THE USE OF SEEA FLOW ACCOUNTS FOR DERIVING CIRCULAR ECONOMY INDICATORS

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ABSTRACT

The transition from linear economy toward circular economy raises the needs of standard circular economy indicators to monitor and evaluate the development processes. System of Environmental-Economic Accounting (SEEA) provides a statistical framework which guides the compilation of environmental-economic accounts. This paper aimed to highlight the use of SEEA flow accounts to derive consistent and comparable circular economy indicators related to waste and recycling, material flows, environmental impact, and R-strategies.

Keywords*: air emission, circular economy, energy, environmental-economic accounts, material, waste, water*

INTRODUCTION

In the last 50 years, the use of materials extracted from natural resources has continued to increase, especially in developing countries (IPBES, 2019). However, this trend was not accompanied by the ability of the ecosystem to provide these materials in a sustainable manner. Environmental degradation that occurs continuously raises the risk of material scarcity to meet the needs of population in the future. Therefore, there it is crucial to shift paradigm in economic activities that are highly dependent on the availability of materials from natural resources. Economic development should begin to pay attention to the utilization of limited materials to generate optimal value added.

Circular economy is an economic model which aims to generate economic growth and reduce environmental impact by preserving and enhancing natural capital, optimizing resource yields, and fostering system effectiveness (Ellen MacArthur Foundation, 2015). The implementation of circular economy can help to accelerate reaching the targets of 2030 Agenda and the Paris Agreement. Circle Economy (2022) stated that the implementation of circular economy principles in seven core societal needs and wants, i.e. housing, nutrition, mobility, communications, services, consumables and healthcare, could decrease greenhouse gas (GHG) emissions by up to 39 percent or around 22.8 billion tonnes. Moreover, circular economy implementation could also reduce the global material use and extraction by 28 percent.

The transition toward circular economy needs to be supported by creating action plan, building platform, conducting pilot project, monitoring system and evaluation in order to reach the economic development targets. Therefore, the circular economy indicators are essential to provide clear picture of the current condition and give insights to policy makers to better planning the next steps in their development agenda.

Many countries have developed circular economy indicator sets based on their national development plan. Platform for Accelerating the Circular Economy (2021) has summarized the circular economy indicators from various countries comprised both the published indicators and those under development. Those indicators were grouped into seven topics, i.e. waste; recycling; material flows; R-strategies; policy and process; environmental impact; and economic and social impact.

However, those indicators still need harmonization and standardization as many indicators suggest similar purposes but have different methodologies. A common framework is fundamental to measure circular economy so that the derived indicators are comparable across countries.

SEEA provides standard statistical framework to understand the relationship between the economy and the environment. Environmental flow accounts, in particular, record the flows of energy, water, and other materials between the environment and the economy as well as the flows within the economy. The objective of this paper is to highlight the use of SEEA flow accounts as a standard framework to derive some related circular economy indicators.

LITERATURE REVIEW

Circular Economy

Circular economic activities aim to consume products and materials effectively in the production process cycle. This concept is different from a linear economy that applies a "take, make, waste" process, in which after raw materials are processed into products and used or consumed, those products will then be discarded into non-renewable waste (Lacy et al., 2020). In a circular economy, products that have been consumed will be reused in various stages of production until they are completely non-recyclable.

World Economic Forum (2014) defines circular economy as an industrial system that is restorative or regenerative which aims to eliminate waste through the superior design of materials, products, systems, and business models. Thus, the application of the circular economy concept will extend the lifespan of a product through reuse and efficiency so that the amount of raw material extracted from natural resources as well as the amount of waste disposed into the environment will be minimized.

There are several strategies in implementing circular economy concepts. An approach has been developed to reduce the use of natural resources and material consumption in production process, called R-strategies (Potting et al., 2017). R-strategies consist of 10 strategies which ordered by the level of circularity. Lower R-number represents the higher level of circularity.

Table 1. Circularity Strategies within the Production Chain

R-number	Strategy	Description
R0	Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
R1	Rethink	Make product use more intensive (e.g. through sharing products, or by putting multi-functional products on the market)

R-number	Strategy	Description
R2	Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resource and materials
R3	Re-use	Re-use by another consumer of discarded product which is still in good condition and fulfils its original function
R4	Repair	Repair and maintenance of defective product so it can be used with its original function
R5	Refurbish	Restore an old product and bring it up to date
R6	Remanufacture	Use parts of discarded product in a new product with the same function
R7	Repurpose	Use discarded product or its parts in a new product with a different function
R8	Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality
R9	Recover	Incineration of materials with energy recovery

Source: Potting et al. (2017)

Flow Accounts

Flow account is a type of environmental-economic accounts within SEEA framework which measures the flows of natural inputs into the economy and releases of residuals to the environment (United Nations et al., 2014). The use of SEEA flow accounts allows the derivation of indicators for the consumption of resources relative to economic indicators derived from national accounts, such as output or value added, since the residence principle of SEEA framework is in line with the System of National Accounts.

SEEA flow accounts comprise three subsystems: material flow accounts, energy accounts, and water accounts. Within the framework of material flow accounts, there is also other types of flow accounts, such as air emission accounts and solid waste accounts, which are focused on specific type of residuals. The measurement of SEEA flow accounts is generally carried out in physical units and presented using the structure of supply and use table.

METHODOLOGY

Circular Economy Indicators from Material Flow Accounts

Economy-wide material flow accounts (EW-MFA) provides aggregate overview in physical terms of the material inputs and outputs of an aconomy, including inputs from the environment, outputs to the environment, and the physical amounts of imports and exports. As one of the objective of circular economy is to keep the utility of materials as long as possible while maintaining the economic growth, the EW-MFA framework could be used to derive the material productivity indicators.

The basic indicator derived from EW-MFA is Domestic Material Consumption (DMC). DMC measures the mass of materials needed for domestic consumption activities. Therefore, DMC equals to the mass of materials extracted from the domestic environment plus materials imported from other countries less materials exported to other countries. To be classified as circular economy indicator, DMC should be divided by Gross Domestic Product (GDP) to form DMC per unit of GDP indicator because the circular economy aims to reach more economic growth with less material consumption.

As a material productivitiy indicators, DMC has limitation in terms of material coverage from/to the rest of the world. DMC only measures direct imports and exports of raw materials, whereas the consumption of materials also includes processed products. Consequently, all materials imported or exported should be measured in terms of raw material equivalent to better covers all materials required for consumption activities. Therefore, material footprint per unit of GDP indicator is recommended to represent as material productivity indicator. However, the calculation of material footprint is complex and data intensive.

Circular Economy Indicators from Solid Waste Accounts

Solid waste accounts (SWA) provides information on the generation of solid waste and the management of flows of solid waste to recycling facilities, to controlled landfills or directly to the environment. SWA could be used to derive circular economy indicators on waste and recycling.

Physical supply table for solid waste provides information on total volume of solid waste generated. The figure should be divided by total population to form total volume of solid waste generated per capita in order to exclude the population growth effect in the generation of solid waste. By presenting the solid waste data by type, it is also possible to derive specific waste indicators such as food waste, construction and demolition waste, and electronic waste.

Physical use table for solid waste presents information on the volume of solid waste recycled. Hence, it could be used to derive recycling rate indicator, which is defined as the quantity of material recycled in the country of total waste generated in the country.

The framework of solid waste accounts in SEEA Central Framework also differentiates between solid waste residual and solid waste products. The amount of solid waste products reused by industries in production processes could be good indicators for 9R-strategies in circular economy framework, which includes reuse, repair, refurbish, remanufacture, repurpose, and recycle (Potting, et al., 2017).

Circular Economy Indicators from Air Emission Accounts

Air emission accounts (AEA) records the generation of air emission by resident economic units. One of circular economy principles is to preserve and enhance natural capital by controlling finite stock and balancing resource flows, such as by replacing fossil fuels, which generates greenhouse gas (GHG), with renewable energy. Therefore, AEA could be used to derive GHG emission per unit of GDP indicator as part of circular economy indicator sets on environmental impact.

Circular Economy Indicators from Energy Flow Accounts

Energy flow accounts record the flows of energy from the environment into the economy, the flows of energy products within the economy, and the flows of energy back to the environment. Energy flow accounts could be used to derive renewable energy share in the total final energy consumption indicator as part of circular economy indicator sets related to circular economy principle to preserve and enhance natural capital.

Furthermore, the energy flow accounts also record the amount of energy recovered from waste. The incineration of solid waste to generate energy is part of 9R-strategies in circular economy. It is also related to the circular economy principle to optimise resource yields.

Circular Economy Indicators from Water Flow Accounts

Water flow accounts present information on flows of water, encompassing the initial abstraction of water resources from the environment into the economy, to the water flows within the economy, and flows of water back to the environment. Water flow accounts could be used to derive water use productivity indicator as a circular economy indicator related to preserve and enhance natural capital principle.

RESULTS AND DISCUSSION

This chapter presents some circular economy indicators for Indonesia which were derived from SEEA flow accounts. The flow accounts were compiled by using source data from various ministries and government institutions in Indonesia.

DMC per Unit of GDP

The material productivity in Indonesia was reflected in DMC per unit of GDP per capita indicator, as presented in figure 1 below. The results show that the trend of DMC per unit of GDP was not always in line with the trend of DMC. During 2016-2017, for instance, the DMC had increased from 1186 million tonnes to 1231 million tonnes, but the DMC per unit of GDP had declined from 125.75 tonnes per billion IDR to 124.15 tonnes per billion IDR. It indicates that the economic activities in 2017 utilized raw material more efficiently to generate value added than in 2016 even though the domestic consumption of raw materials increased.

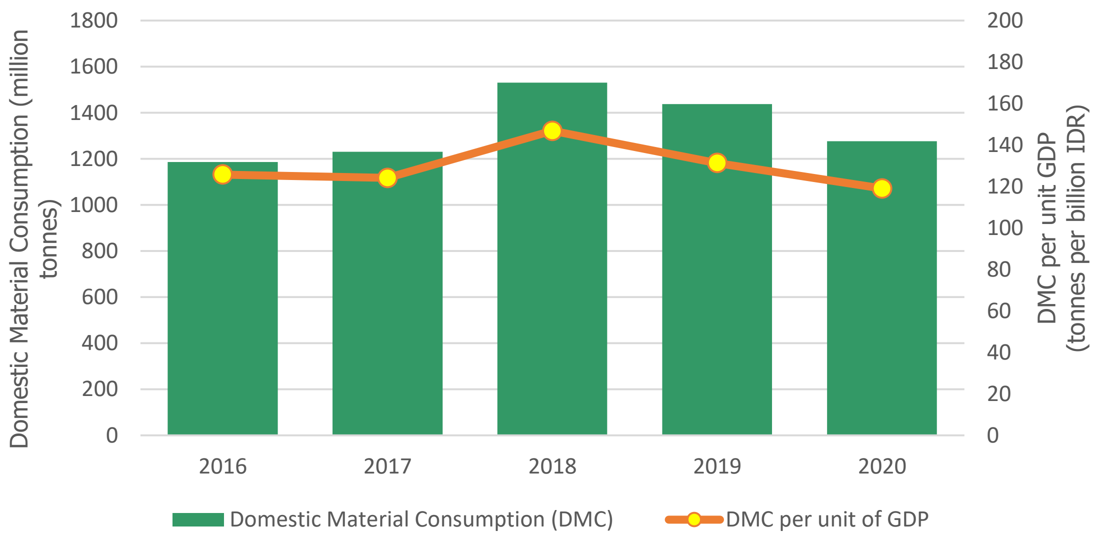


Figure 1. Domestic material consumption and domestic material consumption per unit of GDP in Indonesia, 2016-2020

Solid Waste Generation per Capita

The waste generation per capita indicator was calculated by using waste generation data and population data. However, the data on waste generation in Indonesia was not available at national level. It was only available at municipality/regency level and not all municipalities/regencies reported the waste generation data to the central government. Therefore, the area coverage of waste generation data might differ from a year to another.

While the waste generation data at national level was unavailable at the moment, it might be still possible to derive waste generation per capita indicator by only taking into account the population data from municipalities/regencies where the waste generation data was available. Figure 2 below presents the solid waste generation per capita in Indonesia during 2019-2021.

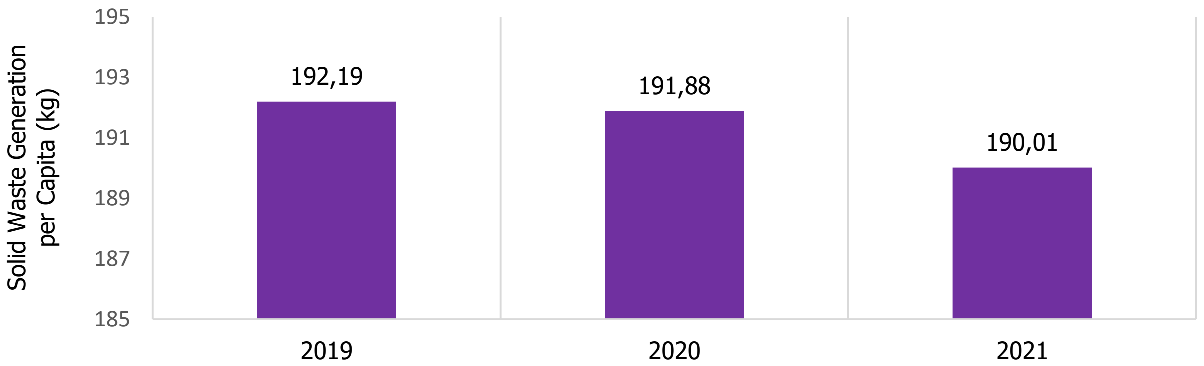


Figure 2. Solid waste generation per capita in Indonesia (kg), 2019-2021

During 2019-2021, the solid waste generation per capita in Indonesia had declined over time. In 2019, the solid waste disposed to the environment per person in 242 municipalities/regencies was 192.19 kg in average. In 2021, the data from 228 municipalities/regencies showed that every person generated 190.01 kg of solid waste in average. It was a positive signal for the circular economy implementation.

GHG Emission per unit of GDP

Air emission accounts present the amount of GHG emissions released to the atmosphere as a result of economic activities. Figure 3 illustrates the GHG emissions in Indonesia in the 2016-2020 period. In general, the GHG emissions in Indonesia had increased over the years during that time, particulary during 2016-2019. In 2016, the GHG emissions in Indonesia was 782938 Gg CO_2-e while in 2019 the GHG emissions increased to 914264 Gg CO_2-e. There was 16.77 percent growth of GHG emission in 3 years.

However, if the GHG emission was divided by GDP, the trend was relatively more constant. The GHG emission per unit of GDP only increased from 82.98 tonnes CO_2-e per billion IDR in 2016 to 83.50 tonnes CO_2-e per billion IDR in 2019. The growth was only 0.62 percent during 2016-2019. In 2020, the condition was much better as both GHG emission and GHG emission per unit of GDP declined.

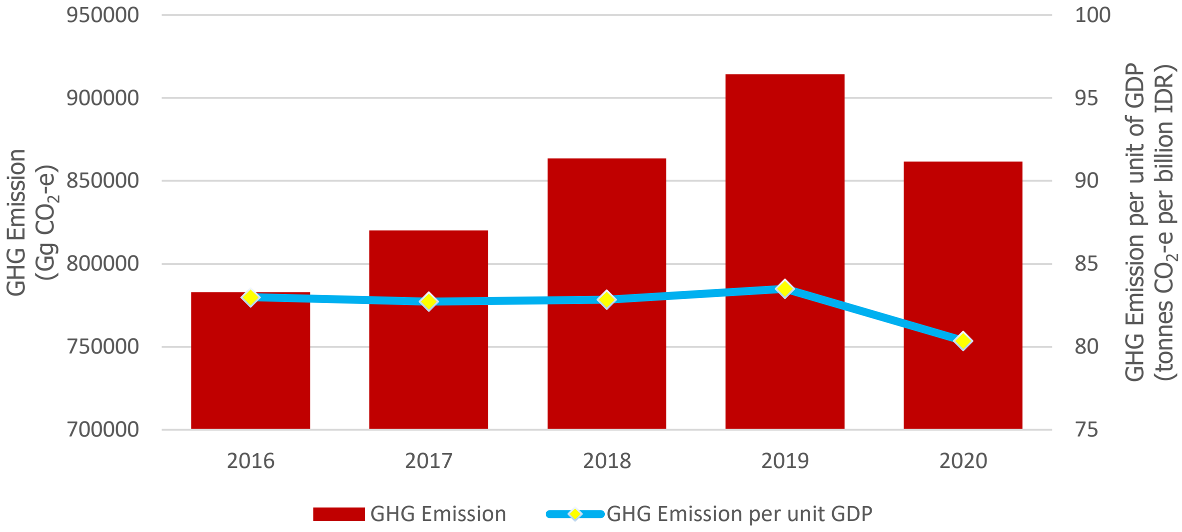
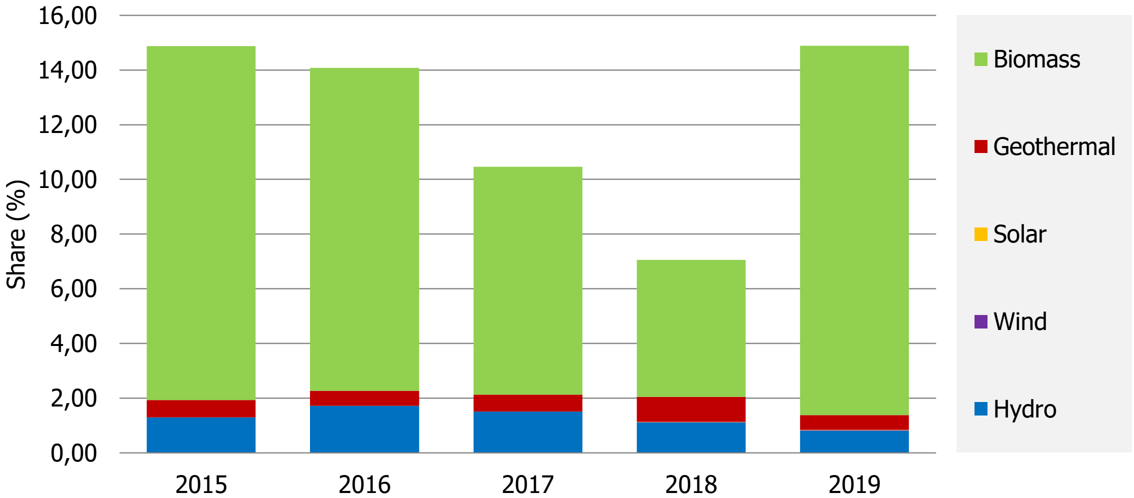


Figure 3. GHG emission and GHG emission per unit of GDP in Indonesia, 2016-2020

Renewable Energy Share in the Total Final Energy Consumption

The series of renewable energy share in the total final energy consumption indicator implies the transformation of the energy use from non-renewable natural resources toward renewable energy resources. Figure 4 describes the contribution of renewable energy to Indonesian final energy consumption during 2015-2019.



Source: BPS (2021)

Figure 4. Renewable energy share in the total final energy consumption in Indonesia (percent), 2015-2019

There was declining trend of renewable energy share in the total final energy consumption during 2015-2018 before it increased to 14.89 percent in 2019. That significant change was mainly caused by the increase of biomass-based energy consumption, even though the renewable energy captured from geothermal and hydro power decreased.

CONCLUSION

SEEA flow accounts provides standard framework to produce consistent and comparable statistics and indicators related to circular economy. The scope of circular economy indicators derived from SEEA flow accounts comprise indicators on waste, recycling, material flows, environmental impact, and R-strategies. However, some issues are still need to be addressed, such as the agreed methodology on material footprint modelling and the classification of solid waste for deriving comparable indicators for specific type of solid waste.

REFERENCES

BPS. (2021). *Energy Flow Accounts and Greenhouse Gas Emissions Accounts of Indonesia 2015-2019*. Jakarta: BPS-Statistics Indonesia.

Circle Economy. (2022). *The Circularity Gap Report 2022* (pp. 1-64, Rep.). Amsterdam: Circle Economy.

Ellen MacArthur Foundation. (2015). *Delivering the Circular Economy: A Toolkit for Policymakers*.

Eurostat. (2018). *Economy-Wide Material Flow Accounts Handbook.* European Union: Luxembourg.

IPBES (2019), *Global assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*, Brondízio, E. S., Settele, J., Díaz, S., Ngo, H. T. (eds). IPBES secretariat, Bonn, Germany. 1144 pages. ISBN: 978-3-947851-20-1

Lacy, Peter, Jessica Long, Wesley Spindler. (2020). *The Circular Economy Handbook: Realizing the Circular Advantage.* Washington D.C.: Palgrave Macmillan.

Platform for Accelerating the Circular Economy. (2021). *Circular Indicators for Governments.*

Potting, Jose, Marko Hekkert, Ernst Worrell and Aldert Hanamaaijer. (2017). *Circular Economy: Measuring Innovation in the Product Chain.* PBL Netherlands Environmental Assessment Agency: The Hague.

United Nations, European Commission, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organization for Economic Cooperation and Development and World Bank. (2014). *System of Environmental-Economic Accounting 2012: Central Framework*. Studies in Methods, Series F, No. 109. Sales No. E.12. XVII.12.

World Economic Forum. (2014). *Towards the Circular Economy: Accelerating the scale-up across global supply chains.* Geneva: World Economic Forum.