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UTILIZATION OF AGRICULTURAL WASTE FOR SUSTAINABLE FOOD PRODUCTION IN INDONESIA

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ABSTRACT

The production of agricultural products must continuously increase to keep pace with the increasing global demand for food. The increased production of agricultural products will consequently increase the volume of agricultural waste, which include agricultural residue and by-products. Unfortunately, the agricultural wastes have not been utilized widely and optimally. Bioeconomy offers a solution in utilizing these agricultural wastes to produce various bio-based products that can generate added value, provide employment opportunities, and at the same time overcome environmental problems. Bioeconomy covers all economic sectors that rely on biological resources, from primary production (crops, livestock, forestry, fishery and aquaculture) to related processing and service industries (food, feed, paper, textiles, chemicals and pharmaceuticals, energy). Currently, more than 60 countries have dedicated bioeconomy strategies in achieving more sustainable natural resource management. Agri-food systems have great transformational potential since these occupy the biggest share of the bioeconomy from an economic added-value perspective. Indonesia is a large agricultural country that results in various agricultural products and waste that can be processed biologically to produce various bio-based products: food, feed, fiber, and fuel, and create jobs, added value, and at the same time maintain environmental conditions. There is no denying that the industrialization of agricultural products and the accompanying agricultural waste by implementing bioeconomy model is a necessity for Indonesia. The purpose of this paper is to explain the rationality of implementing the bioeconomy strategy in Indonesia in processing the main product and waste, particularly oil palm, to produce a variety of intermediate and final goods that are useful in meeting food demands. To achieve this goal, this paper will reveal various problems related to the utilization of oil palm commodity and waste, as well as discuss various policies that need to be developed to support this goal.

Keywords: circular economy and bioeconomy, added value, oil palm,

INTRODUCTION

Agricultural production has increased significantly by more than threefold in the last five decades due to the expansion of agricultural land use, developments in agricultural technology, and accelerated population growth (FAO 2017). However, agricultural production in the future is faced with increasingly greater problems and constraints, considering that available resources are increasingly limited and the impact of climate change is intensifying, so that each unit of agricultural product must be able to be produced with fewer and fewer resources.

Increasing agricultural production, both from plants, animals, and fisheries, will also increase the amount of agricultural waste produced, which includes agricultural residue and agro-industrial waste. These agricultural wastes have great potential economic value considering that agricultural wastes are a valuable raw material that can be used in the agricultural sector itself, for example in the form of manure, or outside the agricultural sector (industry) to produce various processed products (Agapkin et al. 2022). Unfortunately, this agricultural waste has not been optimally utilized, especially in developing countries. When this waste is not managed properly, it will create various environmental problems, such as contamination of soil, surface, and ground water, and contributing to air pollution, with subsequent influences population health and the sustainability of ecosystems put at risk.

Agriculture is one of the largest biological sectors with the highest biomass production (European Commission 2015), which becomes an essential input for the bioeconomy (EC 2012). This represents a great opportunity, not only because its use and exploitation favors the reduction of fossil fuel use and greenhouse gas emissions (McCormick and Kautto 2013), but also because it contributes to the development of new green markets and jobs by promoting the conversion of agricultural waste into value-added products, such as food, feed, bioproducts and bioenergy (EC 2017; EU 2013).

Production of agricultural products in Indonesia increases continuously, and this increase proportionately to the amount of agricultural waste. Agricultural waste is the residue and by-products generated from farming activities that are not utilized for commercial purposes. It includes crop residues, livestock waste, agrochemical waste, food processing waste, and by-products. These are renewable resources that can be used to produce various bio-based products. Agricultural products and waste can be transformed into valuable resources, mitigating environmental impacts, and fostering a more sustainable agricultural sector. Unfortunately, this agricultural waste has not been utilized optimally. Thus, industrialization of agricultural products and the accompanying agricultural waste by implementing bioeconomy methods is a necessity for Indonesia.

There are many important agricultural commodities produced in Indonesia: food crops, plantation, horticulture, and others, as presented in the Table 1. Among those commodities, there are some highly important commodities, including (in 2021): rice (total production 55.42 million tons), palm oil (46.22 million tons), corn (23.04 million tons), cassava (15.73 million tons), and sugar cane (2.42 million tons). Even though these commodities are produced in large quantities, Indonesian farmers earn relatively low incomes, since they receive only the value of the main products: rice, corn, palm fruit bunches, sugar cane, coconut, and others; while the waste remains unutilized and pollutes the environment. This raises several questions: Why did this happen? What factors determining this condition? Is agricultural residue and by-product processing not feasible economically? Do human resources have no (limited) capacity and technology to process the waste? Will waste utilization improve food production and security? This research will not be able to answer all the above research questions. The main objectives of this paper are as follows: (1) to identify the potential utilization of crop residue and by-product for food production and their economic, social, and environmental impacts; and (2) to suggest the improvement programs for agricultural waste management by implementing bioeconomy model in Indonesia. Among various important commodities produced in Indonesia (as presented in Table 1), this article will discuss only oil palm commodity which has important role in Indonesia's social economy.

Table 1. Planting Area and Production of Food Crops and Plantation in Indonesia, 2019-2021

	Planting Area (000 Hectares)			Production (000 Tons)		
	2019	2020	2021	2019	2020	2021
Food Crops:						
Rice	11,060.58	11,173.41	10,784.96	54,604.03	54,649.20	54,415.29
Corn	4,089.48	4,109.00	4,148.57	22,586.21	22,920.00	23,042.77
Soybean	302.78	189.14	142.04	285.27	182.07	134.69
Groundnut	337.54	347.55	286.42	332.88	324.34	302.25
Sweet potato	80.05	79.39	67.93	1,515.74	1,604.18	1,424.15
Mungbean	168.02	187.82	189.30	195.84	222.63	211.18
Cassava	653.24	722.06	601.57	13,424.24	16,271.02	15,730.97
Plantation:						
Oil Palm	14,456.60	14,858.30	14,663.60	47,120.20	48,296.90	46,223.30
Coconut	3,401.90	3,396.80	3,374.60	2,839.90	2,811.90	2,853.30
Rubber	3,675.90	3,681.30	3,776.30	3,301.60	2,884.60	3,121.30
Coffee	1,245.20	1,242.80	1,258.80	752.50	753.90	774.60
Cacao	1,560.70	1,528.40	1,478.00	734.70	713.40	706.50
Sugar cane	413.12	420.70	444.80	2,227.00	2,130.70	2,418.40
Tea	111.10	112.70	105.50	129.90	127.90	145.10

Sources: BPS Indonesia, http://www.bps.go.id/ Various sources and years (2020, 2022, 2023)

AGRICULTURAL WASTE, CIRCULAR ECONOMY, AND BIOECONOMY

Agricultural waste has become increasingly crucial for the Asia and Pacific region. The World Bank (2018) reported that this region generated 468 million tons of waste in 2016, with 53% of this being organic, especially from the food industry. However, despite this high amount of generated waste, most of these wastes are immediately disposed of to the landfill or incinerated. As the waste is immediately disposed of, the failure to gain economic value from the by-products is inevitable and might cause economic loss.

Agricultural waste processing transforms our economic system from linear economy to circular economy. Circular economy is an economic system in which the wastes of one process are not discarded directly, but, instead, become the resources for other means (Pearce and Turner 1989; Ellen MacArthur Foundation 2013). Further, Geissdoerfer et al. (2017) defined circular economy as "an economic system aimed at eliminating waste and ensuring the continual use of resources, through reuse, sharing, repair, refurbishment, remanufacturing and recycling to create a closed-loop system, minimizing the use of resource inputs and reducing the creation of waste, pollution and carbon emission". Implementation of the circular economy is important in improving the efficiency in the supply chain process and increasing the performance of waste management. The circular economy delineates a closed-loop system in which the resources remain in the loop, enabling them to be sustainable by prolonged waste into new value (McDonough and Braungart 2002). Circular economy turns waste streams into worth. Circular economy application is commonly found in agri-food sectors, as the problems that have tried to be solved by the circular economy are embedded and have systemic relevancy. Agricultural waste can be turned into bio-products such as fertilizers, energy, materials and compounds (McCarthy et al. 2019).

The agri-food supply chain is pivotal in terms of the production process of staple products. The implementation of circular economy in this supply chain has the final goal of sustainability, in which the whole food supply chain system would be able to provide for itself due to the diversity of processes contained within the system (Nattassha 2020). Thus, circular economy represents a pivotal shift from conventional (linear) agricultural practices toward a holistic and sustainable approach that aligns with the goal of global sustainability. This paradigm offers a comprehensive solution to the challenges posed by climate change, environmental degradation, and resource scarcity (Sirisha 2023).

The Bioeconomy concept was proposed in the Global Bioeconomy Summit in 2018. Bioeconomy is defined as the production, utilization, conservation, and regeneration of biological resources, including related knowledge, science, technology, and innovation, to provide sustainable solutions (information, products, processes and services) within and across all economic sectors and enable a transformation to a sustainable economy (Global Bioeconomy Summit Communiqué 2020). Bioeconomy aims to drive both sustainable development and circularity. In particular, the principles of the circular economy are a fundamental part of the bioeconomy. Through reuse, repair and recycling, the total amount of waste and its impact is reduced. It also saves energy, minimizes pollution of soil, air, and water, thus helping to prevent damage to the environment, climate, and biodiversity[1].

Currently, more than 60 countries and regions have bioeconomy or bioscience-related strategies which, among objectives such as increasing food and energy security, supporting livelihoods and incomes, and fostering innovations, contribute to their efforts to meet their nationally determined contributions to cut GHG emissions and adapt to climate change (Gomez et al. 2023). Policymakers should pay urgent attention to how the bioeconomy could shape the climate path going forward. The resource efficient circular bioeconomy alone is projected to reach a value of USD 7.7 trillion in 2030 (FAO 2023), and it is important that the right structures are put in place at all levels so that bioeconomy development supports climate action and the achievement of the SDGs.

In the European Union, bioeconomy strategy aimed to ensure food and nutrition security, manage our natural resources sustainably, reduce the dependence on non-renewable and unsustainable resources, mitigate and adapt to climate change, and create jobs across Europe. Though there are many variant concepts of bioeconomy: circular economy, bio-circular-green economy, green economy, or other, the bioeconomy concept offers opportunities and solutions in overcoming economic, social, and environmental problems and challenges, such as unemployment, climate change, food and energy security, and resource efficiency by utilizing technology and innovation.

Agrifood systems account for the largest share of the global bioeconomy and thus have enormous potential to bring about transformative solutions to many sustainable development challenges (FAO 2023). Biological resources are renewable – if we look after them, we can ensure many other co-benefits including climate change mitigation, biodiversity conservation, ecosystem restoration, clean air, water provision, energy and food security. This requires extracting the maximum value from biological resources through their whole life cycle.

The bioeconomy's cross-cutting nature offers a unique opportunity to comprehensively address inter-connected societal challenges such as food security, natural resource scarcity, fossil resource dependence and climate change, while achieving sustainable economic growth (European Commission 2012). Ensuring food security is a very important contribution of the bioeconomy since global population growth by 2050 is estimated to lead to a 70% increase in food demand. The Bioeconomy Strategy will contribute to a global approach in meeting this challenge by developing the knowledgebase for a sustainable increase in food demand, considering all options from cutting-edge science to local and tacit knowledge.

[1] Iberdrola, https://www.iberdrola.com/sustainability/circular-economy).

**SUSTAINABLE MANAGEMENT OF AGRICULTURAL WASTE:
PALM OIL INDUSTRY IN INDONESIA**

Oil palm (*Elaeis guineensis*) is one important commodity in Indonesia that has been processed into various products which have important economic contribution, particularly in terms of value added and labor absorption. Currently, the palm oil industry is a major component of contemporary global agriculture, supplying food to billions of people, plus a host of non-food products (Murphy et al. 2021). Indonesia and Malaysia are by far the largest producers of oil palm, with the highest productivity per hectare. The two neighboring countries are the largest exporters of its derived products (85% of global palm oil production). Oil palm is a very productive crop: it produces 36% of the world's oil but uses less than 9% of croplands devoted to oil production.

Palm oil industry produces large quantities of biomass by-products (up to almost 5 times the weight of oil production) which are hardly used for adding value to the production chain (Elbersen et al. 2005). Enhancing the sustainability of the palm oil production chain can be achieved by fully exploiting the abundantly available biomass wastes (including shells, fiber, press cake, empty fruit bunches, palm fronts, and others) as renewable resources in added value products. Currently only part of the waste is used as a fuel feedstock in plant operations (van Dam 2009).

Sustainable management of agricultural waste involves various approaches: waste reduction and reuse, biogas, and bioenergy production through anaerobic digestion, composting for organic fertilizers, recycling, and proper disposal of agrochemical waste, raising public awareness about best practices.

Circular economy and bioeconomy approaches consistently increased focus on industrial practices to recover these resources as value-add materials. Waste valorization (waste reclamation) is the process of waste products or residues from an economic process being valorized (given economic value), by reuse or recycling to create economically useful materials. Waste valorization into economically viable food products is supported by the concept of a circular bioeconomy.

Palm oil industry in Indonesia. Palm oil is a versatile product which is used in a range of products across the world: (i) Food: over two-thirds (68%) is used in foods ranging from margarine to chocolate, pizzas, breads and cooking oils; (ii) Industrial applications: 27% is used in industrial applications and consumer products such as soaps, detergents, cosmetics and cleaning agents; (iii) Bioenergy: 5% is used as biofuels for transport, electricity or heat.

Oil palm produces various wastes, in the form of residue and by-products, which can be used to produce various new products with high economic value. Apart from increasing the economic value of the product, palm oil waste is processed to achieve zero waste, thereby reducing negative impacts on the environment. The goal is to promote a globally competitive and sustainable industry. The Zero Waste Strategy is usually implemented to optimize the utilization of oil palm biomass such as empty fruit bunches, fronds, and trunks for field mulching; and for use in commercial products such as pulp and paper and medium density fiber board. The generation of by-products or co-products from the production of palm oil is unavoidable but these products need not be disposed of as waste if they are utilized effectively (Tan, 2006). There are many products that can be produced from palm oil waste, both in the form of residues and by-products. Palm oil by-products have been used extensively to produce palm oil derivative products, including oleofood, oleochemical and biofuel.

Indonesia currently is implementing the downstreaming palm-oil oleofood complex. This program processes crude palm oil or crude palm kernel oil into intermediate products. Then the processing/application continues to produce a final product (finished product) either for direct consumption or used as production input by the food industry (Sipayung 2024). The food group produced from palm oil processing consists of intermediate products, namely culinary oils/fats, bakery oils/fats, chocolate and confectionery fats, dairy fat alternatives, and functional oils/fats. Meanwhile, palm oil-based finished products which are also consumed in daily life include cooking oil, margarine, packaged chocolate, noodles, ice cream, biscuits, and milk for babies and toddlers. Apart from food products, the micronutrient/bioactive compounds contained in palm oil can also be used for health/pharmaceutical products (PASPI 2023). The aims of downstreaming of the oleofood complex are: (1) to produce palm-based food products, both intermediate products and finished products; (2) to produce palm-based food products to substitute food/pharmaceutical products that are still imported; (3) to produce palm-based food/pharmaceutical products with higher added value for export purposes; and (4) to increase the added value of palm-based food and pharmaceutical products enjoyed domestically (Sipayung 2024).

Currently, Indonesia still imports several food/pharmaceutical products that could have been produced domestically. For example, in food products, Indonesia imports cocoa butter products with a trend that continues to increase during the 2011-2022 period. This product is used by the food and beverage industry to produce chocolate products or food/drinks containing chocolate. Therefore, oleofood complex downstream strategies and policies should not only be oriented towards export promotion strategies, but also import substitution strategies and policies are needed which are expected to encourage the growth of the domestic oleofood complex industry to replace imported food/pharmaceutical products. To support this goal, the government must design export levies on finished products, which are lower than intermediate products and raw materials.

Derived palm oil products. Oil palm is by far the most important global oil crop, supplying about 40% of all traded vegetable oil, followed by soybean oil (28%) and canola oil (12%) (FAO 2023). Palm oils are key dietary components consumed daily by over three billion people, mostly in Asia, and have a wide range of important non-food uses including in cleansing and sanitizing products (Murphy et al. 2021).

Palm oil products are the most traded vegetable oil commodities in the global market. Tandra (2022) states that Indonesia and Malaysia are the two main exporters of palm oil with the highest competitiveness and export specialization. These two countries have developed various palm oil derivative products and exported them to various countries. In Indonesia, palm oil downstreaming that has been ongoing in Indonesia since 2011 can be grouped into three downstream pathways, namely: oleofood complex, oleochemical complex, and biofuel complex. Oleofood complex is industries that process refinery industry products to produce intermediate oleofood products and to finished oleofood products. Various oleofood products that have been produced in Indonesia include palm cooking oil, margarine, vitamin A, Vitamin E, shortening, ice cream, creamer, cocoa butter/specialty fat and others (GAPKI 2017).

Palm oil derivative products can be grouped based on the 6-digit code of the Harmonized System (HS). Indonesian oleofood products consist of 16 HS groups, while oleochemicals and biofuels consist of 32 and 2 HS groups, respectively. UN Comtrade (2022) data shows that exports of oleofood and oleochemicals from Indonesia and Malaysia are much higher than exports of biofuel products. Some examples of oleofood products include HS 151710 (margarine, excluding liquid margarine); HS151790 (edible mixture of preparation of animal, vegetable or microbial fats or oils), HS 180400 (cocoa; butter, fat, and oil), and others (GAPKI 2017).

A comparison of exports of palm oil derivative products (oleofood, oleochemical, and biofuel) and their raw materials (crude palm oil, refined palm oil and palm kernel) is presented in Figure 1. This shows the proportion of exports of derivative products from Indonesia and Malaysia was 27% and 36% respectively on average from 2013 until 2021. This comparison shows that Malaysia is relatively higher in exporting palm oil derivative products than Indonesia. The figure also shows that dependence on raw material exports in Malaysia is relatively lower compared to Indonesia, even though Indonesia has many export destination countries (155 countries, compared to 146 countries). This indicates that the development of production and export of palm oil derivative products in Indonesia has not been maximized since the downstream development program was carried out as the initial acceleration of Indonesia's downstream policy (Tandra et al. 2022; Tandra and Suroso 2023). Increasing the added value of palm oil products is still wide open if Indonesia carries out a more intensive and progressive downstream programs, especially if the bioeconomy model is used in its development.

The total value of derived products from palm oil is very large and contributes significantly to the Indonesian economy. However, because the total value of palm oil products is not available, this paper only discusses the role of palm oil in the total value of exports and imports of palm oil derivative products. In 2021, total exports of palm oil derivative products reached USD 11.8 billion – originating from 50 HS products, while the import value reached USD 1.6 billion (Table 2). Thus, Indonesia experienced a trade surplus of USD 10.2 billion. The contribution value of oleofood exports reached USD 3.1 billion, around 26.7% of the total export value of palm oil derivative products, while the import value reached USD 0.4 billion, equivalent to 25.1% of the total value of imports of Indonesian palm oil derivative products. Although the import value is around 13.2% of the total export value of palm oil derivative products, Indonesia should develop import substitution policies to encourage the growth of the domestic oleofood industry to replace imported food/pharmaceutical products.

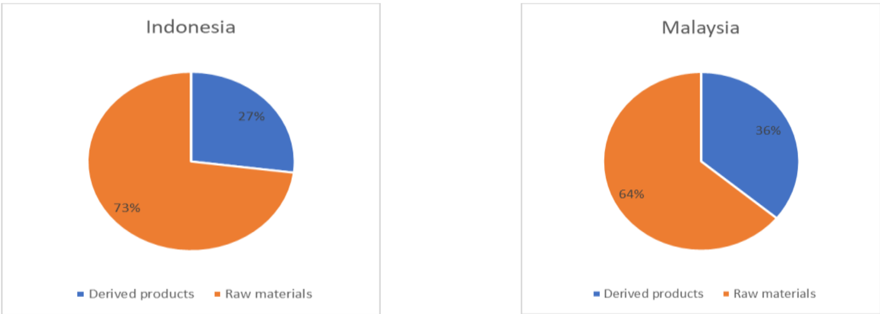

Figure 1. Average proportion of exports of raw material products and derivative products from Indonesia and Malaysia, 2013-2021

Table 2. Export and import values of Indonesia's oil palm derived products, 2021

Product Category	Number of derived products	Value of Export (USD Million, 2021)	Value of Import (USD Million, 2021)
Oleofood	16	3,151.74	391.86
Oleochemical	32	8,460.16	1,164.41
Biofuel	2	191.99	0.88
Total	50	11,803.89	1,557.15

Source: UN Comtrade (2022)

The comparative advantages of the derivatives of palm oil products are classified into four groups (Tandra et al. 2022). Group A: products have positive comparative advantage growth and export growth; Group B: products have positive comparative advantage growth and negative export growth; Group C: products have negative comparative advantage growth but have positive export growth; and

Group D: products have comparative advantage growth and negative export growth. Based on the Revealed Symmetric Comparative Advantage (RSCA) analysis, comparative advantage positions of the three product groups (oleofood, oleochemical and biofuel) can be classified in Table 3. From the results of this analysis, it can be concluded that Indonesia and Malaysia have comparative advantages and export specialization in the trade of palm oil derivative products. The results of this research also suggest that Indonesia needs to strengthen downstream palm oil production capacity, increase investment flows in the palm oil industry, as well as develop integrated production and trade policies related to downstream palm oil products.

The results of the analysis reveal that trading conditions for palm oil derivative products in Indonesia and Malaysia essentially have different objectives. The development of Malaysian palm oil derivative products is more oriented towards strengthening (expanding) exports, especially for oleochemical products; Meanwhile, Indonesia is more oriented towards import substitution products, especially for oleofood products, where imports of oleofood products have decreased gradually over time (Tandra et al. 2022).

Table 3. Number of oil palm derived products of Indonesia and Malaysia, 2019-2021

Category	Period: 2019-2021			Total
	Oleofood	**Oleochemical**	**Biofuel**	
Indonesia	**16**	**32**	**2**	**50**
- Group A	7	16	1	24
- Group B	1	2	0	3
- Group C	1	1	0	2
- Group D	7	13	1	21
Malaysia	**16**	**32**	**2**	**50**
- Group A	6	19	1	26
- Group B	0	1	0	1
- Group C	4	0	1	5
- Group D	6	12	0	18

CONCLUSION

Environmental policy and the growing demand for a wide variety of biobased products have led to a shift toward a greater focus on finding new uses for agricultural by-products. The currently underutilized residues and polluting wastes, particularly from the palm oil industry, have big potential for value addition and technical product development that also could substantially contribute to the reduction of greenhouse gas emissions.

Since Indonesia produces a variety of agricultural products and their accompanying wastes, the development of agricultural waste management has good prospects for Indonesia in the mid- and long-term period. The utilization of agricultural waste (residues and by-products) of oil palm and other commodities by comprehensively adopting technology and innovation in line with the circular economy and bioeconomy approaches must be designed in a sustainable way to produce food, feed, fiber, and fuel and at the same time offers opportunities and solutions in overcoming social, economic, and environmental problems and challenges.

Farmer's human resource condition becomes one of the important challenges in developing circular economy and bioeconomy in Indonesia. The farmers do not understand the right mechanism of waste utilization, lack of appropriate technology, and lack of capital to apply it. To overcome this problem, human resource capabilities of the farmers and other stakeholders to supports bioeconomy approaches need to be continuously developed, in accordance with the agro-ecosystem, social and economic conditions of the community, so that they can better process the waste resulted from their production activities. Apart from focusing on developing farmers' capabilities, the palm oil downstream program must be balanced with a raw material development program, considering the many problems faced by farmers in producing oil palm: low productivity, limited operating capital for plant care, a high proportion of damaged plants, and delays in rejuvenating the old oil-palm plants. Harmonization of upstream and downstream industries is important to support the competitiveness of Indonesian palm oil products in the global market.

Development of technology and innovation is urgently needed to process various agricultural commodities and their residues and by-products. To support this effort, investment in advancing research and development must focus on developing certain “superior commodities” that have great leverage in overcoming national and regional problems. This should be followed by the local-based sustainable economic development approach, which is in line with the objectives of regional autonomy program in Indonesia.

Currently there are no viable alternatives to oil palm in terms of its yield and delivery of a range of derivative products for human use, including oleofood, oleochemicals and biofuels. However, there are well founded concerns about the expansion of oil palm plantations into sensitive habitats, such as highly biodiverse tropical forests and peatlands. It is therefore important to implement transparent and effective certification schemes right across the industry to guarantee that oil palm products can be labelled as being derived from environmentally sustainable and socially responsible sources.

REFERENCES

Agapkin, A.M., I.A. Makhotina, N.A. Ibragimova, O.B. Goryunova, A.K. Izembayeva, and S.L. Kalachev. 2022. The problem of agricultural waste and ways to solve it. 2022 IOP Conf. Ser.: Earth Environ. Sci. 981 022009. DOI 10.1088/1755-1315/981/2/022009

Elbersen, H.W., J.E.G. van Dam, and R.R. Bakker. 2005. "Oil palm by-products as a biomass source: Availability and sustainability". 14th European Biomass Conference, Paris, France,17-21 October 2005.

Ellen MacArthur Foundation. 2013. Towards the circular economy Vol. 1: an economic and business rationale for an accelerated transition.

European Commission. 2012. Innovating for Sustainable Growth: A Bioeconomy for Europe. Office of the European Union, Brussels, Belgium. https://data.europa.eu/doi/10.2777/6462

European Commission, 2015. EIP-AGRI Workshop “Opportunities for Agriculture and Forestry in the Circular Economy”. Workshop Report 28-29 October 2015. Brussels, Belgium. https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_ws_circular_economy_final_report_2015_en.pdf.

Food and Agriculture Organization. 2017. Strategic work of FAO for sustainable food and agriculture. http://www.fao.org/3/ai6488e.pdf

Food and Agriculture Organization. 2021. Bioeconomy for sustainable food and agriculture. https://www.fao.org/3/cb6564en/cb6564en.pdf

Food and Agriculture Organization. 2023. Crops and Livestock Products. Http://www.fao.org/faostat/en/#data/TCL

Food and Agriculture Organization. 2023. Bioeconomy for sustainable food and agriculture. https://openknowledge.fao.org/server/api/core/bitstreams/d8f82717-d3f1-495c-a788-863f7512fa89/content

GAPKI. 2017. Strategi dan Kebijakan Pengembangan Industri Hilir Minyak Sawit Indonesia. https://gapki.id/news/2017/05/10/strategi-dan-kebijakan-pengembangan-industri-hilir-minyak-sawit-indonesia/

Global Bioeconomy Summit Communiqué. 2020. Expanding the Sustainable Bioeconomy –Vision and Way Forward. Berlin, November 2020. https://gbs2020.net/wp-content/uploads/2020/11/GBS2020_IACGB-Communique.pdf

Geißdörfer, M., P. Savaget, N. Bocken, E. Hultink. The Circular Economy: A new sustainability paradigm? Journal of Cleaner Production 143:757–768. doi:10.1016/j.jclepro.2016.12.048.

Gomez S.J., S. Harnett, and I. Albinelli. 2022. Sustainable and circular bioeconomy in the climate agenda: Opportunities to transform agrifood systems. Rome, FAO. https://doi. org/10.4060/cc2668en

Iberdrola, https://www.iberdrola.com/sustainability/circular-economy).

McCarthy B, A.B. Kapetanaki, P. Wang. 2019. Circular agri-food approaches: will consumers buy novel products made from vegetable waste? Rural Soc.;28(2):91–107.

McCormick, K. and N. Kautto. 2013. The Bioeconomy in Europe: An Overview. Sustainability 2013, 5(6), 2589-2608; https://doi.org/10.3390/su5062589

McDonough W. and M. Braungart. 2002. Design for the triple top line: new tools for sustainable commerce. Corp Environ Strat. 9(3):251–8.

Murphy D.J., K. Goggin, and R.R.M. Paterson. 2021. Oil palm in the 2020s and beyond: challenges and solutions. CABI Agriculture and Bioscience 2:39. https://cabiagbio.biomedcentral.com/articles/10.1186/s43170-021-00058-3

Nattassha R., Y. Handayati, T.M. Simatupang, and M. Siallagan. Understanding circular economy implementation in the agri-food supply chain: the case of an Indonesian organic fertilizer producer.

PASPI (Palm Oil Agribusiness Strategic Policy Institute). 2023. Mitos dan Fakta Industri Minyak Sawit Indonesia dalam Isu Sosial, Ekonomi, dan Lingkungan Global. Edisi Keempat. Bogor (ID): PASPI.

Pearce, D.W. and R.K. Turner. 1989. Economics of natural resources and the environment. Baltimore: JHU Press.

Sipayung, T. 2024. Strategi dan Kebijakan Hilirisasi Sawit Jalur Oleofood Complex. https://palmoilina.asia/jurnal-kelapa-sawit/strategi-kebijakan-hilirisasi/

Sirisha. 2023. Circular Agriculture: A Pathway to Global Sustainability. https://scaleclimateaction.org/agriculture/circular-agriculture-a-pathway-to-global-sustainability/

Tan, Y. 2006. By-products of palm oil extraction and refining. OCL Journal 13(1):9-11. Https://www.ocl-journal.org/articles/ocl/pdf/2006/01/ocl2006131p9.pdf

Tandra, H., A.I. Suroso, Y. Syaukat, and M. Najib. 2022. The Determinants of Competitiveness in Global Palm Oil Trade. Economies 10(6):1-20. https://doi.org/10.3390/economies10060132

Tandra, H., and A.I. Suroso. 2023. The determinant, efficiency, and potential of Indonesian palm oil downstream export to the global market. Cogent Economics & Finance 11:2189671 https://doi.org/10.1080/23322039.2023.2189671

Trigo, E., H. Chavarria, C. Pray, S.J. Smyth, A. Torroba, J. Wesseler, D. Zilberman, and J. Martinez. 2023. The Bioeconomy and Food Systems Transformation. Sustainability 2023, 15, 6101. https://doi.org/10.3390/su15076101

UN Comtrade. 2022. UN Comtrade Database. http://comtrade.un.org/data/

van Dam, J.E.G. 2009. Options for sustainability improvement and biomass use in Malaysia: Palm oil production chain and biorefineries for non-food use of residues and by-products including other agricultural crops (No. 1084). Agrotechnology & Food Sciences Group. https://research.wur.nl/en/publications/options-for-sustainability-improvement-and-biomass-use-in-malaysi

Wesseler, J. and M. Kardung. 2022. Agriculture in the Bioeconomy: Economics and Policies, Chapter in: Lanzerath et al.Bioeconomy and Sustainability: Perspectives from Natural and Social Sciences Economics and Ethics. Springer.

World Bank. 2018. What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. https://openknowledge.worldbank.org/handle/10986/30317.