Studi Pemulihan Ekonomi Hijau Melalui Ekonomi Sirkular di Industri Makanan dan Minuman

(Green Economic and Inclusive Recovery through Circular Economy in Food & Beverage Sectors)

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Dr. Eng. Yosi Hidayat, S.T., M.T.

UNDP | Kementerian PPN/ Bappenas | KIREI

Latar Belakang

Studi Pemulihan Ekonomi Hijau Melalui Ekonomi Sirkular

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OUTLINE PRESENTASI

- ✓ Latar Belakang
- ✓ Metodologi Studi
- ✓ Kebutuhan Data
- ✓ Hasil Luaran Studi
- ✓ Lini Waktu
- ✓ Tim Ahli

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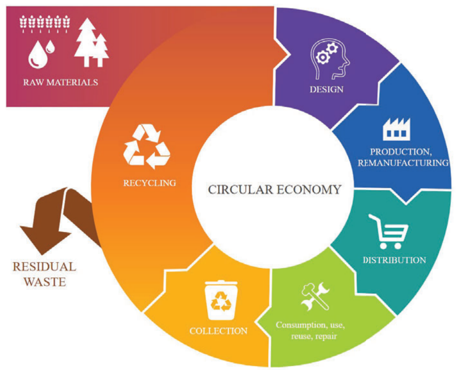
Background

Ekonomi Sirkular (Circular Economy)



- A model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible.
- *Sistem regeneratif yang meminimalkan penggunaan sumber daya, limbah, emisi, dan kelebihan energi dengan memperlambat, menutup, dan mempersempit siklus energi dan material.*

" Designing out waste and pollution, keeping products and materials in use, and regenerating natural systems. "

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Peralihan Menuju Sirkular Ekonomi

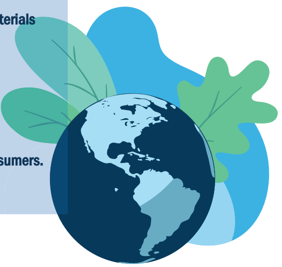
(Switching to Circular Economy)

Drivers

- **Growing world's population** and with it the **demand for raw materials**.
- **Limited supply** of crucial raw materials; countries are dependent on other countries.
- **Major impact on the environment** by extracting and using raw materials: increasing energy consumption and CO2 emissions.

Benefits

- Reducing pressure on the environment
- Improving the security of the supply of raw materials
- Increasing competitiveness
- Stimulating innovation
- Boosting economic growth
- Creating jobs
- More durable and innovative products for consumers.



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"The Economic, Social, and Environmental Benefits of Circular Economy in Indonesia"
Bappenas, UNDP, Government of Denmark. 2021.

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Contribution VS Generated Waste

	GDP in 2019 IDR trillion [1]	Share of total %	Employment in 2019 Millions [2]	Share of total %
Food & beverage	1,014	9.3%	13.1	10.1%
Textiles	146	1.3%	1.2	0.9%
Construction	1,108	10.1%	7.6	5.9%
Wholesale & retail trade	1,168	10.7%	19.8	15.3%
Electrical & electronic equipment	204	1.9%	1.6	1.3%
Total	3,640	33.2%	43.3	33.5%

1. GDP figures are in 2010 prices
2. The employment for the focus sectors was estimated using the sector employment data published by BPS. Due to the limited data availability on sub - sector employment, it was assumed that the labour productivity is constant across the sub-sectors

SOURCE: Bank Indonesia; BPS

The five sectors contributed over 30 percent to Indonesia's current GDP and employed more than 43 million people or one-third of Indonesia's workforce in 2019.

	Waste today millions of tonnes	Projected increase in waste in 2030 (%)
Food & beverage (Food loss & waste)	57.5	54%
Textiles (Textile waste)	2.3	70%
Construction (Construction waste)	29.0	82%
Wholesale & retail trade (Plastic packaging waste)	5.4	40%
Electronics (E-waste)	1.8	39%

The five sectors generated a significant amount of waste in 2019. **Food loss and waste** was nearly 57.4 million tonnes (excluding food loss at production). The volume of waste could increase by up to 82 percent by 2030 in some sectors.

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Peluang Penerapan Ekonomi Sirkular di Indonesia

(The Circular Economy Oppportunity fo Indonesia)

Indonesia's economy could grow by USD 45 billion by 2030 with lower emission and waste through the full adoption of a zero-waste circular economy model in five key sectors. Around 4.4 million new jobs could be created by 2030.

5 SECTORS IN INDONESIA HAVE LARGE POTENTIAL TO ADOPT A CIRCULAR APPROACH

These five sectors represent 1/3 of Indonesia's GDP and employed >43 million people in 2019

"The Economic, Social, and Environmental Benefits of Circular Economy in Indonesia" Bappenas, UNDP, Government of Denmark. 2021.

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Ekonomi Sirkulas dan Pemulihan Paska Covid-19

(Circular Economy and COVID-19 Recovery)

- A **circular economy** adoptions for all industries **could help the world recover financially** from COVID-19.
- Embracing the **transformative capabilities of digital technologies** for **supply chain resilience.**

Opportunities for circular economy :

- ✓ **Local manufacturing and re-manufacturing** of **essential medical** accessories
- ✓ CE strategies for **managing hospital medical and general waste**
- ✓ Embracing **resource efficiency** in the construction and built environment
- ✓ **Bio-cycle economy** and the **food sector**
- ✓ Opportunities for CE in the **transport and mobility sector**
- ✓ Sustaining improvements in **air quality**
- ✓ **Digitalisation for supply chain resilience** post COVID-19
- ✓ **Policy measures, incentives and regulatory support** for CE transitioning

T. Ibn-Mohammed, et al, A critical analysis of the impacts of COVID-19 on the global economy and ecosystems and opportunities for circular economy strategies, *Resources, Conservation and Recycling*, Volume 164, 2021, doi: 10.1016/j.resconrec.2020.105169

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Ekonomi Sirkular di Industri Makanan dan Minuman

(Circular Economy in Food & Beverage Sector)

- Due to the current **linear nature** of its value chain, F&B sector is generally wasteful, contributes to **environmental degradation**, **disrupts nutrient flows**, thereby **diminishing the nutritional quality of food.**

Regenerative Agriculture	Returning organic matter to the soil in the form of food waste or composted by-products or digestates from treatment plants	Preservation of soil health through closing nutrient loops through
Anaerobic digestion facilities	Transforming ensuing methane from food waste into carbon-neutral energy	Value recovery from organic nutrients
Urban and peri-urban agriculture	Cultivating food in proximity to where it will be consumed	Mitigation of carbon footprint can be mitigated in numerous ways

- In the context of COVID-19, CE strategies offers **both economic and environmental benefits** for **the food system.** They will be an integral part of a more resilient and healthy food system that allows **greater food security** and **less wastage.**

T. Ibn-Mohammed, et al, A critical analysis of the impacts of COVID-19 on the global economy and ecosystems and opportunities for circular economy strategies, *Resources, Conservation and Recycling,* Volume 164, 2021, doi: 10.1016/j.resconrec.2020.105169

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Peluang Spesifik di Industri Makanan dan Minuman

(Food & Beverage Sector Specific Opportunities)

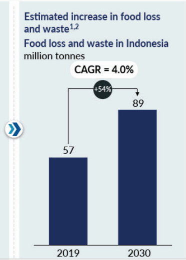
There is significant food loss and waste today in Indonesia, which could increase significantly by 2030.

FOOD AND BEVERAGE

Food loss and waste could get worse by 2030

Growing consumer class
- An estimated 90 million Indonesians could join the ranks of the consuming class by 2030, creating higher demand for food
- Higher per capita incomes tend to lead to greater food wastage at the consumption stage

Higher urbanisation rate
- Over 35 million people are expected to move to cities in Indonesia between now and 2030
- Urbanisation leads to longer supply chains as consumption moves away from production centres, likely leading to greater losses in the supply chain



1. Calculated based on total waste estimates of the Ministry of Environment and Forestry in 2019 and FAO's estimates for growth in Indonesia's food demand
2. Excludes waste generated at production stage

SOURCE: United Nations Population Division, WRI; Ministry of Environment and Forestry; World Bank (see annex for more details)

CE Opportunities in F&B Sector

FOOD AND BEVERAGE

Examples of circular economy opportunities and benefits in the food & beverage sector

#	Circular opportunities	5Rs	Brief description	Significance/Examples
1	Reduce post-harvest food loss	Reduce	Overcoming wastage due to poor storage facilities and insufficient infrastructure, particularly amongst smallholders	37% of food loss and waste occurs during the post-harvest stage in South and Southeast Asia[1]
2	Reduce supply chain food loss	Reduce	Reducing food loss and waste during processing, packaging, and distribution of food. Example levers to reduce waste include affordable cold storage transportation systems and new packaging films	19% of food loss and waste occurs during the supply chain stage in South and Southeast Asia
3	Reduce consumer food waste	Reduce	Reducing food waste at the point of consumption. Example levers include better information on "use by" labelling, trayless dining, etc.	13% of food waste occurs during the consumption stage in South and Southeast Asia
3	Process food loss and waste	Recycle	Finding more productive uses of food waste, such as energy, composting, and nutrient extraction. This includes bio-refineries that capture the full value of by-product and waste streams by extracting several different products	Impact assessment suggests that cascading bio-refineries could create an annual value of EUR300 - 500 million in Denmark by 2035

1. Based on WRI's estimates for the average amount of food loss and wasted in South and Southeast Asia in the food value chain

SOURCE: Ellen MacArthur Foundation; WRI; focus group discussions; expert interviews

"The Economic, Social, and Environmental Benefits of Circular Economy in Indonesia" Bappenas, UNDP, Government of Denmark. 2021.

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Peran Pemangku Kepentingan pada Ekonomi Sirkular di Industri Makanan dan Minuman

(Stakeholders Role in Circular Economy for F&B)

ACTORS	ROLE
FOOD PRODUCERS	• Use available tools and technologies to help shift to regenerative practices for growing food and measure the impacts • (Peri-urban farmers) Connect with local consumer markets and use organic fertilisers made from urban food by-product streams • Take advantage of educational and funding programmes that support the adoption of regenerative practices
FOOD BRANDS	• Redesign food products that: • Use innovative plant-based protein in place of animal protein • Use food processing by-products as ingredients • Are safe to cycle • Use marketing influence to increase popularity of circular products
RETAILERS AND COMMODITIES/FOOD BUYERS AND TRADERS	• Prioritise sourcing products produced regeneratively, and locally where appropriate • Preferentially market, price, and promote regeneratively grown products • Prevent edible food waste through improved logistics, matching food volumes to demand, redistribution, using 'ugly' produce as ingredients, etc.

RESTAURANTS, AND OTHER FOOD PROVIDERS	• Redesign food products so they:
	  • Use by-products as ingredients
	  • Use innovative plant-based protein in place of animal protein
	  • Generate by-products that are safe to cycle
	• Create seasonal product offerings that use locally-grown ingredients
	• Use by-products from making one product as ingredients for new products

ACTORS	ROLE
WASTE MANAGEMENT COMPANIES	• Innovate for advanced organic waste collection and treatment systems • Reconnect urban nutrient flows with peri-urban farmers • Work with public and private sector players to develop valuable bioeconomy products made from their food by-products • Implement wastewater treatment systems that make the most of nutrients contained within urban human waste
CITY GOVERNMENTS	• Collaborate with regional/national governments to introduce programmes that provide educational and financial support for farmers to adopt regenerative practices • Shape public procurement policies to source food grown regeneratively, and locally where appropriate • Put in place infrastructure and policies for separate organic waste collection and wastewater treatment systems • Advance infrastructure to enable local food sourcing and the return of organic fertilisers to peri-urban farms • Provide incentives through policies and funding programmes for food businesses to take actions based on circular economy principles
LEARNING INSTITUTIONS	• Integrate food as an important component of circular economy courses • Advance the research needed to further build the evidence for shifting to a circular food system • Partner with local organisations and government to establish innovation hubs to help find solutions to overcome the challenges to achieving the vision • Implement the three ambitions on campuses
FINANCIAL INSTITUTIONS	• Provide financial tools to de-risk and stimulate the transition from conventional to regenerative food production • Steer capital towards businesses leading the shift towards a circular economy for food

"Cities and Circular Economies for Food". Ellen Macrthur. 2019.

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F&B: Food Loss and Waste

FOOD AND BEVERAGE

The "Reduce" and "Recycle" approaches offer the highest potential for circularity in the food & beverage sector in Indonesia

High potential · Low potential · Prioritised for further assessment

Qualitative assessment of potential in Indonesia

		Potential
REDUCE	The Food Loss and Waste Action Partnership aims to reduce Indonesia's food loss and waste by 50% by 2030	High potential
REUSE	Not relevant since food is a single-use good	Low potential
RECYCLE	~11% of food waste is estimated to be recycled in Indonesia. In the US, 25% of food waste is used to produce compost and energy	High potential
REFURBISH	Not relevant since food is a single-use good	Low potential
RENEW	More renewable sources of energy could be used in the food value chain but that could have limited impact on food loss and waste	Low potential

SOURCE: WRI; Environmental Protection Agency (EPA); focus group discussions; expert interviews

FOOD AND BEVERAGE

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SOURCE: Ellen MacArthur Foundation; WRI; focus group discussions; expert interviews

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Wholesale and retail trade: Plastic packaging waste

WHOLESALE & RETAIL TRADE

The "Reduce", "Reuse", and "Recycle" approaches offer the highest potential for circularity in plastic packaging in Indonesia

High potential · Low potential · Prioritised for further assessment

Qualitative assessment of potential in Indonesia

REDUCE	Non-essential plastics[1] could make up around 15% of all plastic packaging in Indonesia by 2040
REUSE	50% of plastic (including plastic packaging) is used only once before it is thrown away
RECYCLE	50% of all plastic packaging can be recycled. The recycling rate in Indonesia for plastic waste is however only 12%
REFURBISH	Limited potential since most of plastic packaging's structural integrity is maintained after its disposal
RENEW	30% of plastic packaging cannot be reused or recycled till it is redesigned and substituted with more sustainable materials

1. Non-essential plastics refers to plastics that can be eliminated without compromising the functionality of the original product. For example, plastic microbeads that are present in many personal cosmetic and personal care products

SOURCE: Ellen MacArthur Foundation; World Economic Forum; Plastic Oceans; literature review; focus group discussions; expert interviews

Examples of circular economy opportunities and benefits in the wholesale and retail trade (plastic packaging) sector

#	Circular opportunities[1]	5Rs	Brief description
1	Reduce and reuse plastic packaging	Reduce, reuse	Reducing plastic packaging waste by eliminating non-essential plastic packaging, maximising reuse of plastic packaging, and by creating new delivery models that avoid single-use plastics
2	Replace with more sustainable packaging	Renew	Substituting plastic packaging with more sustainable alternatives, such as paper, coated paper, or compostable materials
3	Redesign plastic packaging for improved recyclability	Renew	Redesigning products to increase their recyclability. For example, removing dyes and additives to minimise the loss rates of plastics from mechanical recycling
4	Increase recycling rate of recyclable packaging	Recycle	Increasing the recycling rates for plastic packaging waste that is recyclable

1. Opportunities listed above are based on key levers highlighted by National Plastic Action Partnership in its solution scenario modelling in 2019 on plastic waste in Indonesia

SOURCE: World Economic Forum; focus group discussions; expert interviews

Plastic packaging from rigid monomaterials are commonly used for water bottles, food service, and disposables

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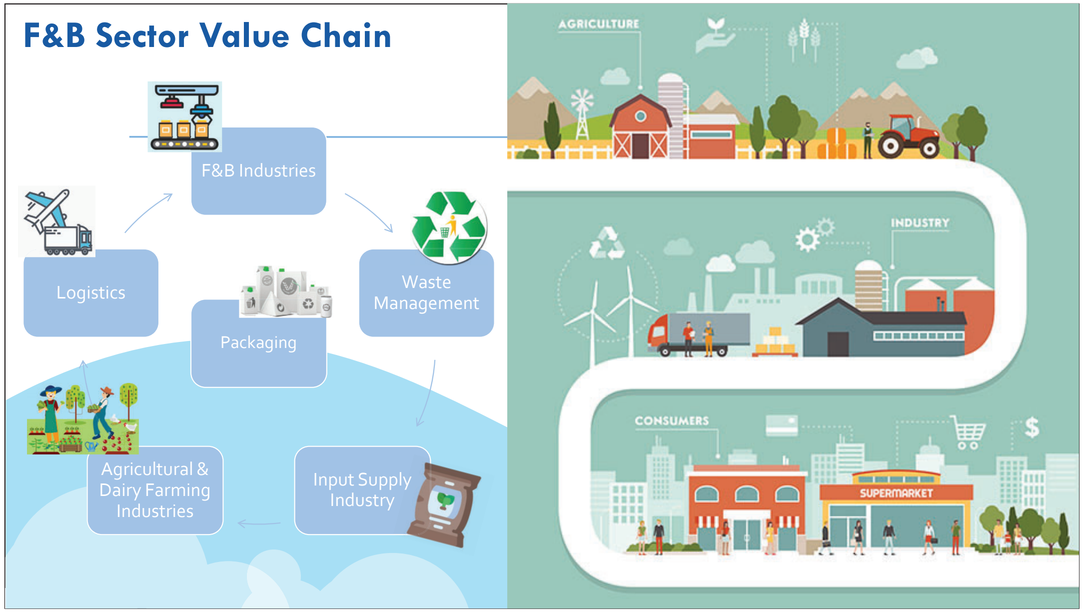
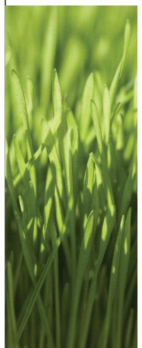
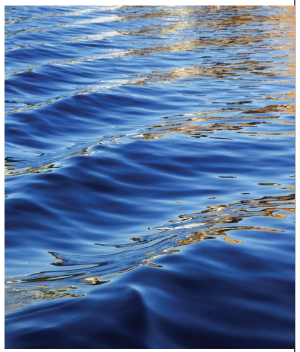
F&B Sector Value Chain





Metodologi Studi

Studi Pemulihan Ekonomi Hijau Melalui Ekonomi Sirkular



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Metodologi Studi
Metodologi Umum

F&B Sector

QA/RA
Quick Assessment / Rapid Assessment

MCDM
Multiple-Criteria Decision-Making
- Circular Economy
- Low Carbon Development

Selected Potential F&B Subsector for CE and LCDI

WCR LCA
Waste & CO_2 Reduction Life Cycle Assessment

5 komponen rantai nilai yang berpengaruh paling signifikan untuk penerapan CE dan green recovery / LCDI

SD
System Dynamics in selected F&B subsector and selected value chains

Rekomendasi kegiatan dan kebijakan CE di subsektor terpilih dan di 5 rantai nilai yang paling berpengaruh untuk *green recovery*

RE
Resource Efficiency Potential Assessment in Plastic Packaging

RECP
Resource Efficient and Cleaner Production UNIDO

Rekomendasi Kebijakan untuk pengurangan penggunaan plastik (*packaging*) & peningkatan RE (dalam konteks plastik) di Sektor F&B

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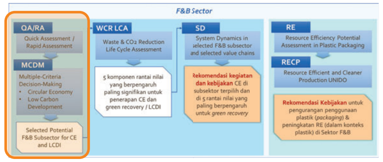
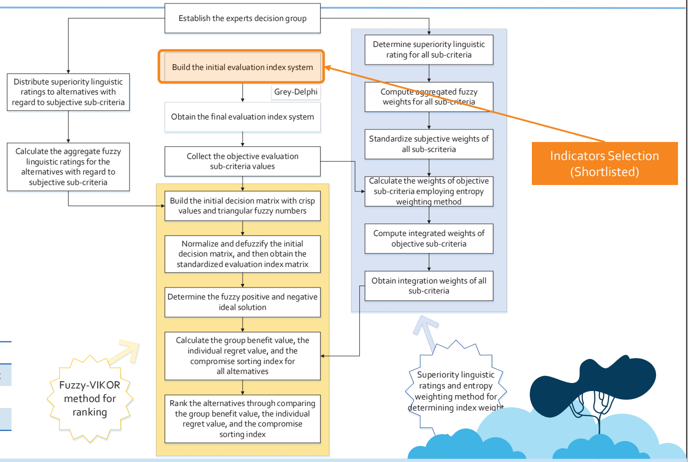
Metodologi Studi
Pengambilan Keputusan Multi-Kriteria
(Multiple-Criteria Decision-Making)





No	Referene	Context
1.	Zhao, Zhao, dan Guo (2017)	Industrial park
2.	Avdiushchenko, dan Zajac (2019)	Regional
3.	Sun, et.al (2020)	Cities

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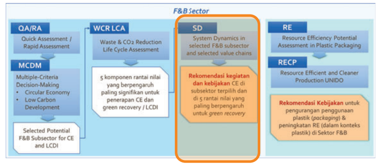
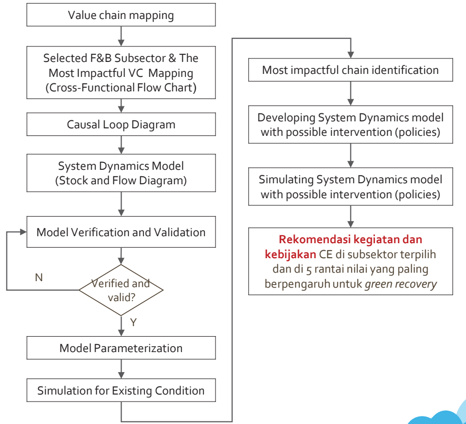
Metodologi Studi
Dinamika Sistem (Systems Dynamics)





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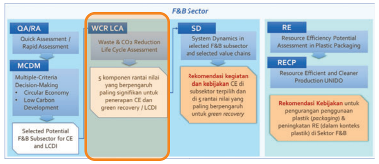
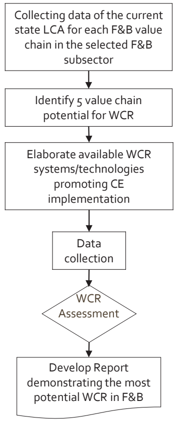
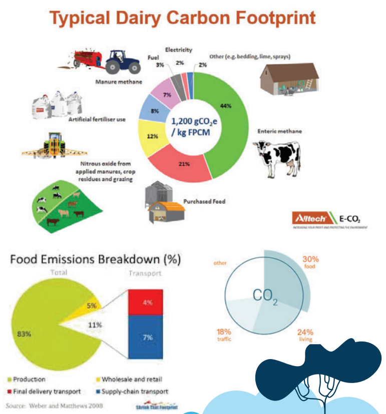
Metodologi Studi
Life Cycle Assessment







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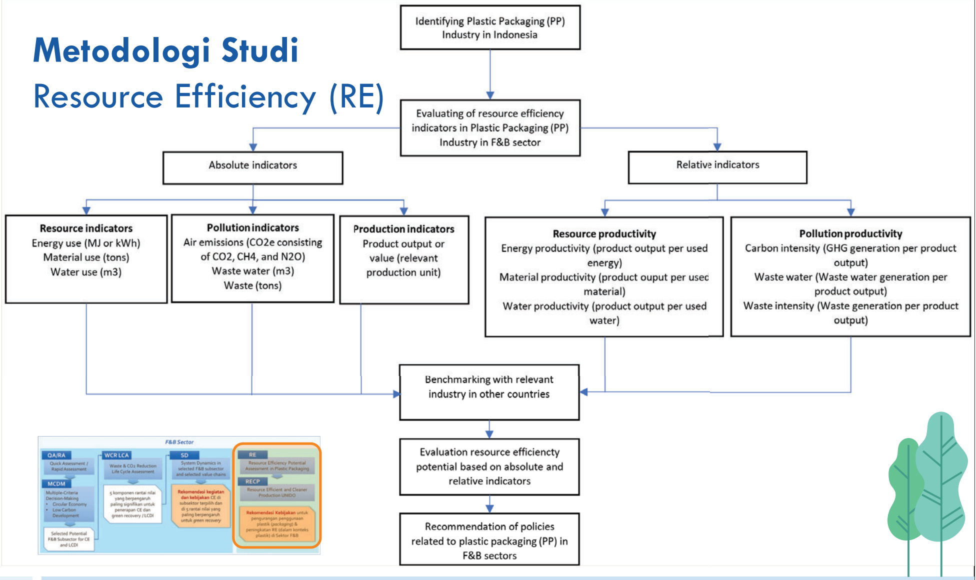
Metodologi Studi
Resource Efficiency (RE)



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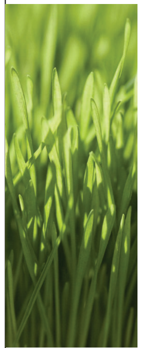

Kebutuhan Data

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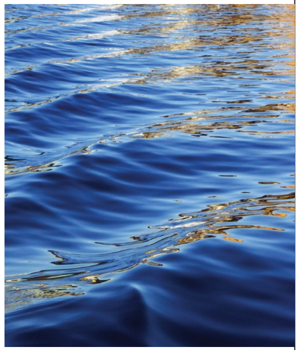

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Kebutuhan Data

1 | Quick Assessment / Rapid Assessment

75 Indicators in 16 Categories

Category	Indicator	Unit	Data Source (possible)	Note
Economic	Economic Annual average growth rate of	%/tahun	BPS	CE Indicator
	Per capital industrial added value	Rp	BPS	CE Indicator
	Industrial assets	Rp	BPS	CE Indicator
	The proportion of research and development	%	BPS	CE Indicator
	The proportion of high-tech output value in	%	BPS	CE Indicator
Social	Contribution rate of scientific and technological	%	BPS	CE Indicator
	Social Government revenue	Rp	BPS	CE Indicator
Environmental	Employment increase promoting degree	Orang	BPS	CE Indicator
	Environmental Comprehensive energy	kWh/Rp	BPS	CE Indicator
	Fresh water consumption per unit of industrial	million m3	BPS	CE Indicator
	Industrial water recycling rate	m3/year	BPS	CE Indicator
	Reclaimed water reuse rate	%	BPS	CE Indicator
	Recycling rate of industrial solid waste	%	BPS	CE Indicator
	Repeated utilization ratio of raw material	%	BPS	CE Indicator
	Energy recycling rate	%	BPS	CE Indicator
	The substitution of raw material source	-	BPS	CE Indicator
	Gross industrial output value per unit of	Rp	BPS	CE Indicator
	The COD emissions of per unit of industrial	Tonnes/Rp	KLHK	CE Indicator
	The solid waste emissions of per unit of	Tonnes/Rp	KLHK	CE Indicator
	The CO2 emissions of per unit of industrial	Tonnes/Rp	KLHK	CE Indicator
	Centralized sewage treatment rate	Tonnes/year	BPS	CE Indicator
	Hazardous waste disposal rate	Tonnes/year	BPS	CE Indicator
	Harmless disposal rate of garbage	Tonnes/year	BPS	CE Indicator
	Waste chain perfection	-	BPS	CE Indicator
	Waste treatment facilities	Number	BPS	CE Indicator
	Toxic and hazardous waste emissions of per	Tonnes/Rp	BPS	CE Indicator
Macro System	Total Energy Consumption of Industrial	MtCO2	BPS	LCD Indicator
	Total carbon emissions of industrial	million tons of standard coal	KLHK	LCD Indicator
	Carbon emissions per unit of industrial	tCO2/RMB	KLHK	LCD Indicator
Energy System	Coal consumption as a percentage of total	%	BPS	LCD Indicator
	Natural gas consumption as a proportion of	%	BPS	LCD Indicator
	Energy consumption reduction rate per unit of	%	BPS	LCD Indicator
	power consumption reduction rate per unit of	%	BPS	LCD Indicator
	water consumption reduction rate per unit of	%	BPS	LCD Indicator
Industrial System	The proportion of tertiary industry to GDP (C1)	%	BPS	LCD Indicator
	The proportion of industrial added value to	%	BPS	LCD Indicator
	Energy consumption reduction rate per unit of	%	BPS	LCD Indicator

Category	Indicator	Unit	Data Source (possible)	Note
Environmental system	PM10 annual average concentration (D1)	micro-g/m3	KLHK	LCD Indicator
	Industrial sulfur dioxide emissions per unit of	ton/RMB	BPS	LCD Indicator
	Industrial wastewater discharged per unit of	ton/RMB	BPS	LCD Indicator
	Sewage treatment rate (D4)	%	BPS	LCD Indicator
Land System	Green area per capita (E1)	m2/person	BPS	LCD Indicator
	The green coverage rate of urban built-up	%	BPS	LCD Indicator
	Forest coverage (E3)	%	BPS	LCD Indicator
	Rate of decline in construction area per unit of	%	BPS	LCD Indicator
Living system	Annual per capita production of urban	kg/person/year	BPS	LCD Indicator
	Urban water consumption per capita (F2)	L/person	BPS	LCD Indicator
	Annual electricity consumption per capita for	Kwh/person	BPS	LCD Indicator
	Urban per capita living construction area (F4)	m2/person	BPS	LCD Indicator
	Number of buses owned by ten thousand	Vehicles/10^(4)person	BPS	LCD Indicator
Economic prosperity economy	GDP	per capita, fixed prices, PLN	World Bank	CE Indicator
	Average life expectancy at birth for men	years	BPS	CE indicator
	Registered unemployment rate	%	BPS	CE indicator
	At-risk-of-poverty rate	%	BPS	CE indicator
Zero-waste economy	Municipal waste collected selectively in	%	KLHK	CE indicator
	Municipal waste collected per one inhabitant	tons/person	KLHK	CE indicator
	Industrial and municipal wastewater purified in	%	KLHK	CE indicator
	Outlays on fixed assets serving environmental	per capita, fixed prices, PLN	KLHK	CE indicator
Innovative economy	Expenditures on research and development	per capita, fixed prices, PLN	BPS	CE indicator
	Average share of innovative enterprises in the	%	BPS	CE indicator
	Adults participating in education and training	%	BPS	CE indicator
	Patent applications for 1 million inhabitants		BPS	CE indicator
Energy-efficient and renewable energy-based economy	Share of renewable energy sources in total	%	BPS	CE indicator
	Outlays on fixed assets serving environmental	per capita, fixed prices, PLN	BPS	CE indicator
	Electricity consumption	kWh/person	BPS	CE indicator
Low carbon economy	Carbon dioxide emission from plants	tons/person	BPS	CE indicator
	Emission of particulates	tons/1 km2	BPS	CE indicator
	Passenger cars	Cars/1000 population	BPS	CE indicator
	Pollutants retained or neutralized in pollutant	%	BPS	CE indicator
	Outlays on fixed assets serving environmental	per capita, fixed prices, PLN	BPS	CE indicator
Smart economy	Households with personal computer with	%	BPS	CE indicator
	enterprises with access to the Internet via a	%	BPS	CE indicator
Spatially effective economy	Forest cover indicator	%	KLHK	CE indicator
	Street greenery and share of parks, lawns and	%	BPS	CE indicator
	Urbanization rate	%	BPS	CE indicator

Kebutuhan Data

1 | Quick Assessment / Rapid Assessment

Requested Data (2015 – 2020):

- **Circular Economy Indicators**
- **Low Carbon Development Indicators**

for **38 subsectors** based on **4 digits of KBLI**

KBLI

1011 - KEGIATAN RUMAH POTONG DAN PENGEPAKAN DAGING BUKAN UNGGAS
1012 - KEGIATAN RUMAH POTONG DAN PENGEPAKAN DAGING BUKAN UNGGAS
1013 - INDUSTRI PENGOLAHAN DAN PENGAWETAN PRODUK DAGING DAN DAGING UNGGAS
1021 - INDUSTRI PENGOLAHAN DAN PENGAWETAN IKAN DAN PRODUK IKAN
1022 - INDUSTRI PENGOLAHAN DAN PENGAWETAN IKAN DAN BIOTA AIR DALAM KALENG
1029 - INDUSTRI PENGOLAHAN DAN PENGAWETAN BIOTA AIR LAINNYA
1031 - INDUSTRI PENGOLAHAN DAN PENGAWETAN BUAH-BUAHAN DAN SAYURAN DENGAN CARA DIASINKAN, DILUMATKAN, DIKERINGKAN DAN DIBEKUKAN
1032 - INDUSTRI PENGOLAHAN DAN PENGAWETAN BUAH-BUAHAN DAN SAYURAN DALAM KALENG
1033 - INDUSTRI PENGOLAHAN SARI BUAH DAN SAYURAN
1039 - INDUSTRI PENGOLAHAN DAN PENGAWETAN LAINNYA BUAH-BUAHAN DAN SAYURAN
1041 - INDUSTRI MINYAK DAN LEMAK NABATI DAN HEWANI (BUKAN KELAPA DAN KELAPA SAWIT)
1042 - INDUSTRI KOPRA, MINYAK MENTAH DAN MINYAK GORENG KELAPA, DAN PELET KELAPA
1043 - INDUSTRI MINYAK MENTAH/MURNI KELAPA SAWIT (CRUDE PALM OIL) DAN MINYAK GORENG KELAPA SAWIT
1049 - INDUSTRI MINYAK MENTAH DAN LEMAK NABATI DAN HEWANI LAINNYA
1051 - INDUSTRI PENGOLAHAN SUSU SEGAR DAN KRIM
1052 - INDUSTRI PENGOLAHAN SUSU BUBUK DAN SUSU KENTAL
1053 - INDUSTRI PENGOLAHAN ES KRIM DAN SEJENISNYA
1059 - INDUSTRI PENGOLAHAN PRODUK DARI SUSU LAINNYA
1061 - INDUSTRI PENGGILINGAN SERELIA DAN BIJI-BIJIAN LAINNYA (BUKAN BERAS DAN JAGUNG)
1062 - INDUSTRI PATI DAN PRODUK PATI (BUKAN BERAS DAN JAGUNG)
1063 - INDUSTRI PENGGILINGAN BERAS DAN JAGUNG DAN INDUSTRI TEPUNG BERAS DAN JAGUNG
1071 - INDUSTRI PRODUK ROTI DAN KUE
1072 - INDUSTRI GULA
1073 - INDUSTRI KAKAO, COKELAT DAN KEMBANG GULA
1074 - INDUSTRI MAKARONI, MIE DAN PRODUK SEJENISNYA
1075 - INDUSTRI MAKANAN DAN MASAKAN OLAHAN
1076 - INDUSTRI PENGOLAHAN KOPI, TEH DAN HERBAL (HERB INFUSION)
1077 - INDUSTRI BUMBU-BUMBUAN DAN PRODUK MASAK LAINNYA
1079 - INDUSTRI PRODUK MAKANAN LAINNYA
1080 - INDUSTRI MAKANAN HEWAN
1101 - INDUSTRI MINUMAN BERALKOHOL HASIL DESTILAS
1102 - INDUSTRI MINUMAN BERALKOHOL HASIL FERMENTASI ANGGUR DAN HASIL PERTANIAN LAINNYA
1103 - INDUSTRI MINUMAN BERALKOHOL HASIL FERMENTASI MALT DAN INDUSTRI MALT
1104 - INDUSTRI MINUMAN RINGAN
1105 - INDUSTRI AIR KEMASAN DAN AIR MINUM ISI ULANG
1109 - INDUSTRI MINUMAN LAINNYA
1201 - INDUSTRI ROKOK DAN PRODUK TEMBAKAU LAINNYA
1209 - INDUSTRI PENGOLAHAN TEMBAKAU LAINNYA

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Kebutuhan Data

2 | Life Cycle Assessment

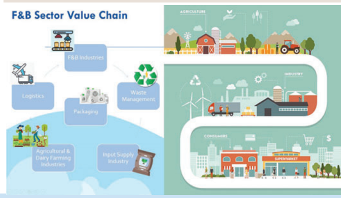
Requested Data (2015 – 2020):

- **CO_2 emission**
- **CH_4 emission**
- **Nitrogen oxides (NOx), volatile organic compounds (VOCs), peroxyacyl nitrates (PANs), aldehydes and ozone**
- **Phosphorous and nitrogen**
- **Land use**
- **Water use**
- **Solid waste**
- **Minerals and fossil fuels**
- **Electricity consumption**
- **Chemicals used**

List of Value Chains:

- **Agriculture or Dairy Farming Industry**
- **Production & Processing**
- **Storage & Transportation**
- **Consumption**
- **Packaging**

F&B Sector Value Chain



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Kebutuhan Data

2 | Life Cycle Assessment

Contoh Form Kebutuhan Data

Value chain:	Upstream Activities (Input Supply Industry)	
Data	**Unit**	**Description**
CO_2 emission	kg CO_2 eq	Fertilizer, pesticides, feed production
CH_4 emission	kg CO_2 eq	Fertilizer, pesticides, feed production
Nitrogen oxides (NOx), volatile organic compounds (VOCs), peroxyacyl nitrates (PANs), aldehydes and ozone.	kg C_2H_4 eq	Photochemical oxidation potential
Phosphorous and nitrogen	kg PO_4 eq	Eutrophication is the release of nutrients (mainly phosphorous and nitrogen) into land and water systems, altering biotopes, and potentially increasing algal growth and causing related toxic effects
Land use	Ha*annual	Total exclusive use of land for a given time for occupation by the built environment, forestry production and agricultural production processes
Water use	kL H_2O	Net water use. Total of all water used by the processes considered.
Solid waste	kg	Net solid waste generated. Total of all solid waste generated by the processes considered.
Minerals and fossil fuels	MJ Surplus	The additional energy required to extract the resources (both mineral and fossil) due to depletion of reserves, leaving lower quality reserves behind.
Electricity consumption	Kwh	Fertilizer, pesticides, feed production
Chemicals used	kg	Fertilizer, pesticides, feed production

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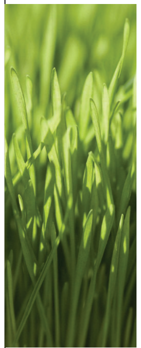
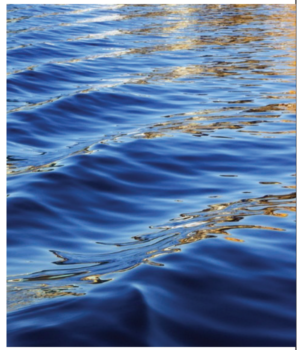


Hasil Luaran Studi

Studi Pemulihan Ekonomi Hijau Melalui Ekonomi Sirkular



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Kebutuhan Data

3 | Resource Efficiency Potential Assessment

Requested Data (2015 – 2020):

- **Daftar industri penghasil plastik di Indonesia (PP)**
- **Detail data terkait industri penghasil plastik**
  - *Energy use (including source of energy)*
  - *Material use*
  - *Water use*
  - *Air emissions*
  - *Wastewater*
  - *Waste*
  - *Product output or value*

No.	Data	Satuan
1	Energy use (including source of energy)	MJ/kWh
2	Material use	tons
3	Water use	m3
4	Air emissions	m3
5	Wastewater	m3
6	Waste	tons
7	Product output or value	relevant production unit

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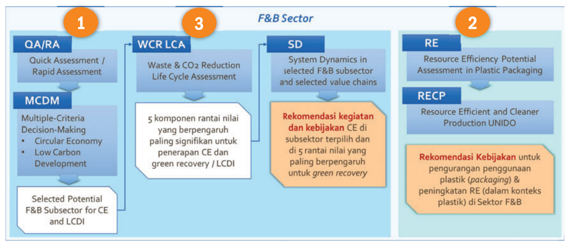
Hasil Luaran Studi

1) Quick/Rapid Assessment of Food & Beverage Subsectors Report
2) Resource Efficiency Potential Assessment Report
3) Waste & CO2 Potential Reduction Assessment Report



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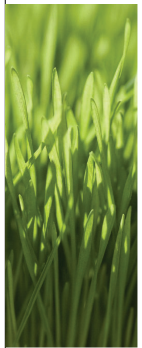

Lini Waktu

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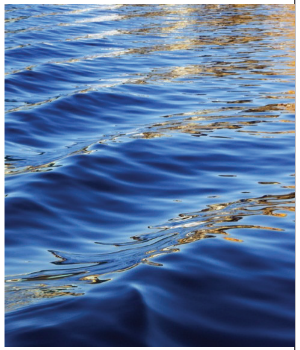

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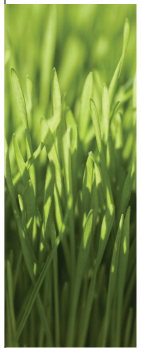

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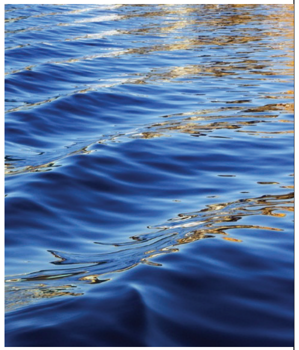
Studi Pemulihan Ekonomi Hijau Melalui Ekonomi Sirkular



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Lini Waktu (Timeline)

No	Activities	Month																				
			Oct-21				Nov-21				Dec-21				Jan-22				Feb-22			
1.	**Internal Kick Off Meeting with Bappenas**																					
a.	First Internal Coordination Meeting (22nd of Sept 2021)	■																				
b.	Second Internal Coordination Meeting (30th of Sept 2021)	■																				
c.	Third Internal Coordination Meeting (6th of Oct 2021)		■																			
2.	**Rapid/Quick Assessment**																					
a.	Desk/Literature Review (First and Second week of Oct 2021)		■	■	■																	
b.	Data Collection through FGD with key line ministry					■																
c.	Data Collection (continuity)						■															
d.	Data analysis through MCDM to select sub-sector in FnB							■														
e.	FGD to present pre-liminary result (selected sub-sector in FnB)							■														
3.	**RE in Plastic Packaging**																					
a.	Desk/Literature Review (First and Second week of Oct 2021)		■	■	■																	
b.	Data Collection through FGD with key line ministry					■																
c.	Data Collection (continuity)						■															
d.	Data analysis through RECP analysis							■														
e.	FGD to present pre-liminary result (PP)								■													
4.	**Waste & CO_2 Reduction Assesment**																					
a.	Desk/Literature Review (First and Second week of Oct 2021)		■	■																		
b.	LCA analysis to select impatful VC								■													
c.	Development sysdyn in Fn B sector									■	■											
d.	Policy simulation (in selected sub-sector and impactful VC)											■	■	■	■							
e.	FGD to share findings															■	■					
f.	Final Presentation																	■	■			

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Tim Tenaga Ahli (Our Experts Team)

Addressed Problems	Personel
	(Team Leader: Dr. Eng. Yosi Agustina Hidayat)
Resource Efficiency Potential Assessment in five value chain of food and beverages sectors as well as in value chain of food and beverage plastic packaging sectors	1. Dr. Kania Dewi, ST., MT. (Environmental Engineering) 2. Mayrina Firdayati, S.Si., M.T. (Environmental Engineering) 3. Addina Shafiyya Ediansjah, S.T., M.T. (Environmental Engineering)
Quick/rapid assessment of Food & Beverage sub- sectors that contribute most significantly to green economic recovery in the context of LCDI and identification of CE potential	1. Dr. Titah Yudhistira (Industrial Engineering) 2. Dr. Rully Tri Cahyono (Industrial Engineering) 3. Muchammad Arya Zamal, M.Sc. (Industrial Engineering)
In-depth assessment on **Waste & CO2 Reduction Potential** in Food & Beverage sub-sectors.	1. Dr. Kania Dewi, ST., MT. (Environmental Engineering) 2. Wibawa Hendra Saputera, S.Si., M.Si., M.SC., Ph.D. (Chemical Engineering) 3. Grace Lugito, Ph.D. (Chemical Engineering)
Administration and Research Assistants	1. Daniel Wiyogo, S.T., M.T.

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Terima Kasih

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OUTLINE

- ✓ Latar belakang, tujuan, dan metodologi umum
- ✓ Penentuan indikator
- ✓ Pengumpulan dan pengolahan data
- ✓ Asesmen dan pemilihan sub-sektor potensial

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Quick/Rapid Assessment on Food & Beverages Sub-sectors for Circular Economy & Low Carbon Development Implementation

Titah Yudhistira, Ph.D.

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Pendahuluan

Assessment of CE & LCD Indicators Selection for Potential Subsectors

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Pendahuluan
Latar Belakang

- Pemerintah menetapkan bahwa pembangunan ekonomi pascapandemi Covid-19 salah satunya ditopang oleh upaya *green economy recovery* melalui konsep circular economy (CE) dan *low carbon development Indonesia* (LCDI).
- Penelitian Bappenas bersama UNDP dan Kedubes Denmark telah mengidentifikasi **lima sektor industri yang potensial**, diantaranya adalah **industri makanan dan minuman (F&B)**.
- **Industri F&B merupakan sektor terbesar** dari industri manufaktur dengan sumbangan terhadap GDP nasional mencapai 9,3% di tahun 2019.
- Dengan mengacu **klasifikasi KLBI**, industri F&B memiliki **38 subsektor**.

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Pendahuluan
Tujuan

1. **Mengembangkan kriteria dan indikator** untuk pemilihan sub-sektor yang potensial untuk implementasi konsep CE dan LCD dalam rangka *green economy recovery*;
2. **Mengumpulkan data dan melakukan estimasi** terhadap indikator-indikator terpilih;
3. **Melakukan asesmen dan menyusun ranking** subsektor-subsektor di sektor F&B yang potensial untuk penerapan CE dan LCD untuk penerapan konsep CE dan LCD.

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Pendahuluan
Metodologi Umum

Tahapan 1: Menyusun kriteria dan indikator pemilihan sub-sektor potensial

Tahapan 2: Mengumpulkan data dan melakukan perhitungan indikator yang digunakan untuk asesmen sub-sektor

Tahapan 3: Melakukan asesmen, perankingan, dan rekomendasi atas potensi subsektor makanan dan minuman

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Tahapan 1 – Pemilihan Indikator
Metodologi Keseluruhan

Tahapan 1 – Menyusun dan pemilihan Indikator

- **Langkah 1.1**: Studi literatur untuk mengumpulkan kriteria dan indikator
- **Langkah 1.2**: *Desk evaluation* terhadap kriteria dan indikator dari literatur
- **Langkah 1.3**: Survei terhadap *expert* dan *stakeholder* untuk pemilihan indikator
- **Langkah 1.4**: Pengolahan data dengan metode *grey clustering method* dan *weighted average method*
- **Langkah 1.5**: Diskusi/FGD dengan *stakeholder* untuk finalisasi indikator

Tahapan 2 – Pengumpulan dan Analisis Data

- **Langkah 2.1**: Pengumpulan data dari BPS 38 subsector KBLI 4 digit
- **Langkah 2.2**: Pengumpulan data dari SIINAS 38 subsector KBLI 4 digit
- **Langkah 2.3**: Asesmen dan penyaringan data
- **Langkah 2.4**: Imputasi dan estimasi indikator

Tahapan 3 – Asesmen Terhadap Subsektor

- **Langkah 3.1**: Penentuan skenario penilaian dan input metode
- **Langkah 3.2**: Perhitungan skor tiap sub-sektor berdasarkan tiap skenario
- **Langkah 3.3**: Perankingan dan perbandingan hasil tiap skenario
- **Langkah 3.4**: Rekomendasi sub-sektor

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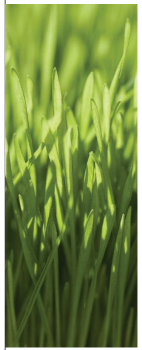
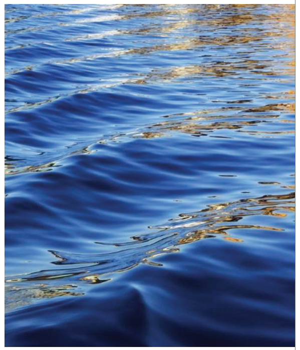


Tahapan 1
Pemilihan Indikator

Assessment of CE & LCD Indicators Selection for Potential Subsectors



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Tahapan 1 – Pemilihan Indikator
1.1 | Studi literatur

- Literatur acuan: paper ilmiah dan *report* studi CE dan LCDI di Indonesia sebelumnya*.
- Hasil:
  - ➢ 19 kriteria
  - ➢ 91 indikator
- Kesembilanbelas kriteria dan indikator-indikatornya ini masih mengandung:
  - ✓ **kriteria yang tidak redundan** (misal: *economic* dan *prosperity economy*)
  - ✓ **kriteria yang kurang relevan dengan studi ini** (misal: *smart economy* dan *spatially effective economy*)

* Referensi:

Avdiushchenko & Zajac (2019) "Circular Economy Indicators as a Supporting Tool for European Regional Development Policies" *Sustainability*, 11, 3025

Bappenas (2021) "Green recovery road map Indonesia 2021-2024: Building back better low carbon development Post-Covid 19"

Bappenas, Embassy of Denmark, UNDP (2021) "The economic, social, and environmental benefits of circular economy in Indonesia"

Sun, Wu, Cheng, Tang, Li, & Mei (2020) "How Industrialization Stage Moderates the Impact of China's Low-Carbon Pilot Policy?", *Sustainability*, 12, 10577

Zhao, Zhao, & Guo (2017) "Evaluating the comprehensive benefit of eco-industrial parks by employing multi-criteria decision making approach for circular economy" *Journal of Cleaner Production*, 142, 2262-2276

Tahapan 1 – Pemilihan Indikator
1.2 | Desk Evaluation

Proses dalam tahap ini:
- Kriteria dan indikator yang tidak/kurang relevan: **dihapus**
- Kriteria dan indicator yang mirip/redundan: **dihapus/digabungkan**

Hasil *Desk Evaluation*:
- Jumlah kriteria: 8
- Jumlah indikator: 42

Daftar Kriteria

1. *Economy*
2. *Social*
3. *Circularity potential*
4. *Energy system*
5. *Environmental system*
6. *Low carbon initiatives*
7. *Investment or outlays*
8. *Government support*

Tahapan 1 – Pemilihan Indikator
1.3 | Experts & Stakeholders Survey

- *Long list* calon responden dikumpulkan dari *network* peneliti serta Google dan LinkedIn (menggunakan kata kunci *circular economy, green economy, low carbon economy/development*).
- Responden dikontak melalui email atau WhatsApp dengan *link* kuesioner untuk menilai kepentingan dari masing-masing kriteria dan indikator (skala 1-5: sangat tidak penting s.d sangat penting).
- Pengumpulan data 24 November s.d. 8 Desember 2021.

Statistik Responden

***Long list* calon responden:**
- Jumlah: 45 orang calon responden
- Kalangan: pemerintahan, akademisi, think-tank/organisasi internasional, dan industri/swasta.

Respon yang didapat:
- Jumlah : 24 orang
  - Pemerintahan: 3 orang
  - Akademisi: 7 orang
  - Think-tank/LSM/organisasi internasional: 12 orang
  - Industri: 2 orang
- Dari 24 responden, satu responden dieliminasi karena menjawab seragam.

***Response rate*:** 55%

Tahapan 1 – Pemilihan Indikator

1.4 | Data Processing

- Respon dianalisis dengan 2 tahap:
  1. menggunakan metode *grey clustering* dan menghasilkan **37 indikator** yang dipertahankan karena masuk ke kelompok sangat penting atau penting. Lima indikator lainnya dieliminasi.
  2. Mengingat 37 indikator terlalu banyak dan tidak operasional dalam tahap berikutnya, digunakan langkah berikutnya dengan **me-ranking tingkat kepentingan** melalui skor rata-rata (terbobot) dari ke-37 indikator tersebut.
- Skor rata-rata kepentingan diperoleh dengan merata-ratakan (*grand average*) rata-rata skor kepentingan tiap kelompok, sehingga kelompok *expert* tertentu tidak *over/under-represented.*

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Tahapan 1 – Pemilihan Indikator

1.4 | Data Processing

Aspek yang dipertimbangkan dalam memilih *short-listed indicators* :

1. **Tiap kriteria perlu terwakili** dalam daftar *short-listed* indicators
2. **Jumlah indikator final cukup kecil** (tidak lebih dari 20)

Berdasarkan kedua aspek ini maka dipilih **dua indikator** dengan rata-rata skor tertinggi pada masing-masing kriteria, dengan **pengecualian kriteria yang indikator dengan** ranking ketiga memiliki skor sangat tinggi (*top 10* di antara 37 indikator) tetap dipertahankan.

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Tahapan 1 – Pemilihan Indikator

1.4 | Data Processing

Criterion	Indicator	No.	Weight
Economy	Economic annual average growth rate of sub-sektor added value	1	4.354
	Potential to increase employment	2	4.500
Social	Potential to educate or to increase awareness on environment issues	3	4.583
	Potential to reduce poverty	4	4.479
Circularity	Industrial water recycling rate	5	4.708
	Energy recycling rate	6	4.813
	The substitution of raw material source with recycled material	7	4.708
Energy System	Potential power consumption reduction rate per unit sub-sektor output	8	4.521
	Potential energy consumption reduction rate per unit sub-sektor output	9	4.542
	Potential use of renewable energy sources	10	4.500
Environment System	Waste treatment facilities	11	4.563
	Potential toxic and hazardous waste emissions reduction	12	4.604
Low Carbon Development	Potential carbon dioxide emission reduction	13	4.583
	Potential other GHG emission reduction	14	4.563
Investment or Outlays Needed	Investment or outlays needed on fixed assets related to energy saving	15	4.604
	Investment or outlays needed related to carbon reducing system	16	4.521
Stakeholder Involvement	Government priority	17	4.521
	Potential of private sektor involvement	18	4.813

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Tahapan 1 – Pemilihan Indikator

1.4 | Data Processing

Hasil *short-listed indicators* selanjutnya dievaluasi bersama untuk diperoleh indikator final

Disepakati indikator yang digunakan hanya yang bersifat objektif dan terdapat data kuantitatif.

Criterion	Indicator	No.	Data/Proxies to be Collected	Final
Economy	Economic annual average growth rate of sub-sektor added value	1	GDP / value added	1
	Potential to increase employment	2	Number of employee	2
Social	Potential to educate or to increase awareness on environment issues	3	Qualitative	
	Potential to reduce poverty	4	GDP / employee	
Circularity	Industrial water recycling rate	5	Water consumption	3
	Energy recycling rate	6	Energy consumption	4
	The substitution of raw material source with recycled material	7	Qualitative / expert (percentage)	
Energy System	Potential power consumption reduction rate per unit sub-sektor output	8	Power consumption	5
	Potential energy consumption reduction rate per unit sub-sektor output	9	Energy consumption	
	Potential use of renewable energy sources	10	Qualitative / expert	
Environment System	Waste treatment facilities	11	Jumlah fasilitas / volume	6
	Potential toxic and hazardous waste emissions reduction	12	Toxic emission (B3)	7
Low Carbon Development	Potential carbon dioxide emission reduction	13	CO2 emission (tidak ada)	8
	Potential other GHG emission reduction	14	Other GHG emission (tidak ada)	9
Investment or Outlays Needed	Investment or outlays needed on fixed assets related to energy saving	15	n.a (qualitative/expert knowledge)	
	Investment or outlays needed related to carbon reducing system	16	n.a (qualitative/expert knowledge)	
Stakeholder Involvement	Government priority	17	Qualitative	
	Potential of private sektor involvement	18	Qualitative	

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Tahapan 1 – Pemilihan Indikator

1.5 | Focus Group Discussions

Hasil *short-listed indicators* selanjutnya dievaluasi bersama untuk diperoleh indikator final

Disepakati indikator yang digunakan hanya yang bersifat objektif dan terdapat data kuantitatif.

Indicators	Data Collected (from SIINAS)	Data Collected / Calculated
Economic annual average growth rate of sub-sektor added value	GDP / value added	1
Potential to increase employment	Number of employee	2
Potential to educate or to increase awareness on environment issues	Qualitative	
Potential to reduce poverty	GDP / employee	
Industrial water recycling rate	Water consumption	3
Energy recycling rate	Energy consumption	4
The substitution of raw material source with recycled material	Qualitative / expert (percentage)	
Potential power consumption reduction rate per unit sub-sektor output	Power consumption	5
Potential energy consumption reduction rate per unit sub-sektor output	Energy consumption	
Potential use of renewable energy sources	Qualitative / expert	
Waste treatment facilities	Jumlah fasilitas / volume	6
Potential toxic and hazardous waste emissions reduction	Toxic emission (B3)	7
Potential carbon dioxide emission reduction	CO2 emission (tidak ada)	8
Potential other GHG emission reduction	Other GHG emission (tidak ada)	9

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Tahapan 2 – Pengumpulan dan Analisis Data

Metodologi Umum

Langkah 2.1: Pengumpulan data dari BPS

Langkah 2.2: Pengumpulan data dari SIINAS

Langkah 2.3: Asesmen dan penyaringan data

Langkah 2.4: Imputasi dan estimasi indikator

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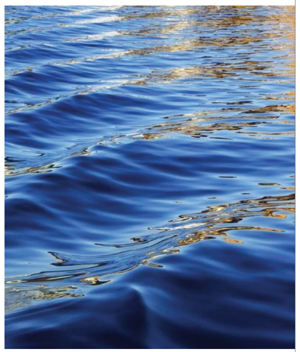
Tahapan 2

Pengumpulan dan Analisis Data

Assessment of CE & LCD Indicators Selection for Potential Subsectors



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Tahapan 2 – Pengumpulan dan Analisis Data

2.1 | Pengumpulan Data BPS

- Pengumpulan data BPS dilakukan menggunakan publikasi Statistik Manufaktur Indonesia 2019 (publikasi terbaru).
- Data BPS di publikasi ini diperoleh dari survey dan menggunakan metode estimasi (tidak dijelaskan detil) diperoleh estimasi nilai total nasional untuk sub-sektor tersebut.

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Tahapan 2 – Pengumpulan dan Analisis Data

2.2 | Pengumpulan Data SIINAS

- Data dari Kemenperin diperoleh dari sampel terhadap perusahaan yang mengisi SIINAS.
- Dari data perusahaan sampel dihitung rata-rata sampel perusahaan untuk indikator-indikator yang datanya terekam di SIINAS.
- Untuk mendapatkan estimasi nilai nasional, dilakukan pengalian rataan sampel dengan jumlah perusahaan di sub-sektor tersebut di seluruh Indonesia (data jumlah perusahaan dari BPS).

Tahapan 2 – Pengumpulan dan Analisis Data

2.3 | Asesmen Kondisi Data: Kelengkapan

Gambaran sumber data

Indicators	Data (Proxy)	BPS	SIINAS
Economic annual average growth rate of sub-sektor added value	GDP / value added	Available	Not Available
Potential to increase employment	Number of employee	Available	Available
Industrial water recycling rate	Water consumption	Not Available	Available
Energy recycling rate	Energy consumption	Available	Available
Potential power consumption reduction rate per unit sub-sektor output	Power consumption	Available	Available
Waste treatment facilities	Jumlah fasilitas / volume	Not Available	Estimated
Potential toxic and hazardous waste emissions reduction	Toxic emission (B3)	Estimated	Estimated
Potential carbon dioxide emission reduction	CO_2 emission (tidak ada)	Estimated	Estimated
Potential other GHG emission reduction	Other GHG emission (tidak ada)	Estimated	Estimated

Tahapan 2 – Pengumpulan dan Analisis Data

2.3 | Asesmen Kondisi Data: Diskrepansi

Contoh diskrepansi estimasi data: konsumsi solar total (liter)

KLBI	BPS	Kemenperin*	Selisih	Persentase Selisih
1013	628.611	1.523.928	895.317	142%
1021	21.806.496	28.226.680	6.420.184	29%
1022	1.910.762	6.685.872	4.775.110	250%
1029	4.167.612	2.320.992	1.846.620	44%
1041	650.797	8.746.700	8.095.903	1244%
1042	10.186.372	2.555.787	7.630.585	75%
1043	229.096.872	717.057.673	487.960.801	213%
1051	1.218.882	1.752.911	534.029	44%

*Estimasi Data Kemenperin: rata-rata sampel Kemenperin dikalikan jumlah perusahaan di Indonesia (data BPS).

Tahapan 2 – Pengumpulan dan Analisis Data

2.4 | Imputasi dan Estimasi Indikator

- Namun demikian, masih terdapat banyak data yang *missing* (tidak ada nilainya) sehingga perlu diberi perlakuan (tidak dapat sekedar digantikan nol).
- Karena isu *missing value* yang terlalu banyak dapat bermasalah pada akurasi estimasi, untuk indikator dengan dua sumber data, dipilih sumber data dengan titik data yang lebih lengkap.
- Terdapat dua alternatif perlakuan *missing data*:
  1. Digantikan (imputasi) dengan nilai terkecil dari subsektor yang ada nilainya di indikator tersebut;
  2. Digantikan (imputasi) rataan dari nilai semua subsektor yang ada nilainya di indikator tersebut.
- Proses imputasi menggunakan sumber data yang sama.

Tahapan 2 – Pengumpulan dan Analisis Data

2.4 | Imputasi dan Estimasi Indikator

Contoh estimasi indikator dengan data yang ada

Bahan Bakar	Fraksi perhitungan energi (Mega Joule)	Fraksi perhitungan CO2 (gram)	Fraksi perhitungan GHG (Methana) [gram]	Fraksi perhitungan GHG (NO2) (gram)	Fraksi perhitungan B3 (ton)
Bensin (Liter)	31,54	2392,00	0,1004	0,0000	-
Minyak solar (Liter)	38,00	2640,00	0,1506	0,0572	-
Batubara (Kg)	29,30	2562,87	0,2712	0,0397	0,00007
Briket batubara (Kg)	30,35	2868,21	0,2712	0,0441	-
Gas PGN (M3)	38,18	2459,00	0,0373	0,0035	-
Gas bukan dari PGN (M3)	38,18	2459,00	0,0373	0,0035	-
LPG (Liter)	25,00	1665,00	0,0740	0,0159	-
Pelumas (Liter)	0,00	2351,52	0,1136	0,0198	0,0008

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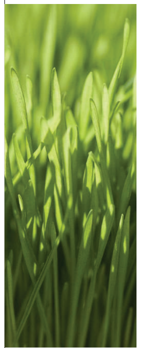
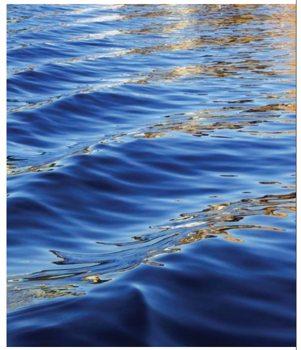


Tahapan 3

Asesmen Terhadap Subsektor

Assessment of CE & LCD Indicators Selection for Potential Subsectors



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Tahapan 2 – Pengumpulan dan Analisis Data

2.4 | Imputasi dan Estimasi Indikator

Contoh Dataset dengan Imputasi Nilai Minimum

KBLI	GDP/value added	Pekerja	Konsumsi air	Energi (Mjoule)	Listrik (kWh)	Pengolahan limbah (liter)	B3 (ton)	CO2 (gram)	GHG (gram)
1043	267.410.121.426	270.765	40.119.256.350	11.522.415.264	1.949.406.238	83.177.627	11.052	826.301.791.606	55.346.142
1071	22.031.098.315	114.715	8.982.581.640	2.175.305.224	165.804.979	21.302.559	214	145.656.522.866	5.397.537
1076	17.539.603.591	57.526	10.260.550	2.561.732.858	150.028.434	36.359.620	478	178.392.704.170	10.352.030
1077	58.249.637.800	53.981	442.626	2.994.320.713	483.369.453	464.898	1.225	207.182.831.770	10.174.224
1104	15.534.492.310	31.791	128.52	660.813.548	104.819.913	3.78	147	45.642.397.117	2.297.909
1105	18.075.251.912	51.314	403.92	463.506.456	167.749.718	11.88	147	33.037.003.746	2.261.652
1201	147.048.088.674	266.437	650.001.202	950.000.518	142.089.461	1.114.557	21	67.908.067.890	3.941.269

Contoh Dataset dengan Imputasi Nilai Rataan

KBLI	GDP/value added	Pekerja	Konsumsi air	Energi (Mjoule)	Listrik (kWh)	Pengolahan limbah (liter)	B3 (ton)	CO2 (gram)	GHG (gram)
1043	267,410,121,426	270,765	40,119,256,350	11,570,782,199	1,949,406,238	83,177,627	11,052	826,301,791,606	55,848,557
1071	22,031,098,315	114,715	8,982,581,640	2,175,305,224	165,804,979	21,302,559	214	145,656,522,866	5,397,537
1076	17,539,603,591	57,526	10,260,550	2,561,732,858	150,028,434	36,359,620	478	178,392,704,170	10,352,030
1077	58,249,637,800	53,981	442,626	2,994,320,713	483,369,453	464,898	1,225	207,182,831,770	10,174,224
1104	15,534,492,310	31,791	639,258,932	823,389,782	104,819,913	6,083,235	147	45,642,397,117	2,922,505
1105	18,075,251,912	51,314	2,009,099,500	511,873,390	167,749,718	19,118,739	147	33,037,003,746	2,764,067
1201	147,048,088,674	266,437	650,001,202	1,054,573,206	142,089,461	1,114,557	158	67,908,067,890	5,039,989

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Tahapan 3 – Asesmen Terhadap Subsektor

3.2 | Penentuan Skenario

Beberapa Isu dan Skenario

1. Sumber data yang dipakai untuk indikator dengan dua sumber data: BPS atau Kemenperin.
   - Karena isu *missing value* yang terlalu banyak dapat bermasalah pada akurasi estimasi, untuk indikator dengan dua sumber data, dipilih sumber data dengan titik data yang lebih lengkap.
2. Data nol/kosong di imputasi dengan menggunakan: (i) nilai minimum (ii) nilai rata-rata.
   - Proses imputasi menggunakan sumber data yang sama.
3. Magnitude indikator sub-sektor dapat sangat berbeda: (i) pengelompokan per jenis: makanan dan minuman (ii) digabungkan makanan, minuman, tembakau.

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Tahapan 3 – Asesmen Terhadap Subsektor
3.1 | Penentuan Skenario

Kode abjad untuk alternatif kelompok analisis:

A	Makanan saja
B	Minuman saja
C	Semua sektor

Kode angka untuk alternatif data perankingan:

1	Imputasi minimum
2	Imputasi rataan
3	Simple ranking (ordinal data)

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Tahapan 3 – Asesmen Terhadap Subsektor
3.2 | Perhitungan Skor

- Menggunakan metode *Multicriteria Decision Making* (MCDM) VIKOR (*non-fuzzy*).
- Dasar pemilihan:
  1. Terdapat banyak kriteria/indicator.
  2. Masing-masing indikator diukur dengan satuan dan *magnitude* berbeda, sehingga penilaian harus relatif (angka dalam ton tidak bisa dibandingkan dengan angka dalam rupiah).
  3. Hanya ada kriteria obyektif yang dipertimbangkan sehingga tidak menggunakan *fuzzy-VIKOR*, seperti rencana di awal.
- Prinsip VIKOR adalah penilaian skor relatif antar alternatif (sub-sektor). Langkah umum:
  1. Setiap *kriteria* bisa memiliki *ideal point* sebagai *maximum or minimum*.
  2. Setiap *alternatif* mendapat *nilai relatif dari jarak terhadap ideal point* dari alternatif-alternatif yang ada (*scaled*).
  3. Alternatif terbaik adalah yang *maksimum benefit* (total jarak dari ideal dikali bobot kriteria) terkecil.

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Tahapan 3 – Asesmen Terhadap Subsektor
3.3 | Perankingan dan perbandingan skenario

- Perankingan dilakukan dengan mengurutkan Skor VIKOR dari yang terkecil s.d yang terbesar untuk masing-masing skenario.
- Perbandingan dilakukan dengan membuat daftar 10 besar sub-sektor pada masing-masing skenario dan mengidentifikasi sub-sektor yang sering muncul di posisi tertinggi untuk tiap skenario.
- Analisis dilakukan dengan melihat nilai indikator-indikator untuk sub-sektor yang muncul di ranking tertinggi.

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Tahapan 3 – Asesmen Terhadap Subsektor
3.3 | Perankingan dan perbandingan skenario

Skenario A1: Makanan saja, imputasi minimum

Penjelasan:
- ❑ Menggunakan **data BPS sebagai referensi utama** dan hanya menggunakan **data Kemenperin** untuk perhitungan "*water consumption*" dan "*water treatment facilities*"
- ❑ Apabila terdapat **data yang masih kosong**, maka **diimputasi** dengan **nilai minimum** dari indikator tersebut
- ❑ Subsektor yang ditinjau hanya yang merupakan kategori **"Makanan"**
- ❑ **Bobot** yang digunakan dari **hasil kuesioner penentuan indikator penting**
- ❑ **Metode** yang digunakan adalah **VIKOR**

Rank	KBLI	Subsektor	Skor VIKOR
1	1043	INDUSTRI MINYAK MENTAH/MURNI KELAPA SAWIT (CRUDE PALM OIL) DAN MINYAK GORENG KELAPA SAWIT	0,001
2	1071	INDUSTRI PRODUK ROTI DAN KUE	0,878
3	1077	INDUSTRI BUMBU-BUMBUAN DAN PRODUK MASAK LAINNYA	0,908
4	1080	INDUSTRI MAKANAN HEWAN	0,911
5	1042	INDUSTRI KOPRA, MINYAK MENTAH DAN MINYAK GORENG KELAPA, DAN PELET KELAPA	0,936
6	1079	INDUSTRI PRODUK MAKANAN LAINNYA	0,938
7	1072	INDUSTRI GULA	0,944
8	1021	INDUSTRI PENGOLAHAN DAN PENGAWETAN IKAN DAN PRODUK IKAN	0,947
9	1074	INDUSTRI MAKARONI, MIE DAN PRODUK SEJENISNYA	0,959
10	1061	INDUSTRI PENGGILINGAN SERELIA DAN BIJI-BIJIAN LAINNYA (BUKAN BERAS DAN JAGUNG)	0,965

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Tahapan 3 – Asesmen Terhadap Subsektor

3.3 | Perankingan dan perbandingan skenario

Skenario B1: Minuman saja, imputasi minimum

Penjelasan:
- Menggunakan **data BPS sebagai referensi utama** dan hanya menggunakan **data Kemenperin** untuk perhitungan "*water consumption*" dan "*water treatment facilities*"
- Apabila terdapat **data yang masih kosong**, maka **diimputasi** dengan **nilai minimum** dari indikator tersebut
- Subsektor yang ditinjau hanya yang merupakan kategori **"Minuman"**
- **Bobot** yang digunakan dari **hasil kuesioner penentuan indikator penting**
- **Metode** yang digunakan adalah **VIKOR**

Rank	KBLI	Subsektor	Skor VIKOR
1	1076	INDUSTRI PENGOLAHAN KOPI, TEH DAN HERBAL (HERB INFUSION)	0,001
2	1105	INDUSTRI AIR KEMASAN DAN AIR MINUM ISI ULANG	0,767
3	1052	INDUSTRI PENGOLAHAN SUSU BUBUK DAN SUSU KENTAL	0,777
4	1073	INDUSTRI KAKAO, COKELAT DAN KEMBANG GULA	0,815
5	1104	INDUSTRI MINUMAN RINGAN	0,816
6	1051	INDUSTRI PENGOLAHAN SUSU SEGAR DAN KRIM	0,862
7	1031	INDUSTRI PENGOLAHAN DAN PENGAWETAN BUAH-BUAHAN DAN SAYURAN DENGAN CARA DIASINKAN, DILUMATKAN, DIKERINGKAN DAN DIBEKUKAN	0,929
8	1109	INDUSTRI MINUMAN LAINNYA	0,939
9	1053	INDUSTRI PENGOLAHAN ES KRIM DAN SEJENISNYA	0,948
10	1059	INDUSTRI PENGOLAHAN PRODUK DARI SUSU LAINNYA	0,970

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Tahapan 3 – Asesmen Terhadap Subsektor

3.3 | Perankingan dan perbandingan skenario

Skenario C1: Semua sub-sektor, imputasi minimum

Penjelasan:
- Menggunakan **data BPS sebagai referensi utama** dan hanya menggunakan **data Kemenperin** untuk perhitungan "*water consumption*" dan "*water treatment facilities*"
- Apabila terdapat **data yang masih kosong**, maka **diimputasi** dengan **nilai minimum** dari indikator tersebut
- Meninjau **keseluruhan subsektor**
- **Bobot** yang digunakan dari **hasil kuesioner penentuan indikator penting**
- **Metode** yang digunakan adalah **VIKOR**

Rank	KBLI	Subsektor	Skor VIKOR
1	1043	INDUSTRI MINYAK MENTAH/MURNI KELAPA SAWIT (CRUDE PALM OIL) DAN MINYAK GORENG KELAPA SAWIT	0,001
2	1071	INDUSTRI PRODUK ROTI DAN KUE	0,878
3	1201	INDUSTRI ROKOK DAN PRODUK TEMBAKAU LAINNYA	0,886
4	1077	INDUSTRI BUMBU-BUMBUAN DAN PRODUK MASAK LAINNYA	0,908
5	1076	INDUSTRI PENGOLAHAN KOPI, TEH DAN HERBAL (HERB INFUSION)	0,908
6	1080	INDUSTRI MAKANAN HEWAN	0,911
7	1042	INDUSTRI KOPRA, MINYAK MENTAH DAN MINYAK GORENG KELAPA, DAN PELET KELAPA	0,936
8	1079	INDUSTRI PRODUK MAKANAN LAINNYA	0,938
9	1072	INDUSTRI GULA	0,944
10	1021	INDUSTRI PENGOLAHAN DAN PENGAWETAN IKAN DAN PRODUK IKAN	0,946

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Tahapan 3 – Asesmen Terhadap Subsektor

3.3 | Perankingan dan perbandingan skenario

Skenario A2: Makanan saja, imputasi rataan

Penjelasan:
- Menggunakan **data BPS sebagai referensi utama** dan hanya menggunakan **data Kemenperin** untuk perhitungan "*water consumption*" dan "*water treatment facilities*"
- Apabila terdapat **data yang masih kosong**, maka **diimputasi** dengan **nilai rata-rata** dari indikator tersebut
- Subsektor yang ditinjau hanya yang merupakan kategori **"Makanan"**
- **Bobot** yang digunakan dari **hasil kuesioner penentuan indikator penting**
- **Metode** yang digunakan adalah **VIKOR**

Rank	KBLI	Subsektor	Skor VIKOR
1	1043	INDUSTRI MINYAK MENTAH/MURNI KELAPA SAWIT (CRUDE PALM OIL) DAN MINYAK GORENG KELAPA SAWIT	0,001
2	1071	INDUSTRI PRODUK ROTI DAN KUE	0,883
3	1077	INDUSTRI BUMBU-BUMBUAN DAN PRODUK MASAK LAINNYA	0,912
4	1080	INDUSTRI MAKANAN HEWAN	0,915
5	1042	INDUSTRI KOPRA, MINYAK MENTAH DAN MINYAK GORENG KELAPA, DAN PELET KELAPA	0,940
6	1079	INDUSTRI PRODUK MAKANAN LAINNYA	0,942
7	1072	INDUSTRI GULA	0,948
8	1021	INDUSTRI PENGOLAHAN DAN PENGAWETAN IKAN DAN PRODUK IKAN	0,951
9	1074	INDUSTRI MAKARONI, MIE DAN PRODUK SEJENISNYA	0,963
10	1061	INDUSTRI PENGGILINGAN SERELIA DAN BIJI-BIJIAN LAINNYA (BUKAN BERAS DAN JAGUNG)	0,968

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Tahapan 3 – Asesmen Terhadap Subsektor

3.3 | Perankingan dan perbandingan skenario

Skenario B2: Minuman saja, imputasi rataan

Penjelasan:
- Menggunakan **data BPS sebagai referensi utama** dan hanya menggunakan **data Kemenperin** untuk perhitungan "*water consumption*" dan "*water treatment facilities*"
- Apabila terdapat **data yang masih kosong**, maka **diimputasi** dengan **nilai rata-rata** dari indikator tersebut
- Subsektor yang ditinjau hanya yang merupakan kategori **"Minuman"**
- **Bobot** yang digunakan dari **hasil kuesioner penentuan indikator penting**
- **Metode** yang digunakan adalah **VIKOR**

Rank	KBLI	Subsektor	Skor VIKOR
1	1104	INDUSTRI MINUMAN RINGAN	0,310
2	1076	INDUSTRI PENGOLAHAN KOPI, TEH DAN HERBAL (HERB INFUSION)	0,437
3	1105	INDUSTRI AIR KEMASAN DAN AIR MINUM ISI ULANG	0,443
4	1109	INDUSTRI MINUMAN LAINNYA	0,743
5	1031	INDUSTRI PENGOLAHAN DAN PENGAWETAN BUAH-BUAHAN DAN SAYURAN DENGAN CARA DIASINKAN, DILUMATKAN, DIKERINGKAN DAN DIBEKUKAN	0,754
6	1052	INDUSTRI PENGOLAHAN SUSU BUBUK DAN SUSU KENTAL	0,775
7	1073	INDUSTRI KAKAO, COKELAT DAN KEMBANG GULA	0,830
8	1103	INDUSTRI MINUMAN BERALKOHOL HASIL FERMENTASI MALT DAN INDUSTRI MALT	0,845
9	1101	INDUSTRI MINUMAN BERALKOHOL HASIL DESTILAS	0,849
10	1033	INDUSTRI PENGOLAHAN SARI BUAH DAN SAYURAN	0,870

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Tahapan 3 – Asesmen Terhadap Subsektor

3.3 | Perankingan dan perbandingan skenario

Skenario C2: Semua sub-sektor, imputasi rataan

Penjelasan:
- Menggunakan **data BPS sebagai referensi utama** dan hanya menggunakan **data Kemenperin** untuk perhitungan "*water consumption*" dan "*water treatment facilities*"
- Apabila terdapat **data yang masih kosong**, maka **diimputasi** dengan **nilai rata-rata** dari indikator tersebut
- Meninjau **keseluruhan subsektor**
- **Bobot** yang digunakan dari **hasil kuesioner penentuan indikator penting**
- **Metode** yang digunakan adalah **VIKOR**

Rank	KBLI	Subsektor	Skor VIKOR
1	1043	INDUSTRI MINYAK MENTAH/MURNI KELAPA SAWIT (CRUDE PALM OIL) DAN MINYAK GORENG KELAPA SAWIT	0,001
2	1071	INDUSTRI PRODUK ROTI DAN KUE	0,882
3	1201	INDUSTRI ROKOK DAN PRODUK TEMBAKAU LAINNYA	0,887
4	1077	INDUSTRI BUMBU-BUMBUAN DAN PRODUK MASAK LAINNYA	0,912
5	1076	INDUSTRI PENGOLAHAN KOPI, TEH DAN HERBAL (HERB INFUSION)	0,912
6	1080	INDUSTRI MAKANAN HEWAN	0,915
7	1042	INDUSTRI KOPRA, MINYAK MENTAH DAN MINYAK GORENG KELAPA, DAN PELET KELAPA	0,940
8	1079	INDUSTRI PRODUK MAKANAN LAINNYA	0,942
9	1105	INDUSTRI AIR KEMASAN DAN AIR MINUM ISI ULANG	0,947
10	1072	INDUSTRI GULA	0,948

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Tahapan 3 – Asesmen Terhadap Subsektor

3.3 | Perankingan dan perbandingan skenario

Skenario A3: Makanan saja, simple ranking

Penjelasan:
- Menggunakan **data BPS sebagai referensi utama** dan hanya menggunakan **data Kemenperin** untuk perhitungan "*water consumption*" dan "*water treatment facilities*"
- Apabila terdapat **data yang masih kosong**, maka **diimputasi** dengan **nilai rata-rata** dari indikator tersebut
- Subsektor yang ditinjau hanya yang merupakan kategori **"Makanan"**
- **Bobot** yang digunakan dari **hasil kuesioner penentuan indikator penting**
- Metode yang digunakan adalah **menentukan ranking subsektor** pada **setiap indikator** kemudian **dikali dengan bobot**

Rank	KBLI	Subsektor	Skor VIKOR
1	1043	INDUSTRI MINYAK MENTAH/MURNI KELAPA SAWIT (CRUDE PALM OIL) DAN MINYAK GORENG KELAPA SAWIT	40,356
2	1071	INDUSTRI PRODUK ROTI DAN KUE	161,467
3	1077	INDUSTRI BUMBU-BUMBUAN DAN PRODUK MASAK LAINNYA	212,129
4	1072	INDUSTRI GULA	248,967
5	1079	INDUSTRI PRODUK MAKANAN LAINNYA	265,386
6	1080	INDUSTRI MAKANAN HEWAN	267,719
7	1021	INDUSTRI PENGOLAHAN DAN PENGAWETAN IKAN DAN PRODUK IKAN	290,574
8	1042	INDUSTRI KOPRA, MINYAK MENTAH DAN MINYAK GORENG KELAPA, DAN PELET KELAPA	313,47
9	1074	INDUSTRI MAKARONI, MIE DAN PRODUK SEJENISNYA	359,707
10	1061	INDUSTRI PENGGILINGAN SERELIA DAN BIJI-BIJIAN LAINNYA (BUKAN BERAS DAN JAGUNG)	478,875

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Tahapan 3 – Asesmen Terhadap Subsektor

3.3 | Perankingan dan perbandingan skenario

Skenario B3: Minuman saja, simple ranking

Penjelasan:
- Menggunakan **data BPS sebagai referensi utama** dan hanya menggunakan **data Kemenperin** untuk perhitungan "*water consumption*" dan "*water treatment facilities*"
- Apabila terdapat **data yang masih kosong**, maka **diimputasi** dengan **nilai rata-rata** dari indikator tersebut
- Subsektor yang ditinjau hanya yang merupakan kategori **"Minuman"**
- **Bobot** yang digunakan dari **hasil kuesioner penentuan indikator penting**
- Metode yang digunakan adalah **menentukan ranking subsektor** pada **setiap indikator** kemudian **dikali dengan bobot**

Rank	KBLI	Subsektor	Skor VIKOR
1	1076	INDUSTRI PENGOLAHAN KOPI, TEH DAN HERBAL (HERB INFUSION)	113,916
2	1104	INDUSTRI MINUMAN RINGAN	142,986
3	1105	INDUSTRI AIR KEMASAN DAN AIR MINUM ISI ULANG	155,572
4	1052	INDUSTRI PENGOLAHAN SUSU BUBUK DAN SUSU KENTAL	240,923
5	1051	INDUSTRI PENGOLAHAN SUSU SEGAR DAN KRIM	262,924
6	1073	INDUSTRI KAKAO, COKELAT DAN KEMBANG GULA	336,833
7	1053	INDUSTRI PENGOLAHAN ES KRIM DAN SEJENISNYA	343,323
8	1031	INDUSTRI PENGOLAHAN DAN PENGAWETAN BUAH-BUAHAN DAN SAYURAN DENGAN CARA DIASINKAN, DILUMATKAN, DIKERINGKAN DAN DIBEKUKAN	364,978
9	1109	INDUSTRI MINUMAN LAINNYA	383,649
10	1101	INDUSTRI MINUMAN BERALKOHOL HASIL DESTILAS	395,312

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Tahapan 3 – Asesmen Terhadap Subsektor

3.3 | Perankingan dan perbandingan skenario

Skenario C3: Semua sub-sektor, simple ranking

Penjelasan:
- Menggunakan **data BPS sebagai referensi utama** dan hanya menggunakan **data Kemenperin** untuk perhitungan "*water consumption*" dan "*water treatment facilities*"
- Apabila terdapat **data yang masih kosong**, maka **diimputasi** dengan **nilai rata-rata** dari indikator tersebut
- Meninjau **keseluruhan** subsektor
- **Bobot** yang digunakan dari **hasil kuesioner penentuan indikator penting**
- Metode yang digunakan adalah **menentukan ranking subsektor** pada **setiap indikator** kemudian **dikali dengan bobot**

Rank	KBLI	Subsektor	Skor VIKOR
1	1043	INDUSTRI MINYAK MENTAH/MURNI KELAPA SAWIT (CRUDE PALM OIL) DAN MINYAK GORENG KELAPA SAWIT	40,356
2	1071	INDUSTRI PRODUK ROTI DAN KUE	210,449
3	1076	INDUSTRI PENGOLAHAN KOPI, TEH DAN HERBAL (HERB INFUSION)	323,565
4	1201	INDUSTRI ROKOK DAN PRODUK TEMBAKAU LAINNYA	354,898
5	1072	INDUSTRI GULA	359,759
6	1077	INDUSTRI BUMBU-BUMBUAN DAN PRODUK MASAK LAINNYA	367,985
7	1080	INDUSTRI MAKANAN HEWAN	383,574
8	1079	INDUSTRI PRODUK MAKANAN LAINNYA	410,658
9	1021	INDUSTRI PENGOLAHAN DAN PENGAWETAN IKAN DAN PRODUK IKAN	464,184
10	1105	INDUSTRI AIR KEMASAN DAN AIR MINUM ISI ULANG	489,131

KIREI

Tahapan 3 – Asesmen Terhadap Subsektor

3.3 | Perankingan dan perbandingan skenario

Rangkuman

Ranking	Skenario								
	A1	A2	A3	B1	B2	B3	C1	C2	C3
1	1043	1043	1043	1076	1104	1076	1043	1043	1043
2	1071	1071	1071	1105	1076	1104	1071	1071	1071
3	1077	1077	1077	1052	1105	1105	1201	1201	1076
4	1080	1080	1072	1073	1109	1052	1077	1077	1201
5	1042	1042	1079	1104	1031	1051	1076	1076	1072
6	1079	1079	1080	1051	1052	1073	1080	1080	1077
7	1072	1072	1021	1031	1073	1053	1042	1042	1080
8	1021	1021	1042	1109	1103	1031	1079	1079	1079
9	1074	1074	1074	1053	1101	1109	1072	1105	1021
10	1061	1061	1061	1059	1033	1101	1021	1072	1105

Keterangan singkat:
1043: Sawit
1071: Roti dan Kue
1077: Bumbu
1076: Kopi, teh, herbal
1105: Air minum kemasan
1152: Susu bubuk dan kental
1104: Minuman ringan
1201: Tembakau

Tahapan 3 – Asesmen Terhadap Subsektor

3.3 | Perankingan dan perbandingan skenario

Analisis sensitivitas

Skenario C1

- Skenario mempertimbangkan **semua subsektor**
- **Imputasi** nilai kosong dengan **nilai minimum**
- **Metode** yang digunakan adalah **VIKOR** dengan **bobot** dari **hasil kuesioner**

	Indicators	Bobot awal	Diubah menjadi
Sensitivitas 1	**Indikator kriteria "Economy" diubah menjadi nol**		
	Economic annual average growth rate of sub-sektor added value		0
	Potential to increase employment		0
Sensitivitas 2	**Indikator kriteria "Circularity" diubah menjadi lima**		
	Industrial water recycling rate		5
	Energy recycling rate		5
Sensitivitas 3	**Indikator kriteria "Economy" diubah menjadi nol dan indikator kriteria "Circularity" diubah menjadi lima**		
	Economic annual average growth rate of sub-sektor added value		0
	Potential to increase employment		0
	Industrial water recycling rate		5
	Energy recycling rate		5

Tahapan 3 – Asesmen Terhadap Subsektor

3.3 | Perankingan dan perbandingan skenario

Daftar Kode KBLI

KBLI	Frekuensi	Subsektor
1043	6	INDUSTRI MINYAK MENTAH/MURNI KELAPA SAWIT (CRUDE PALM OIL) DAN MINYAK GORENG KELAPA SAWIT
1071	6	INDUSTRI PRODUK ROTI DAN KUE
1077	6	INDUSTRI BUMBU-BUMBUAN DAN PRODUK MASAK LAINNYA
1080	6	INDUSTRI MAKANAN HEWAN
1079	6	INDUSTRI PRODUK MAKANAN LAINNYA
1072	6	INDUSTRI GULA
1076	6	INDUSTRI PENGOLAHAN KOPI, TEH DAN HERBAL (HERB INFUSION)
1042	5	INDUSTRI KOPRA, MINYAK MENTAH DAN MINYAK GORENG KELAPA, DAN PELET KELAPA
1021	5	INDUSTRI PENGOLAHAN DAN PENGAWETAN IKAN DAN PRODUK IKAN
1105	5	INDUSTRI AIR KEMASAN DAN AIR MINUM ISI ULANG
1074	3	INDUSTRI MAKARONI, MIE DAN PRODUK SEJENISNYA
1061	3	INDUSTRI PENGGILINGAN SERELIA DAN BIJI-BIJIAN LAINNYA (BUKAN BERAS DAN JAGUNG)
1052	3	INDUSTRI PENGOLAHAN SUSU BUBUK DAN SUSU KENTAL
1073	3	INDUSTRI KAKAO, COKELAT DAN KEMBANG GULA
1104	3	INDUSTRI MINUMAN RINGAN
1031	3	INDUSTRI PENGOLAHAN DAN PENGAWETAN BUAH-BUAHAN DAN SAYURAN DENGAN CARA DIASINKAN, DILUMATKAN, DIKERINGKAN DAN DIBEKUKAN
1109	3	INDUSTRI MINUMAN LAINNYA
1201	3	INDUSTRI ROKOK DAN PRODUK TEMBAKAU LAINNYA

Tahapan 3 – Asesmen Terhadap Subsektor

3.3 | Perbandingan hasil analisis sensitivitas

Rangkuman Analisis Sensitivitas

Ranking	Skenario dasar	Analisis sensitivitas		
	C1	S1	S2	S3
1	1043	1043	1043	1043
2	1071	1071	1201	1076
3	1201	1076	1076	1080
4	1077	1080	1080	1077
5	1076	1077	1071	1071
6	1080	1042	1077	1072
7	1042	1079	1072	1042
8	1079	1072	1079	1079
9	1072	1021	1042	1074
10	1021	1201	1021	1021

- Tidak terjadi perubahan pada ranking 1
- Ranking 1-10 tidak terjadi perubahan yang signifikan kecuali sub sektor 1201 (Tembakau) yang sensitif terhadap perubahan bobot kriteria "Economy"

Tahapan 3 – Asesmen Terhadap Subsektor
3.3 | Perankingan dan perbandingan skenario

Rangkuman

Untuk skenario sektor makanan saja (skenario A), ketiga skenario memberikan hasil stabil dengan urutan tiga besar:

1. Industri pengolahan minyak sawit;
2. Industri roti dan kue;
3. Industri bumbu-bumbuan dan produk masak lainnya.

Untuk skenario sektor minuman saja (skenario B), ketiga skenario secara umum memberikan sub-sektor tiga besar yang sama, dengan urutan yang sedikit berbeda. Ketiga sektor yang paling sering muncul dalam tiga besar:

1. Industri pengolahan kopi, teh, dan herbal;
2. Industri air minum dalam kemasan;
3. Industri minuman ringan.

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Tahapan 3 – Asesmen Terhadap Subsektor
3.3 | Perankingan dan perbandingan skenario

Rangkuman

Untuk skenario seluruh subsektor makanan, minuman, dan tembakau (skenario C), terdapat empat subsektor yang muncul dalam semua skenario:

1. Industri pengolahan minyak sawit;
2. Industri roti dan kue;
3. Industri rokok dan produk tembakau lainnya;
4. Industri pengolahan kopi, teh, dan herbal.

Untuk seluruh skenario, subsektor yang muncul di 3 besar (diurutkan dari yang paling sering muncul di tempat teratas):

1. Industri pengolahan minyak sawit;
2. Industri pengolahan kopi, teh, dan herbal;
3. Industri roti dan kue;
4. Industri minuman ringan;
5. Industri air minum dalam kemasan;
6. Industri rokok dan produk tembakau lainnya;
7. Industri bumbu-bumbuan dan produk masak lainnya.

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Tahapan 3 – Asesmen Terhadap Subsektor
3.3 | Perankingan dan perbandingan skenario

Analisis Hasil

- Sub-sektor Pengolahan Minyak Sawit selalu muncul di ranking teratas pada semua scenario, termasuk saat bobot indikator diubah-ubah (analisis sensitivitas). Hal ini disebabkan karena untuk semua indikator (ekonomi, lingkungan, social) sub-sektor ini memiliki nilai yang (jauh) lebih tinggi dari sub-sektor lainnya.
- Sub-sektor makanan secara umum memiliki posisi lebih tinggi dibandingkan sub-sektor miniman.
- Untuk sub-sektor minuman Pengolahan Kopi, Teh, dan Herbal memiliki ranking lebih tinggi dibandingkan sub-sektor minuman ringan dan AMDK terutama disebabkan oleh indikator penggunaan energi dan emisi yang jauh lebih tinggi, meskipun indikator nilai tambah GDP dan jumlah tenaga kerja tidak berbeda jauh.
- Sub-sektor Industri Rokok dan Pengolahan Tembakau menembus ranking 3 besar untuk scenario gabungan semua sub-sektor terutama disebabkan karena nilai tambah GDP dan jumlah tenaga kerja yang jauh lebih besar (kecuali terhadap Pengolahan Minyak Sawit) dibandingkan dengan sub-sektor lainnya.

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Tahapan 3 – Asesmen Terhadap Subsektor
3.4 | Rekomendasi

- Untuk tahapan studi lebih lanjut terkait dengan analisis lebih mendalam menggunakan LCA dan WCR, sub-sektor Pengolahan Minyak Sawit memiliki potensi terbesar untuk sektor makanan dan Pengolahan Kopi, Teh, dan Herbal untuk sektor minuman.
- Terkait sub-sektor Pengolahan Kopi, Teh, dan Herbal, sub-sektor ini memiliki heterogenitas tinggi, sehingga asesmen LCA dan WCR diperkirakan memiliki kompleksitas operasional dan data yang tinggi. Selain itu dari sisi impak ke kriteria ekonomi dan sosial tidak terlalu jauh dari ranking kedua dan ketiga di subsektor minuman (industri AMDK dan minuman ringan).
- Industri Rokok dan Pengolahan Tembakau, meskipun memiliki ranking lebih tinggi dari sub-sektor minuman, industri ini bukan industri yang dalam kategori dikembangkan dan memiliki dampak negatif bagi kesehatan masyarakat
- Dengan demikian, mempertimbangkan hasil tahapan QA/RA dan potensi kualitas analisis tahapan berikutnya yang mempertimbangkan kompleksitas pemodelan sub-sektor dan ketersediaan data, maka sub-sektor terpilih yang direkomendasikan adalah:
  1. Sub-sektor Pengolahan Minyak Sawit (KLBI: 1043)

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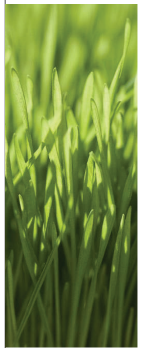
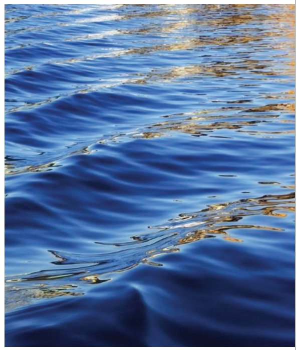


Lampiran 1
Detail ranking indikator per kriteria

Assessment of CE & LCD Indicators Selection for Potential Subsectors



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Ranking of Indicator Importance
Criterion: Social

No.	Indicator	Criterion Rank	Overall Rank
1.	Potential to educate or to increase awareness on environment issues	2	8
2.	Social intangible benefit potential	3	36
3.	Potential to reduce poverty	1	20
4.	Potential to increase women employment rate	5	42
5.	Potential to increase household saving	4	40

The two highest ranked indicators are very relevant and the rest of indicators have very low overall rank. In addition, potential to increase women employment rate and potential in increase household saving can be reflected by potential to reduce poverty.

KIREI

Ranking of Indicator Importance
Criterion: Economy

No.	Indicator	Criterion Rank	Overall Rank
1.	Economic annual average growth rate of sub-sektor added value	2	27
2.	Potential to increase employment	1	18
3.	Research and development input value in the sub-sektor	4	41
4.	Gross sub-sektor output value per unit of land	3	38

Although the second most important indikator in this criterion has a quite low rank in overall rank (below median), and considering economic added growth is closely related to GDP, then this indikator is included in the final indikator list.

KIREI

Ranking of Indicator Importance
Criterion: Circularity

No.	Indicator	Criterion Rank	Overall Rank
1.	Industrial water recycling rate	2.5	4
2.	Reclaimed water reuse rate	6	24
3.	Recycling rate of industrial solid waste	4	7
4.	Repeated utilization ratio of raw material	5	11
5.	Energy recycling rate	1	1
6.	The substitution of raw material source with recycled material	2.5	3

This criterion has very highly ranked indicators. The first four highest ranked indicators even are ranked in the top ten of overall rank. However, to keep the number of indicators for each criterion more balanced, recycling rate of industrial solid waste is dropped. This indikator to some extent can be reflected also by indikator 6: the substitution of raw material source with recycled material

KIREI

Ranking of Indicator Importance
Criterion: Energy System

No.	Indicator	Criterion Rank	Overall Rank
1.	Current coal consumption	5	33
2.	Current natural gas consumption	6	35
3.	Current power consumption	4	22
4.	Potential power consumption reduction rate per unit sub-sektor output	2	16
5.	Potential energy consumption reduction rate per unit sub-sektor output	1	13
6.	Potential use of renewable energy sources	3	19

The indikator of potential use of renewable energy sources is included although it is ranked number 3 because the importance is still higher than the median and using the other more highly ranked indicators still can not provide complete situation.

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Ranking of Indicator Importance
Criterion: Environmental System

Although this criterion has the most potential indicators, only two indikator: waste treatment facilities and potential toxic and hazardous waste emission reduction have overall rank in the top ten. Additionally, the third rank indikator, *potential hazardous waste disposal* reduction is closely related to *potential toxic and hazardous waste emission reduction.*

No.	Indicator	Criterion Rank	Overall Rank
1.	PM10 emission annual average concentration	11	39
2.	Potential industrial sulfur dioxide emissions reduction	8	32
3.	Potential industrial wastewater discharged reduction	5	25
4.	Sewage treatment rate	9	34
5.	The COD emissions of per unit of industrial added value	10	37
6.	The solid waste emissions of per unit of industrial added value	6	28
7.	Potential hazardous waste disposal reduction	3	14
8.	Potential harmless disposal rate of garbage reduction	7	29
9.	Waste treatment facilities	2	10
10.	Potential toxic and hazardous waste emissions reduction	1	5
11.	Fresh water consumption per unit of industrial added value	4	23

KIREI

Ranking of Indicator Importance
Criterion: Low Carbon Initiatives

No.	Indicator	Criterion Rank	Overall Rank
1.	Potential carbon dioxide emission reduction	1	9
2.	Potential other GHG emission reduction	2	12
3.	Potential to capture carbon emission/to absorb carbon	3	21

The third ranked indikator, potential to capture carbon emission is quite significantly lower of importance than the second ranked indikator. Moreover, in near future, the carbon capture technology is still not mature and costly, and is still difficult to be implemented in Indonesia esp. for SME.

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Ranking of Indicator Importance
Criterion: Investment or outlays needed

No.	Indicator	Criterion Rank	Overall Rank
1.	Investment or outlays needed on fixed assets related to environmental protection	3	26
2.	Investment or outlays needed on fixed assets related to energy saving	1	6
3.	Investment or outlays needed in pollutant reduction systems	4	30
4.	Investment or outlays needed related to carbon reducing system	2	15

The third and fourth ranked indicators have low importance score, hence only the top two are retained.

KIREI

Ranking of Indicator Importance
Criterion: Investment or outlays needed

No.	Indicator	Criterion Rank	Overall Rank
1.	Investment or outlays needed on fixed assets related to environmental protection	3	26
2.	Investment or outlays needed on fixed assets related to energy saving	1	6
4.	Investment or outlays needed related to carbon reducing system	2	15

The third and fourth ranked indicators have low importance score, hence only the top two are retained.

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Ranking of Indicator Importance
Criterion: Stakeholder Involvement

No.	Indicator	Criterion Rank	Overall Rank
1.	Government priority	2	17
2.	Potential of private sektor involvement	1	2
3.	Potential of international support	3	31

The third ranked indicators has low importance score. It also may reflect the thoughts of the experts the initiatives should not be depended on international support.

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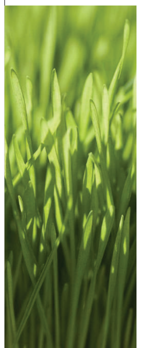
Final Result
Final Indicators

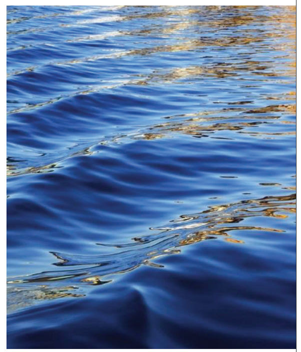
Criterion	Indicator	Numbering
Economy	Economic annual average growth rate of sub-sektor added value	1
	Potential to increase employment	2
Social	Potential to educate or to increase awareness on environment issues	3
	Potential to reduce poverty	4
Circularity	Industrial water recycling rate	5
	Energy recycling rate	6
	The substitution of raw material source with recycled material	7
Energy System	Potential power consumption reduction rate per unit sub-sektor output	8
	Potential energy consumption reduction rate per unit sub-sektor output	9
	Potential use of renewable energy sources	10
Environment System	Waste treatment facilities	11
	Potential toxic and hazardous waste emissions reduction	12
Low Carbon Development	Potential carbon dioxide emission reduction	13
	Potential other GHG emission reduction	14
Investment or Outlays Needed	Investment or outlays needed on fixed assets related to energy saving	15
	Investment or outlays needed related to carbon reducing system	16
Stakeholder Involvement	Government priority	17
	Potential of private sektor involvement	18

KIREI



Lampiran 2
Daftar Expert Undangan Survey

Assessment of CE & LCD Indicators Selection for Potential Subsectors



KIREI

Lampiran 2

List of Experts Invited in the Survey

No	Nama	Jabatan	Institusi	Kategori
1	Mohamad Bijaksana Junerosano	CEO and Founder Waste4Change	Waste4Change	Think Tank/CSO
2	Dr Ichsan	Business Advisor A-Wing Group	A-Wing Group	Industri
3	Dyah Roro Esti	Chair & Co-Founder of Indonesian Energy and Environmental Institute (IE2I)	Indonesian Energy and Environmental Institute (IE2I)	Think Tank/CSO
4	Muhammad Agung Saputra	Founder and CEO Surplus	Surplus	Think Tank/CSO
5	Nirarta Samadhi	Direktur WRI (Worlds Resources Institute) Indonesia	World Resources Institute) Indonesia	Think Tank/CSO
6	Nurdiana Darus	Head of Corporate Affairs and Sustainibility-Unilever	Unilever	Industri
7	Rosa Vivien Ratnawati, SH., M.Sc.	Direktur Jenderal Pengelolaan Limbah, Sampah, dan Bahan Beracun Berbahaya (PSLB3) - Kementrian Lingkungan Hidup dan Kehutanan	Kementerian Lingkungan Hidup dan Kehutanan	Pemerintah
8	Shinta Widjaja Kamdani	Chief Executive Officer at Sintesa Group; President of Indonesia Business Council for Sustainable Development (IBCSD); Vice Chairwoman for Int'l Relations KADIN	Sintesa Group	Industri
9	Intan Anggita Pratiwie	Recycling Artist, Sustainability Practicioner, Co-Founder di Setali Indonesia	Setalil Indonesia	Industri
10	Maria Dian Nurani	CSR & Sustainability Management Expert	Management Expert	Akademisi
11	Jane Marlen von Rabenau	CEO & Co-Founder of Siklus	Siklus	Industri
12	Professor M Akbar Rhamdhani	Director of Fluid and Process Dynamics (FPD) Group at Swinburne	Swinburne University	Akademisi
13	Professor Tjandra Setiadi	Guru Besar Teknik Kimia ITB	Institut Teknologi Bandung	Akademisi
14	Ir. Achmad gunawan Widjaksono, MAS	Direktur Verifikasi pengelolaan Limbah Bahan Berbahaya beracun, Limbah Non Bahan Berbahaya beracun KLHK	Kementrian Lingkungan Hidup dan Kehutanan	Pemerintah
15	Dr. Ir. Mohamad Satori, MT., IPU.	Ketua Forum Bank Sampah Jawa Barat/ Dekan Fakultas Teknik Unisba	Universitas Islam Bandung	Akademisi
16	Prof. Dr. Ir.Udisubakti Ciptomulyono M.Eng.Sc.	Dosen Institut Teknologi Sepuluh Nopember Surabaya	Institut Teknologi Sepuluh Nopember Surabaya	Akademisi
17	Ir. Noer Adi Wardojo, M.Sc	Kepala Pusat Standardisasi Lingkungan dan Kehutanan	Kementrian Lingkungan Hidup dan Kehutanan	Pemerintah

Lampiran 2

List of Experts Invited in the Survey

No	Nama	Jabatan	Institusi	Kategori
18	Ir. Muhammad Khayam. M.T.	Direktur Jenderal Industri Kimia, Farmasi, dan Tekstil (KEMENPERIN)	Kementrian Perindustrian	Pemerintah
19	Sri Gadis Paribekti	Analis Kebijakan Pusat Industri Hijau Kementrian Perindustrian	Kementrian Perindustrian	Pemerintah
20	Karyanto Wibowo	Sustainability Director-Danone | Chairman of PRAISE	Danone	Industri
21	Egi Suarga	Low Carbon Development Initiative (LCDI) Program Lead at World Resources Institute	World Resource Institute	Think Tank/CSO
22	Dadan Kusdiana	Director General NREEC Ministry of Energy and Mineral Resources	Kementrian ESDM	Pemerintah
23	Chrisnawan Andistya	Direktur Aneka Energi Baru dan Energi Terbarukan Kementrian ESDM	Kementrian ESDM	Pemerintah
24	Irfan Darliazi Yunanto	Perencana Direktorat Lingkungan Hidup Bappenas	Bappenas	Pemerintah
25	Dr. Eng. Pandji Prawisudha ST, MT	Dosen FTMD ITB	Institut Teknologi Bandung	Akademisi
26	Hendricus Andy Simarmata, ST, M.Si.	Dosen Pengembangan Perkotaan UI; Ketua Umum IAPI (Ikatan Ahli Perencanaan Indonesia)	Universitas Indonesia	Akademisi
27	Dr. Mahawan Karuniasa	Dosen Teknik Lingkugan UI; CEO Environment Institute	Universitas Indonesia	Akademisi
28	Dr. Ir. Agung Hendriardi	Kepala Badan Ketahanan Pangan Kementerian Pertanian RI	Kementrian Pertanian	Pemerintah
29	Welly Soegiono	Corporate Affairs Director Great Giant Pineapple (GGP)	Great Giant Pineapple (GGP)	Industri
30	Dr. Tri Edhi Budhi Soesilo	Direktur Sekolah Ilmu Lingkungan, Universitas Indonesia	Universitas Indonesia	Akademisi
31	Prof. Purnomo Yusgiantoro	Guru Besar Institut Teknologi Bandung, Pendiri Purnomo Yusgiantoro Center (PYC)	Institut Teknologi Bandung	Akademisi
32	Dr. Agus Prabowo	Head of Environment Unit, UNDP Indonesia	UNDP Indonesia	OI
33	Dr. Verania Andria	Senior Advisor on Sustainable Energy	UNDP Indonesia	OI
34	Mariski Nirwan	Knowledge and Capacity Development Lead @Global Green Growth Institute	Global Green Growth Institute	Think Tank/CSO
35	Ari W. Adipratomo	Project Coordinator for LCDI @World Resource Institute (WRI)	World Resource Institute	Think Tank/CSO
36	Andriati Cahyaningsih	Koordinator fungsi kerjasama, harmonisasi kebijakan, pengendalian dan pengawasan industri hijau, Direktorat Industri Kimia Hilir	Kementrian Perindustrian	Pemerintah
37	Prof.Dr.Ir. Enri Damanhuri	Guru Besar Teknik Lingkungan ITB	Institut Teknologi Bandung	Akademisi

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Lampiran 2

List of Experts Invited in the Survey

No	Nama	Jabatan	Institusi	Kategori
38	Angga Dwiartama, S.Si., M.Si., Ph.D.	Associate Professor SITH ITB	Institut Teknologi Bandung	Akademisi
39	Paul Butarbutar	Direktur Eksekutif	Masyarakat Energi Terbarukan Indonesia (METI)	Think Tank/CSO
40	Moekti (Kuki) Soejachmoen	Direktur Eksekutif	Indonesia Research Institute for Decarbonization (IRID)	Think Tank/CSO
41	Faisal	Direktur Eksekutif	CORE Indonesia	Think Tank/CSO
42	Misbah Hasan	Direktur Eksekutif	SEKNAS FITRA/ GENERASI HIJAU	Think Tank/CSO
43	Tiza Mafira	Direktur Eksekutif	CPI International	Think Tank/CSO
44	Dr. Ir. Janti Gunawan, M.Eng.Sc., M.Com.IB	Dosen ITS, Green Economy Expert	ITS Surabaya	Akademisi

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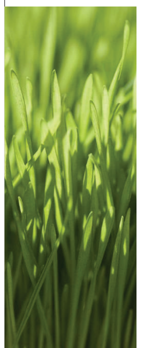
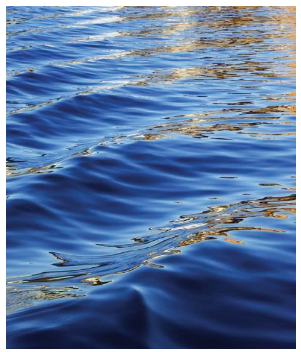
Kementerian PPN/ Bappenas



Lampiran 3

Bobot Kepentingan Indikator

Assessment of CE & LCD Indicators Selection for Potential Subsectors



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Lampiran 3

Indicators Importance Score

Indicator	Importance	Indicator	Importance	Indicator	Importance	Indicator	Importance
Economy 1	4,354	Circularity 1	4,708	Environment System 1	4,104	Low Carbon Development 1	4,583
Economy 2	4,500	Circularity 2	4,417	Environment System 2	4,292	Low Carbon Development 2	4,563
Economy 3	3,792	Circularity 3	4,583	Environment System 3	4,417	Low Carbon Development 3	4,479
Economy 4	4,125	Circularity 4	4,563	Environment System 4	4,229	Investment & Outlay 1	4,396
Social 1	4,583	Circularity 5	4,813	Environment System 5	4,146	Investment & Outlay 2	4,604
Social 2	4,146	Circularity 6	4,708	Environment System 6	4,354	Investment & Outlay 3	4,333
Social 3	4,479	Energy System 1	4,271	Environment System 7	4,542	Investment & Outlay 4	4,521
Social 4	3,792	Energy System 2	4,188	Environment System 8	4,333	Stakeholder 1	4,521
Social 5	3,833	Energy System 3	4,438	Environment System 9	4,563	Stakeholder 2	4,813
		Energy System 4	4,521	Environment System 10	4,604	Stakeholder 3	4,292
		Energy System 5	4,542	Environment System 11	4,438		
		Energy System 6	4,500				

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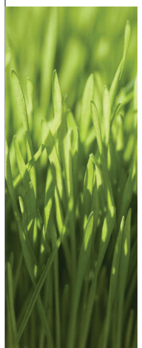
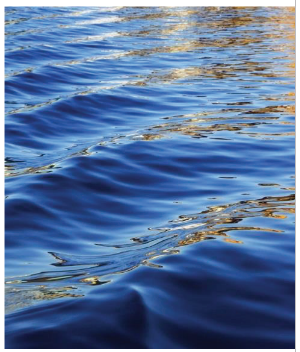

Lampiran 4

Detil Algoritma Vikor

Assessment of CE & LCD Indicators Selection for Potential Subsectors

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1. Penilaian alternatif

- Penilaian alternatif keputusan dilakukan oleh pengambil keputusan terhadap seluruh alternatif pada setiap kriteria.
- **Penilaian alternatif keputusan** dirangkum pada sebuah matriks penilaian, yang disebut **matriks A.**
- Matriks penilaian dengan sejumlah m alternatif keputusan dan n kriteria keputusan adalah sebagai berikut

$$A = \begin{bmatrix} x_{11} & x_{12} & \cdots & \tilde{x}_{1p} \\ x_{21} & x_{22} & \cdots & \tilde{x}_{2p} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & \tilde{x}_{mp} \end{bmatrix}$$

KIREI

2. Normalisasi penilaian

- Langkah kedua dilakukan normalisasi terhadap matriks agregasi penilaian. Normalisasi dilakukan dengan menggunakan persamaaan (1)

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{m} a_{ij}} (i = 1,2, \dots, m; j = 1,2, \dots, p) \quad (1)$$

3. Tentukan solusi ideal positif dan solusi ideal negatif

- Penentuan solusi ideal positif dan negatif dilambangkan dengan notasi B^+ dan B^-. Persamaan (2) dan (3) adalah perhitungan B^+ dan B^-.

$$B^+ = (b_j^+) = \{(\max_i b_{ij} | j \in J_1), (\min_i b_{ij} | j \in J_2)\} \quad (2)$$

$$B^- = (b_j^-) = \{(\min_i b_{ij} | j \in J_1), (\max_i b_{ij} | j \in J_2)\} \quad (3)$$

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4. Perhitungan nilai S_i dan R_i

- Perhitungan indeks *group benefit value* S_i dan *individual regret value* R_i dilakukan dengan menggunakan persamaan (4) dan (5).

$S_i = \sum_{j=1}^{n} w_j.(f_j^* - f_{ij})/(f_j^* - f_j^-)$	(4)
$R_i = \max\left(w_j.(f_j^* - f_{ij})/(f_j^* - f_j^-)\right)$	(5)

5. Perhitungan nilai Q_i

- Nilai *utility* (Q_i) dari setiap alternatif dihitung dengan menggunakan persamaan (6).
- Di mana $S^* = \min S_i$, $S^- = \max S_i$, $R^* = \min S_i$, $R^- = \max S_i$, dan $v = 0{,}5$ untuk pengambilan keputusan dengan konsensus di antara pengambil keputusan (Opricovic & Tzeng, 2007; Devi, 2011).

$Q_i = v.\frac{(S_i - S^*)}{(S^- - S^*)} + (1-v).(R_i - R^*)/(R^- - R^*)$	(6)

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6. Penentuan peringkat alternatif berdasarkan S_i, R_i, dan Q_i

- Peringkat alternatif dibuat berdasarkan nilai ketiga indeks S_i, R_i, dan Q_i.
- **Semakin kecil nilainya, peringkat sebuah alternatif semakin tinggi** karena semakin dekat dengan solusi ideal positif dan jauh dari solusi ideal negatif (Opricovic et al, 2007; Devi, 2011).

7. Penentuan solusi kompromi

- Langkah kesepuluh merupakan penentuan solusi alternatif keputusan terbaik hasil kompromi. Solusi terbaik dengan **nilai *utility* (Q_i) minimum merupakan alternatif solusi terbaik jika memenuhi kondisi berikut:**
  - Kondisi *acceptable advantage* (1)

  Di mana $Q(A^{(2)})$ adalah nilai *utility* alternatif terbaik kedua, dan nilai DQ adalah $DQ = 1/(J-1)$, dengan J adalah **jumlah alternatif keputusan.**

$Q(A^{(2)}) - Q(A^{(1)}) \geq DQ$	(7)

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8. Penentuan solusi kompromi - Lanjutan

- Langkah kesepuluh merupakan penentuan solusi alternatif keputusan terbaik hasil kompromi. Solusi terbaik dengan nilai *utility* (Q_i) minimum merupakan alternatif solusi terbaik jika memenuhi kondisi berikut:
  - Kondisi *acceptable stability in decision making* (2)

  Alternatif $A^{(1)}$ harus merupakan alternatif keputusan terbaik juga berdasarkan nilai Si dan Ri. Jika salah satu dari dua kondisi tidak terpenuhi, solusi alternatif keputusan terbaik diusulkan dengan pertimbangan berikut.
    - Alternatif $A^{(1)}$ dan $A^{(2)}$ jika hanya kondisi (2) yang tidak terpenuhi.
    - Alternatif $A^{(1)}, A^{(2)}, \ldots, A^{(m)}$ jika kondisi (1) tidak terpenuhi, dimana $A^{(m)}$ ditentukan dengan persamaan 9

$Q(A^{(M)}) - Q(A^{(1)}) < DQ$	(8)

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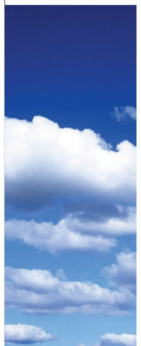
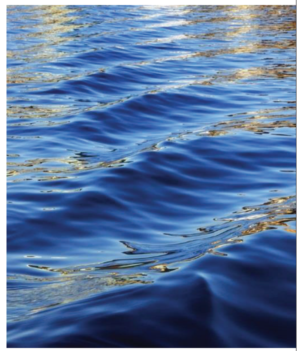


Life Cycle Assessment Waste and CO_2 Reduction

Assessment Plan

Graecia Lugito, Ph.D.
Wibawa Hendra Saputera, S.Si., M.Si., M.SC., Ph.D.



Kementerian PPN/ Bappenas

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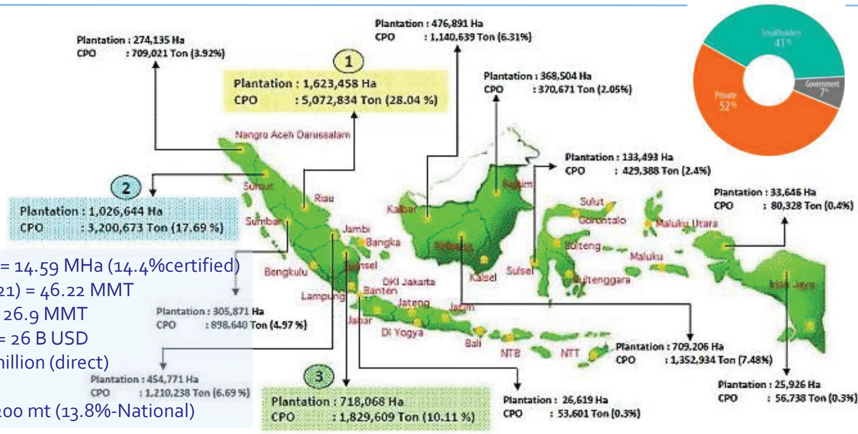
Indonesian Palm Oil Industry Profile



Planted Area (2020) = 14.59 MHa (14.4%certified)
CPO production (2021) = 46.22 MMT
CPO export (2021) = 26.9 MMT
Export value (2021) = 26 B USD
Employment = 4.2 million (direct)
12 million (indirect)
CO_2-eq emission = 200 mt (13.8%-National)

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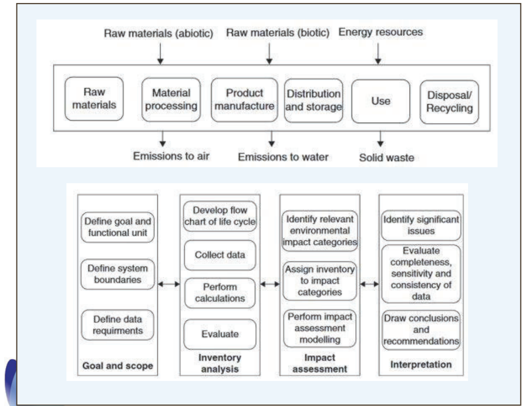
Sources: BPS & Dept. of Agriculture & Forestry, Indonesia, MP08

Scope of LCA



Verghese, et al. (2012). *Emerging Food Packaging Technologies*, 380-408

Goals: Waste and carbon reduction from palm oil processing and refinery

Unit: 100 kg CPO – 25 kg cooking oil (25% OER)

System Boundaries:
- Raw materials : Palm oil fresh fruit bunches
- Products : Crude palm oil (CPO) & cooking oil
- Material processing – see scope of study
- Product manufacture : production of CPO & cooking oil
- Distribution & storage : transportation + plastic packaging
- Use : food processing
- Disposal/recycling : Palm oil mill effluent (POME) + Empty fruit bunch (EFB) & cooking oil recycle

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SWOT Analysis on the Life Cycle Assessment of Palm Oil Mill & Refinery

	Helpful	Harmful
Internal	**STRENGTHS** - Growing market (high demand) - High impact in terms of GHG & society - Primary needs (staple food) - Good awareness (large pool of literature) - ISPO, RSPO & SPOI (standardized) - Indonesian Oil Palm Research Institute - Relatively low complexity (specific scope of products) - Using plastic packaging (initial concern of the study)	**WEAKNESSES** - Lack of Inventory database for Indonesian practices. - High complexity in terms of geological spread distribution - Unclear benefit for the data provider - Time limit
External	**OPPORTUNITIES** - Comprehensive inventory database from Ecoinvent - Malaysia & Global - Good relations with the stakeholders (PTPN V, BPDPKS, PT. Smart / PT. Wilmar) - Rising issue (good momentum)	**THREATS** - Lack of updated quantitative data - Conflict of interest - No dedicated PIC - Unrepresentative data (primary and secondary data source)

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Scope of Study

Plantation

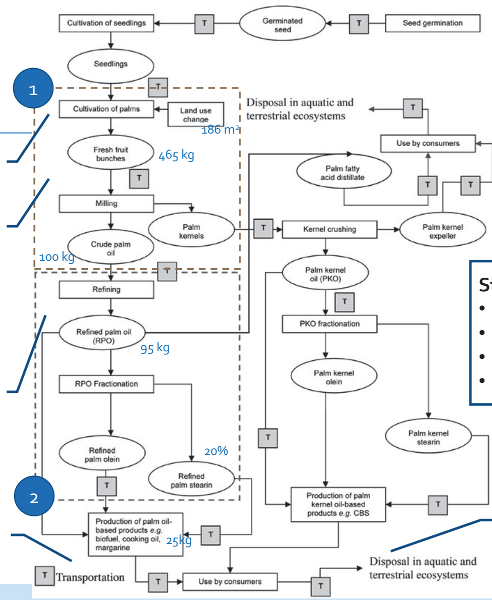
Mill

1 CPO Production

2 Cooking oil Production

Refinery

Packaging & Transportation



Source: Journal of Oil Palm Research 22:913-926.

Stakeholders:
- PTPN V
- BPDPKS
- PT. Smart
- PT. Wilmar

Consumption & disposal

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Data Collections

Plantation
- Production FFB
- Fertilizer application (nutrient & dosage)
- Pesticides application (active ingredient & dosage)
- Energy consumption (diesel, gasoline, electricity)
- Waste management (liquid & solid)
- Current local waste mitigation strategies

Mill
- Raw material (FFB)
- Production CPO
- Waste production (liquid & solid)
- Waste management (liquid & solid)
- Energy consumption (diesel, gasoline, electricity)
- Current local waste mitigation strategies

Refinery
- Raw material (CPO)
- Chemicals application (acid, base, bleaching agents)
- Waste production (liquid & solid)
- Waste management (liquid & solid)
- Energy consumption (diesel, gasoline, electricity)
- Current local waste mitigation strategies

Packaging & Transport
- Packaging use (kg/tone product)
- Geological spread distribution
- Energy consumption (diesel, gasoline, electricity)
- Current local waste mitigation strategies

Consumption & Disposal
- Cooking oil consumption
- User practices
- Municipal waste management (liquid & solid) related to cooking oil disposal
- Current local waste mitigation strategies

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No	Item Data	Tahun					Satuan	Keterangan
		2017	2018	2019	2020	2021		
1	**JUMLAH PRODUKSI**							
	CPO (*Crude Palm Oil*)						Ton	
	PKO (*Palm Kernel Oil*)						Ton	
2	**PENGGUNAAN ENERGI**							
	Sumber Energi:							
	Solar						Liter	
	Gas/LPG						kWh	
	Bahan Bakar Fosil (Batu Bara)						Kg	
	Listrik						kWh	
	Intensitas Energi						kW/Jumlah Produksi	
3	**PENGGUNAAN MATERIAL DAN BAHAN KIMIA**							lokal/import
	PUPUK						Kg/Jumlah Produksi	
	(Jenis-jenis pupuk yang digunakan silahkan dilist di bawah)							
	1...						Kg	
	2...						Kg	
	3... (dst)						Kg	
	PESTISIDA						Kg/Jumlah Produksi	
	(Jenis-jenis pestisida yang digunakan silahkan dilist di bawah)							
	1...						Kg	
	2...						Kg	
	3... (dst)						Kg	
	BAHAN KIMIA						Kg/Jumlah Produksi	
	(Jenis-jenis bahan kimia yang digunakan silahkan dilist di bawah)							
	1...						Kg	
	2...						Kg	
	3... (dst)						Kg	
4	**PENGGUNAAN AIR**							
	Sumber Air:							
	Air Permukaan (Sungai)						m3	
	Air Tanah atau Air Sumur Dalam/Dangkal						m3	
	Air PDAM						m3	
	Intensitas Air						m3/Jumlah Produksi	

No	Item Data	Tahun					Satuan	Keterangan
		2017	2018	2019	2020	2021		
5	**EMISI UDARA**							
	Sumber : Listrik, Gas, Bahan Bakar Boiler dll)							
	CO						Kg	
	CO2						Kg	
	TSP						Kg	
	CH4						Kg	
	N2O						Kg	
	HFC						Kg	
	PFC						Kg	
	NOx						Kg	
	SOx						Kg	
	O3						Kg	
	Upaya mitigasi emisi udara							
	Persentase pengurangan emisi udara						%	
6	**LIMBAH CAIR (PermenLH 5/2014)**							
	Debit (Q)						m3	
	pH							
	BOD5						mg/l	
	COD						mg/l	
	TSS						mg/l	
	Minyak dan Lemak							
	N - Total						mg/l	
	POME *(Palm Oil Mill Effluent)*						m3/Jumlah Produksi	
7	**LIMBAH PADAT**							
	Limbah Domestik (Limbah Non B3)						Kg	
	Limbah B3						Kg	
	Intensitas Limbah Domestik						Kg/Jumlah Produksi	
	Intensitas Limbah B3						Kg/Jumlah Produksi	

No	Item Data	Tahun					Satuan	Keterangan
		2017	2018	2019	2020	2021		
8	**UPAYA MITIGASI YANG TELAH DILAKUKAN UNTUK LIMBAH POME**							
	1...						%	Persentase pengurangan emisi
	2...						%	
	3... (dst)						%	
9	**UPAYA MITIGASI YANG TELAH DILAKUKAN UNTUK LIMBAH PADAT**							
	1...						%	Persentase pengurangan emisi
	2...						%	
	3... (dst)						%	
10	**PERSENTASE INDUSTRI YANG MENGGUNAKAN PRODUK**							
	1. Refinery						%	
	2...						%	
	3... (dst)						%	

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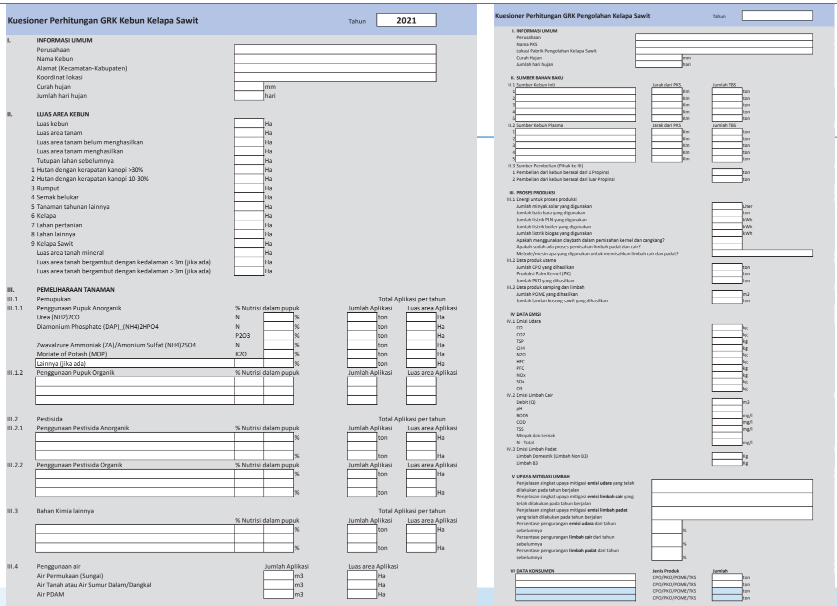
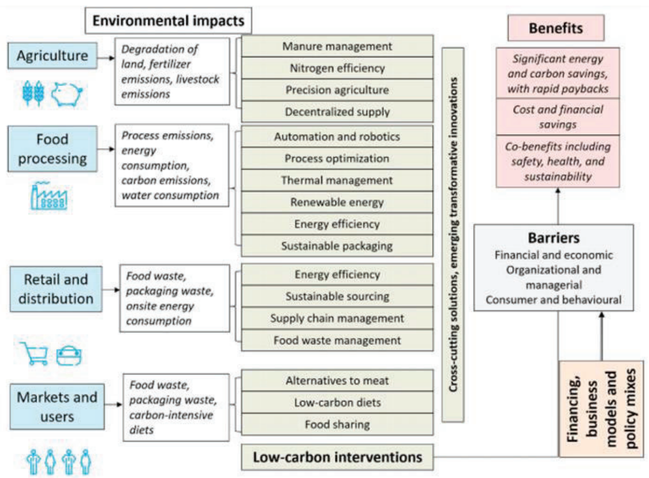


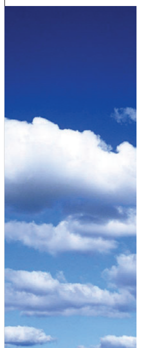
Timeline

No.	Activities	May 2022					June 2022			
		#1	#2	#3	#4	#5	#1	#2	#3	#4
1	Data Collection: Plantation & Mill		■	■	■	■				
2	Data Collection: Refinery				■	■	■	■		
3	Data Collection: Association				■	■	■	■		
4	Forum Group Discussion #1						■			
5	Forum Group Discussion #2								■	
6	Assessment + Analysis			■	■	■	■	■	■	
7	Final Report									■



Interventions, benefits, barriers, and policies for decarbonizing the food and beverage sociotechnical system

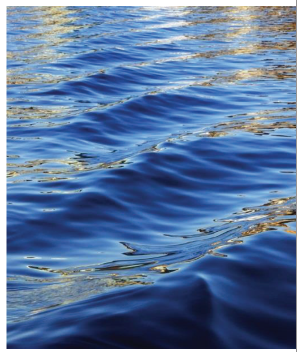
Source: Renewable and Sustainable Energy Reviews 2021, 143, 10856.



System Dynamics

Assessment Plan

Rully Tri Cahyono, Ph.D



Dynamic System FLW

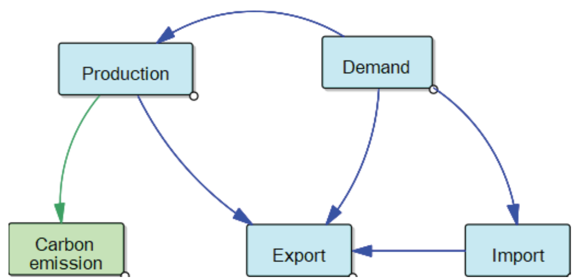
Decision Variables

1. Disincentives for industries that are not low-carbon:
   - Carbon tax
2. Government incentives for related industries to initiate low-carbon effort. The incentives that can be given:
   - Reduction/elimination of taxes for industries that are able to implement carbon reduction.
3. Low-carbon investments, such as the amount of budget from industries to buy:
   - Production machines
   - Transportations

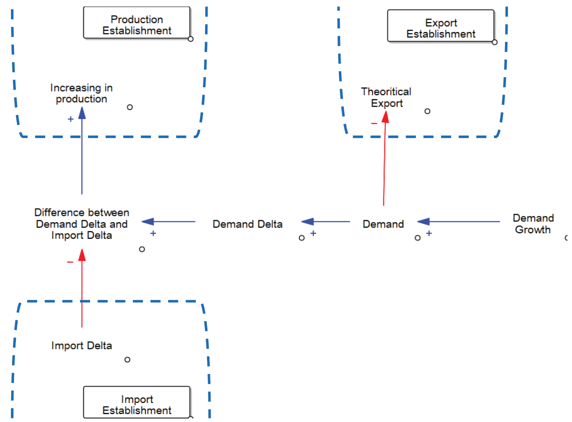
Performance Criterias

1. Carbon emission.
2. Contribution of industry to GDP.
3. The amount of labor.

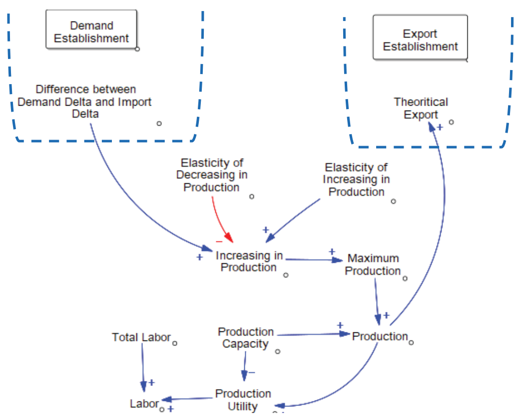
Basic Models



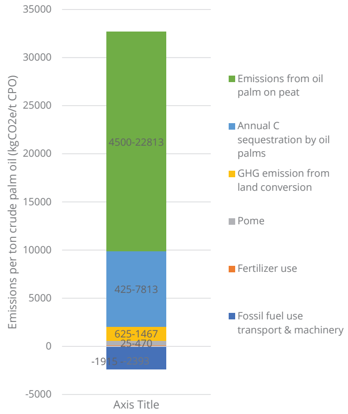
Basic Models: Production Sub-Model



Basic Models: Demand Sub-Model



Emissions per metric ton CPO



GHG emission factor	Emissions per tonne CPO (kg CO2-eq/tonne CPO)
Fossil fuel use transport & machinery	+45 to +125
Fertilizer use	+250 to +470
Fuel of mill & utilization of mill by products	0
POME	+625 to +1,467
Total operations	+920 to +2,007
GHG emission from land conversion	+425 to +7,813
Annual C sequestration by oil palms	-1,915 to -2,393
Emissions from oil palm on peat	+4,500 to +22,813
Total emissions related to carbon stock exchange	+3,010 to +28,233
Total	**+3,930 to +30,240**

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Incentives and Disincentives for Carbon Emission

Incentives

1. Export duty deduction. This policy has been implemented before, but due to cooking oil scarcity before, the export duty is raised.
2. Income tax subsidies. This policy was implemented as a result of pandemic situation, regulated in Peraturan Menteri Keuangan Nomor 44 /PMK.03/2020.

Disincentives

1. Carbon tax as the government program on the UU Nomor 7 Tahun 2022 tentang Harmonisasi Peraturan Perpajakan. Carbon tax will be implemented for power plant per 1 April 2022 with a levy of Rp30,00 per tonnes CO2 emission.
2. Carbon tax for palm oil industry has not decided yet, but by 2025 carbon tax will be implemented also on the transportation, building, and land-based sector.

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Selling price and COGS of CPO

Aspect	Value (Rp/ton)	Reference
Selling Price	9.100.000	
	24.454.000	Bappebti, 2022
	20.051.360	Bisnis.com, 2022
COGS	5.731.000	Samuel Equity Research, 2019
	8.023.000	Andri and Yudha, 2017
	5.600.000	Bisnis.com, 2019

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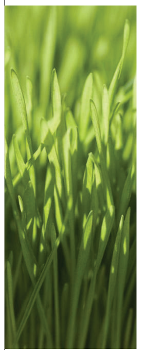
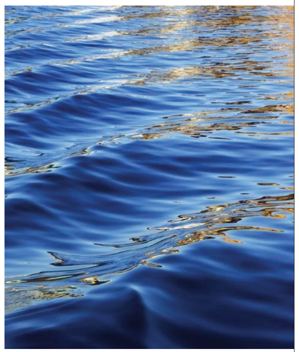


Terima Kasih

Studi Pemulihan Ekonomi Hijau Melalui Ekonomi Sirkular



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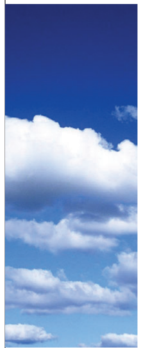
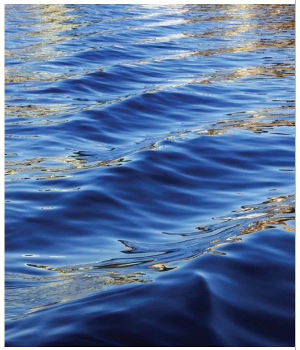


Studi Pemulihan Ekonomi Hijau Melalui Ekonomi Sirkular di Industri Makanan dan Minuman

(Green Economic and Inclusive Recovery through Circular Economy in Food & Beverage Sectors)

4 Juli 2022

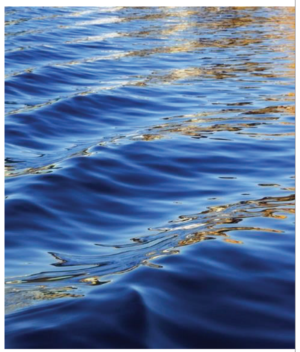
Dr. Eng. Yosi Hidayat, S.T., M.T. & Tim



F&B Sector Value Chain

Methodology

Studi Pemulihan Ekonomi Hijau Melalui Ekonomi Sirkular & LCDI



Study Overview

F&B Sector

QA/RA
Quick Assessment / Rapid Assessment

MCDM
Multiple-Criteria Decision-Making
- *Circular Economy*
- *Low Carbon Development*

Selected Potential F&B Subsector for CE and LCDI

WCR LCA
Waste & CO2 Reduction Life Cycle Assessment

5 komponen rantai nilai yang berpengaruh paling signifikan untuk penerapan CE dan *green recovery* / LCDI

SD
System Dynamics in selected F&B subsector and selected value chains

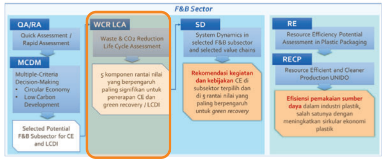
Rekomendasi kegiatan dan kebijakan CE di subsektor terpilih dan di 5 rantai nilai yang paling berpengaruh untuk *green recovery*

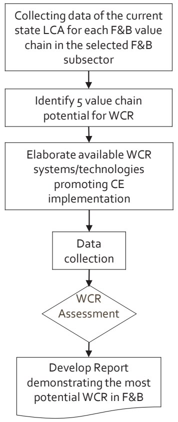
RE
Resource Efficiency Potential Assessment in Plastic Packaging

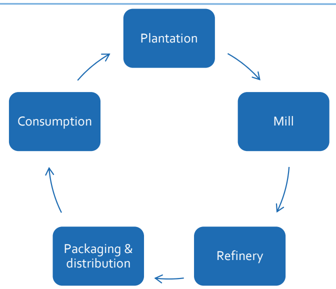
RECP
Resource Efficient and Cleaner Production UNIDO

Efisiensi pemakaian sumber daya dalam industri plastik, salah satunya dengan meningkatkan sirkular ekonomi plastik

Methodology
Life Cycle Assessment – Waste & CO_2 Reduction







Data sources:
SimaPro inventory database
Data collection from stakeholders
Data proxy from FGDs
Literature study
Statistics

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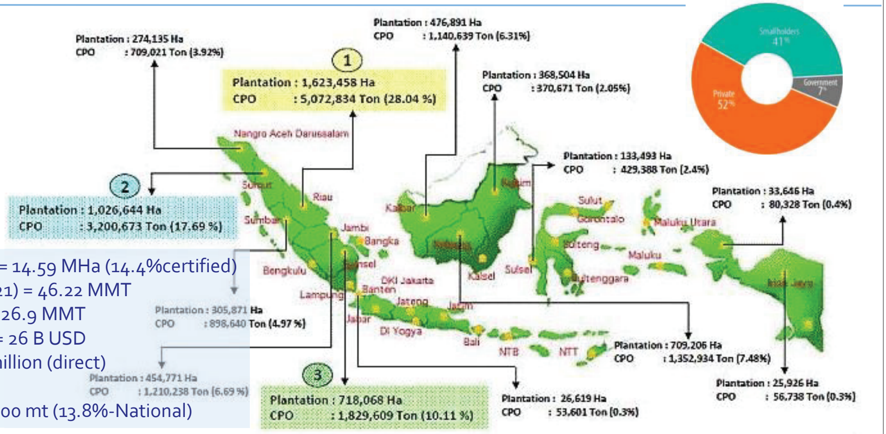
Indonesian Palm Oil Industry Profile



Planted Area (2020) = 14.59 MHa (14.4%certified)
CPO production (2021) = 46.22 MMT
CPO export (2021) = 26.9 MMT
Export value (2021) = 26 B USD
Employment = 4.2 million (direct)
12 million (indirect)
CO_2-eq emission = 200 mt (13.8%-National)

Sources: Statista, BPS & Dept. of Agriculture & Forestry, Indonesia, MPO8

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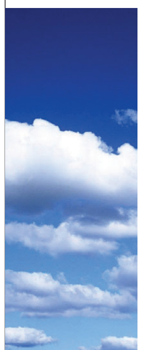

Life Cycle Assessment
Waste and CO_2 Reduction

Assessment Plan

Graecia Lugito, Ph.D.
Wibawa Hendra Saputera, S.Si., M.Si., M.SC., Ph.D.

Kementerian PPN/ Bappenas

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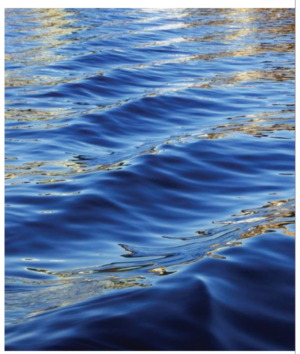
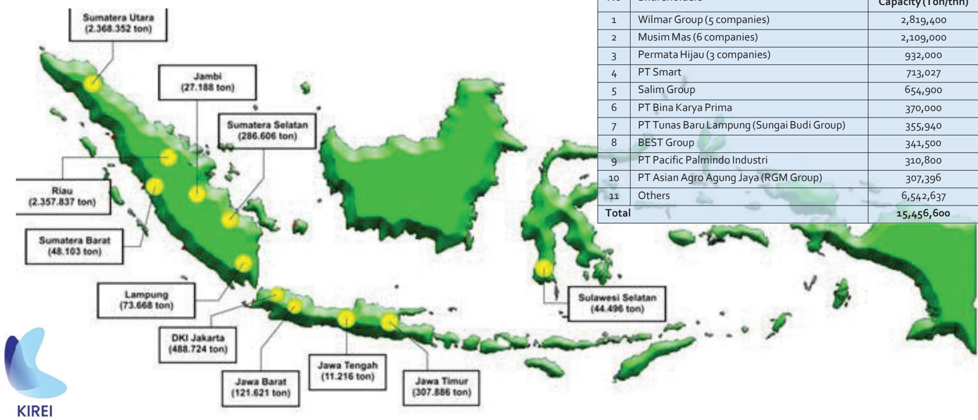


Indonesian Cooking Oil Industry Profile



No	Shareholders	Production Capacity (Ton/thn)	Market Share (%)
1	Wilmar Group (5 companies)	2,819,400	18.24
2	Musim Mas (6 companies)	2,109,000	13.64
3	Permata Hijau (3 companies)	932,000	6.03
4	PT Smart	713,027	4.61
5	Salim Group	654,900	4.24
6	PT Bina Karya Prima	370,000	2.39
7	PT Tunas Baru Lampung (Sungai Budi Group)	355,940	2.30
8	BEST Group	341,500	2.21
9	PT Pacific Palmindo Industri	310,800	2.01
10	PT Asian Agro Agung Jaya (RGM Group)	307,396	1.99
11	Others	6,542,637	42.33
Total		15,456,600	100.00

Profil Komoditas Minyak Goreng, Kemenperin (2009)

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Stakeholders and PIC

Government

PIC:
Pak Salman

Private Sector

PIC:
Pak Haskar
Head of Sustainability

Smallholders

via Web

PIC:
Dr. Tatang Hernas Soerawidjaya

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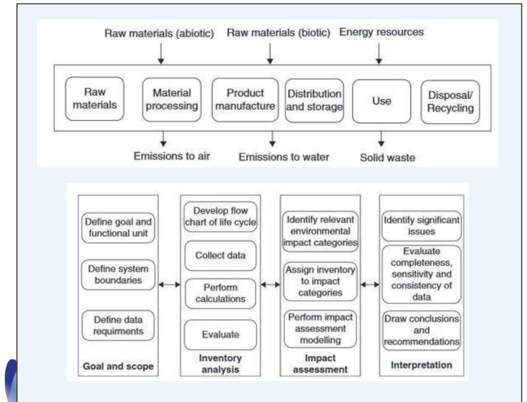
Scope of LCA



Verghese, et al. (2012). *Emerging Food Packaging Technologies*, 380-408

Goals: Waste and carbon reduction from palm oil processing and refinery

Unit: 100 kg CPO – 14.3 kg cooking oil (20% CPO was processed and consumed as cooking oil)

System Boundaries:

- Plantations through disposal
- Raw materials : Palm oil fresh fruit bunches
- Products : Crude palm oil (CPO) & cooking oil
- Material processing – see scope of study
- Product manufacture : production of CPO & cooking oil (including plastic packaging)
- Distribution & storage : transportation
- Use : Consumption of cooking oil (27,75 kg per capita)
- Disposal/recycling : Palm oil mill effluent (POME) + Empty fruit bunch (EFB) & cooking oil recycle

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Scope of Study

1 CPO Production

2 Cooking oil Production

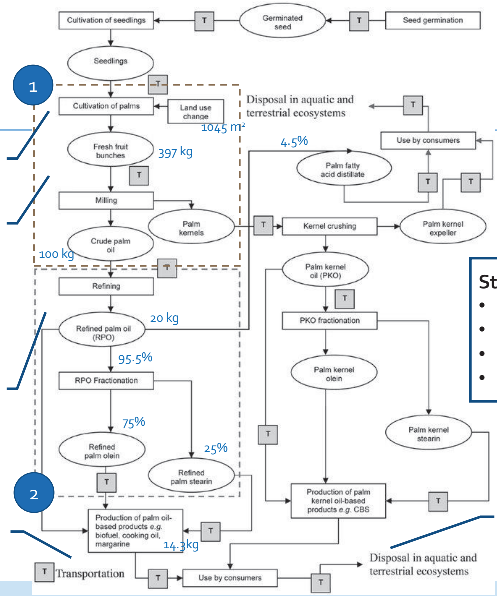
Plantation

Mill

Refinery

Packaging & Transportation

Consumption & disposal



Stakeholders:

- PTPN V
- PT. Smart
- SPOI
- GAPKI, GIMNI

Yewai, et al. (2010). Journal of Oil Palm Research 22:913-926.

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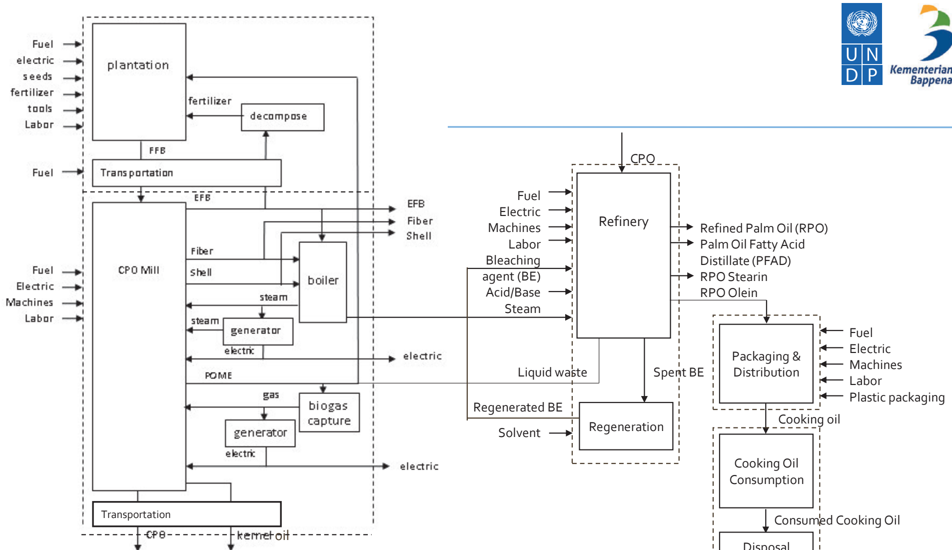

Communications in Computer and Information Science 516:76-88

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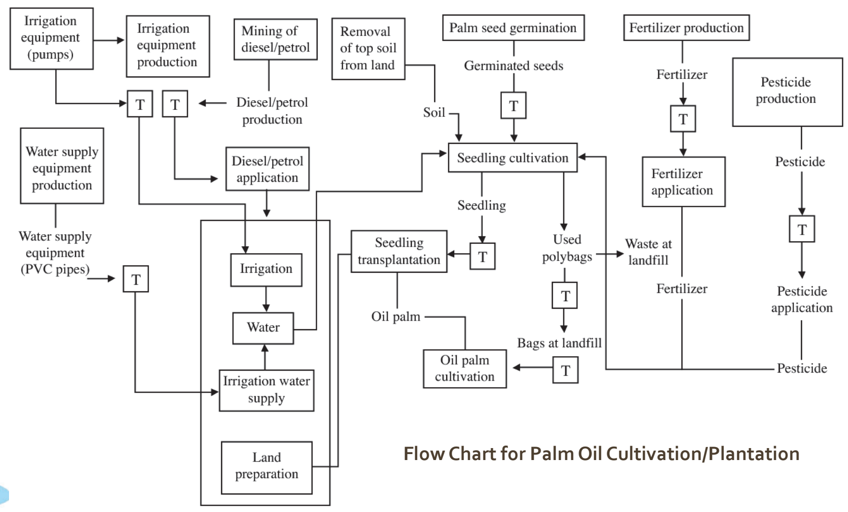

Flow Chart for Palm Oil Cultivation/Plantation

Halimah, et al. (2010). Journal of Oil Palm Research 22:878-886

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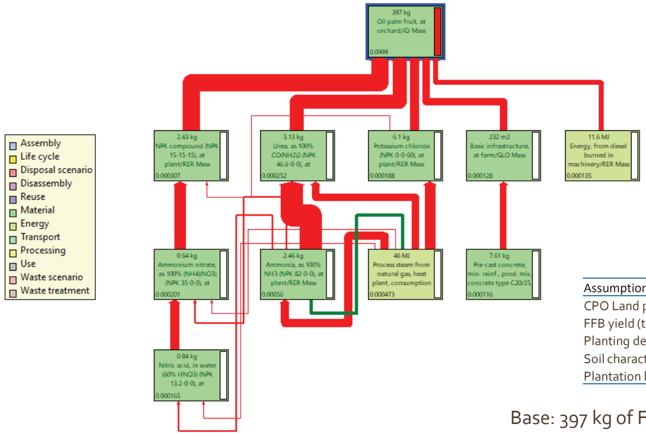
Results for Plantation



Assumptions	
CPO Land productivity (ton/ha/year)	5.375
FFB yield (ton/ha/year)	25
Planting density (palm/ha)	142
Soil characteristics	Mineral soils
Plantation lifetime (years)	25

Base: 397 kg of FFB

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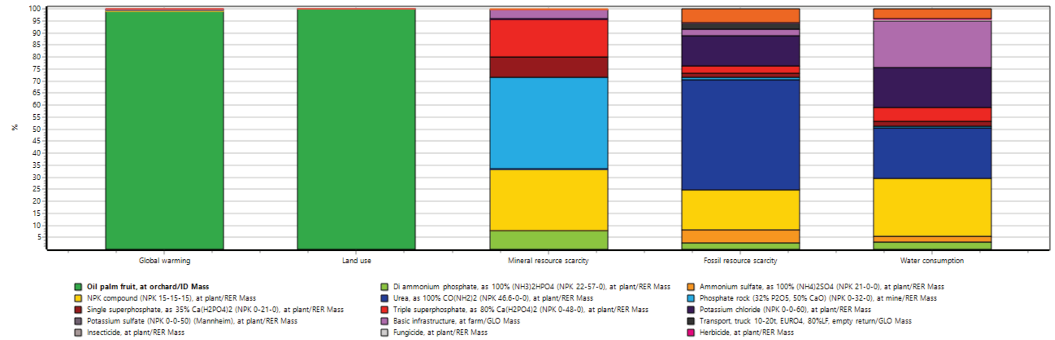
LCIA for Plantation



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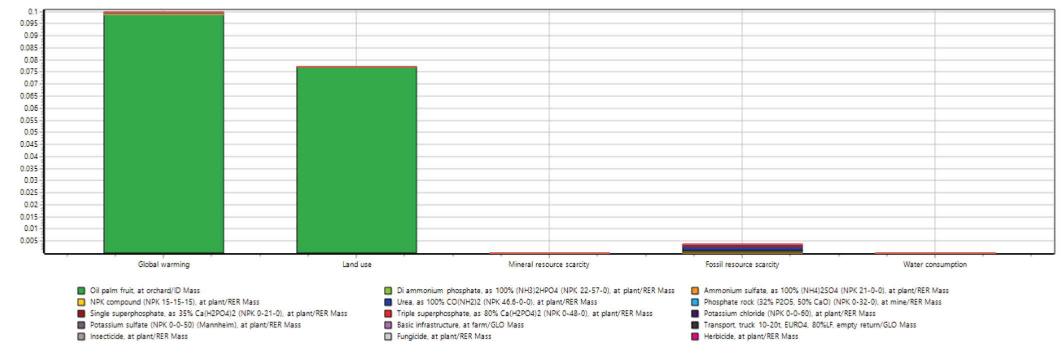
Impact Assessment (Normalized)



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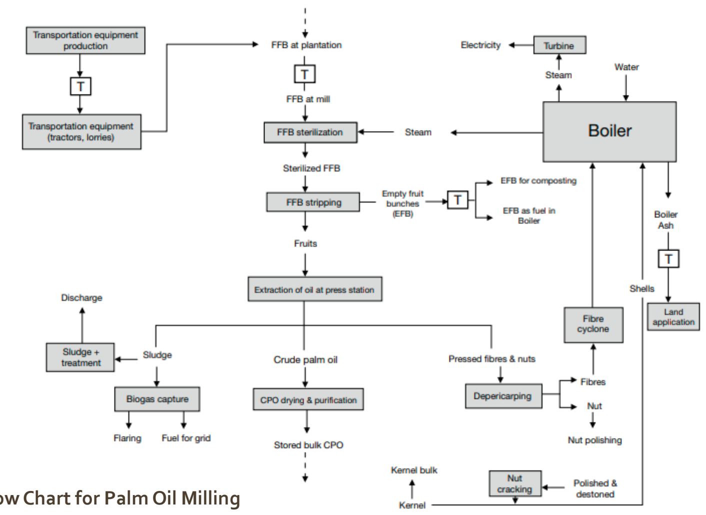
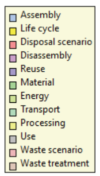
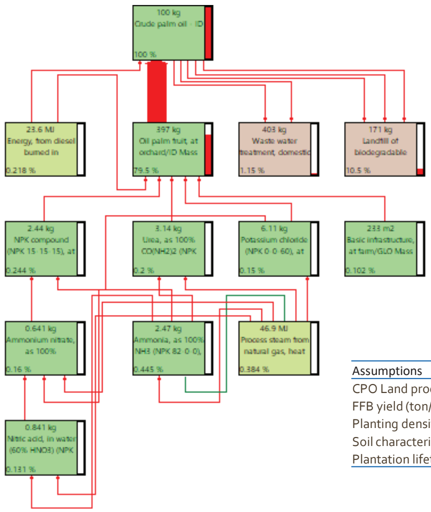
Flow Chart for Palm Oil Milling



Vijaya, et al. (2010). Journal of Oil Palm Research 22:895-903

Result for Mills





Assumptions	
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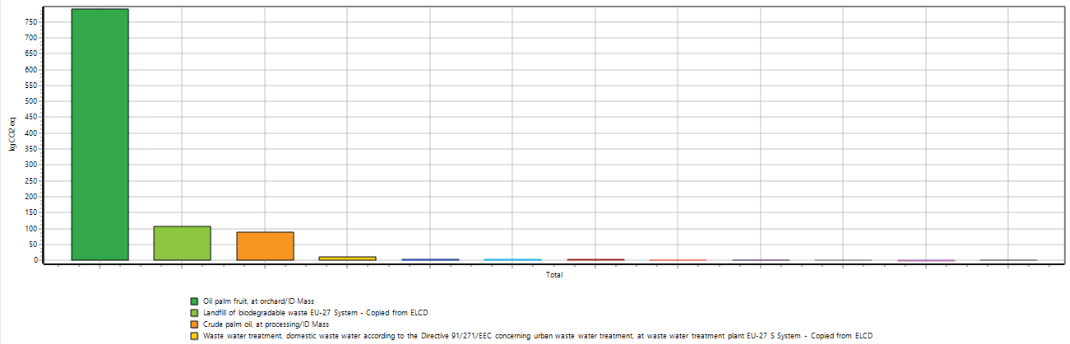
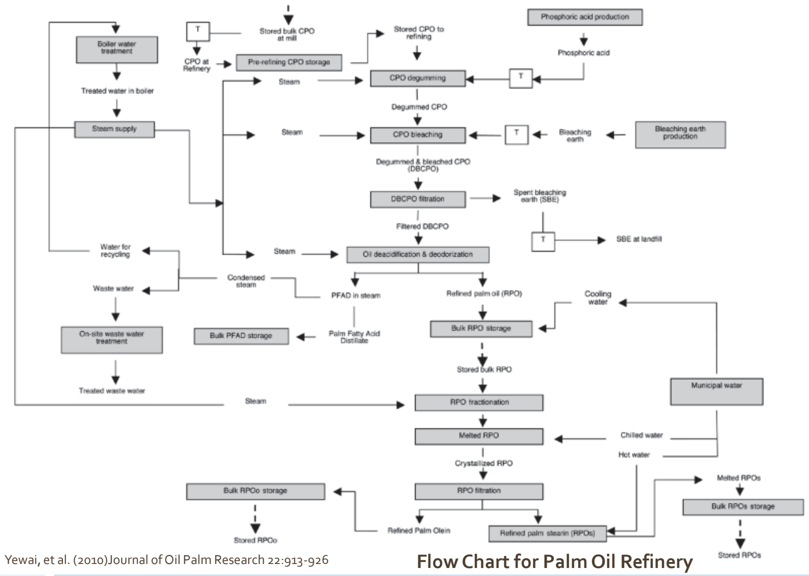
FFB yield (ton/ha/year)	25
Planting density (palm/ha)	142
Soil characteristics	Mineral soils
Plantation lifetime (years)	25

Global Warming Impact Assessment (Normalized) at Mill

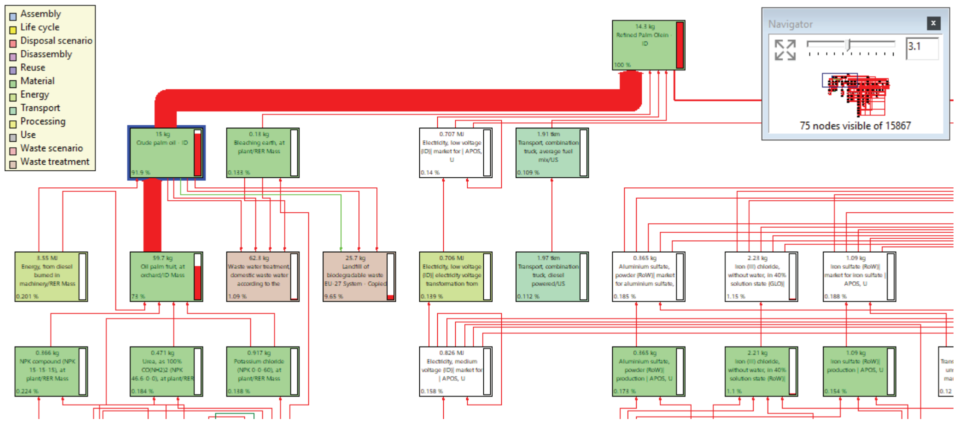


Flow Chart for Palm Oil Refinery



Yewai, et al. (2010)Journal of Oil Palm Research 22:913-926

Result for Refinery



Global Warming Potential at Plantation-Mills Value Chains

Data Input

No	Item Data
1	**JUMLAH PRODUKSI**
	CPO (*Crude Palm Oil*)
	PKO (*Palm Kernel Oil*)
2	**PENGGUNAAN ENERGI**
	Sumber Energi:
	Solar
	Gas/LPG
	Bahan Bakar Fosil (Batu Bara)
	Listrik
	Intensitas Energi
3	**PENGGUNAAN MATERIAL DAN BAHAN KIMIA**
	PUPUK
	(Jenis-jenis pupuk yang digunakan silahkan dilist di bawah)
	1.Urea
	2.Dolomite
	3.MOP
	4.Kieserit
	5.Borate
	6.TSP
	7.LCKS
	8.RP
	9.NPK
	10.Tankos
	PESTISIDA
	(Jenis-jenis pestisida yang digunakan silahkan dilist di bawah)
	1.Amcofur
	2.Nara Up
	3.Racumin
	4.Marshall
	5.Santrino
	6.Klerat
	7.Beta Sipermatine
	8.Dithane
	9.Methil Metsulfuron
	10.Starane 480 ec
	11.Asefat
	12.Rexroot
	13..Zhipos
	14.Koller
	15.Konidin Klamidospora
	16.Herb.Sun Up
	17.Herb.Crash
	BAHAN KIMIA
	(Jenis-jenis bahan kimia yang digunakan silahkan dilist di bawah)
	1. alumunium sulfat
	2. soda ash
	3. BWT 2041
	4. BWT 2200
	5. BWT 2430
	6. BWT 2520
	7. Coustik Soda
	8. Asam Sulfat
	9. Alkohol
	10. Shell sholl
4	**PENGGUNAAN AIR**
	Sumber Air:
	Air Permukaan (Sungai)
	Air Tanah atau Air Sumur Dalam/Dangkal
	Air PDAM
	Intensitas Air
5	**EMISI UDARA**
	Sumber : Genset
	Total Partikulat
	CO
	NO2
	SO2
	O2
	N2O
	HFC
	PFC
	NOx
	Kecepatan Alir
	Percent Isokinetic
	Upaya mitigasi emisi udara
	Persentase pengurangan emisi udara
6	**LIMBAH CAIR (PermenLH 5/2014)**
	Debit (Q)
	pH
	BOD5
	COD
	TSS
	Minyak dan Lemak
	N - Total
	POME *(Palm Oil Mill Effluent)*
7	**LIMBAH PADAT**
	Limbah Domestik (Limbah Non B3)
	Limbah B3
	Intensitas Limbah Domestik
	Intensitas Limbah B3

Data Collections

Cultivation/Plantation
- Production FFB
- Fertilizer application (nutrient & dosage)
- Pesticides application (active ingredient & dosage)
- Energy consumption (diesel, gasoline, electricity)
- Waste management (liquid & solid)
- Current local waste mitigation strategies

Mill
- Raw material (FFB)
- Production CPO
- Waste production (liquid & solid)
- Waste management (liquid & solid)
- Energy consumption (diesel, gasoline, electricity)
- Current local waste mitigation strategies

Refinery
- Raw material (CPO)
- Chemicals application (acid, base, bleaching agents)
- Waste production (liquid & solid)
- Waste management (liquid & solid)
- Energy consumption (diesel, gasoline, electricity)
- Current local waste mitigation strategies

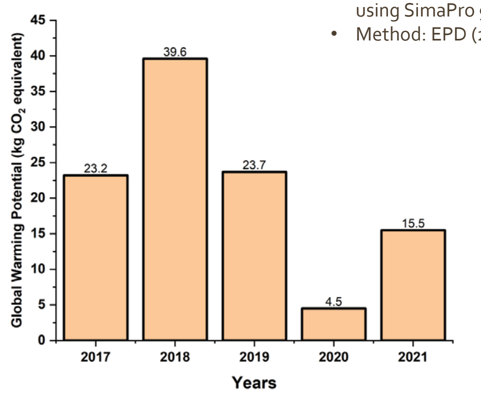
Packaging & Distribution
- Packaging use (kg/tone product)
- Geological spread distribution
- Energy consumption (diesel, gasoline, electricity)
- Current local waste mitigation strategies

Consumption
- Cooking oil consumption
- User practices
- Municipal waste management (liquid & solid) related to cooking oil disposal
- Current local waste mitigation strategies

Global Warming Potential at Plantation-Mills Value Chains

Assumptions:

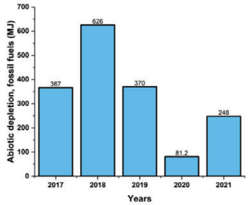
1. GWP calculation based on the production of **100 kg CPO**
2. GWP calculation only covers **plantation and mills value chains**
3. GWP calculation using the aggregate data provided by **PTPN from 12 different palm oil plantations**
4. GWP calculation is **not considered** consumption, transportation and distribution yet.

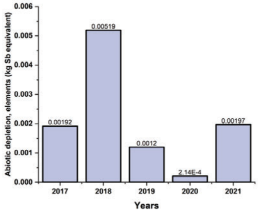


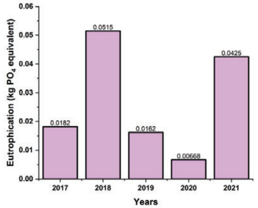
- GWP calculation was conducted using SimaPro 9.0.0.48
- Method: EPD (2018) V.1.01

Other Impact Assessments at Plantation-Mills Value Chains

- GWP calculation was conducted using SimaPro 9.0.0.48
- Method: EPD (2018) V.1.01







Abiotic depletion:
The measure of the use of nonrenewable sources for energy production.
a. Element: Extraction of element
b. Fossil fuels: Total amount of energy from fossil fuels and/or energy contained in carbon-based minerals

Eutrophication:
the buildup of excess nutrients, such as nitrogen and phosphorus, in a body of water.

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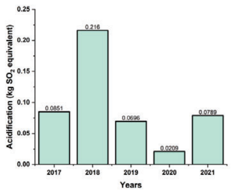
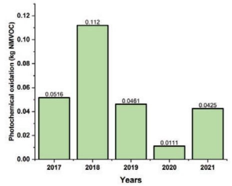
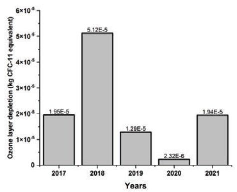
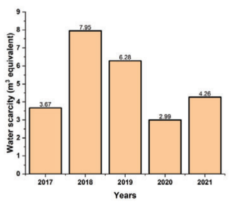
Other Impact Assessments at Plantation-Mills Value Chains

- GWP calculation was conducted using SimaPro 9.0.0.48
- Method: EPD (2018) V.1.01









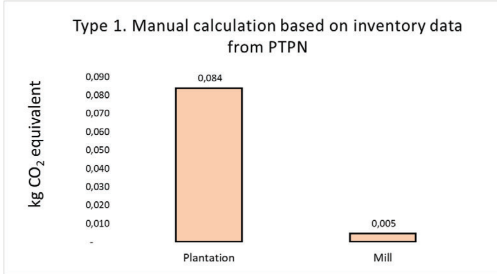
Acidification
The compounds that are precursors to acid rain. These include sulfur dioxide (SO_2), nitrogen oxides (NOx), nitrogen monoxide (NO), nitrogen dioxide (N_2O), and other various substances.

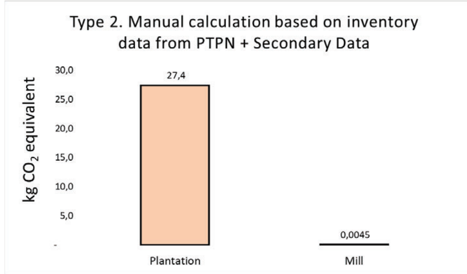
Photochemical oxidation
secondary air pollution, also known as summer smog.
Photochemical ozone creation potential.

Ozone layer depletion
How much a product or service contributes to **stratospheric ozone depletion**.

Water scarcity
fraction of those impacts which are related to water. They include **impacts associated with water use, and the subsequent effect on water availability for humans and ecosystems,** as well as direct impacts on the water resource and its users from emissions to air, soil and water.

Global Warming Potential at Plantation (PKS-TPU 2021)





Explanation:
1. GWP calculation based on the production of **100 kg CPO**
2.Type 1, used inventory data from PTPN including production in mature palm step and CPO extraction.
3. Type 2, used inventory data from PTPN including production in mature palm step, CPO production, as well as secondary data in nursery step and immature palm step

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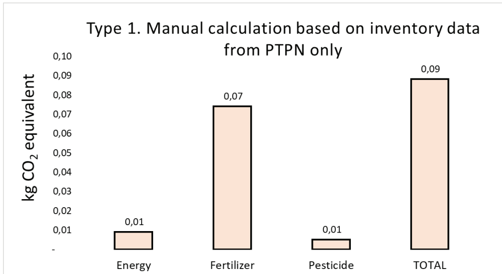
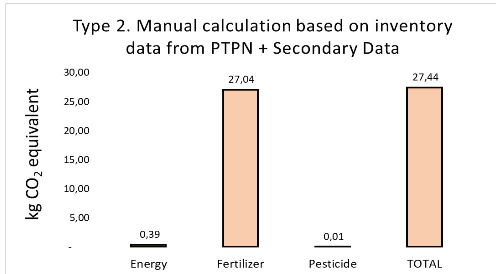
Global Warming Potential at Plantation-Mills (PKS-TPU 2021)





Explanation:
1. GWP calculation based on the production of **100 kg CPO**
2.Type 1, used inventory data from PTPN including production in mature palm step and CPO extraction.
3. Type 2, used inventory data from PTPN including production in mature palm step, CPO production, as well as secondary data in nursery step and immature palm step
4. Fertilizers contributed as hotspot in this LCA analysis

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Plastic Packaging & Distribution

Packaging type	Material	Volume	Weight	Lifetime
Sachet	LDPE	60 mL	2 g	Single-use
Glass	PET	150 mL	8 g	Single-use
Standing pouch	PE	1000 mL	18g	Single-use
Bottle	PET & PP	2000 mL	86 g & 2 g	Single-use
Jerrycan	HDPE	5000 mL	200 g	

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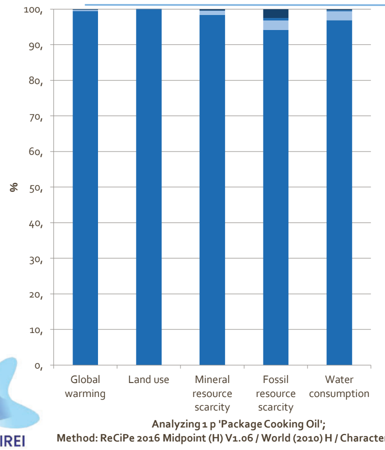
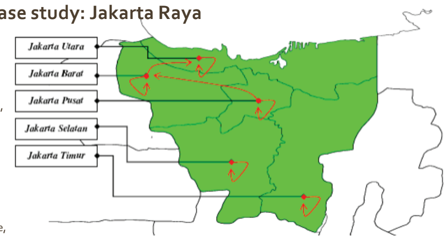
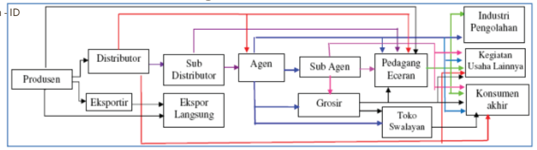
Result for Packaging and Distribution



Case study: Jakarta Raya



Freight lorry 16-32t,
average distribution distance = 100 km



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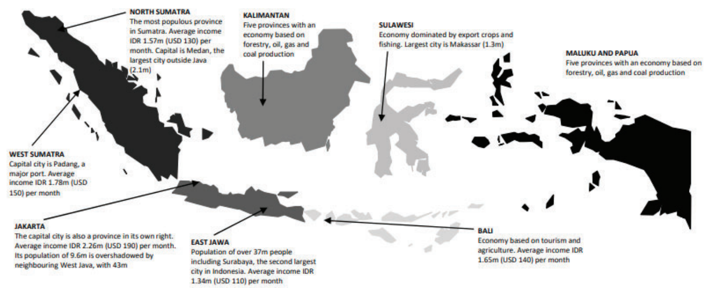
P. Tsarouhas et al. Journal of Cleaner Production 93 (2015) 75-83; Profil Komoditas Minyak Goreng, Badan Pusat Statistik, 2009

Indonesian Archipelago



Sumatra	Java	Kalimantan	Bali & Nusa Tenggara	Sulawesi	Maluku and Papua
(10 provinces)	(6 provinces)	(5 provinces)	(3 provinces)	(6 provinces)	(4 provinces)
55 million	145 million	15 million	14 million	19 million	7 million

TOTAL
255 million*

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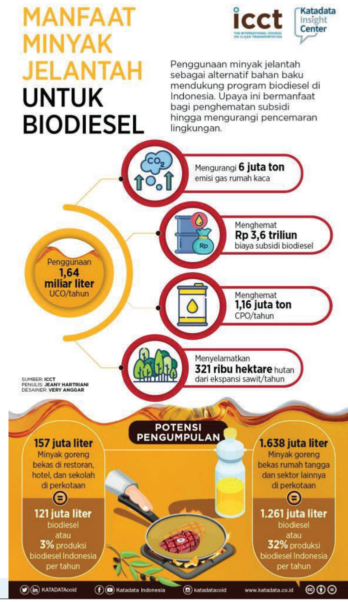
LTC Partners, Indonesian Logistic Market Overview: 2019 Edition



Result for Consumption and Disposal

- Vegetable cooking oil is carbon neutral (CO2 released when it burned is the same as CO2 taken by plant to grow)
- When used cooking oil is poured down the drain, it hardens and infiltrates into local sewer, water and waste management facilities.
- When tossed in the trash or carelessly littered in the dirt or grass outside, fats, oils, and greases seep into our ecosystems and affects our food supply.
- Through purification, refinement, and transesterification, 1.8 MM^3/year used cooking oils could produce 1.38 MM^3 (35% of yearly biodiesel demand) , reduce 6 MT GHG, save 1.16 MT CPO/year, and save 321 thousands ha forestation.

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Future Progress: Sociotechnical System

Part of sociotechnical system	Decarbonization options
Agriculture (e.g., farms, factory farms, ranches, slaughterhouses)	*Better land use management, manure management, nitrogen efficiency, precision agriculture, decentralized food chains and distributed food manufacturing*
Food processing (e.g. manufacturing, preparation, packaging, working conditions)	*Automation and process optimization, thermal management and heat recovery, adoption of renewable electricity and heat/fuel switching, energy efficiency, sustainable packaging*
Retail and distribution (supermarkets, grocery stores, restaurants, pubs)	*Energy efficiency, sustainable sourcing, supply chain management, minimizing food waste*
Markets and user practices (e.g. eating patterns, household preferences)	*Alternatives to meat and cellular agriculture, less carbon intensive diets, food sharing*

78 emerging and possibly transformative innovations e.g. nanotechnology, cold plasma processing, and robotic chefs

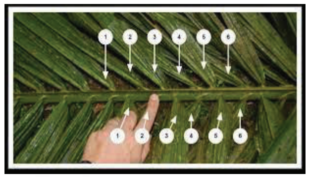
Sociotechnical options for decarbonizing the food and beverage system

Source: Renewable and Sustainable Energy Reviews 2021, 143, 10856.

Available Waste and CO2 Reduction Technologies

1. Reduce the use of chemical inorganic fertilizers

➢ Precision agriculture in fertilizing – sampling units



➢ Utilization of by-product

Palm Oil Mill effluent for Organic Liquid Fertilizers

Direct EFB utilization (left) and composting (right)

Available Waste and CO2 Reduction Technologies

2. Enhance Productivity

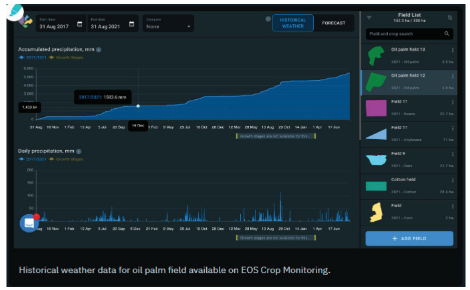
➢ Legume cover crops optimization

Legume cover crops in oil palm plantation

➢ Integrated Pest Management

Available Waste and CO2 Reduction Technologies

3. Advanced watering system

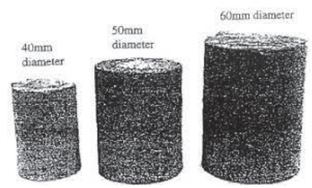


Historical weather data for oil palm field available on EOS Crop Monitoring.

Available Waste and CO2 Reduction Technologies

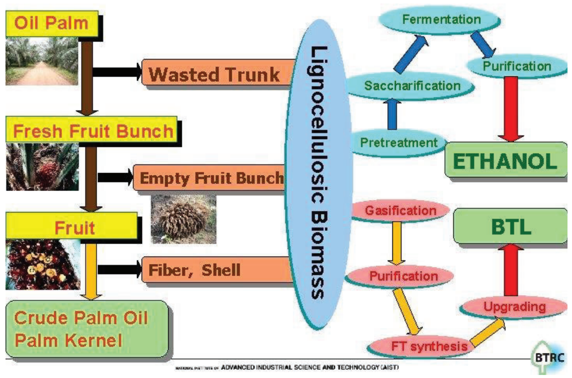
4. Add Value to Byproduct

- Biomass fuels



Briquetting palm fiber, shell, and kernel

- Bioethanol



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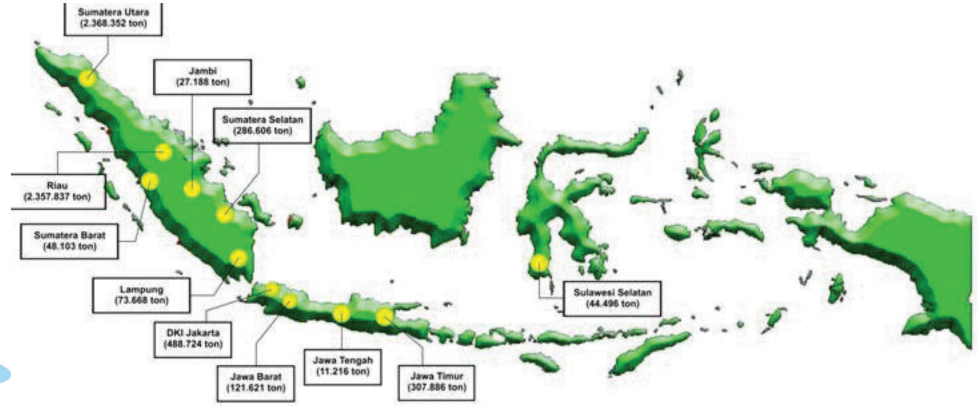
Available Waste and CO2 Reduction Technologies

5. Decentralized Supply, Smallholders Support and Collaboration



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Available Waste and CO2 Reduction Technologies

5. POME Conversion into Biomethane – Methane Capture

produce electricity

fuel plantation trucks

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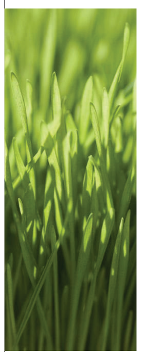
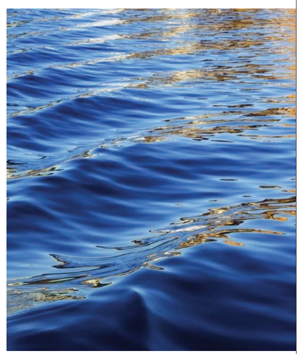
Kementerian PPN/ Bappenas



Thank You

Studi Pemulihan Ekonomi Hijau Melalui Ekonomi Sirkular



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Data Sources Plantation

Unit process	Process starts	Nature of transmission	Process ends	Data type (B/F*)/Data source
Electricity production	Mining and extraction of fossil fuels	Energy conversion	Distribution to the grid at the point of use	B/Malaysian data from SIRIM
Irrigation water supply	Water from surface water	Physical	Water at nursery	F/site specific data
Irrigation	Water at nursery	Physical	Water applied to germinated seeds/seedlings	F/site specific data
Fertilizer production N, P_2O_5 and K_2O	Acquisition of raw materials	Chemical processing	Fertilizers at the production unit gate	B/Ecoinvent database
Transportation of fertilizers N, P_2O_5 and K_2O to nurseries (includes intermediate storage and retailing)	Collection of fertilizers from port in Malaysia to nursery	Physical	Delivery of fertilizers to nursery	B/reference to other site specific data
Application of fertilizers N, P_2O_5 and K_2O (includes incorporation into soil at the recommended dosage)	Fertilizers stored at nursery	Physical	Fertilizers into soil	F/site specific data
Production of insecticides thiocarbamate, pyrethroid and organophosphate	Acquisition of raw materials	Chemical processing	Pesticides at the production unit gate	B/Ecoinvent database
Transportation of insecticides thiocarbamate, pyrethroid and organophosphate to nurseries (include intermediate storage and retailing)	Collection of pesticides from port in Malaysia to nursery	Physical	Delivery of pesticides to nursery	B/reference to other site specific data
Application of insecticides thiocarbamate, pyrethroid and organophosphate (including preparations for application at the recommended dosage)	Pesticides stored at nursery	Physical	Pesticides applied to seedlings	F/site specific data

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Data Sources Plantation

Unit process	Process starts	Nature of transmission	Process ends	Data type (B/F*)/Data source
Herbicide production; unspecified herbicide (glufosinate ammonium, urea/sulfonylurea and glyphosate)	Acquisition of raw materials	Chemical processing	Herbicides at the production unit gate	B/Ecoinvent database
Transportation of herbicides; unspecified herbicide (glufosinate ammonium, urea/sulfonylurea and glyphosate) to nurseries (includes intermediate storage and retailing)	Collection of herbicides from port in Malaysia to nursery	Physical	Delivery of herbicides to nursery gate	B/reference to other site specific data
Application of herbicides; unspecified herbicide (glufosinate ammonium, urea/sulfonylurea and glyphosate) (including preparations for application at the recommended dosage)	Herbicides stored at nursery	Physical	Herbicides applied to soil	F/site specific data
Fungicides production: dithiocarbamate	Acquisition of raw materials	Chemical processing	Fungicides at the production unit gate	B/Ecoinvent database
Transportation of fungicides; (dithiocarbamate) to nurseries (includes intermediate storage and retailing)	Collection of fungicides from port in Malaysia to nursery	Physical	Delivery of fungicides to nursery gate	F/reference to other site specific data
Application of fungicides (dithiocarbamate) (including preparations for application at the recommended dosage)	Fungicides stored at nursery	Physical	Fungicides applied to soil	F/site specific data
Polybag production	Acquisition of raw materials	Chemical processing	Polybags at the production unit gate	B/SIRIM database

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Data Source Plantation

Unit process	Process starts	Nature of transmission	Process ends	Data type (B/F*)/Data source
Transportation of polybags to nurseries (includes intermediate storage and retailing)	Collection of polybags from port in Malaysia to nursery	Physical	Delivery of polybags to nursery gate	B/reference to other site specific data
Use of polybags	Polybags stored at nursery	Physical	Polybags used at nursery	B/reference to other site specific data
Top soil supply	Acquisition from land	Physical	Soil for seedling cultivation	B/reference to other site specific data
Transportation of top soil to nurseries (includes intermediate storage and retailing)	Collection of top soil from estate or contractor to nursery	Physical	Delivery of top soil to nursery gate	B/reference to other site specific data
Oil palm seedling cultivation	Acquisition of oil palm germinated seeds	Biological	10- to 12-month-old oil palm seedlings for planting in plantations	B/reference to other site specific data

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Data Source Mill

Unit process	Process starts	Nature of transmission	Process ends	Data type (B/F*)/Data source
Transportation of FFB to mill	Collection of FFB from the plantation unit gate	Physical	Delivery of FFB to milling unit gate	F/site specific data
Transportation of diesel to mill	Collection of fuel from supplier gate	Physical	Delivery of fuel oil to refining gate	F/site specific data
Extraction of crude palm oil from FFB	FFB as delivered and stored at mill	Physical and Chemical processing	Crude palm oil Palm Oil Mill Effluent (POME)	F/site specific data
Water treatment	Extraction of water from aquifers or surface water (river)	Physical, chemical and biological processing	Potable water at water works gate	B/Ecoinvent database
Water supply (for steam and chilled water supply)	Potable water at water works gate	Physical	Potable water at refining and fractionation unit gate	B/Ecoinvent database
Management of solid waste in mill	EFB, Kernel with retained oil and moisture	Physical, chemical and biological processing	solid waste processing unit	F/site specific data
Biogas capture	POME	Physical	Biogas	F/site specific data
Wastewater treatment	POME after Biogas capture	Chemical and biological processing	Treated waste water (to be discharged)	F/site specific data
Electricity generation	Mining and extraction of fossil fuels	Physical	Distribution to grid at the points of use	B/Ecoinvent database
Production of fuel for boilers	Biogas	Energy conversion	fuel for boilers	B/reference to other site specific data
Capital goods	FFB at mill gate	Physical/chemical processing	CPO at mill gate	B and F/Ecoinvent data base, reference to other site specific data

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Data Source Refinery

Unit process	Process starts	Nature of transmission	Process ends	Data type (B/F*)/Data source
Transportation of CPO from mill to refinery	Collection of CPO from the milling unit gate	Physical	Delivery of CPO to refining unit gate	B and F/Ecoinvent data base, reference to other site specific data
Electricity production	Mining and extraction of fossil fuels	Physical	Distribution to grid at the points of use	B/Ecoinvent database
Electricity usage	Refining gate	Energy conversion	Points of use at the refining and fractionation unit gate	B/reference to other site specific data
Fuel oil production	Mining and extraction of fossil fuels	Physical	Fuel at supplier gate	B/Ecoinvent database
Transportation of fuel oil from supplier to refinery	Collection of fuel from supplier gate	Physical	Delivery of fuel oil to refining gate	B/reference to other site specific data
Fuel usage	Boiler in refinery	Energy conversion	Fuel use for boiler	B/reference to other site specific data
Water treatment	Extraction of water from aquifers or surface water (river)	Physical, chemical and biological processing	Potable water at water works gate	B/Ecoinvent database
Water supply (for steam and chilled water supply)	Potable water at water works gate	Physical	Potable water at refining and fractionation unit gate	B/Ecoinvent database
Phosphoric acid production	Acquisition of raw materials	Physical and chemical processing	Phosphoric acid at the production unit gate	B/Ecoinvent database
Transportation of phosphoric acid to refinery (includes intermediate storage and retailing)	Collection of phosphoric acid from production unit gate	Physical	Delivery of phosphoric acid to refining unit gate	B/reference to other site specific data
Phosphoric acid usage	Phosphoric acid store at refinery	Physical	Phosphoric acid for degumming CPO	B/reference to other site specific data

Data Source Refinery

Unit process	Process starts	Nature of transmission	Process ends	Data type (B/F*)/Data source
Bleaching earth production	Acquisition of raw materials	Physical and chemical processing	Bleaching earth at the production unit gate	B/Ecoinvent database
Transportation of bleaching earth to refinery (includes intermediate storage and retailing)	Collection of bleaching earth from production unit gate	Physical	Delivery of bleaching earth to refining unit gate	B/reference to other site specific data
Bleaching earth usage	Bleaching earth store at refinery	Physical	Bleaching earth for adsorptive cleansing of CPO	B/reference to other site specific data
CPO degumming and earth bleaching	CPO as delivered and stored at refinery	Physical and Chemical processing	Degummed, bleached palm oil Solid waster - spent bleaching earth (SBE)	B/reference to other site specific data
Solid waste handling (includes transportation)	SBE with retained oil and moisture	Physical	SBE at landfill	B/reference to other site specific data
Solid waste recycling (includes transportation)	SBE with retained oil and moisture	Physical	SBE and spent earth oil at SBE processing unit gate	B/reference to other site specific data
Palm oil deacidification and deodorization	Degummed, bleached palm oil	Physical processing	Refined palm oil (RPO)	B/reference to other site specific data
Recovery of palm fatty acid distillate (PFAD) from waste water	Waste water from processing of CPO	Physical	Waste water and PFAD	B/reference to other site specific data
On-site waste water treatment	Waste water after recovery of PFAD	Chemical/chemical processing	Treated waste water (to be discharged)	B/reference to other site specific data
Storage of PFAD	PFAD ready	Physical	PFAD at refining unit gate	B/reference to other site specific data
Storage of RPO (on tank farm)	RPO ready	Physical	RPO at the refining unit gate	B/reference to other site specific data

Data Source Refinery

Unit process	Process starts	Nature of transmission	Process ends	Data type (B/F*)/Data source
Capital goods use including steel and concrete in buildings and processing plant equipment	CPO at RPO gate	Physical/chemical processing	RPO at refining and fractionation gate	B and F/Ecoinvent data base, reference to other site specific data
RPO fractionation	Refined palm oil at refining gate	Physical processing	Refined palm olein and palm stearin	B/reference to other site specific data
Storage of refined palm olein and refined palm stearin	Refined palm olein and refined palm stearin ready	Physical	Refined palm olein and refined palm stearin at fractionation unit gate	B/reference to other site specific data

Data Inventory

SEEDLING

Base 1 seed

Input	Unit	Amount
Electricity	kWhr	0.006
Diesel	Liter	0.004
Polybag	kg	0.0021
Water	Liter	1.5
Fertilizers		
N	kg	0.00051
P_2O_5	kg	0.00026
K_2O	kg	0.00021
Pesticides		
Thiocarbamate	kg	0.0000112
Pyrethroid	kg	0.00000354
Organophosphate	kg	0.00002
Dithiocarbamate	kg	0.0000961
Unspecified pesticide	kg	0.00000135
Urea/sulfonyl urea	kg	0.0000217
Glyphosate	kg	0.0000089
Transportation Van (< 3.5 t) B250	tkm	6.47E-09
Capital good		
Polyvinylchloride for pipes	kg	0.000713

PLANTATIONS		low	base	high	source
FFB Production	t/ha/yr	17	20	31	FRIM, IPCC
N fertilizer use	t N/ha/yr	50	73	120	literature
EF for AS fertilizer production	kg CO_2 eq/kg N	0.9	2.7	7.6	literature
EF for urea fertilizer production	kg CO_2 eq/kg N	0.9	1.3	4	literature
EF N_2O from managed soil	kg N_2O-N/t N	3	10	30	literature
Diesel consumption	Gj/ha/yr	2.1	3.2	5.1	literature

Oil content	25%
Seeds	25%
Mesocarp fiber	13%
Shell	7%
EFB	23%
Others	7%
FFB	100%

Data Inventory

MILLS

Input	Unit	Amount
Base CPO	ton	1
Fresh fruit bunches	ton	3.97
Power consumption from turbine	MJ	224.08
Power consumption from grid	MJ	1.76
Diesel consumption for mill	MJ	100.33
Transportation of diesel to mill	tkm	0.54
Fuel used in boiler:		
Mesocarp fibre	ton	0.36
Shells	ton	0.09
Boiler water consumption	ton	1.57
Water for processing	ton	2.17
Kernels	ton	0.41
Mesocarp fibre	ton	0
Shells	ton	0.23
Empty fruit bunches (EFB)	ton	0.71
Palm oil mill effluent (POME)	ton	1.86
Methane gas	kg	22.21
CO_2 from POME pond	kg	36.04
Boiler ash	ton	0.01
Steam input to turbine	ton	1.62
Steam input for sterilization	ton	1.56

Flue gas from stack:		
Particulate matter	kg	0.12
CO	kg	0.04
CO_2	kg	41.28
Sox	kg	0.0006
Nox	kg	0.07
Wastes:		
EFB	Mulching	
POME	Treated as	
Excess mesocarp fibre and	fertilizer	
shells	Sold as fuel	
Boiler ash	Land application	
Capital goods:		
Buildings, steel	kg	1
Buildings, concrete	kg	3.14
Oil mill machinery	kg	2.83
Tractors	kg	0.02

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National CPO Production & Consumption

Production volume of CPO	46.88 MMt	100%
Production volume of CPKO	4.41 MMt	
Total production	51.29 MMt	
Export r-CPO	25.7 MMt	54.8%
Export Oleochemical	4.14 MMt	
Export CPO	2.73 MMt	5.8%
Export Lauric	1.48 MMt	
Export Biodiesel	0.163 MMt	
Total Export	34.213 MMt	
Local Consumption Food	8.95 MMt	19.1%
Local Consumption Biodiesel	7.34 MMt	
Local Consumption	2.12 MMt	
Total Local Consumption	18.42 MMt	

Source: GAPKI, 2021

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Data Inventory

REFINERY

Base: RPO	**kg**	**1000**
Electricity	kWhr	11.94
Boiler fuel	MJ	476.91
Boiler fuel	kg	11.09
Water	litre	113.39
Crude palm oil (CPO)	ton	1.05
Phosphoric acid	kg	0.59
Bleaching earth	kg	9.11
Road Transport		
CPO transport (distance) from mill to refinery (28-t truck)	km	120
Transport of CPO to refinery tkm	tkm	126
Fuel oil transport (distance) from supplier to refinery (28-t truck)	km	500
Transport of fuel oil to refinery	tkm	5.545
Phosphoric acid transport (distance) from chemical plant to refinery (28-t truck)	km	500
Transport of phosphoric acid to refinery	tkm	0.3
Bleaching earth transport (distance) from chemical plant to refinery (16-t truck)	km	100
Transport of bleaching earth to refinery	tkm	0.91
Spent bleaching earth transport (distance) from refinery to landfill (16-t truck)	km	15
Transport of spent bleaching earth to landfill	tkm	0.17

Sea Transport		
Phosphoric acid sea transport (distance)	km	15000
Transport of phosphoric acid	tkm	8.85
Bleaching earth sea transport (distance)	km	3000
Transport of bleaching earth	tkm	27.33
Waste water	litre	42.16
Palm fatty acid distillate	kg	45.62
Spent bleaching earth	kg	11.09
Waste water biochemical oxygen demand (BOD)	kg	1.12
Waste water chemical oxygen demand (COD)	kg	3.26
Fractionation		
Electricity	kWhr	9.84
Water	litre	76.27
Cooking oil (refined-Olein)	kg	715
Refined-stearin	kg	239.4

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Timeline

No.	Activities	May 2022					June 2022			
		#1	#2	#3	#4	#5	#1	#2	#3	#4
1	Data Collection: Plantation & Mill		■	■	■	■				
2	Data Collection: Refinery				■	■	■	■		
3	Data Collection: Association				■	■	■	■		
4	Forum Group Discussion #1						■			
5	Forum Group Discussion #2								■	
6	Assessment + Analysis			■	■	■	■	■	■	
7	Final Report									■

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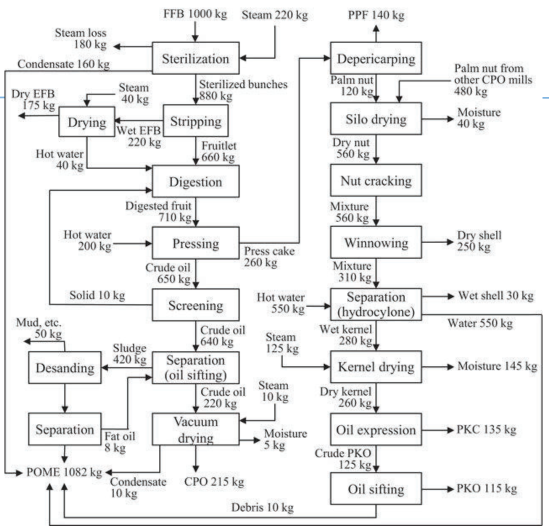
Kementerian PPN/ Bappenas



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Journal of Japan Institute of Energy 2015, 94, 143-150

Kementerian PPN/ Bappenas

OUTLINE

- Framework
- Modelling
- Analysis
- Recommendation

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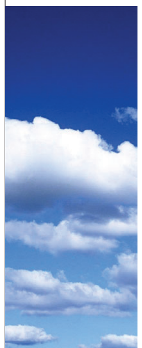
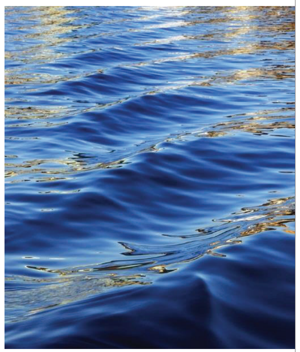


System Dynamics Models for CPO Industry Considering Circular Economy Concept

Dr. Rully Tri Cahyono



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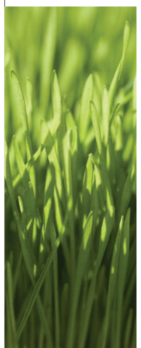
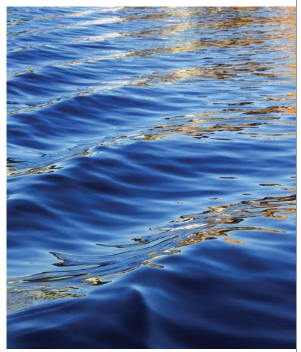


Framework

System Dynamics Models



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Framework
Global CPO Industry Profile

No	Country	Production (ton/year)	Domestic demand (ton/year)	Export (ton/year)	Import (ton/year)
1	Indonesia	44,500	15,675	26,874	-
2	Malaysia	18,700	3,440	15,878	1,300
3	Thailand	3,120	2,510	608	-
4	Colombia	1,615	1,139	454	156
5	Nigeria	1,400	1,665	18	424

- The table above is **palm oil production data for 2021/2022** for several countries.
- Based on the table above, it can be seen that **Indonesia is** one of the **world's main producers** of CPO with a production of 44,500 tons/year.
- Indonesia's **competitor country is Malaysia** with a production of 18,700 tons/year

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Framework
Decision Variables (Policies)

Carbon tax

Carbon emission initiative

Tax reduction incentives by government

Performance Measures

DIRECT

1. Economy: taxes collected by government
2. Social: labor
3. Environment: carbon emission reduction

INDIRECT

1. Export
2. Production realization
3. Profit after taxes CPO company Indonesia

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Framework
Indonesia CPO Industry Profile

in Ton

Year	Capacity
2010	37.614.843
2011	40.182.102
2012	44.586.617
2013	46.046.088
2014	47.321.124
2015	49.545.214
2016	49.286.446
2017	54.485.644
2018	63.035.940
2019	63.609.093
2020	64.181.027

Year	Production	Domestic Demand	Export	Import
2010	22.496.857	6.234.000	16.291.856	46.720
2011	23.995.973	6.940.000	16.436.202	23.344
2012	26.015.519	7.835.000	18.845.020	616
2013	27.782.004	9.020.000	20.577.976	65.561
2014	29.278.189	7.065.000	22.892.224	299
2015	31.070.015	8.310.000	26.467.564	7.572
2016	31.487.986	12.750.000	22.761.814	2.658
2017	34.940.289	11.056.000	27.353.337	2.518
2018	42.883.631	13.491.000	27.898.875	806
2019	47.120.247	16.747.000	28.279.350	93.285
2020	44.759.147	17.349.000	25.935.257	957

in USD/Ton

Year	Indonesia	Malaysia	World
2010	862	638	912
2011	1.007	754	1.144
2012	914	659	1.007
2013	798	545	886
2014	744	554	852
2015	555	498	632
2016	638	609	700
2017	662	641	711
2018	537	514	609
2019	498	489	574
2020	672	637	723

in Labor

Year	Indonesia
2010	80.524
2011	93.566
2012	106.256
2013	121.792
2014	130.973
2015	135.273
2016	143.149
2017	189.689
2018	173.999
2019	193.642
2020	205.774

The CPO industry turns out to be an **export-oriented industry**. So that the amount of Indonesian CPO production will depend **on foreign demand**. This domestic production will directly affect the number of workers

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Framework
Indonesia CPO Industry Profile

The amount of **foreign demand** will depend on **three** factors:

A. Domestic production capacity, in this case our capacity is large, the amount of production is always smaller than capacity, and the rest is a lot.

B. Price competition between Indonesia and competitors. In this case, our main competitor is Malaysia. But if you look at it, Malaysia's prices are actually always more competitive (price MY < price ID). Actually the unit of analysis should be ID vs MY. However, because MY data is difficult to find (see slide 8), we use the ID vs World approach. It can be seen that Indonesian prices are more competitive than world prices.

C. Transportation costs from ID to export destination countries vs. transportation costs from MY to export destination countries. Because in number 2 MY data is difficult to find, our unit of analysis is ID vs world, so this third point is temporarily ignored.

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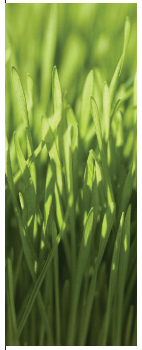

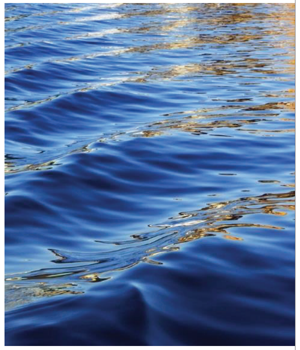

Modelling

System Dynamics Models

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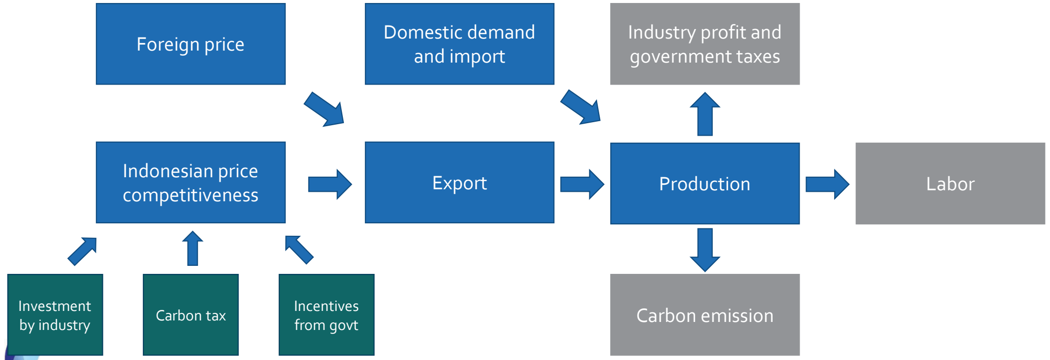
Modelling
Modelling Framework



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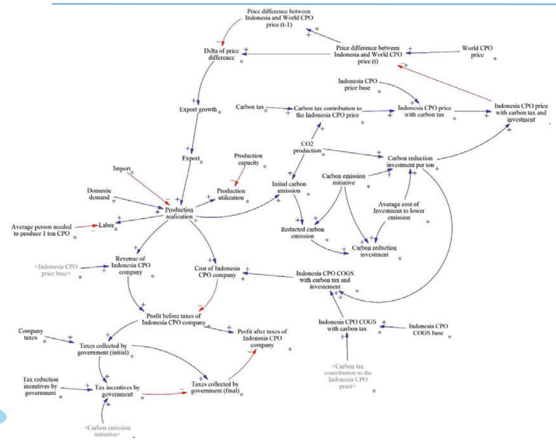
Modelling
Causal-loop diagram



- : Positive polarity
- : Negative polarity

- **Positive polarity** means that if **variable A increases,** then it will cause the **variable B increases.**
- **Negative polarity** means that if **variable A increases,** then it will cause the **variable B decreases.**

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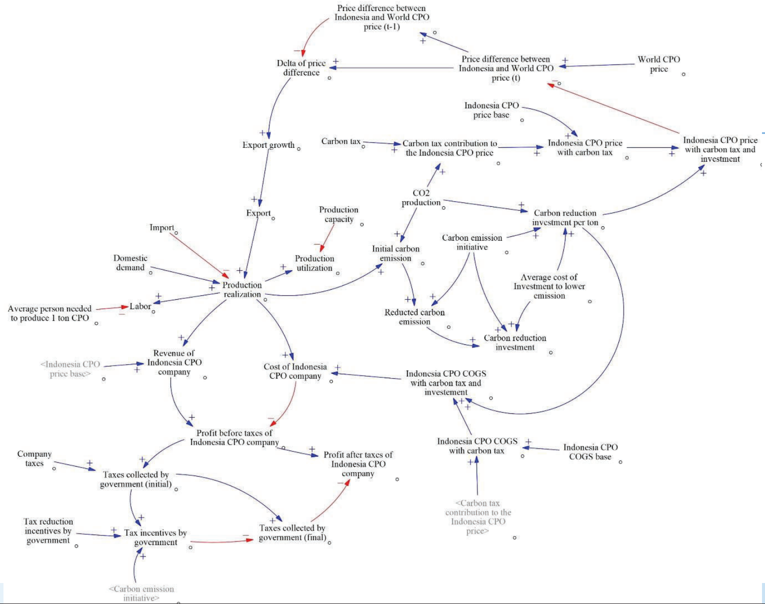

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Modelling

Parameters

- CPO base price Indonesia : USD 862/ton in 2010.
- CPO base price world : USD 912/ton in 2010.
- Export base : 16,291,856 ton in 2010.
- Domestic demand base : 6,234,000 ton in 2010.
- Production capacity base : 37,614,843 ton in 2010.
- Labor productivity : 0.0042 person/ton produced CPO.
- CO_2 production : 17.09 ton CO_2e/ton produced CPO.
- Investment to lower carbon em. : USD 50/ton CO_2e (min), USD 500/ton CO_2e (max).
- COGS CPO production Indonesia : USD 444/ton.
- Company taxes : 22% from profit.

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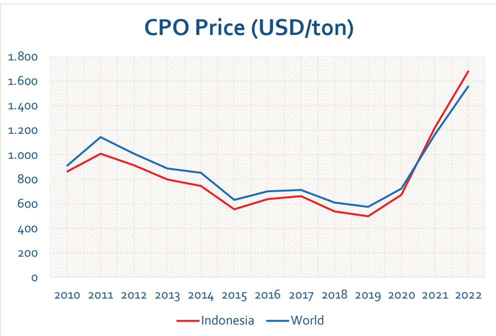
Modelling

CPO Price: Indonesia vs World



Indonesian CPO **prices** are **more competitive** than world CPO prices.

Competitive prices make Indonesia **able to export large quantities** of CPO.

If Indonesian prices become more uncompetitive (more expensive), then exports decrease -> domestic production decreases -> labor decreases -> taxes received by the government decrease.

Things that make Indonesian prices more expensive:

A. Carbon tax.

B. Industrial investment to reduce carbon emissions.

Things that make Indonesian prices cheaper :

A. Government tax incentives for industries that reduce carbon emissions.

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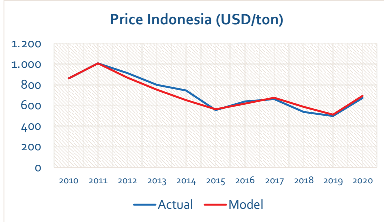
Modelling

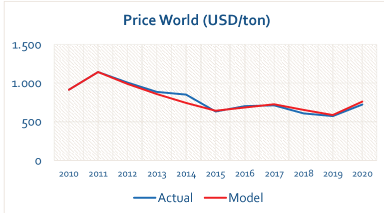
CPO Price Modelling and Validation



Parameter	Value
n	11.00
r	0.97
R^2	0.95

Based on ***Theil inequality test***, *we* found that the **R-squared** of **Price Indonesia Model** is **0.95** that can be concluded that the **model is valid** and **representative.**

(R-squared model that acceptable is greater than 0.5)



Parameter	Value
n	11.00
r	0.97
R^2	0.95

Based on ***Theil inequality test***, *we* found that the **R-squared** of **Price World Model** is **0.95** that can be concluded that the **model is valid** and **representative.**

(R-squared model that acceptable is greater than 0.5)

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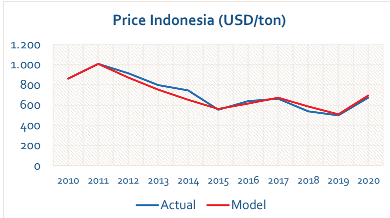
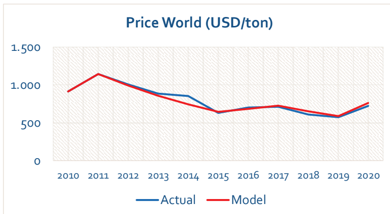
Modelling

CPO Price Modelling and Validation





CPO price growth per annum ($g(t)$)	Indonesia	World
2010-2011	16,82%	25,44%
2012-2015	-13,52%	-13,41%
2016-2017	9,36%	6,17%
2018-2019	-13,07%	-10,05%
2020-2022	36,22%	29,76%
2023-onwards	9,12%	9,86%

Price base (2010)
Indonesia : USD 862/ton
World : USD 912/ton

$p(t) = [1 + g(t)] \times p(t-1)$
$p(t)$ = price in year-(t)
$g(t)$ = annual growth of prices in year-(t)

From the table above, we can see that the **growth per annum** between CPO Indonesia Price and World Price **is similar**. This data **support** that **both model** of CPO Indonesia Price and World Price is valid.

Between 2012-2015 the **growth was negative** around -13%, and **between 2018-2019** was **negative** around **-12%.** And **after 2020** the **growth** of CPO p.a. is **increasing** around 9%.

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Modelling
Export modeling and validation

Year	Difference between world and Indonesian prices (USD/ton)	Annual difference between world and Indonesia prices (USD/ton)	Export growth (%/year)	Export decline elasticity (%/year)
2010	50			
2011	137	87	0.89%	
2012	93	- 44	14.66%	
2013	88	- 5	9.20%	
2014	108	20	11.25%	
2015	77	- 31	15.62%	
2016	62	- 15	-14.00%	0.93%
2017	49	- 13	20.17%	
2018	72	23	1.99%	
2019	76	4	1.36%	
2020	51	- 25	-8.29%	0.33%

If the **delta price difference** is **negative**, **exports will fall**, because it means that world prices (competitors) are cheaper than Indonesian prices, so that foreign consumers switch to competitors' products.

0.63% was obtained from an average of 0.93% and 0.33%. 0.93% is obtained from -14.00% divided by -15%. 0.33% is obtained from -8.29% divided by -25.

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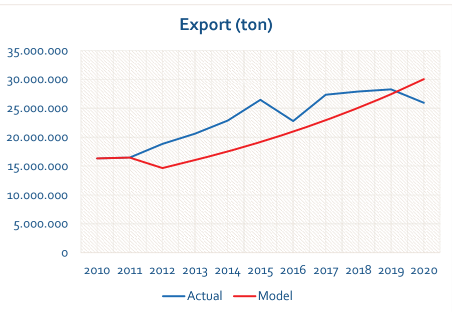
Modelling
Export modeling and validation



Parameter	Value
n	11.00
r	0.79
R^2	0.62

Based on ***Theil inequality test**, we* found that the **R-squared** of **Export Model** is **0.62** that can be concluded that the **model is valid** and **representative**.

(R-squared model that acceptable is greater than 0.5)

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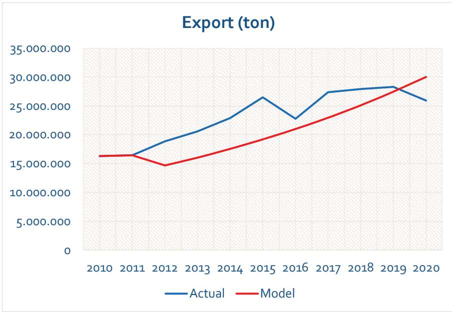
Modelling
Export modeling and validation



As mentioned before, that if **ID price** is **higher (more expensive)** than **World Price** that our **export will dropped**.

Assumption of a minimum delta price that will make exports decrease = - USD 16/ton (difference between world and Indonesian prices)

Example in 2012. World price USD 990.56/ton, Indonesian price USD 870.81/ton, delta price difference USD -17.25/ton.

A. Because the delta price difference is < -16, using negative growth, the growth in 2012 was 0.63% x -17.25 = -10.91%

B. 2012 exports = (1+(-10.91%)) x 2011 exports = (1+(-10.91%)) x 16,436,202 = 14,642,821 MT.

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Modelling
Domestic demand modeling

Year	Domestic demand growth yearly
2010	
2011	11.32%
2012	12.90%
2013	15.12%
2014	-21.67%
2015	17.62%
2016	53.43%
2017	-13.29%
2018	22.02%
2019	24.13%
2020	3.59%
2021	6.18%
2022	11.77%

Based on the data shown, we can conclude that the **average of demand growth** is **8.16% per annum**

So we can formulate that:

Demand on year (t) = Demand on year t-1) x 8.16%

Data on 2016 or the yellow-highlighted **is outlier** in the dataset

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Modelling
Import modeling

Year	Import (ton)
2010	46.720
2011	23.344
2012	616
2013	65.561
2014	299
2015	7.572
2016	2.658
2017	2.518
2018	806
2019	93.285
2020	957
2021	0
2022	0

For Import Data, there is **no some specific pattern** or behavior that shown from data that collected.

Can be concluded that Import will be same as a **constant**

The constant is obtained by the **average of import** from year of 2010 until 2020

The value of constant is 18,795 ton/year

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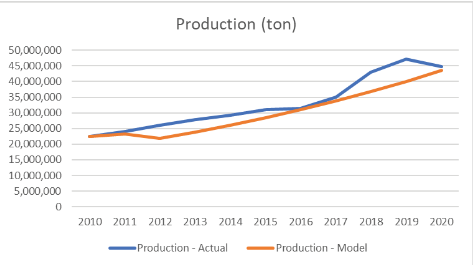
Modelling
Production modeling and validation



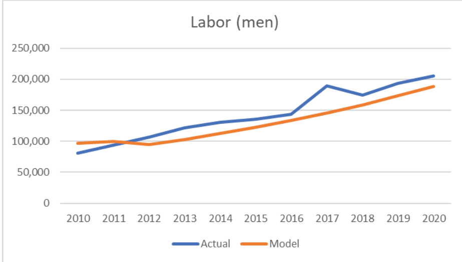
Parameter	Value
n	11.00
r	0.96
R^2	0.93

Based on ***Theil inequality test***, *we* found that the **R-squared** of **Production Model** is **0.93** that can be concluded that the **model is valid** and **representative**.

(R-squared model that acceptable is greater than 0.5)

KIREI

Modelling
Labor modeling and validation



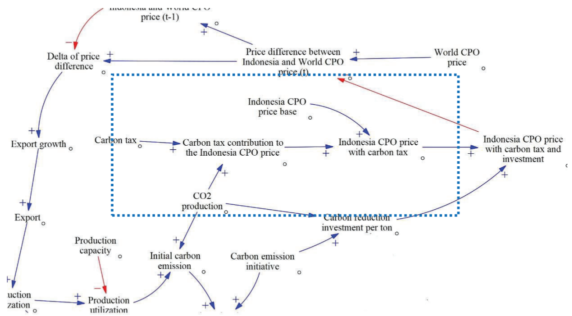
Parameter	Value
n	11.00
r	0.95
R^2	0.90

Based on ***Theil inequality test***, *we* found that the **R-squared** of **Labor Model** is **0.90** that can be concluded that the **model is valid** and **representative**.

(R-squared model that acceptable is greater than 0.5)

KIREI

Modelling
Carbon tax price modeling



1. The application of **carbon tax** will **influence** the **CPO price** since it will increase the carbon tax contribution to CPO price.
2. The amount of carbon tax on this model is **USD 2 per ton CO2e** or **USD 34.17 per ton CPO.** This value is based on the **new policy** of **Indonesia government** who want to implement the carbon tax.
3. As it affects the Indonesia CPO price, it will also increase more gap with price difference between Indonesia and World CPO price.

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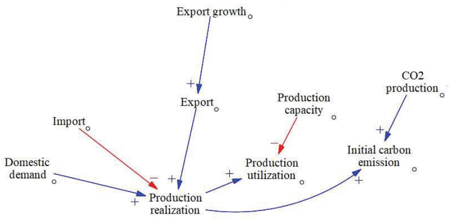
Modelling
Carbon emission modeling



Carbon emission is **influenced** by the **amount of CPO** produced in Indonesia. The **more CPO** is generated, **more carbon emission** will be produced.

1. To calculate the carbon emission, we need to calculate “Production realization” and “Production utilization”.
2. Based on the data that we gathered, “Production realization” variable can be calculated by adding “Domestic demand” with “Export”, then subtracting it with “Import”.
3. Then, “Production utilization” variable calculates about the number of production that can be achieved compared to the “Production capacity”.
4. “Production utilization” is calculated with dividing the “Production realization” with “Production capacity”.
5. “Initial carbon emission” is the number of carbon emission produced before there is any intervention policy.
6. “Initial carbon emission” is calculated by multiplying “CO2 production” with “Product realization”

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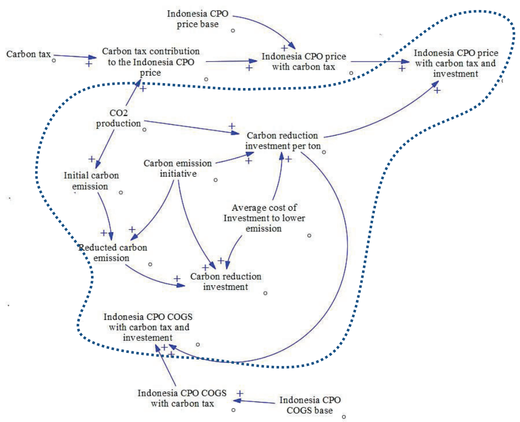
Modelling
Investment to reduce carbon emission modeling



1. “Carbon emission initiative” is one of the decision variables that determine the amount of money needed in “Carbon reduction investment per ton” (million USD/ton) variable.
2. To calculate “Carbon reduction investment per ton”, we need to multiply “Average cost of investment to lower emission” (million USD) with “Carbon emission initiatives” (%/CO2e produced) and “CO2 production” (ton CO2e/ton CPO)
3. “Average cost of investment to lower emission” is a parameter that describes about the amount money to implement reforestation as a way to reduce CO2 emission.

Carbon emission initiative as an obligation to conduct investment that lower carbon emission also will **increase CPO price** and **CPO COGS.**

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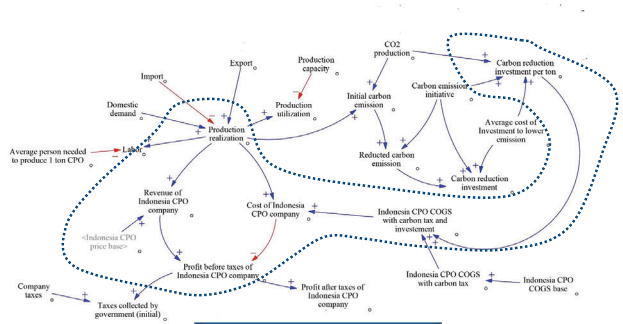
Modelling
Company revenue, cost and profit modeling



The **suspected policy** that **influence revenue, cost, and profit before taxes** are **carbon emission** and **average cost of investment to lower carbon emission**

1. “Production realization” will be multiplied by “Indonesia CPO price base” and become “Revenue of Indonesia CPO company”
2. “Carbon reduction investment per ton” will add cost on “Indonesia CPO COGS with carbon tax” and become “Indonesia CPO COGS with carbon tax and investment”
3. “Production realization” will be multiplied by “Indonesia CPO COGS with carbon tax and investment” and become “Cost of Indonesia CPO company”
4. “Profit before taxes” is the amount of profit before deducted by taxes. It is calculated by subtracting “Revenue of Indonesia CPO company” with “Cost of Indonesia CPO company”

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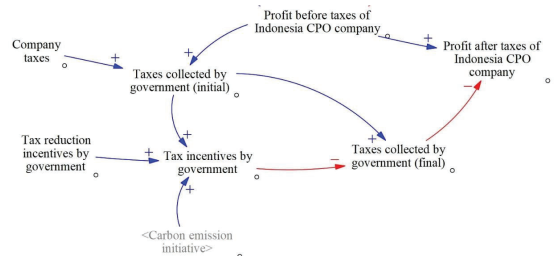
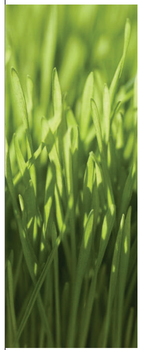
Modelling
Taxes and government incentives modeling



Tax incentive by government will **decrease** the amount of **tax collected by government** and **increase profit after taxes**

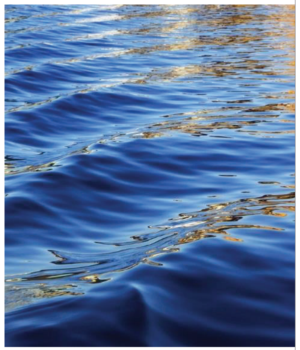
1. “Profit before taxes” deducted by “Taxes collected by government (initial)” will result . It is calculated by subtracting “Revenue of Indonesia CPO company” with “Cost of Indonesia CPO company”
2. “Taxes collected by government (initial)” is portion of profit that become taxes. It is generated with multiplying “Company taxes” (%) with “Profit before taxes” .
3. “Tax reduction incentives by government” is one of decision variable that show the percentage to compensate the percentage of the obligation to conduct investment to lower the carbon emission.
4. “Tax incentives by government” is the amount of taxes that is not deducted for CPO company. It is generated by multiplying “Taxes collected by government (initial)” , “Tax reduction incentives by government” , and “Carbon emission initiative”

KIREI



Analysis

System Dynamics Models



KIREI

Scenario Analysis
Carbon Emission Reduction

in Million Ton

Scenario	2022	2023	2024	2025	2026	2027
Existing	0,00	0,00	0,00	0,00	0,00	0,00
1	0,00	0,00	0,00	0,00	0,00	0,00
2	3.512,73	3.809,23	4.130,81	4.479,63	4.857,99	5.268,40
3	3.512,73	3.809,23	4.130,81	4.479,63	4.857,99	5.268,40
4	467,08	507,61	551,66	599,56	651,63	708,25
5	467,08	507,61	551,66	599,56	651,63	708,25
6	513,87	558,79	607,66	660,81	718,64	781,55
7	4.144,42	4.500,23	4.886,72	5.306,53	5.762,54	6.257,91
8	473.399	514.518	559.223	607.830	660.679	718.145

1. To reduce the carbon emission, the application of **carbon tax only** will **not affect** the **carbon emission** reduction as shown on the Scenario 1.
2. The application of **tax incentives** also do **not affect the carbon emission reduction**.
3. The **carbon emission initiatives** is the factor that **really reduce the carbon emission**.
4. The greater percentage of obligation to invest of lowering carbon emission will generate more carbon emission reduction.
5. The **reduction** of **average cost of investment to lower carbon emission** also **will increase** the amount of **carbon emission reduction**. It happens because it is **cheaper** to reduce carbon emission.
6. The **reduction** of **average cost of investment to lower carbon emission** also **generate more carbon emission reduction** than reduction of the **other decision variables.**

KIREI

Scenario Analysis

Scenario	Carbon tax (USD/ton)	Tax reduction incentive	Carbon emission initiatives (%)	Average cost of investment to lower carbon emission (USD/ton CO2e)
Existing condition	0	0	0	0
1	2	0	0	275
2	2	0	1	275
3	2	1	1	275
4	2	5	0,1	275
5	2	10	0,1	275
6	1	5	0,1	275
7	2	5	1	140
8	2	5	0,1	140

1. The **goal of scenario analysis** is to **know** the **result** if **one or some policy** will be **implemented in real case**.
2. Scenario analysis is conducted by changing the value of **four decision variables**, namely carbon tax, carbon emission initiative, average cost of investment to lower carbon emission, and tax reduction incentives by government.
3. There are **9 simulations**, with one simulation is existing condition without any intervention policy, while the others have intervention policy.

KIREI

Scenario Analysis
Taxes Collected by Government

in Million USD

Scenario	2022	2023	2024	2025	2026	2027
Existing	5.595	6.776	8.199	9.912	11.973	14.452
1	4.471	5.435	6.597	7.997	9.683	11.710
2	3.060	3.962	4.799	5.804	7.012	8.461
3	3.029	3.922	4.751	5.746	6.941	8.376
4	4.321	5.286	6.415	7.775	9.411	11.380
5	4.319	5.283	6.411	7.771	9.407	11.375
6	4.867	5.942	7.199	8.714	10.537	12.730
7	3.547	4.450	5.397	6.536	7.906	9.552
8	4.393	5.358	6.503	7.882	9.542	11.539

1. The application of **carbon tax and carbon emission initiative reduce** the **amount of taxes collected by government**. **Especially**, the **carbon emission initiative.**
2. These things happen because both carbon tax and carbon emission initiative will **increase the cost of Indonesia CPO company** and **reduce the profit before taxes.**
3. The application of **tax reduction incentives** also **decrease** the **amount of taxes collected by the government**, but it is **not as much** as the decreasing because of **carbon tax and carbon emission initiative**.
4. The **reduction** of **average cost of investment to lower carbon emission** will **decrease** the amount of **taxes collected by government** but it is **not as much as** the decreasing because of **carbon tax, carbon emission initiative , and tax reduction incentives.**
5. The **reduction** because of **average cost of investment to lower carbon emission** give **better result** than the other decision variables.

KIREI

Scenario Analysis
Labor

in Person

Scenario	2022	2023	2024	2025	2026	2027
Existing	145.000	157.773	171.676	186.809	203.283	221.216
1	121.340	131.891	143.364	155.838	169.403	184.154
2	88.808	96.304	104.435	113.253	122.819	133.195
3	88.808	96.304	104.435	113.253	122.819	133.195
4	118.087	128.332	139.471	151.580	164.745	179.058
5	118.087	128.332	139.471	151.580	164.745	179.058
6	129.917	141.273	153.627	167.065	181.685	197.589
7	104.778	113.774	123.545	134.159	145.688	158.211
8	119.684	130.079	141.382	153.670	167.032	181.560

1. The application of **carbon tax and carbon emission initiative reduce** the amount of **labor. Especially,** the **carbon emission initiative.**
2. The application of **tax incentives** also do **not affect labor**.
3. The **reduction** of **average cost of investment to lower carbon emission** will **decrease** the amount of **labor** but it is **not as much** as the **decreasing because of carbon tax and carbon emission initiative.**
4. The **reduction** because of **average cost of investment to lower carbon emission** give **better result** than the other decision variables.

KIREI

Scenario Analysis
Export

in Million Ton

Scenario	2022	2023	2024	2025	2026	2027
Existing	17,62	19,27	21,0	23,06	25,22	27,59
1	12,14	13,28	14,52	15,89	17,38	19,01
2	4,61	5,04	5,51	6,03	6,60	7,22
3	4,61	5,04	5,51	6,03	6,60	7,22
4	11,38	12,45	13,62	14,90	16,30	17,83
5	11,38	12,45	13,62	14,90	16,30	17,83
6	14,12	15,45	16,90	18,49	20,22	22,12
7	8,30	9,08	9,94	10,87	11,89	13,01
8	11,75	12,86	14,07	15,39	16,83	18,41

1. The application of **carbon tax and carbon emission initiative reduce** the amount of **export. Especially,** the **carbon emission initiative.**
2. The application of **tax incentives** do **not affect export.**
3. The **reduction** of **average cost of investment to lower carbon emission** will **decrease the amount of export** but it is **not as much as** the decreasing because of carbon tax and carbon emission initiative.
4. The **reduction** because of **average cost of investment to lower carbon emission** give **better result** than the other decision variables.

KIREI

Scenario Analysis
Production Realization

in Million Ton

Scenario	2022	2023	2024	2025	2026	2027
Existing	33,57	36,53	39,75	43,25	47,06	51,21
1	28,09	30,53	33,19	36,08	39,22	42,63
2	20,56	22,30	24,18	26,22	28,43	30,84
3	20,56	22,30	24,18	26,22	28,43	30,84
4	27,34	29,71	32,29	35,09	38,14	41,45
5	27,34	29,71	32,29	35,09	38,14	41,45
6	30,08	32,71	35,57	38,68	42,06	45,74
7	24,26	26,34	28,60	31,06	33,73	36,63
8	27,71	30,12	32,73	35,58	38,67	42,03

1. The application of **carbon tax and carbon emission initiative reduce** the amount of **production realization. Especially,** the **carbon emission initiative.**
2. The application of **tax incentives** do **not affect production realization.**
3. The **reduction** of **average cost of investment to lower carbon emission** will **decrease** the amount of **production realization** but it is **not as much** as the **decreasing because of carbon tax and carbon emission initiative.**
4. The **reduction** because of **average cost of investment to lower carbon emission** give **better result** than the other decision variables.

KIREI

Scenario Analysis
Profit after Taxes of Indonesia CPO Company

in Million Ton

Scenario	2022	2023	2024	2025	2026	2027
Existing	19.838	24.025	29.068	35.141	42.449	51.239
1	15.853	19.270	23.390	28.353	34.329	41.518
2	10.849	14.047	17.013	20.578	24.859	29.997
3	10.880	14.087	17.061	20.636	24.929	30.082
4	15.330	18.752	22.758	27.582	33.389	40.374
5	15.332	18.755	22.761	27.586	33.394	40.380
6	17.266	21.079	25.541	30.915	37.383	45.162
7	13.423	16.843	20.425	24.737	29.921	36.152
8	15.587	19.008	23.070	27.963	33.853	40.939

1. The application of **carbon tax and carbon emission initiative reduce** the amount of **profit after taxes** Indonesia CPO company . **Especially, the carbon emission initiative.**
2. The application of **tax reduction incentives** also **decrease** the amount of **profit after taxes** Indonesia CPO company, but it is **not as much as the decreasing** because of **carbon tax and carbon emission initiative. The difference with or without tax incentives** is **very small**.
3. The **reduction** of **average cost of investment to lower carbon emission** will **decrease** the **amount of profit after taxes** of Indonesia CPO company but it is **not as much as the decreasing** because of **carbon tax and carbon emission initiative.**

KIREI

Scenario Analysis
Conclusion

1. The application of **tax reduction initiatives** do **not give** any **huge effects** on the **carbon emission, labor, production realization, and export**. This intervention policy only give **a small effect** on **taxes collected by the government and profit after taxes of Indonesia CPO company.**
2. The **intervention** policy that **really affect all the performance measure** are the **carbon tax, the average cost of investment to lower carbon emission, and the carbon emission initiative**.
3. The **reduction of carbon tax** will result all the **performance criterias**, **except carbon emission**, **have closer value** to **existing condition** (without intervention policy). In addition, the application of carbon tax solely **do not have any effect** on the **carbon emission reduction**.
4. The **reduction of carbon emission initiative** will result all the **performance criterias have closer value to existing condition** (without intervention policy). However, the **smaller number of carbon emission initiatives** will result a **smaller carbon emission reduction.**
5. The **reduction of average cost of investment** to lower carbon emission will result **all the performance criterias have closer value to existing condition** (without intervention policy). It happens because the reduction of average cost of investment **give a cheaper solution** to reduce the carbon emission without sacrificing a lot of money.
6. The **best combination** of the decision variable is **keeping** the **carbon tax and average cost of investment** to lower the carbon emission **as low as possible**, while the **carbon emission initiatives** in a **certain number** (not too small).

Improvement of the models

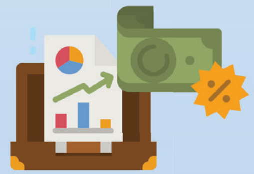
1. Apparently, investment to lower carbon emission is very costly. Industry would not benefit (financially) from merely tax (or others) incentive from the government.
2. To make carbon emission initiative attractive for industry, government should exercise these plans, and these should be included in the future models:
   a) How to lower investment CAPEX per CO2e reduction.
   b) If there any revenue benefits for industry by investing CAPEX to lower emission, i.e., by lowering carbon, industry's products would sell more, especially for the developed countries markets.
   c) If investment in lowering carbon emission would decrease other cost structure, i.e., modern machinery needs lower cost than the existing ones.
3. This study is based on Indonesia vs World price competition. It should be extended on more detail level, i.e., Indonesia vs competitor country competition.

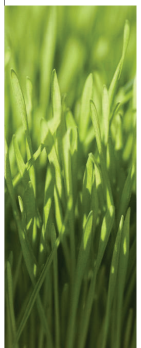
Recommendation

Looking for the **cheaper options** to conduct **investment that lower the carbon emission.**

Prioritize the application of the intervention **policies** that implement the **carbon tax, carbon emission initiatives, and average cost of investment to lower the carbon emission.**

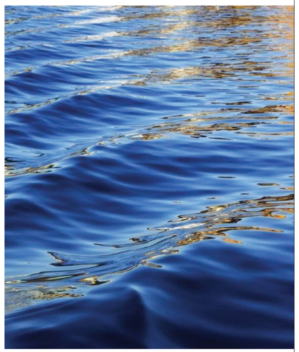
Consider to change the **tax incentives** to a **subsidy** or **incentives** that can **reduce the average cost of investment** to lower the carbon emission.





Thank You

System Dynamics Models



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