ECONOMIC, SOCIO-DEMOGRAPHIC AND ENVIRONMENTAL ANALYSIS OF FOOD LOSS/ WASTE (FLW) IN INDONESIA

NELI NURHASANAH

Master of Applied Economics, Padjadjaran University, Indonesia
Email: neli.nurhasanah@gmail.com

Abstract - Food loss/ waste (FLW) has become a global issue and concern due to its influences and linkages with food security, economic performance, and environmental sustainability. As the second largest contributor to food waste in the world, each person in Indonesia is estimated to produce 300 kg of FLW per capita per year. This study aims to analyze the economic, socio- demographic, and environmental aspects of food loss/ waste (FLW) in Indonesia. The research method used is quantitative research using panel data regression analysis and Environmental Input-Output (EIO) analysis. The results showed that GDP per capita and the percentage of households with home ownership had a negative and insignificant effect, the population had a negative and significant effect, and the percentage of households with contract home ownership had a positive and insignificant effect on food waste in Indonesia. The accommodation and food supply sector is the sixth largest contributor to emissions in Indonesia at 44,308 tons while the water supply, waste management, and recycling sector contributes 3,032 tons of emissions change.

Keywords - Food Loss, Food Waste, Environmental IO, EEIO, Economic-Social Demographics, SDGs

I. INTRODUCTION

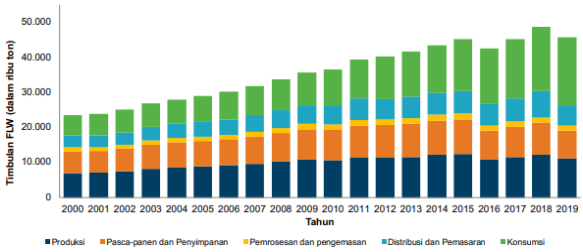
Food loss and food waste (FLW) have become important topics in sustainabledevelopment. Over the past few decades, the issue of food loss and waste has received increased attention from scientists and policymakers due to its magnitude and linkages to food security, nutrition, and environmental sustainability (Bravi et al., 2020).

The UN included the issue of food loss and waste in its Sustainable Development Goals target 12.3, which aims to halve global food waste per capita at the retail andconsumption levels and reduce food loss alongthe production and supply chain.

With the global population expected to grow by 3 billion in the next 30 years (World Bank, 2020), actors across the food supply chain will face increasing pressure to meet demand (Chen, Chaudhary, & Mathys, 2020). FLW is a significant and growing challenge due to a growing world population and increasing need for sufficient and healthy food. While total food production exceeds total demand (Messner, Johnson, & Richards, 2021), distribution is uneven and many people lack access to sufficient food and face hunger while others' habits are wasteful (FAO, 2019; Movilla Pateiro, Mahou-Lago, Doval, & Simal- Gandara, 2021).

Indonesia is one of the most populous countries in the world. Indonesia is ranked 4th in the world after China, India, and America. About one-third of the edible portion of food produced for human consumption is lost orwasted globally, which is about 1.3 billion tons per year (Khoerunisa & Noorikhsan, 2021). Indonesia is the second largest contributor to food waste in the world (Stephen et al., 2019). Food loss and waste have a significant impact on human life, including causing hunger. According to the Global Hunger Index, the level of hunger in Indonesia is at a serious level, where many people are starving out there, while those of us who are well-off (lots of food) are not spent and like to waste food (Hendriadi & Ariani, 2020). Based on data from Indonesia's Ministry of Environment and Forestry (KLHK), in 2018 as much as 44 percent of waste generation in Indonesia was food waste.

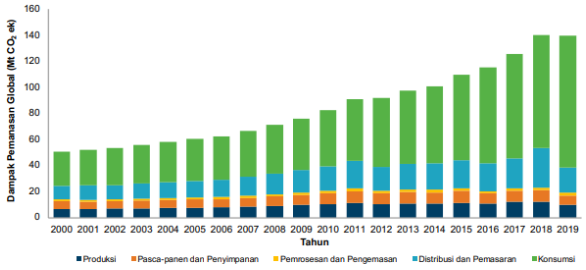
Indonesia is also claimed to be the second largest FLW producer in the world, estimated at 300 kg per capita per year. FLW generation in Indonesia in 2000 - 2019 was 23-48 million tons/year, or equivalent to 115- 184 kg/capita/year. However, Indonesia does not yet have comprehensive information and strategies on FLW, especially at the national level.



Source: Bappenas

Fig1. Indonesia's Food Loss and Waste Generation 2000 - 2019 per Stage of the Food Supply Chain (in thousand tons)

FLW arising at the longer stages of the supply chain will have a larger emission burden than FLW arising at the earlier stages. This is because the emission load at the end- of-life stage of the supply chain includes the emission load from the previous stages.



Source: Bappenas

Fig 2. Contribution of 5 Stages of the Food Supply Chain to Total FLW GHG Emissions per Year 2000-2019

With average emissions of 2,324.24 kg CO2-ek/1 ton FLW, the total potential global warming impact of FLW in Indonesia over the past 20 years is estimated at 1,702.9 Mton CO2- ek, equivalent to 7.29 percent of Indonesia's average GHG emissions over 20 years. The largest contributor to global warming impacts over 20 years is 2018, while the largest global warming impact in the 5 stages of the supply chain is the consumption stage.



Source: Bappenas

Fig 3. Comparison of FLW Percentage toEconomic Loss in the 5 Food Sectors

The amount of FLW in Indonesia from 2000 to 2019, which reached 23-48 million tons/year, resulted in an economic loss of 213- 551 trillion rupiah/year or equivalent to 4-5 percent of Indonesia's GDP/year. There is a possibility that the potential economic loss is greater because the data used in calculating economic loss uses available food price data, namely 64-88 commodities out of a total of 146 commodities contained in the NBM. Several previous studies have been conducted to enrich the understanding of FLW during this research. So far, there are not many studies that discuss food waste policy and food security, at least in Indonesia. Previous research has mostly emphasized understanding what FLW is, its causes, and the impacts it can have.

From several research journals that have been mentioned, it can be seen that there are still few studies that specifically discuss the economic and environmental impacts of food loss/waste in Indonesia. Thus, it can be concluded that the research to be carried out is relatively new and has not been carried out by many previous researchers. As an effort to show the novelty between this research and previous research, the researcher applies Environmentally Extended Input Output (EEIO) as an analytical method in addition to using panel data regression analysis.

Based on the background and identification of the problems described above, this research seeks to answer the research question, namely "What is the description of the economic, socio-demographic, and environmental aspects of food loss/waste (FLW) in Indonesia". Thus, the objectives achieved in this study are to analyze the economic, socio-demographic, and environmental aspects of food loss/waste (FLW) in Indonesia.

II. LITERATURE REVIEW

Food loss/waste (FLW) occurs at various stages of the food supply chain with 30% of the world's total food production wasted or lost for various reasons (World Bank, 2020). Several definitions have been given in the scientific literature for food loss or food waste (Goodman-Smith et al., 2020; Gustavsson et al., 2011; Principato et al., 2019; Teigiserova et al., 2020). The most common definitions of these terms indicate differences related to the stages of the food supply chain at which they occur: agricultural production, post-harvest activities, processing and manufacturing, retail and wholesale, consumption, and services. Most often, food loss is defined as a decrease in the quantity or quality of edible food before consumption, including post-harvest losses (FAO, 2014a), while food waste is defined as food originally produced for human consumption that is discarded or not consumed by humans (IFPRI, 2016). (IFPRI, 2016).

The issue of food waste is recognized inthe context of the UN 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs). In particular, Goal 2 "Zero Hunger" aims to end hunger, achieve food security, and improve nutrition while promoting sustainable agriculture. Goal 12 "Ensure sustainable consumption and production patterns" includes ambitious goals and targets, among them target 12.3 related to the need "to halve global food waste per capita at retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses", target 12.4 relates to the "environmentally sound management of chemicals and all wastes throughout their life cycle, following agreed international frameworks", and target 12.5highlights the need to "substantially reduce waste production through prevention, reduction, recycling, and reuse" (UN, 2020; FAO, 2020).

FLW results in the loss of resources, energy, and time invested in food production (Krishnan, Agarwal, Bajada, & Arshinder, 2020). FLW can cause food prices to rise (due to reduced supply),

ultimately preventing access to affordable food (Shafiee-Jood & Cai, 2016). FLW is also a major cause of greenhouse gas (GHG) emissions (Schanes, Dobernig, & Gozet, 2018) stemming from the decomposition of food in landfills and the unnecessary emissions generated in growing, transporting, and selling food that is ultimately wasted.

Food waste is becoming a global issue as about one-third of all food produced worldwide for human consumption is wasted each year along the food supply chain while a large number of people (about 822 million people) still do not have enough to eat. Food waste is a critical issue, especially in developed countries where individual and household food waste propensity is much higher compared to developing countries (Lemaire and Limbourg, 2019; Principato etal., 2019).

Reducing food loss and waste is urgently needed to improve the sustainability of food systems from environmental, socio- economic, ethical, and human health standpoints (Lemaire and Limbourg, 2019; Gobel et al., 2015). Reducing food waste can greatly affect the degradation and depletion of natural capital stocks, climate change, food insecurity, and national security (Buonocore et al., 2018).

From an environmental perspective, food waste incurs environmental costs and impacts. Massive resource flows (e.g., water, fossil fuels, chemicals) are used to produce, transport, process, store, and preserve food along the food supply chain (Skaf et al., 2019). In addition, each stage of the food supply chain also generates substantial emissions and local and global environmental impacts(Read et al., 2020).

Food loss and food wastage imply direct and indirect losses of embodied resources previously used in the food supply chain and also give rise to environmental impacts. Reducing food loss and waste at individual, national, and global scales is therefore necessary to maintain food system impacts within safe environmental boundaries (Willett et al., 2019; Springmann et al., 2018).

According to Muth et al. (2019), despite the growing number of studies identifying food loss and waste reduction as a societal issue, more efforts are needed to assess the effectiveness of interventions along the food supply chain. This aspect was also highlighted by Gobel et al. (2015) who stated that the evaluation and management of food waste should consider indicators of resource consumption and environmental impacts associated with the upstream chain.

In this context, Read et al. (2020) assessed the environmental impact of halving food loss and waste along the US food supply chain using an Environmentally Extended Input Output (EEIO) model with environmental aspects combined with data on food loss and waste rates. Muth et al. (2019) evaluated the environmental and economic impacts of interventions that prevent or reduce food loss and waste at all stages of the food system from farm to consumer in the United States, combining life cycle assessment (LCA) and environmentally extended input-output (EEIO) models.

III. DATA AND METHODOLOGY

The method used in this research is quantitative analysis using Ordinary Least Square (OLS) regression analysis and Environmental Input-Output analysis. This research combines time series data over a period of 4 years (2019-2020) and cross- section data from 34 provinces in Indonesia. Thus, the data analysis used in this study is panel data regression analysis with the Random Effect Model method (based on the Chow Test, Hausman Test, and Lagrange Multiplier Test).

The estimation is done by the Ordinary Least Square (OLS) method according to the following equation:
$\ln Y_{it} = \beta 0_{it} + \beta 1 \ln X1_{it} + \beta 2 \ln X2_{it} + \beta 3 X3_{it} + \beta 4 X4_{it} + \mu_{it}$

The equation used in this study uses the variable of food waste generation as the dependent variable and the variables of Gross Domestic Product (GDP) per capita, population, percentage of households with own home ownership status, and percentage of households with contract home ownership status as independent variables. The model isas follows:

$\text{Ln Food Waste}_{it} = \beta 0_{it} + \beta 1 \ln \text{GDP_Per_Capita}_{it} + \beta 2 \ln \text{Total_Population}_{it} + \beta 3 \text{Own_Home}_{it} + \beta 4 \text{Contract}_t + \mu_{it}$

Description:
ln = Natural logarithm
Food Waste = Food wastegeneration
GDP Per Capita = Gross DomesticProduct (2010 = 100)

Total Population = Number of residents
Own Home = Percentage of households with ownhome ownershipstatus
Contract = Percentage ofhouseholds with contracted homeownership status
μ_{it} = Residual or errorterm
$\beta 0$ = Constant
$\beta 1, \beta 2, \beta 3, \beta 4$ = Regressioncoefficient
I = Cross-section units(provinces in Indonesia)
T = Year studied

Another method used in the research is Input-Output (IO) analysis which describes the reciprocal and interrelated relationship between one sector and

another in economic activities in a region or country at a certain period. The input-output data in this study uses the 2016 Indonesian Input-Output table. This is based on the assumption that changes in economic structure and the use of technology by economic sectors in the process of producing goods and services are implemented in an open economy.

To measure environmental impacts, the Input-Output table is modified into an Environmental Input-Output (Environmental IO) table by adding environmental variables through an approach or proxy for emission levels, namely the sum of CO, CO2, CH4, Sox, NH3, and NMVOC in tons to produce information about the amount of emissions that come out of changes in economic activity. Due to limited Environmental IO data in Indonesia, this study adopted the Environmental IO Table from the author Dahlia Novista, et al (2019) as follows:

Sector	GDP and Emissions Changes		
	Shock	ΔPDB (Rp)	ΔEmissions (Tons)
Agriculture, Forestry and Fisheries	-	6696	64529
Mining and Quarrying	-	5315	2429
Processing Industry	-	28797	45721
Electricity and Gas Procurement	2611	5658	44955
Water Supply, Waste Management, Waste and Recycling	-	93	3032
Construction	56641	57511	58617
Wholesale and Retail Trade; Repair and Maintenance of Automobiles and Motorcycles	-	7674	1359
Transportation and Warehousing	-	2805	66535
Provision of Accommodation and Drinking Meals	14165	14867	44138
Information and Communication	-	1328	118
Financial and Insurance Services	-	1455	22
Real Estate	-	179	30
Company Services	-	1182	108
Government Administration, Defense and Compulsory Social Security	-	344	38
Education Services	-	51	8
Health and Social Services	-	87	11
Other Services	-	85	1480
Total		134127	344929

Table 1. Simulation of Indonesia's Environmental Input-Output in 2016

Source: Dahlia Novista, et al (2019

This Environmental IO analysis is also limited to the water supply, waste management, waste and recycling sector, and the accommodation and food and beverage sector, which are the sectors that contribute the most to food waste generation. The calculation of economic impact is done by adding the monetary or rupiah value of final demand according to the economic growth trend of sectors in the economy.

IV. RESULT AND DISCUSSION

The estimation results regarding the influence of socioeconomic indicators on food waste generation in Indonesia using Eviews 17are as follows:

Dependent Variable: LOG(FOOD_WASTE)
Method: Panel EGLS (Cross-section random effects)
Sample: 2019 2022
Periods included: 4
Cross-sections included: 34
Total panel (balanced) observations: 136
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	15.33856	5.395320	2.842939	0.0052
LOG(GDP_PER_CAPITA)	-0.046870	0.366791	-0.127785	0.8985
LOG(TOTAL_POPULATION)	-0.209307	0.093175	-2.246382	0.0264
OWN_HOME	-0.018542	0.038970	-0.475793	0.6350
CONTRACT	0.030366	0.047697	0.636650	0.5255

Effects Specification	S.D.	Rho
Cross-section random	1.155501	0.8518
Idiosyncratic random	0.481907	0.1482

Weighted Statistics

Root MSE	0.503123	R-squared	0.070086
Mean dependent var	2.421624	Adjusted R-squared	0.041692
S.D. dependent var	0.523667	S.E. of regression	0.512635
Sum squared resid	34.42604	F-statistic	2.468311
Durbin-Watson stat	1.498893	Prob(F-statistic)	0.047914

Unweighted Statistics

R-squared	-0.056459	Mean dependent var	11.86278
Sum squared resid	274.1702	Durbin-Watson stat	0.188208

From the estimation results above, the regression equation is obtained as follows: as follows:
$\ln Food_Waste_{it} = \beta 0_{it} + \beta 1 \ln GDP_Per_Capita_{it} + \beta 2 \ln Total_Population_{it}$

+ β3Own_Homeit + β4Contractit +µit ln Food_Wasteit = 15.34 - 0.05lnGDP_Per_Capitait - 0.21lnTotal_Populationit - 0.02Own_Homeit +0,03Contractit +µit

Based on the research model above, it can be interpreted that GDP Per Capita has a negative influence on food waste with a coefficient of 0.05. This indicates that every 1% increase in GDP per capita will reduce food waste by 0.05% (ceteris paribus assumption). By paying attention to the Prob. (p-value) of t-statistics of 0.90 more than 0.05 (significance level), it can be concluded that GDP Per Capita has no significant effect on food waste.

The same condition is also shown by the total population variable and the variable percentage of households with home ownership, which have a negative influence on food waste with coefficients of 0.21 and 0.02, respectively. This means that a 1% increase in population will reduce food waste by 0.21% and a 1% increase in the percentage of households with home ownership will reduce food waste by 0.02% (ceteris paribus assumption). Taking into account that the Prob. (p-value) of the t-statistics of the population of 0.03 is less than 0.05 (significance level) and the Prob. (p-value) of the t-statistics of the percentage of households with home ownership of 0.63 is more than 0.05 (significance level), it can be concluded that population has a significant effect while the percentage of households with home ownership has no significant effect on food waste in Indonesia.

The variable of the percentage of households with contract house ownership has a positive relationship with Indonesian food waste with a coefficient of 0.03. This means that an increase in the percentage of households with contract house ownership by 1% will increase food waste GDP by 0.03% (assuming ceteris paribus). Taking into account the Prob. (p-value) of the t-statistics of 0.52 more than 0.05 (significance level), it can be concluded that the percentage of households with contract housing ownership does not have a significant effect on Indonesia's food waste. Based on the results of the IO Environment simulation in Table 1, the economy increases by considering changes in final demand in the sectors that have the largest multipliers, and the increase in GDP is assumed by calculating the average GDP over the last three years. The accommodation and food supply sector has the second largest multiplier where the economy increases by 14.165 trillion rupiah. Changes in the accommodation and food services sector and the other two sectors with the largest multipliers can increase GDP by 134,126 billion rupiah.

By sector or business field, the largest change in the Economic Growth Rate (LPE) came from the electricity and gas procurement sector at 5.66 percent. Then, followed by the construction sector and the provision of food and beverage accommodation in second and third place with LPE values of 6.22 percent and 5.26 percent respectively.

In terms of emission changes, the water supply, waste management, waste, and recycling sectors contributed to 3,032 tons of emission changes. Meanwhile, the accommodation and food supply sector was the sixth largest contributor in Indonesia at 44,138 tons.

V. CONCLUSION

Based on the discussion and analysis conducted in this study, the following conclusions can be drawn:

- GDP per capita and the percentage of households with home ownership during the 2019-2022 period had a negative and insignificant influence on food waste generation in 34 provinces in Indonesia
- Population during the 2019-2022 period has a negative and significant influence on food waste generation in 34 provinces in Indonesia.
- The percentage of households with rented housing during the 2019-2022 period has a positive and insignificant effect on food waste generation in 34 provinces in Indonesia.
- The provision of accommodation and food and beverages sector has the second largest multiplier where the economy increased by IDR 14,165 trillion.
- The accommodation and food supply sector was the sixth largest contributor to Indonesia's emissions at 44,138 tons while the water supply, waste management, waste, and recycling sector contributed 3,032 tons of emissions change.

FUNDING

This work was supported by the Indonesian Endowment Fund for Education (LPDP) under funding received from the Ministry of Finance of the Republic of Indonesia.

REFERENCE

[1] Badan Perencanaan dan Pembangunan Nasional. 2020. SDGs Dashboard.Retrieved from
[2] http://sdgs.bappenas.go.id/dashboard. Bravi, L., Francioni, B., Murmura, F., Savelli,
[3] E., 2020. Factors affecting household food waste among young consumers and actions to prevent it. A comparison among UK, Spain and Italy. Resources. Conserv. Recycle. 153.
[4] Buonocore, E., Picone, F., Russo, G.F., Franzese, P.P., 2018. The scientific research on natural capital: a bibliometric network analysis. Journal of Environmental Accounting and Management 6 (4), 374–384.
[5] Chen, C., Chaudhary, A., & Mathys, A. (2020). Nutritional and environmental losses embedded in global food waste. Resources, Conservation and Recycling, 160, Article 104912.
[6] Food and Agriculture Organization (2019). TheState of Food and Agriculture Organization of the United Nations: Moving Forward on Food Loss and Waste Reduction. Retrieved from http://www.fao.org/3/ca6030en/ca6030e n.pdf/.

[7] FAO, 2020. Sustainable Development Goals.
[8] Food and Agriculture Organization. Rome-Italy. http://www.fao.org/sustainable- development-goals/indicators/1231/en/
[9] Gobel, C., Langen, N., Blumenthal, A., Teitscheid, P., Ritter, G., 2015. Cutting food waste through cooperation along the food supply chain. Sustainability 7, 1429–1445.
[10] Goodman-Smith, F., Mirosa, M., Skeaff, S., 2020. A mixed-methods study of retail food waste in New Zealand. Food Pol.
[11] Gustavsson, J., Cederberg, C., Sonesson, U., Emanuelsson, A., 2013. The Methodology of the FAO Study: Global Food Losses and Food Waste- Extent, Causes and Prevention"- FAO, 2011. SIK Report No. 857. The Swedish Institute for Food and Biotechnology (SIK), Gothenburg, Sweden.
[12] Hendriadi, A., & Ariani, M. (2020). Pengentasan Rumah Tangga Rawan Pangan dan Gizi: Besaran, Penyebab, Dampak, dan Kebijakan. Forum Penelitian Agro Ekonomi, 38(1), 13.
[13] IFPRI, 2016. 2016 Global Food Policy Report. https://doi.org/10.2499/9780896295827. Washington, DC.
[14] Kementerian Lingkungan Hidup dan Kehutanan (KLHK) Indonesia. Laporan berbagai edisi.
[15] Khoerunisa, N., & Noorikhsan, F. F. (2021). Perbandingan Tata Kelola Penanganan Pandemi Covid 19 di Indonesia dan India. Journal of Political Issues, 2(2), 89– 101.
[16] Krishnan, R., Agarwal, R., Bajada, C., & Arshinder, K. (2020). Redesigning a food supply chain for environmental sustainability – An analysis of resource use and recovery. Journal of CleanerProduction, 242, Article 118374.
[17] Lemaire, A., Limbourg, S., 2019. How can foodloss and waste management achieve sustainable development goals? Journalof Cleaner Production. 234, 1221–1234.
[18] Messner, R., Johnson, H., & Richards, C. (2021). From surplus-to-waste: A study of systemic overproduction, surplus, andfood waste in horticultural supply chains.Journal of Cleaner Production, 278, Article 123952.
[19] Movilla-Pateiro, L., Mahou-Lago, X. M., Doval,
[20] M. I., & Simal-Gandara, J. 2021. Towarda sustainable metric and indicators for the goal of sustainability in agricultural and food production. Critical Reviews in Food Science and Nutrition, 61(7), 1108–1129.
[21] Muth, M., Birney, C., Cuellar, A., Finn, S., Freeman, M., Galloway, J., Gee, I., Gephart, J., Jones, K., Low, L., Meyer,
[22] E., Read, Q., Smith, T., Weitz, K., Zoubek, S., 2019. A systems approach to assessing environmental and economic effects of food loss and waste interventions in the United States. Sci. Total Environ. 685, 1240–1254.
[23] Novista, Dahlia., Yuhka Sundaya, Ade Yunita Mafruhat. 2019. Analisis Pertumbuhan Ekonomi dan Kualitas Lingkungan di Indonesia. Prosiding Imu Ekonomi, 111-117.
[24] Principato, L., Ruini, L., Guidi, M., Secondi, L., 2019. Adopting the circular approach to food loss and waste: the case of Italian pasta production. Resour. Conserv. Recycle. 144, 82–89.
[25] Read, Q., Brown, S., Cuellar, A., Finn, S., Gephart, J., Marston, L., Meyer, E., Weitz, K., Muth, M., 2020. Assessing the environmental impacts of halving food loss and waste along the food supply chain. Sci. Total Environ. 712
[26] Schanes, K., Dobernig, K., & Gozet, ¨ B. (2018). Food waste matters - A systematic review of household food waste practices and their policy implications. Journal of Cleaner Production, 182, 978–991.
[27] Shafiee-Jood, M., & Cai, X. (2016). Reducing Food Loss and Waste to Enhance Food Security and Environmental Sustainability. Environmental Science & Technology, 50 (16), 8432–8443.
[28] Skaf, P.P. Franzese, R. Capone, E. Buonocore. 2021. Unfolding hidden environmental impacts of food waste: An assessment for fifteen countries of the world. Journal of Cleaner Production310, Article 127523.
[29] Stephen, S., Raymond, R., & Santoso, H. (2019). Aplikasi Convolution Neural Network Untuk Mendeteksi Jenis-jenis Sampah. Jurnal Sistem Informasi Dan Telematika (Telekomunikasi, MultimediaDan Informatika), 122–130.
[30] UN, 2020. Sustainable Development Goal 12: Ensure Sustainable Consumption and Production Patterns. United Nations Sustainable Development Goals Knowledge Platform, New York-USA. https://sustainabledevelopment.un.org/sdg12.
[31] World Bank (2020). Addressing Food Loss and Waste: A Global Problem with Local Solutions.Retrievedfromhttps://openknowledge.worldbank.org/bitstream/handle/ 10986/34521/Addressing-Food-Loss- and-Waste-A-Global-Problem-with- Local-Solutions.pdf? sequence=1&isAllowed=y/.

★★★