) regulated under West Java Governor Regulation 56/2012, with the addition of socioeconomic considerations. The emission reduction target is set at 9.94% by 2030, with the agricultural sector capable of achieving a reduction of 10.96% and the waste sector achieving a reduction of 22.74% from the Business as Usual (BaU) scenario after mitigation actions[60].

Meanwhile, in Central Java, there is Governor Regulation 43/2012 regarding RAD-GRK for the period 2010-2020, which refers to Presidential Regulation 61/2011 with a target of reducing greenhouse gas emissions in the agricultural sector by 4.37% and waste management by 22.27%[61]. The Central Java government also promotes the Climate Village Program (ProKlim) regulated under Governor Regulation 51/2019, with one of its components being mitigation efforts including waste management and low GHG emission agricultural land handling[62]. Additionally, the RPRKD document for Central Java has been prepared and is currently under review by Bappenas[63].

For Bali itself, Governor Regulation 49/2012 addresses the RAD-GRK[64]. Furthermore, in late 2021, the Bali provincial government, together with Bappenas, issued the economic roadmap "Kerthi Bali Economy towards a New Era for Bali," one of its six major strategies being "Green Bali" through the application of climate change mitigation and adaptation policies, implementation of blue economy development, increased use of renewable energy, environmentally friendly transportation, and improved waste management. Several recommendations regarding waste management in this document include developing food and waste management and a food bank system. The strategies outlined are projected to reduce Bali's emissions by approximately 40-80% by 2045 compared to the Business-as-Usual scenario[65].

In addition to regulation, other initiatives, such as voluntary agreements and behaviour change campaigns, have the potential to make an impact on reducing FLW. Therefore, recommendation of options which need to be considered for developing policies, guidelines and programs at the regional level for the three provinces, with detail as follows.

1. Food loss and waste prevention or productive use of surplus food

Prevention of FLW might be implemented by:

- Procure and improve basic infrastructure facilities to support agriculture process, particularly in post-harvest stage.
- Conduct Good Handling Practice (GHP) training and regular monitoring for food handlers or workers in the food sector.

[60] Bappenas, UNPage, and West Java Government (2022). West Java Regional Low-Carbon Development Plan (RPRKD).
[61] Central Java Governor Regulation Number 43 of 2012 regarding Regional Greenhouse Gas Action Plan (RAD-GRK) 2010-2020.
[62] Central Java Governor Regulation Number 51 of 2019 regarding Climate Village Program.
[63] Radio Republik Indonesia (2023): https://rri.co.id/index.php/iptek/199723/terapkan-circular-ekonomi-jateng-susun-pembangunan-rendah-karbon
[64] Bali Governor Regulation Number 49 of 2012 regarding Regional Greenhouse Gas Action Plan (RAD-GRK)
[65] Bappenas and Bali Government (2021). Economic Roadmap Kerthi Bali Economy towards a New Era for Bali: Green, Strong, and Prosperous.

- Improve management of food resources by businesses and households, as well as encourage redistributing food for human consumption that would otherwise go to waste. This could be promoted through communication and behaviour change campaigns targeting consumers and businesses. See, for example, WRAP's citizen-facing Love Food, Hate Waste communications campaign or Guardians of Grub, a campaign and toolkit that aims to give the hospitality and foodservice sector business skills to improve profitability by reducing the amount of food they waste. Redistribution of surplus can be promoted through voluntary initiatives (e.g. the Courtauld Commitment in the UK) or through regulation requiring redistribution, such as that adopted by France in 2016. In the UK, the Government is seeking to introduce mandatory reporting of food waste by businesses working in the food sector, which will create a powerful incentive to prevent food waste while providing a means of measuring it. Meanwhile, in Indonesia, the central government is currently drafting regulations related to food banks to better regulate and provide legal protection for food bank activities in managing surplus food. In line with the formulation of these regulations, pilot activities will be conducted to optimize food banks.

2. Effective management of food waste following the food and drink waste hierarchy

Diverting food waste that cannot be prevented from landfills and towards more appropriate disposal routes, including composting, anaerobic digestion and energy recovery. This could take the form of regulation requiring businesses to produce a written plan for managing their food waste and introducing a legal requirement for businesses and municipalities to follow the food waste hierarchy wherever possible. Regions can create their own regulations regarding this matter to strengthen the national legal framework. This is likely to require a degree of infrastructural development.

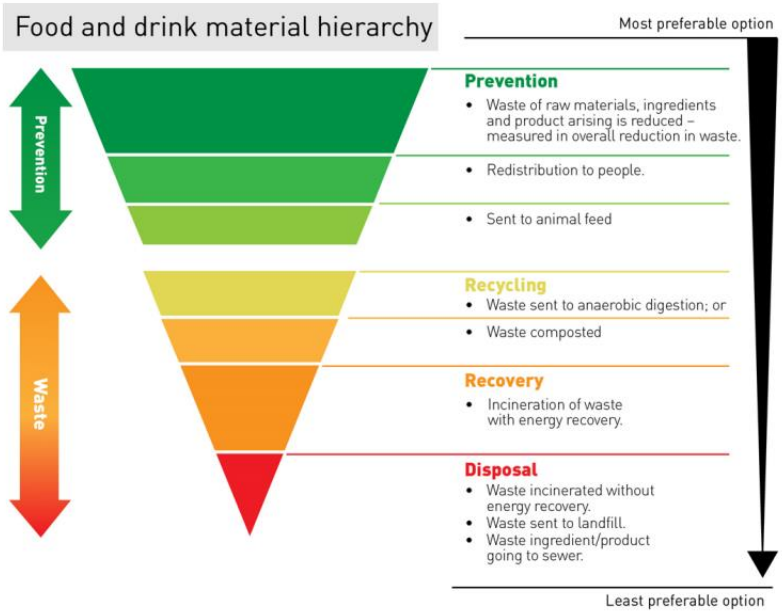


Figure 16. The food and drink waste hierarchy

Efforts to reduce and utilise food waste should be accompanied by data collection at the city or regency level and ongoing reinforcement and monitoring. The collected data consists of Food Balance Sheets utilized as a reference for calculating food loss and the completion of the SIPSN as a national integrated platform for waste data, including food waste. This data is regularly collected, typically every 6 months or once a year.

While Karangasem and Buleleng in Bali have facilities, including sorting facilities, composting plants, maggot farms and eco-enzyme facilities, the development of sorting and treatment infrastructure in the other study areas (Cianjur Regency, Cirebon Regency, Purbalingga Regency, and Pekalongan Regency) would allow a transition away from disposal to landfill. Implementing food waste reduction and utilisation efforts should accompany city/regency-level data collection and periodic strengthening and monitoring.

Furthermore, a pilot program in Bali is currently underway for waste management, particularly organic waste (consisting of garden and food waste), using the Osaki composting method. This program includes equipment, mentoring, and regular monitoring by the Bali Environmental Agency (DKLH Bali) in collaboration with JICA.

Beside policies and interventions, there is also a compelling need for further monitoring and research to delve deeper into the relationship between causes and drivers of FLW with the generation of FLW at each stage of the supply chain. This will facilitate the development of relevant strategies and action plans. The following are some recommendations for further research.

1. Research on FLW in the import and export processes is necessary to complement the data on FLW generation. This data can be utilised to formulate regulations regarding the timing and quota of food product imports, aiming to prevent FL due to domestic food products from being absorbed by the market.
2. Social research on reasons for food waste and what drives differences between provinces and regencies. While current data includes field notes on observed differences (see Appendix 2), generalisation from such anecdotal evidence will inappropriate. A follow-up study could make use of tools such as:
    - Interviews and surveys to assess residents' beliefs, opinions and self-reported behaviours.
    - Food waste diaries provide details on what is disposed of, why and by whom.
    - Regression modelling to assess to what extent demographic and other variables predict food waste or drive food waste production.

In addition to the aforementioned recommendations, there are several considerations based on the existing conditions in each province.

West Java

1. In the West Java RPRKD, low-carbon programs have been formulated for each priority sector, including waste management, agriculture, and animal husbandry, accompanied by delineation of roles for respective stakeholders[66]. Stakeholder mapping is crucial to ensure and enhance the participation of each stakeholder following their respective mandates. Additionally, the sustainability of program implementation is supported by factors such as funding sources and regular monitoring and evaluation.

2. It is also important to integrate policy strategy recommendations to reduce FLW[67] in supporting the implementation of low-carbon development policies, such as increasing budget allocations or funding support to enhance the quantity and quality of agricultural products and reduce food loss. Additionally, raising consumer or public awareness regarding the importance of preventing food waste is essential.

[66] Bappenas, UNPage, and West Java Government (2022). West Java Regional Low-Carbon Development Plan (RPRKD).
[67] UNPage (2023). Executive Summary: Policy Reform to Reduce Food Loss & Waste and Support the Implementation of Low Carbon Development Policies in West Java Province-Indonesia.

Central Java

1. Align with Climate Village Program (ProKlim) regulated under Governor Regulation 51/2019, with one of its components being mitigation efforts including waste management and agricultural land handling with low GHG emission[68], the Central Java government can encourage existing climate villages or villages intending to implement ProKlim to integrate food loss and waste reduction initiatives into their climate mitigation efforts.

2. Considering Governor Regulation 43/2012 regarding the RAD-GRK concerning mitigation in the agricultural sector[69], the activities outlined are also expected to reduce food loss. As stated in this regulation, farmers' acceptance of the proposed mitigation options is one crucial factor that needs to be assessed. It is important to educate farmers about the importance of climate mitigation, provide regular training for the transition of farming and animal husbandry patterns, and offer incentives to encourage this transition.

   One of the main activities regarding climate mitigation in the agriculture sector is using local feed sources for livestock. Black Soldier Fly (BSF) larvae can be considered a potential livestock feed source due to their efficiency in converting food waste into high-quality protein biomass. This reduces environmental impact and offers cost-effectiveness, as BSF larvae utilize inexpensive food waste, minimizing reliance on costly feed ingredients.

Bali

1. Following the economic roadmap "Kerthi Bali Economy towards a New Era for Bali" which recommends various measures for waste management, including the establishment of a food and waste management system and a food bank[70], it is necessary to demonstrate direct commitment to developing food & waste management and optimizing the food bank in Bali, in alignment with the ongoing national FLW and food bank regulation being drafted.

   The Bali government can draw numerous lessons from waste management efforts, particularly in food waste, within the ongoing pilot project model areas to expand and gradually scale up across the entire province of Bali. It can be initiated to optimise food banks by providing a legal framework for food bank activities or similar initiatives that utilize surplus food.

   Additionally, the modernization efforts in agriculture towards organic farming, as outlined in the economic roadmap, are not only aimed at enhancing the quantity and quality of agricultural produce but also at the sustainability of this strategy, which must consider the significant strengthening of farmers and the importance of reducing food loss for environmental preservation.

2. Bali is renowned for its cultural traditions, with the local population often prioritizing adherence to customary rules over other regulations. Therefore, reinforcing the role of traditional villages (*desa adat*) is essential to accelerate the responsible implementation of FLW management.

[68] Central Java Governor Regulation Number 51 of 2019 regarding Climate Village Program.
[69] Central Java Governor Regulation Number 43 of 2012 regarding Regional Greenhouse Gas Action Plan (RAD-GRK) 2010-2020.
[70] Bappenas and Bali Government (2021). Economic Roadmap Kerthi Bali Economy towards a New Era for Bali: Green, Strong, and Prosperous.

APPENDIX

Appendix 1: Household waste composition and field notes

Province	Regency	Income	Food Waste (Edible)	Food Waste (Inedible)	Garden Waste	Paper	Plastic	Metal	Textile	Rubber	Glass	Others	Notes
West Java	Cianjur	High	23.09%	30.42%	2.55%	7.35%	15.51%	0.20%	0.03%	0.00%	1.21%	19.64%	Edible food waste: uneaten food (spoiled rice, side dishes), vegetables and fruits. Other waste, mainly diapers.
		Middle	16.29%	34.93%	5.08%	8.04%	20.27%	0.16%	0.04%	0.80%	1.97%	12.42%	A lot of FMCG products have high plastic packaging %. Inedible food waste generated from home cooking.
		Low	21.41%	25.55%	0.02%	7.21%	19.87%	0.58%	3.33%	0.00%	3.05%	18.96%	Low waste due to lack of activity at home
	Cirebon	High	4.29%	45.51%	1.11%	10.64%	23.19%	1.66%	2.20%	0.23%	2.26%	8.92%	Lots of inedible food, plastics, and cardboard. Lots of bulky cardboard packaging from online orders.
		Middle	12.49%	31.54%	12.10%	6.21%	21.66%	0.45%	1.74%	0.17%	1.20%	12.43%	Middle-income people in the area prefer to order online food to cook.
		Low	14.72%	49.57%	6.51%	6.08%	14.36%	0.58%	1.70%	0.85%	0.95%	4.68%	Low-income people in the area like to cook at home. Far from Regency. Lots of inedible food from cooking.
Central Java	Pekalongan	High	10.74%	29.01%	9.95%	11.40%	25.97%	0.00%	2.29%	0.65%	0.00%	9.99%	High mobility, so rarely cook at home. Waste is primarily inedible, such as durian, avocado, and banana waste and plastic food wrap.
		Middle	7.97%	18.73%	14.16%	13.48%	29.20%	0.00%	2.51%	0.88%	0.66%	12.42%	Cook at home. Waste is dominated by inedibles such as vegetable stalks, leaves, food wrapping, eggshells, and plastic waste from food wrappers. Most people stay home and clean the garden in the

Province	Regency	Income	Food Waste (Edible)	Food Waste (Inedible)	Garden Waste	Paper	Plastic	Metal	Textile	Rubber	Glass	Others	Notes
													late afternoon; there is high garden waste.
		Low	12.23%	18.17%	3.12%	13.92%	22.46%	0.98%	16.42%	0.00%	0.32%	12.40%	Mainly workers and traders who leave early in the morning. A very small amount of waste. Textile waste is generated from small tailors and the batik industry in the area.
	Purbalingga	High	19.98%	23%	26.86%	6.17%	12.43%	0.52%	0.51%	0.20%	1.86%	8.46%	A lot of edible food waste (spoiled rice), Garden waste (routine cleaning schedule every 2 days), and Other waste (diapers).
		Middle	9.42%	45.86%	3.66%	8.82%	17.79%	0.75%	2.90%	0.83%	2.28%	7.71%	There is a lot of inedible food waste; some work as food sellers.
		Low	12.24%	50.04%	9.11%	6.37%	17.22%	0.15%	0.93%	0.58%	0.12%	3.24%	Most of the waste is inedible food waste; many cook at home.
Bali	Buleleng	High	21.65%	10.05%	43.12%	5.40%	11.71%	2.10%	1.89%	0.00%	1.47%	2.62%	Don't treat their food as waste. Plastic waste is low due to the prohibition of single-use plastic bags in supermarkets.
		Middle	8.81%	13.31%	49.95%	5.20%	11.89%	0.71%	2.55%	4.91%	0.67%	2.01%	A lot of garden waste due to Hindu praying activities
		Low	8.58%	12.57%	52.32%	5.66%	12.62%	0.47%	2.03%	2.58%	0.56%	2.62%	People shop at conventional markets where there is no ban on the use of single-use plastic.
	Karangasem	High	20.44%	18.72%	39.74%	6.10%	11.36%	0.38%	0.01%	0.05%	0.56%	2.65%	High garden waste and inedible food waste from Hindu praying activities and large trees
		Middle	14.82%	19.30%	42.77%	5.95%	13.92%	0.09%	0.28%	0.00%	0.28%	2.60%	Many Muslim people do not generate garden and food waste from prayer activities.
		Low	8.54%	9.21%	61.65%	2.02%	14.06%	0.27%	0.69%	1.10%	0.00%	2.46%	Garden waste is high due to Hindu praying ceremonies. Lots of gardens.

Appendix 2: Restaurant and markets primary data and field notes

a. Waste from restaurants

Province	Regency	Food Waste (Edible)	Food Waste (Inedible)	Garden Waste	Paper	Plastic	Metal	Textile	Rubber	Glass	Others	Note
West Java	Cianjur	49.08%	44.81%	0.00%	5.65%	5.74%	0.52%	0.03%	0.00%	0.80%	8.65%	Lots of vegetables (fresh vegetables and lalapan). Banana leaves dominate inedible food because they serve rice with banana leaves.
	Cirebon	20.14%	39.33%	4.02%	8.89%	19.54%	0.23%	0.25%	0.00%	0.00%	7.60%	Edible food is dominated by fresh vegetables such as lalapan, rice and parts of food that still can be eaten. Inedible food dominated by coconut shell, bone and leaf wrap. Lots of plastic food packaging. Restaurant visitors have fallen during the pandemic.
Central Java	Pekalongan	12.59%	46.88%	2.34%	15.72%	22.47%	0.00%	0.00%	0.00%	0.00%	0.00%	Inedible food waste is mostly fish bones, chicken bones, eggshells, and vegetable stalks. Plastic and paper from food packaging.
	Purbalingga	43.27%	33%	0%	1.96%	11.23%	0%	0%	0%	0%	10.54%	25% fall in visitors due to the pandemic. Leftover food is used as animal feed.
Bali	Buleleng	44.26%	11.74%	4.78%	8.13%	15.60%	1.26%	0.04%	0.43%	6.47%	7.30%	A large amount of leftover food from visitors. Garden waste is generated from food wrappers and wooden cutlery such as single-use chopsticks.
	Karangasem	36.84%	32.64%	6.36%	2.53%	11.12%	0.30%	0.00%	0.00%	2.34%	7.87%	The waste generated was minimal and decreased visitors by almost 100%.

b. Waste from markets

Province	Regency	Food Waste (Edible)	Food Waste (Inedible)	Garden Waste	Paper	Plastic	Metal	Textile	Rubber	Glass	Others	Note
West Java	Cianjur	80.04%	13.97%	0.00%	1.96%	3.93%	0.02%	0.09%	0.00%	0.00%	0.00%	Rotten vegetables and fruits
	Cirebon	55.13%	28.99%	0.00%	4.26%	10.14%	0.05%	0.06%	0.11%	0.02%	1.23%	Edible food waste is dominated by parts of vegetables that still can be eaten. Inedible dominated by banana bunches
Central Java	Pekalongan	36.14%	0.00%	0.34%	4.69%	5.26%	0.00%	0.00%	0.00%	0.00%	0.00%	Inedible waste: corn skins, coconut fibres, wrappers from banana leaves, and leftover stalks of vegetables. Plastic waste from snack and grocery sellers. Low waste in this market due to the presence of housewives who collect vegetable waste still suitable for cooking.
	Purbalingga	32%	61.44%	0%	4.47%	2.08%	0%	0%	0%	0%	0%	Most waste is from fruit and vegetable sellers. Reduction of visitors due to Covid-19: 50%. Traditional markets in Purbalingga Regency are small markets scattered in every village, managed by the village government.
Bali	Buleleng	46.84%	18.38%	23.15%	4.17%	5.21%	0.00%	0.92%	0.15%	0.00%	1.18%	A high % of food waste is due to many fruit sellers. Garden waste is generated from Hindu praying activities in the market and from sellers selling Hindu praying tools.
	Karangasem	81.36%	5.43%	4.43%	2.64%	3.95%	0.38%	1.15%	0.00%	0.02%	0.62%	Food waste generated from unsold defective products

Appendix 3: Resampled inference script (R)

The R script for resampled inference to calculate confidence intervals for restaurant and market waste is below. The principle behind resampling is as follows:

1. Simulate samples of six restaurants or markets by drawing six values (with replacement, meaning a value can be picked more than once) from the pool of existing sample values and calculate the mean of this sample.

2. Repeat this process for a given number of iterations – in this example, 100,000 iterations were generated for each variable, generating 100,000 simulated samples and sample averages.

3. An estimated 95% confidence interval is produced by taking the central 95% of values from the simulated averages (i.e. the cut-off points for the 2.5 and 97.5 percentiles).

The advantage of this approach is twofold relative to a classical parametric confidence interval based on a t-test. It is considered more robust when small sample sizes and the population values are not normally distributed. In addition, a classical confidence interval for this data crosses zero. The lower bound of the estimate is negative, which is an absurd result in the case of waste generation for restaurants and markets.

```
#Random number seed to make results reproducible
set.seed(5895)

# Simulate restaurant waste (100,000 x n=6)
rWaste<-c(32500,4380,2190,3154,34361,2854)
x<-sample(x = rWaste, size = 600000, replace = TRUE)
bootSamplesrWaste<-matrix(data = x, nrow = 100000, ncol = 6)
bootMeansrWaste<-rowMeans(bootSamplesrWaste)
mean(bootMeansrWaste)
quantile(x = bootMeansrWaste, probs = 0.025)
quantile(x = bootMeansrWaste, probs = 0.975)

# Simulate restaurant food waste (100,000 x n=6)
rFood<-c(30514,2605,1302,2405,19242,1983)
x<-sample(x = rFood, size = 600000, replace = TRUE)
bootSamplesrFood<-matrix(data = x, nrow = 100000, ncol = 6)
bootMeansrFood<-rowMeans(bootSamplesrFood)
mean(bootMeansrFood)
quantile(x = bootMeansrFood, probs = 0.025)
quantile(x = bootMeansrFood, probs = 0.975)

# Simulate market waste (100,000 x n=6)
mWaste<-c(1560240,401500,26258,82125,513595,1112155)
x<-sample(x = mWaste, size = 600000, replace = TRUE)
bootSamplesmWaste<-matrix(data = x, nrow = 100000, ncol = 6)
bootMeansmWaste<-rowMeans(bootSamplesmWaste)
mean(bootMeansmWaste)
quantile(x = bootMeansmWaste, probs = 0.025)
quantile(x = bootMeansmWaste, probs = 0.975)

# Simulate market food waste (100,000 x n=6)
mFood<-c(1466782,337742,9490,76738,334967,965239,531826)
x<-sample(x = mFood, size = 600000, replace = TRUE)
bootSamplesmFood<-matrix(data = x, nrow = 100000, ncol = 6)
bootMeansmFood<-rowMeans(bootSamplesmFood)
mean(bootMeansmFood)
```

quantile(x = bootMeansmFood, probs = 0.025)
quantile(x = bootMeansmFood, probs = 0.975)

Appendix 4: FLW Generation per Commodity

Commodity	FLW Generation in West Java 2021 (tons/year)					
	Production Loss	Post-harvest Handling & Storage Loss	Processing & Packaging Loss	Distribution & Market Waste	Consumption Waste	Total
Cereals	529,387	581,445	221,933	132,212	556,294	**2,021,271**
Starchy Food	10,669	33,182	0	15,602	14,391	**73,844**
Sugar	0	0	0	7,997	0	**7,997**
Pulses Nut & Oilseeds	8,466	15,174	0	12,497	14,189	**50,326**
Fruits	470,359	239,876	0	416,329	510,616	**1,637,180**
Vegetables	264,169	134,739	0	311,493	756,967	**1,467,368**
Meats	54,238	3,027	0	81,550	119,142	**257,957**
Eggs	56,164	0	0	27,460	20,750	**104,374**
Milks	9,919	16,347	4,362	21,375	5,528	**57,530**
Fish	344,904	208,496	0	365,018	113,275	**1,031,694**
Oils and Fats	220	15	3,488	1,989	2,149	**7,861**
Total	**1,748,495**	**1,232,302**	**229,783**	**1,393,522**	**2,113,301**	**6,717,403**

Commodity	FLW Generation in Central Java 2021 (tons/year)					
	Production Loss	Post-harvest Handling & Storage Loss	Processing & Packaging Loss	Distribution & Market Waste	Consumption Waste	Total
Cereals	653,273	720,056	196,331	156,583	645,351	**2,371,594**
Starchy Food	16,763	52,821	0	29,531	26,148	**125,263**
Sugar	0	0	0	12,961	0	**12,961**
Pulses Nut & Oilseeds	11,828	33,339	0	4,217	13,163	**62,546**
Fruits	594,535	141,541	0	304,103	686,816	**1,726,995**
Vegetables	335,893	153,108	0	316,438	548,311	**1,353,750**
Meats	22,943	1,229	0	33,988	51,384	**109,544**
Eggs	29,565	0	0	10,745	20,438	**60,748**
Milks	3,716	6,236	1,763	4,553	3,235	**19,502**
Fish	21,588	65,398	0	48,338	56,615	**191,939**
Oils and Fats	282	79	64	109	1,957	**2,490**
Total	**1,690,386**	**1,173,806**	**198,157**	**921,566**	**2,053,417**	**6,037,333**

Commodity	FLW Generation in Bali 2021 (tons/year)					
	Production Loss	Post-harvest Handling & Storage Loss	Processing & Packaging Loss	Distribution & Market Waste	Consumption Waste	Total
Cereals	51,875	56,920	16,063	9,137	43,379	**177,374**
Starchy Food	553	1,740	0	816	758	**3,866**
Sugar	0	0	0	4,259	0	**4,259**
Pulses Nut & Oilseeds	242	398	0	206	445	**1,291**
Fruits	194,721	99,300	0	89,983	113,311	**497,315**
Vegetables	33,648	17,156	0	20,182	43,402	**114,388**
Meats	6,546	417	0	8,615	17,009	**32,587**
Eggs	5,582	0	0	3,236	2,425	**11,243**
Milks	0	0	165	829	95	**1,088**
Fish	6,255	4,221	0	14,859	3,265	**28,600**
Oils and Fats	1,229	74	185	1,644	2,081	**5,212**
Total	**300,650**	**180,225**	**16,412**	**153,766**	**226,171**	**877,224**

PAGE PARTNERSHIP FOR ACTION ON GREEN ECONOMY

This report presents findings from a Regional Food Loss and Waste study conducted in West Java, Central Java, and Bali — three provinces pivotal to Indonesia's low-carbon development efforts. The study involved a comprehensive analysis of food waste generation and composition through primary and secondary data collection. By enabling data-driven decision-making, this report seeks to guide effective waste management policies and strategies that enhance food security and reduce the environmental impact of food waste across Indonesia.

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STUDY REPORT

FOOD LOSS AND WASTE REGIONAL

WEST JAVA, CENTRAL JAVA, BALI

European Commission

Supported by: Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection based on a decision of the German Bundestag

Ministry for Foreign Affairs of Finland

NORWEGIAN MINISTRY OF CLIMATE AND ENVIRONMENT

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