Measuring sustainability: an elaboration and application of the system of environmental-economic accounting for Indonesia

Pirmana, V.

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Measuring Sustainability: An Elaboration and Application of the System of Environmental-Economic Accounting for Indonesia

PhD Thesis at Leiden University, The Netherlands

The research described in this thesis was conducted at the Institute of Environmental Sciences (CML), Leiden University, the Netherlands.

ISBN: 978-90-5191-201-2

Cover: Sona Sonjaya

Layout: Viktor Pirmana

Printing: GVO Printers & Designers

Measuring Sustainability: An Elaboration and Application of the System of Environmental-Economic Accounting for Indonesia

Proefschrift

ter verkrijging van
de graad van doctor aan de Universiteit Leiden,
op gezag van rector magnificus prof.dr.ir. H. Bijl,
volgens besluit van het college voor promoties
te verdedigen op woensdag 8 juni 2022
klokke 10.00 uur

door

Viktor Pirmana
geboren te Bandung, Indonesia
in 1976

Promotores

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Chapter 1

General Introduction

1.1 Economic growth and the environment

Over the past half-century, the global community has achieved unimaginable levels of prosperity. During this time, global poverty has decreased substantially (UN, 2020). During the period 1960 to 2000, the global economic growth rate was 4%, meaning that in these 40 years, it went up five times (Lucas 2004 in Wade, 2017). Then, in the last ten years before the COVID-19 outbreak, the average global economic growth rate could still be maintained at around 3% (World Bank, 2021). This circumstance helped enormously to lift people out of poverty. The world's population in 1981 was 4.51 billion people. 1.92 billion of these individuals lived in poverty (defined as the population living on less than $1.90 a day at 2011 international prices). As of 2019, the world's population exceeded 7 billion, with only 644,56 million living in poverty, although the recent COVID crisis has resulted in a setback. China saw its population rise from 818 million in 1970 to 1.31 billion in 2015 and had GDP growth levels of 10% or more. This led to an increase in income per capita from $284 in 1970 to $8,067 in 2015. Another example is India, with a population doubling from 555 million in 1970 to 1.31 billion in 2015. It has experienced an average annual economic growth of more than 5% and increased its per capita income from $363 in 1970 to $1606 in 2015. As for Indonesia, there were 114 million people in 1970 versus approximately 258 million in 2015; the country's economy grew by nearly six percent annually, while per capita income increased from $673 in 1970 to $3332 in 2015. So, as we can see that the world and countries such as China, India, and Indonesia have made excellent strides in eliminating poverty through economic growth, more is needed. Analyses plot the Human Development Index (HDI) versus the Gross Domestic Product of countries show that generally, a good quality of life reflected by an HDI of over 0.8 requires an average GDP per capita of at least $5000-$10.000 a year. Or in short, countries like India and Indonesia still need to grow their GDP/capita to provide their citizens with a decent standard of living.

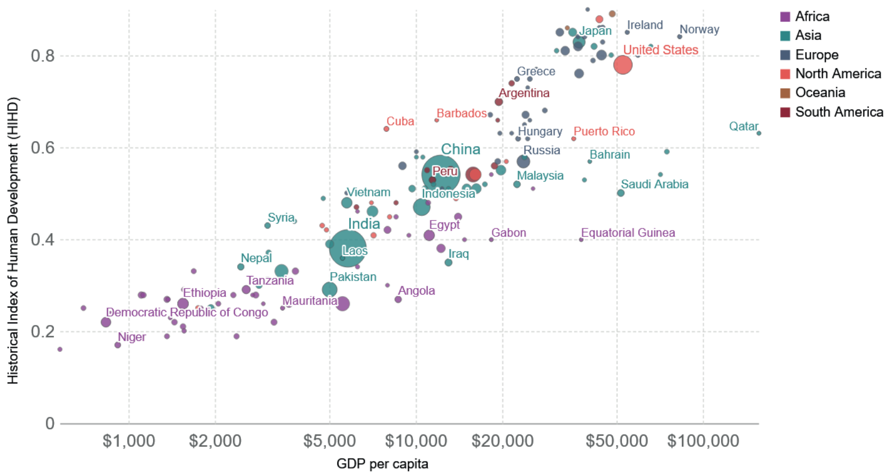


Figure 1.1**.** Human Development Index vs GDP per capita, 2015. Note that the x-axis has a logarithmic scale. Source: Prados de la Escosura (2018), Maddison Project Database 2020 (Bolt and van Zanden (2020))

However, historical experience shows that increased prosperity has almost always come at the cost of environmental damage and degradation (Pezzey, 1992; Liu, 2009; Wang et al., 2017; Mor & Singh, 2019; UN, 2020; Aktekin & Budak, 2021). Development and community activities have also resulted in various environmental problems and various health problems caused by the deteriorating quality of the environment (Appannagari, 2017). Together with the production of goods and services, emissions and waste is generated. This occurs in remnants of materials that cannot be processed and in the form of wastewater and chemical emissions that pollute natural resources such as land, water, and air. Furthermore, such waste and emissions will reduce the function of natural resources as a factor of production and in meeting human needs. So, waste and emission negatively impact human health, productivity levels, and finally, development results. This creates several challenges: how to create a positive relationship between economic development and the preservation of natural resources and the environment as an essential prerequisite for sustainable development; how to anticipate the impact of environmental pollution caused by economic sectors; and how to make effective and efficient use of natural resources/energy in the economy.

The complexity of the relationship between economic growth and environmental quality has been a source of debate and controversy among academicians for quite a long time (Kahuthu, 2006). An illustration of the relationship between economic growth and environmental quality is given in Pezzey (1992). Pezzey (1992) uses a country's stages of industrialization as an explanatory variable for such linkages. For Pathway 1 (P1), Pezzey (1992) argues that in the early stages of a country's industrialization, the environmental quality is at E0, meaning that environmental conditions have not changed. Over time, the quality of the environment decreases to a minimum position of E1, a country's industrialization stage. At this stage, the development process generally tends to use natural resources very intensively and creates high emissions levels. Next, it recovers (uphill to E2 at point B) when a country becomes a developed industrial country with output growth reaching Q2. However, even in this situation, environmental quality is still not optimal, given various pressures due to resource use and pollution by emissions. Further economic growth enables to mitigate of environmental pressures further. Several environmental policies are implemented in an effort to maintain a harmonious relationship between economy and environment, illustrated by the slope of P1, which reflects improved environmental conditions. At the same time, economic output continues to climb above the level of Q2.

In an alternative scenario depicted by the P2 line, environmental quality continues to decline when output rises. In this scenario, the optimistic future expectations, as “promised” by P1, cannot be achieved. The implication is that the environment will not be able to assimilate the generation of emissions and waste anymore, beyond a level where recovery can still occur. By this, economic growth ultimately will come to a halt. This condition is highly undesirable. This model further illustrates that a harmonious relationship between economic growth and environmental quality is supported if the costs of externalities from economical production on the environment are internalized between points A and B.

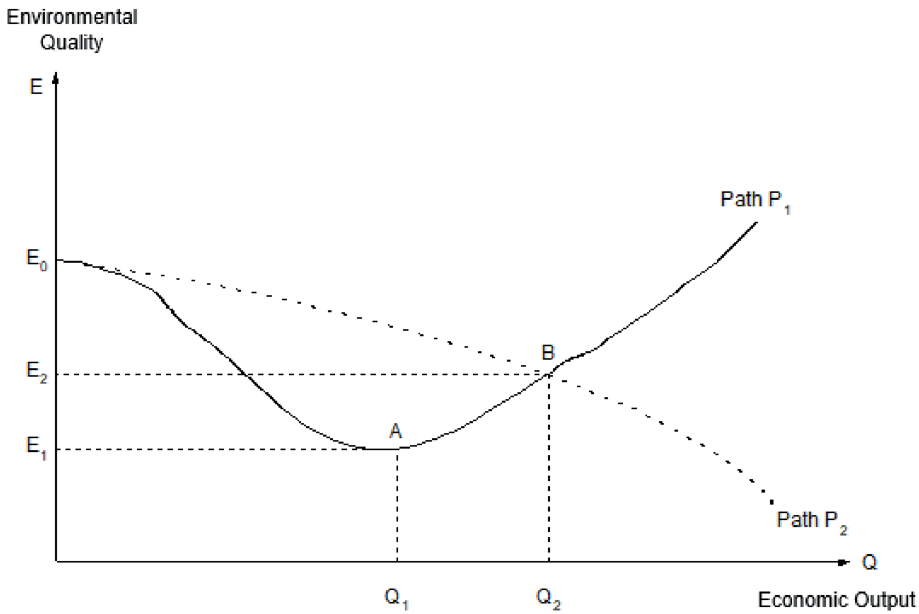


Figure 1.2. Possible trade-offs between output and environmental quality (as output Q grows over time)
Source: Pezzey (1992)

The linkage model above can be explained in the following way. Human life is not yet prosperous at the beginning of the growth phase. In order to enhance prosperity, the consumption of natural resources continues to increase, which causes the environmental quality to decline. Human life continues to develop, but the environment's quality is decreasing due to the tendency for development activities to be resource-intensive (Aktekin & Budak, 2021). Then consumption behavior and attitudes towards the environment change, and humans begin to pay with some of the output produced to restore the quality of the environment (Kahuthu, 2006), leading to a recovery from point A.

The linkage model above suggests that a phase of low environmental quality has to be passed before reaching the advanced industrialization stage. However, that does not mean that developing countries can ignore the importance of implementing environmental policies. The reality shows even that the experience of developing countries is often worse than suggested by the hypothesis above. This is because environmental policies are often very weak in industrialization's early stages (Dasgupta et al., 2005; Le et al., 2016).

There are no environmental property rights (everyone is free to use/take/contaminate). Environmental property rights are only implemented and enforced after economic development has led to a declining environmental quality – at point A, in figure 1.2.–when the consumption of natural resources is high and the production processes generate excessive pollution.

Pezzey's (1992) analysis has many relations with the so-called Environmental Kuznets Curve (EKC). The Kuznets hypothesis states that pollution and degradation of natural resources and the environment will increase rapidly in the early stages of growth. However, at certain income levels, there is a turning point. Beyond a certain growth threshold, the relationship reverses, and pollution decreases (Grossman & Krueger, 1995; Stern, 1996; Kahuthu, 2006; Stern, 2018; Karsch, 2019; Pincheira & Roxane, 2021). This change in relationship has been interpreted as reflecting a shift in priorities. At a given level of economic growth, people are more interested in clean air and a healthy environment than further income increases. (Andreoni and Levinson, 2001; Kahuthu, 2006).

As global environmental degradation became more serious, the EKC hypothesis has become more popular. However, empirical evaluation of the EKC hypothesis has not given clear evidence that the EKC materializes in practice. The validity of the EKC hypothesis with an inverted U-curve shape has been shown in several studies in different regions (Grossman & Krueger, 1991; Agras & Chapman, 1999; Proops & Safonov, 2004; Shen & Hashimoto, 2004; Rousmasset et al., 2008; Sirag et al., 2018). However, other studies contradict the EKC hypothesis. Studies such as Dasgupta et al. (2002) and Perman and Stern (2003) questioned the idea that "getting rich" was a precursor to "environmental consciousness" because they found for various pollutants that the inverted U shape of the characteristic EKC did not materialize.

Pollutants such as sulfur dioxide have been prevalent in EKC studies. Stern (2003) used a variety of dependent variables in his analysis of EKC, including effluent, SO_2, suspended particulate matter (PM2.5), NOx, CO_2, and water consumption. According to Stern (2003), the most coherent evidence of the Kuznets hypothesis is SO_2 because the result resembles an inverted U shape. Analyzes that included CO_2 and suspended particles did not sufficiently produce an inverted U-shape, and therefore the validity of this EKC hypothesis was questioned. Dinda (2004) showed that the EKC only validated air pollutants such as SO_2. Dinda (2004) further explains that the EKC model must include the effects of technological advances and must capture regional and local impacts, not just the total country. Vollebergh et al. (2008) estimated the EKC for two types of pollutants, CO_2 and SO_2, in OECD countries from 1960 to 2000. The study shows that the EKC hypothesis holds for SO2 pollutants but not for CO_2 pollutants. Hidemichi and Shunsuke (2011) tested the EKC hypothesis in 23 OECD countries classified as developed countries using the level of carbon dioxide emissions per sector. Hidemichi and Shunsuke (2011) found that the Environmental Kuznets Curve hypothesis for sector-level CO2 emissions is confirmed in the food, textile, wood, chemical, pulp, steel, machinery, transportation equipment, and construction industries. However, environmental Kuznets curve relationships did not exist in the non-ferrous metal and mining industries. Basarir & Arman's (2013) research reveals that EKC is not fully proven in the Gulf Cooperation Council (GCC) countries. EKC is even N-shaped in OECD countries, Latin America, Asia, and Africa (Beck & Joshi, 2015).

So, in sum, economic growth is unlikely to lead automatically to environmental sustainability. Policymakers must pursue initiatives that enable countries to become environmentally sustainable rather than waiting for economic growth to benefit the environment (Karsch, 2019). It implies that a country must ensure that vital environmental systems are protected or, in case of damage, need to recover. Cooperation with other countries is also required to control issues such as transboundary pollutants (Raymond, 2004).

To overcome the problems associated with economic development with due attention to social and environmental aspects, a paradigm shift in the approach to development is needed. The development approach must ensure that the present generation's welfare is being taken care of and that of the future generation. Moreover, the prerequisite for this development approach is the productive and efficient use of natural resources and energy, with minimal negative impacts on humans and the natural environment.

1.2 Sustainable development paradigm

Attention to environmental issues began to increase in the 1960s. It became a global agenda for the first time when the first United Nations conference on the environment was held on June 5, 1972, in Stockholm, Sweden (Gough, 2018). Since then, the call to apply the concept of sustainable development has increased. Sustainable development is based on the idea that even though conventional economic policies have succeeded in increasing economic growth, they have failed in some social and environmental dimensions. The reason is that conventional development puts the economy at the center of policy considerations and places social and environmental factors in a less important position (Salim, 2010).

The first actual attempt to define sustainable development comes from the World Conservation Strategy (IUCN, 1980 in Gough, 2018; Hasnan, 2016), which defines it as:

> "For development to be sustainable, it must take into account of social and ecological factors, as well as economic ones; of the living and non-living resource base; and of the long-term as well as the short-term advantages and disadvantages of alternative action."

In 1987, the World Commission on Environment and Development (WCED), in its influential report, widely known as Brundtland Report, has defined sustainable development to be (WCED, 1987):

> “Economic and social development that meets the needs of the current generation without undermining the ability of future generations to meet their own needs”

The WCED definition is one of the most widely quoted. Since then, there has been a rapid escalation of alternative definitions of sustainable development, and several authors have given lists (e.g., Mebratu, D, 1998; Pezzey & Toman, 2003; Vare & Scott, 2007; Sterling, 2010; Sartori et al., 2014; Olawumi & Chan, 2018; Rugerio, C.A, 2021).

Despite the variety of definitions, they have some elements in common. Mitlin (1992) notes, for instance, that the definition always involves two important components: the meaning of development (i.e., what are the main goals of development: economic growth, basic needs, rights, etc.), and the conditions necessary for sustainability. Meanwhile, Salim (2010) states that what is needed in sustainable development are three things that grow together: economic, social, and environmental aspects, which interact with one another among the three, as illustrated by the following matrix (Table 1.1)

Table 1.1. Linkages Matrix of Sustainable Development

From/To	**Economy**	**Social**	**Environment**
Economy	Alleviation of the poor	Related impacts	Related impacts
Social	Related impacts	Human development	Related impacts
Environment	Related impacts	Related impacts	Ecosystem preservation

Source: Salim (2010)

The above matrix explains that poverty alleviation, for example, has an economic impact and affects social and environmental development. Similarly, efforts to improve the quality of human resources development will affect the economic and environmental aspects. Ecosystem conservation activities will affect economic and social development. In sustainable development, the form of this linkage and all its impacts must be considered. By exploring each linkage between these various impacts, we can unite the three economic-social-environmental processes in one framework to achieve sustainable development.

Measurable and applicable sustainable development indicators are required to balance the different objectives reflected in Table 1.1 (see Hoekstra (2019) for a detailed discussion). For a long time, the sustainable development paradigm was difficult to operationalize due to its abstract nature and lack of measurable indicators. However, methods have been developed over time to quantify environmental impacts, consider externalities, and measure their economic relevance. This made the internalization of environmental impacts in economic development assessments possible (Alisjahbana & Murtiningtyas, 2018).

The attention at the global level to realize sustainable development continued to increase over time. Important international events helped to institutionalize the concept. The "United Nations Environment and Development (UNCED)" was held in Rio de Janeiro in 1992. The Rio Declaration was born from that meeting that provided 27 principles to guide countries toward sustainable development (Endl et al., 2012). In 2000, 186 countries endorsed the Millennium Development Goals (MDGs), consisting of 8 goals to improve human welfare measured by 21 targets, which were particularly aimed at helping the poorest people in the world (Khaing, 2014). More recently, the "United Nations Sustainable Development Summit" was organized in September 2015 in New York, the United States. At that meeting, all UN members agreed to adopt the new development agenda, "Transforming our world: the 2030 Agenda for Sustainable Development". The agenda includes the "Sustainable Development Goals (SDGs)," a total of 17 goals for economic, environmental, and social progress to be realized by 2030 (Alisjahbana & Murtiningtyas, 2018).

The 17 SDGs are grouped into four pillars that are inseparable and mutually dependent on each other. This structure expresses the importance of a balance between the three main development pillars -- the social, economic, and environmental dimensions—all of which are supported by the governance pillar (see figure 1.3). The environmental pillar is the most critical element

(Stiglitz et al., 2018; Alisjahbana & Murtiningtyas, 2018). The analysis above shows that economic growth often affects environmental sustainability, particularly in the initial development phases. At the same time, the social dimension is important for two reasons. First, a minimum economic income is needed for a good social quality of life. Second, the social dimension is essential since behavioral patterns and societal structures can support reconciling the apparent contradiction between economic growth and environmental sustainability (Pezzey, 1992; Dinda, 2004; Kahuthu, 2006; Raworth, 2012; Kalimeris, 2020).

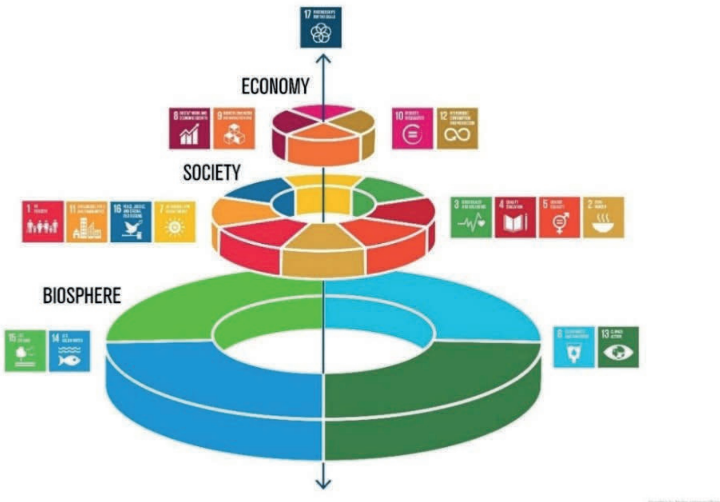


Figure 1.3. The SDGs wedding cake
Source: Stockholm Resilience Center
https://www.stockholmresilience.org/research/research-news/2016-06-14-the-sdgs-wedding-cake.html

1.3 Environmental-economic accounting

The UN and other international agencies, in collaboration with national statistical offices, have developed and standardized economic accounting methods as a tool to measure economic development, the System of National Accounts (SNA). The general objective of the SNA is to provide a comprehensive conceptual and accounting framework for compiling and reporting the macroeconomic statistics used to analyze and evaluate the performance of an economy (Motoryna, 2012). However, such accounts initially did not cover the environmental and social pillars of sustainable development well. The traditional SNA has three main limitations (Ramesh, 2014): (i) It neglects the depletion of natural capital such as minerals, forests, farmland, fishing stock, etc. (ii) The system does not include the environmental degradation mainly from pollution, and (iii) It sees mitigating expenditures done by the community in dealing with the external impacts of environmental degradation as a positive contribution to economic growth.

To overcome the traditional SNA drawbacks, developing an accounting system that integrates the environmental, social, and economic dimensions of sustainable development is essential to provide complete and comprehensive information about the economy and the environment and better understand their interactions. This is because economic and social well-being depends on the environmental quality and the safeguarding of capital stock of natural resources.

Following the need to develop an integrated system of economic, environmental, and social accounts, the United Nations Statistical Division (UNSTAT), as a first step, published an SNA handbook on Integrated Environmental and Economic Accounting in 1993. It presents the scope, concept, and method of an SNA satellite System of Integrated Environmental and Economic Accounting (SEEA) (Akita, 2000; UNESCWA, 2009). This formed the groundwork to include environmental accounts in economic accounting.

The SEEA is considered the most comprehensive framework for integrating environmental consideration into national accounts (Alfsen & Greaker, 2007; Smith, 2007; Palm & Larsson, 2007; IUCN, 2013; March, 2015). The SEEA allows the government to set priorities, monitor economic policies more precisely, establish environmental regulations and resource management strategies more effectively, and design more efficient market instruments (UNESCWA, 2009). Moreover, the SEEA framework can directly measure several SDG indicators and provide supplemental information for numerous others (UN, 2019).

In the SEEA Framework, one way to measure environmental deterioration due to economic activities is by assessing the external costs of such economic activities (Nakamura, 2000; Alisjahbana & Yusuf, 2000; SEEA, 2003). The imputed environmental costs are divided into three categories:

1) Degradation of natural resources: e.g. due to air pollution, water pollution.
2) Destruction of ecosystems: e.g. forest damages, excess felling of cultivated forest; reduction of woodland.

3) Depletion of resources: extraction of non-renewable, sub-soil resources.

1.3.1 Environmental and economic accounting in developing countries

Setting up a sound system of economic accounts is complex, and adding environmental and social accounts is, for many countries, still a challenge. By now, most developing countries have a good working system of economic accounts and have a certain experience with developing environmental accounts. For this reason, this thesis focuses on environmental and economic accounts in developing countries rather than including social accounts, illustrating the added value of such accounts, emphasizing Indonesia.

To support the development and compilation of better quality SEEA data, many international and regional institutions have provided technical assistance to countries worldwide. According to a UNSD 2014 global assessment, out of 85 countries, 69% received technical assistance in setting up their program to compile specific environmental and economic accounts. Of the responding countries, the UNSD was the largest provider of technical assistance in developing countries, while Eurostat was most often cited as a provider of support to developed countries (UNSD, 2015). Other organizations providing assistance are the World Bank, UNDP, UN Environment, UN regional commissions, IEA, OECD, etc. However, despite all these efforts, it is clear that comprehensive environmental accounts have mainly been developed in high-income countries.

1.3.2 Environmental and economic accounting in Indonesia

Indonesia is a country that relies heavily on natural and non-renewable resources to support its economic growth. Indonesia further faces various obstacles in its efforts to achieve sustainable development. Such challenges include a fast-growing population, land and forest degradation, exploitation of forest and mineral resources, etc.

Indonesia has undertaken several attempts to set up an SEEA. Since 1997, the Indonesian Central Bureau of Statistics (BPS) has developed the Indonesian System of Integrated Environmental and Economic Accounting, known as SISNERLING (BPS, 2014). SISNERLING analyses how Indonesian GDP and several aggregate macroeconomic indicators are affected when the calculation includes the environmental dimension. Published annually, SISNERLING calculates an environmentally adjusted net domestic product or so-called Green GDP. SISNERLING has, however, two significant limitations. First, only depletion of natural resources is included in the calculation. Externalities by emissions and resulting environmental degradation are not yet covered. Second, the scope of commodities is still limited and needs to be expanded. Currently, SISNERLING only covers nine commodities – oil, natural gas, coal, bauxite, tin, gold, silver, nickel, and forest resources. These limitations can be explained, among others, due to difficulties related to data availability and quality, low resource support (including budget), limited knowledge, and methodological challenges, especially for natural resource valuation.

Further, SISNERLING sees only limited use as supporting information for formulating public policies and evidence-based development planning (UKP-PPP, 2014). Due to difficulties related to the structure of data sources, measurement and data concepts accounts are still not standardized. Further, data is spread across various institutions, which leads to problems concerning harmonizing data classifications, units, and collection approaches. At present, only asset accounts are included in SISNERLING. The flow accounts are still experimental and will be presented in a separate publication (Tasriah, 2021).

In order to support sustainable development and environmental accounting, the World Bank has set up a global partnership called WAVES (Wealth Accounting and the Valuation of Ecosystem Services). WAVES aims to develop environmental accounts using internationally agreed standards and develop a standardized approach to account for the valuation of environmental services (World Bank, 2017). In Indonesia, WAVES involved the Ministry of National Development Planning (Bappenas), BPS, and several other related ministries and institutions. The program started in 2014 with pilots for selected commodities. The WAVES global partnership bases itself on the SEEA. Operationalizing a standard and coherent set of concepts, definitions, classifications, and accounting rules for development data is crucial to implementing the partnership. Therefore, it would be logical when several ministries/agencies would work together and develop accounts simultaneously as a collaborative program to improve the quality of data and information on development in Indonesia via the WAVES program in the context of One Data for Sustainable Development (UKP-PPP, 2014). In 2016, Indonesia started to implement the 2012 SEEA Core Framework in SISNERLING, using various international initiatives to help and speed up this implementation, including initiatives of the UN Statistical Division, World Bank, FAO, ESCAP, and the Australian Bureau of Statistics (ABS; Tasriah, 2021).

1.3.3 The need for improving Indonesia's environmental cost accounting

Environmental-Economic Accounting (EEA) attempts to integrate environmental assets and ecosystem services measures into everyday accounting practices, both for governments and businesses.

Indonesia is experiencing various challenges related to environmental issues, including the threat of climate change caused by rapid economic growth and extensive consumption of natural resources, primarily from burning fossil fuels (Darwanto et al., 2019). With business as usual (no action is taken), the World Bank estimates that economic loss from climate change in Indonesia will reach 2.5%–7.0% of GDP by 2100, along with soaring health and environmental costs. (World Bank, 2009). Meanwhile, according to Leitmann (2009), the health impact of air pollution in Indonesia could cost more than US$ 400 million per year. Furthermore, the Indonesian Ministry of Finance estimates that without a green planning and budgeting strategy, the threat of climate change and natural resource degradation is estimated to reduce Indonesia's GDP growth from 7.0% to 3.5% in early 2050 (MoF, 2015). Therefore, to support more targeted and effective decision-making and ensure the development is on the sustainable development path, measurable and applicable indicators are needed to obtain accurate data and information regarding environmental costs as a negative impact arising from economic activities. In environmental-economic accounting terminology, this is included in measuring the environmental costs of environmental damage caused by residuals. However, as described in the previous section, the measurement of environmental costs for the case of Indonesia is only limited to measuring environmental costs due to the depletion of mineral and forest resources. Accounts do not include the environmental costs due to emissions and waste generation (Tasriah, 2021).

1.4 Research aims and questions

In sum, developing a System of Environmental and Economic Accounts (SEEA) is crucial for countries such as Indonesia to analyze if they are on a sustainable path or not. Information on environmental pressures and external costs provided by the SEEA can support decision-making on priorities for economic development and analyze priority environmental impacts that need to be mitigated. Against this background, the general research objective of this Ph.D. thesis is:

How can we set up environmental-economic accounts in developing countries such as Indonesia, and how can such accounts support both development as environmental policies?

So, the analysis aims to clarify the hindrances and potential for setting up environmental accounts and show how policymakers can use such accounts in designing policies related to the paradigm of sustainable development in Indonesia. This overall aim will be supported by answering the following research questions:

1. Focusing on developing countries in general: what is the potential of the SEEA in supporting the monitoring of SDGs indicators, what is the current state of the SEEA implementation, and what are the barriers for a comprehensive SEEA implementation? (Chapter 2)
2. How can we enrich the Indonesian SNA with environmental costs accounts and what are the sectors and types of environmental interventions for which such accounts have to be developed with the highest priority? (Chapter 3)
3. Using the SNA enriched with environmental cost accounts, what final demand components drive most external costs and hence would be priorities for consumption-based policies? How much are the environmental costs for each final demand component in Indonesia, what are the economic sectors which perform best when both economic and environmental performance are considered simultaneously? (Chapter 4)
4. How can we use the SNA enriched with environmental cost accounts to assess the economic and environmental implications of investment in new economic activities, illustrated by the potential use of Indonesian natural resources to produce electric vehicle batteries and electric vehicles? (Chapter 5)

1.5 Thesis outline

This thesis consists of 6 chapters. This first chapter gives a general introduction, in which the motivation, the research questions, and the outline of this thesis are provided. The present section describes the structure of this thesis and provides a reading guideline. Figure 1.4 shows an outline of the dissertation concerning each research question (RQ).

Chapter 2 addresses the first question. It assesses the potential of the SEEA to contribute to monitoring SDG-related indicators. This chapter also analyzes the current level of the SEEA implementation and implementation barriers to comprehensive the SEEA implementation, focusing on developing countries. The methods used in chapter 2 are generally based on literature reviews, exploratory reports from international organizations, and specific surveys of the SEEA data producers in developing countries. Explorations of reports from international institutions and literature studies focus on all the essential information about the SEEA. It includes concept, its use, the relevance to the SDGs, its potential use as a tool to support the success of the SDGs, and lastly, on the current state of implementation and development of the SEEA globally. Meanwhile, the survey aims to collect information on the current state of the implementation and development of the SEEA and intends to solicit opinions on the potential of the SEEA to be used to support the monitoring of SDG indicators.

Chapter 3 focuses on research question 2. It describes an initial effort to assess environmental costs for priority setting and as an instrument for assimilating the most relevant environmental aspects into a framework of sustainable socio-economic development. It used environmental costs related to emissions and resource extraction in Indonesia to measure priority. Compared to other studies on environmental costs in Indonesia, the assessment provides the most detailed coverage of emissions type data for each economic sector. Thus, the results will be beneficial in supplementing Indonesia's existing Environmental-Economic Accounts, as official publications of the BPS Indonesia are still limited to measuring depreciation of natural resources without including measurements of environmental costs due to environmental degradation.

Chapter 4 explores Indonesia's environmental costs from emissions and forest resources from a consumption perspective and identifies the priority sectors in terms of economic and environmental performance, hence discussing research question 3. We use environmentally extended input-output analysis (EEIO) to calculate environmental costs and further extension with linkages analysis to identify the priority sectors. The results can guide policymakers in formulating sustainable development policies, especially sustainable consumption and production (SCP) policies.

Chapter 5 answers question 4. A simulation is conducted to analyze the economic and environmental impacts of electric vehicle (EV) production in Indonesia. The impacts are analyzed by simulating all the nickel ore produced to be absorbed for further processing in domestic economic activities consisting of battery production and EVs, assuming that all EVs produced are destined for export.

Chapter 6 synthesizes the previous chapters and answers the research questions, followed by a general discussion and outlook for future work.

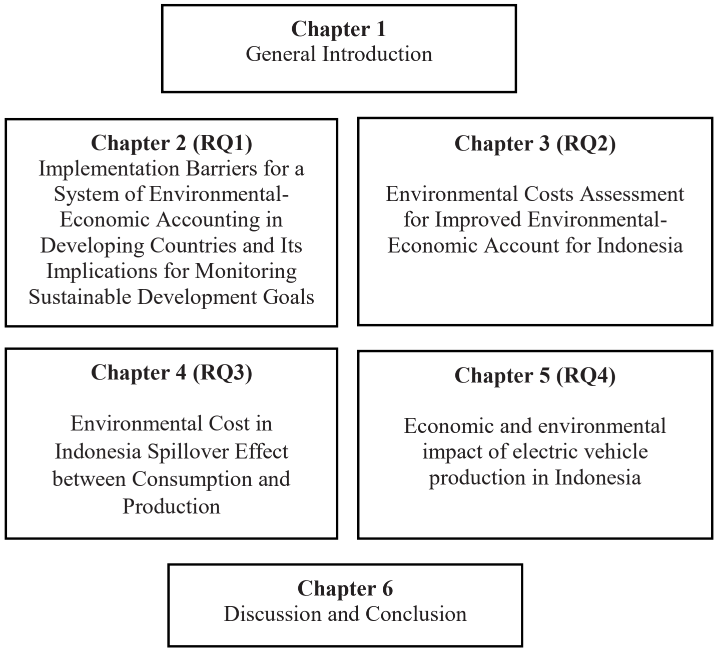


Figure 1.4. Conceptual scheme of the thesis

Chapter 2

Implementation Barriers for a System of Environmental-Economic Accounting in Developing Countries and Its Implications for Monitoring Sustainable Development Goals

Abstract

The desire to include environmental information in national accounts has resulted in the construction of a system of environmental-economic accounting (SEEA). As the international statistical standard for environmental-economic accounting, the SEEA can provide valuable support for monitoring Sustainable Development Goals (SDGs). This study assesses the potential use of the SEEA for monitoring SDGs. This paper shows that, in theory, the potential for this system is significant. However, based on a literature review and survey of SEEA experts, practical problems in implementing the SEEA are significant, especially in developing countries. Such issues include data availability and quality, as well as the availability of funding and human resources. Capacity development is key to establishing successful implementation of the SEEA in developing countries. For example, the World Bank's WAVES program (Wealth Accounting and Valuation of Ecosystem Services) has been instrumental in capacity building in developing countries, which, however, still show great variation in how they implement SEEA.

Published as: Pirmana, V., Alisjahbana,A.S., Hoekstra, R., and Tukker. A. (2019). Implementation Barriers for a System of Environmental-Economic Accounting in Developing Countries and Its Implications for Monitoring Sustainable Development Goals. Sustainability 11 (22), 6417. https://doi.org/10.3390/su11226417

2.1 Introduction

On 25 September 2015, the Sustainable Development Goals (SDGs) were formally adopted. The SDGs represent a vision of the world in the year 2030 (Alisjahbana and Murtiningtyas, 2018). The SDGs contain 17 goals with 169 underlying targets. They have been complemented by about 232 indicators in various social, economic, and environmental areas developed by the Inter-agency and Expert Group on SDG Indicators (IAEG-SDGs) that was set up by the United Nations Statistical Commission. These 232 indicators are grouped into three tiers (Tier Classification for Global SDG Indicators: https://unstats.un.org/sdgs/files/Tier_Classification_of_SDG_Indicators_22_May_2019_web.xlsx; accessed on 27 August 2019; there are six indicators that have multiple tiers):

- Tier 1: The indicator is conceptually clear and has an internationally established methodology; its standards are available, and its data are regularly produced by countries for at least 50 percent of countries and for the population in every region where the indicator is relevant (104 indicators).
- Tier 2: The indicator is conceptually clear, has an internationally established methodology, and standards are available, but data are not regularly produced by countries (88 indicators).
- Tier 3: No internationally established methodology or standards are yet available for the indicator, but the methodology/standards are being (or will be) developed or tested (34 indicators).

As can be seen from the definitions of Tiers 1 and 2, the data availability of each country can be quite different. This obviously has implications for the capacity of each country to monitor the implementation of SDGs. Various reviews of the development of the implementation of SDGs exist, such as the Voluntary National Review (VNR) (Alisjahbana and Murtiningtyas, 2018) and several other studies; for instance, those from the Overseas Development Institute (Nicolai et al., 2015), the Sustainability Development Solution Network (SDSN) (Sachs et al., 2017), and several others. This body of literature finds that there are various issues with data between countries, such as data that are not comparable between countries, incomplete data, and many data sources that are not yet accessible to the public. This situation obviously has major implications for the process and quality of the monitoring system for SDGs, while a sound monitoring system is one of the key factors needed to support the success of SDG implementation.

The SEEA (System of Environmental–Economic Accounting) is an international standard and integrated framework for accounting of environmental data in a way that is consistent with economic accounting. The SEEA thus provides an opportunity that can be used to monitor a significant number of the SDG related indicators in an integrated and consistent manner across countries.

The WAVES (Wealth Accounting and the Valuation of Ecosystem Services) program of the World Bank, while focusing on wealth and natural capital accounting, has supported various developing countries in developing their environmental and economic accounting systems, and thus will also receive attention in this study.

Against this background, the objective of this study is threefold. First, we want to assess the potential of the SEEA to contribute to monitoring SDG related indicators. Second, we analyze the current level of the SEEA implementation, with a focus on developing countries, to see if the monitoring potential related to the first question is actually realized. Third, again with a focus on developing countries, we analyze the implementation barriers for a comprehensive implementation of the SEEA.

After this Introduction, this study is structured as follows. Section 2 describes the methods used in this study. Section 3 summarizes, on the basis of a literature review, reports of international organizations and our assessment of how the SEEA can support the monitoring of SDGs. Section 4 discusses the implementation level of the SEEA in developed and developing countries, again based on a literature review, the reports of international organizations, and our own survey. Section 5 discusses the challenges in implementing and expanding the SEEA and its implication for monitoring SDG indicators. Section 6 summarizes the conclusions of the study.

2.2 Methods of the study

In general, the method of this study will be based on a literature review, an exploration of reports of international organizations, and a dedicated survey of the SEEA data producers in developing countries. Explorations of reports from international institutions and literature studies are focused on all the important information about the SEEA, which includes concepts, their uses, linkages with SDGs, and their potential to be used as tools to support the success of SDGs, especially in terms of monitoring indicators and, finally, regarding the current conditions of the implementation and development of the SEEA globally. Crucial references include, for instance, (March, 2015;

Alfsen and Greaker, 2007; UNSD, 2017).

In addition to the literature search, a survey across experts was conducted. We limited the focus in this survey on developing countries. The assessment was aimed at gathering information on the current conditions of the implementation and development of the SEEA. Moreover, the assessment was also intended to solicit opinions about the potential of the SEEA to be used as a tool to support the monitoring of SDG indicators. Specifically, the survey assessment in this study is intended to:

- Assess the current status of the national implementation of environmental-economics accounting programs
- Assess institutional arrangements for the compilation of environmental-economic Accounts
- Identify priorities and future plans for the compilation of Environmental-economic Accounts
- Identify the constraints in starting the compilation and developing of environmental-economic Accounts
- Identify the role of the WAVES program in compiling and developing of environmental-economic accounts
- Identify the possibilities of Environmental–Economic Accounts to support the monitoring of SDG indicators

The questionnaire in this assessment is designed in the form of close ended questions. In this study, questions related to the implementation of environmental-economic accounting include questions about the country’s economic environmental accounting program, current scope, and future plans for the development of the environmental-economic accounts, institutional arrangements, inhibiting factors, and technical assistance for the compilation of accounts. Meanwhile, questions regarding the role of the SEEA in supporting the successful implementation of SDGs include respondents’ opinions about the potential of Environmental-Economic Accounting to support the monitoring of SDG indicators, as well as which accounts and goals have the most potential to be supported by Environmental-Economic Accounting. The full questionnaire can be found in Appendix.

Questionnaires were sent to 23 carefully selected experts in developing countries, and 14 responded. They were selected after the authors conducted a web-based search for the SEEA experts in developing countries. Based on these findings, the authors chose respondents based on information that they were very familiar with and whether they were involved in the collection and development of the SEEA accounts for their country. In addition, the web-based information also showed whether the experts routinely represent their country in international forums on natural capital accounting/SEEA organized by international institutions such as the UN's Natural Capital Accounting Forum.

The chosen respondents had extensive knowledge about the status of the SEEA in their respective countries. Respondent affiliation and current job were closely related to the development or publication of the SEEA in their countries. In general, we selected respondents affiliated with the National Statistical Institute, which has a specific position directly related to producing/drafting the SEEA publications for their country. We also selected respondents from the WAVES Country Program for their roles as country coordinators for WAVES or as individuals actively involved in it, as well as the SEEA experts from academia (see Appendix, Table 2.5). A detailed methodological flowchart is given in Figure 2.1.

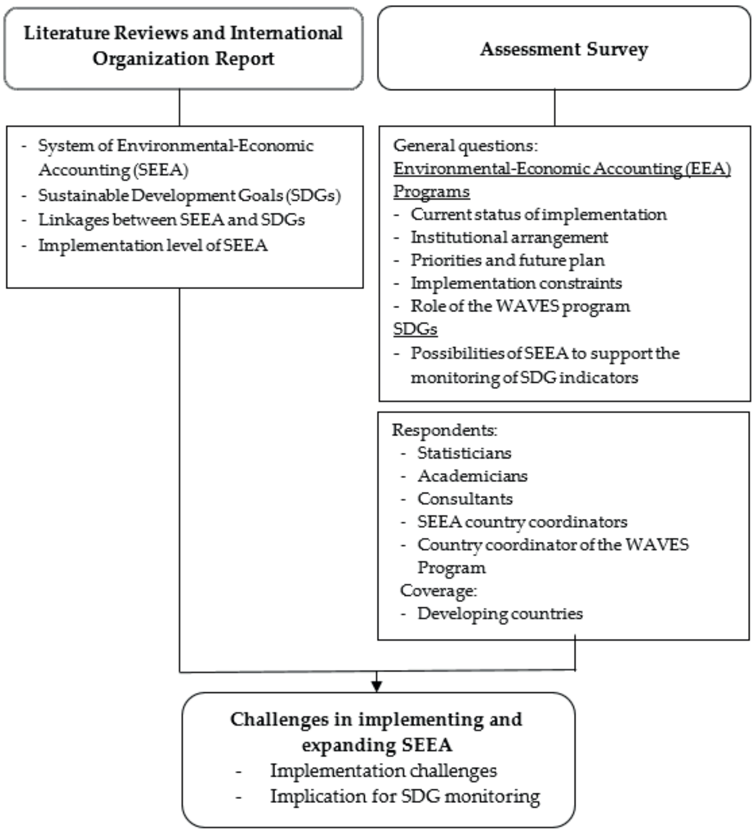


Figure 2.1. Methodological Framework Flow Chart

2.3 Literature review and report analysis from international organizations on the SEEA and the SDGs

2.3.1 Overview of the SEEA

The SEEA is the international statistical standard for measuring the environment and its relationship with the economy; the SEEA is also the most comprehensive framework globally for integrating environmental data into national accounts (March, 2015; Alfsen and Greaker, 2007; Smith, 2007; Palm and Larsson, 2007; Nahman et al., 2016). The SEEA framework uses an accounting structure similar to that of the Systems of National Account (SNA). To facilitate the integration of environmental and economic statistics, the framework uses concepts, definitions, and classifications consistent with the SNA (UN, 20016). As a statistical framework, countries that compile and collect the SEEA will be able to produce reliable environmental–economic datasets that can effectively track progress over time.

The SEEA has become increasingly relevant as the basis for making development policies and evaluations.

- The summary of information in the SEEA (available in the form of aggregates and indicators) can provide information about environmental issues and conditions that are the focus of decision makers.
- More detailed information in the SEEA, for example the main driver of changes in environmental conditions, can be used to provide a deeper understanding of the policy to be taken.
- The data contained in the SEEA can be used to build models and scenarios that can be used to assess different policy scenarios for national and international environmental impacts within a country, between countries, and at the global level.

The importance of the SEEA is reflected by the attention of international institutions to this matter. For example, the WAVES partnership from the World Bank and the work program by the United Nations Statistics Division (UNSD) promotes sustainable development by mainstreaming the value of natural capital accounting in development planning and national accounting systems. WAVES and UNSD use the SEEA to produce "Natural Capital Accounts" in countries as an important tool to inform economic decision making about natural resources. Both organizations work to build countries' capacities to implement the SEEA and to demonstrate its benefits to policy makers. Furthermore, UNSD together with the United Nations Environment Programme (UNEP), the UN Regional Commission, and the Convention on Biological Diversity (CBD) Secretariat began the SEEA EEA trials and ecosystem assessment in several countries.

2.3.2 SDGs and their coverage by the SEEA

Since 2015, the global development agenda has shifted from the Millennium Development Goals to SDGs. SDGs accommodate the three well-known economic, social, and environmental dimensions of development. All countries are committed to implementing SDGs, not only because of international demands, but also because many of the SDG targets and objectives are in line with their overall development goals.

One important factor in supporting the successful implementation of SDGs is the ability to monitor progress towards goals. Thus, it is of interest to determine if the SEEA can be used as a tool to accommodate the regular monitoring of SDG indicators.

The role of SEEA as a potential tool for this purpose is mentioned by the UN Committee of Experts on Environmental–Economic Accounting (UNCEEA) (UNSD, 2015a; UNSD, 2015b). UNCEEA endorsed two technical papers to illustrate how the SEEA can contribute to SDG monitoring (UNSD, 2015a; UNSD, 2015b). These papers are based on detailed screening of SDG indicators and contain recommendations for compliance with the SEEA. Conclusions are presented in a note on the SEEA entitled “A Statistical Framework to Support SDG Indicators” (UNSD, 2015b).

The first technical paper (UNSD, 2015a) considered the need to integrate environmental–economic statistics and the role of the SEEA as a necessary conceptual framework. Furthermore, the paper also discussed the benefits for national and global policy-making and the SDG monitoring process following the integration of environmental–economic statistics. Finally, it laid out a transformative roadmap for aligning SDG monitoring procedures and mechanisms with the statistical standards of the SEEA.

The second technical paper (UNSD, 2015b) illustrated how integrated statistical frameworks, such as the SEEA, can facilitate the production of statistics and indicators by national statistical systems, which can result in higher quality indicators in terms of:

1) Policy relevance and utility. Indicators are supported by detailed and organized information, which promotes a detailed understanding of the factors that drive change.

2) Analytical and methodological soundness. The SEEA acts as a vehicle for harmonizing methodological inconsistencies across the environmental data production process and enables a coherent comparison of environment statistics with economic statistics.
3) Measurability and practicality. The SEEA can create efficiencies in the data production process (UNSD, 2015a).

The information from the SEEA and SNA can provide valuable support to SDG monitoring and reporting initiatives by (1) supporting the development of Integrated Information Systems for Sustainable Development in countries to produce consistent and internationally comparable statistics and (2) by providing a support structure for a sustainable global SDG monitoring mechanism.

As discussed in the Introduction, to monitor SDG implementation, a long list of 232 indicators was proposed by the Inter-Agency Expert Group on SDGs (IAEG-SDGs) (UNSD, 2017). Implementation of the SDGs requires one to understand the multi-dimensional interdependencies and trade-offs between economic activities and the environment. SEEA, as an international statistical standard, can aid in the design of integrated policies and the monitoring of SDG indicators. This capacity arises from the fact that the SEEA provides a comprehensive methodology for compiling physical and monetary accounts for a range of resources, including mineral, energy, water, and timber, and for linking these accounts to information related to the economy (Bann, 2016).

UNCEEA, 2016, sought to investigate the relationship between the SEEA and SDG indicators through a broad-brush analysis of indicators related to SDGs that, in principle, can be monitored using the SEEA. This broad-brush analysis assessed if and to what extent each indicator could be informed by the existence of the SEEA.

This analysis showed that the SEEA is a potential monitoring tool for over 50 out of the 232 potential SDG indicators and can support addressing priority issues in each country. According to the analysis, 10 SDGs (2, 6, 7, 8, 9, 11, 12, 14, 15, 17) are related to the SEEA. This analysis used three categories for the degree of relevance of the SDG indicators in terms of the SEEA (Table 2.1).

Table 2.1. Potential use of the System of Environmental-Economic Accounting (SEEA) for estimating the Sustainable Development Goals (SDG) indicators and targets.

Category	Relevant indicators
Indicator as currently proposed can be informed by the SEEA accounts.	11 indicators
Either current wording and concepts of the indicator need to be aligned to be SEEA compliant, or the indicator needs to be further defined to ensure SEEA compliance (i.e., detailed definitions added).	23 indicators
While the indicator cannot be informed by the SEEA, either (a) the SEEA can provide important contextual information and the indicator should be developed with the SEEA approach in mind; or (b) there is some overlap with the SEEA methodology that should be considered when formulating this indicator.	12 indicators

Source: Adapted from the United Nations Committee of Experts on Environmental-Economic Accounting (UNCEEA), (2016); notes: for complete results, see Appendix, Table 2.6.

Adopting the SEEA handbook will ensure that the SDG indicators are internationally comparable, of high quality, and can be integrated into mainstream information systems. Table 2.1 lists the possible SDG indicators that can be constructed from the SEEA databases (see Appendix, Table 2.6, for details). In their review, the researchers in UNCEEA, 2016 further elaborated the SEEA as a tool for designing, implementing, and reviewing evidence-based SDG policies at the country level. They concluded that the SEEA could be especially helpful for SDGs related to natural capital (SDGs 6, 13, 14, 15, 17) and to sustainable production and consumption (SDGs 2 and 12), energy (SDG 7), economic growth (SDG 8), and sustainable cities (SDG 11).

Table 2.2 summarizes in more detail which type of the SEEA accounts can support monitoring specific SDG goals. The table shows that, as an information system, the SEEA plays an important role in most SDGs. It appears that all the SEEA accounts are useful for monitoring some of the SDG indicators. For instance, for SDG 6 (clean water and sanitation) and SDG 15 (life on land/ecosystems), many indicators can be directly measured using the SEEA accounts. Indicators such as 6.4.1 (change in water-use efficiency) could, in the future, be provided by an SEEA dataset on the water account, namely the Physical Supply and Use Tables (PSUT) and other accounts in the water accounting manual. SDG 15, 15.1.1 (forest area as a proportion of total land area), for example, can be obtained by using data available in the SEEA-and account. This table also shows that for 10 SDG goals related to the SEEA, material accounts are relevant for several indicators spread over nine SDG goals related to the SEEA accounts, followed by environmental activity accounts, where these accounts are relevant for some indicators spread over seven goals related to the SEEA accounts. Moreover, of the approximately 46 indicators identified as having the potential to be monitored through the SEEA, 20 indicators are classified into Tier 1, 16 indicators into Tier 2, 8 indicators into Tier 3, and 2 indicators included in Tier 1/3 (Table 2.3). Based on this information, it is clear that the SEEA could potentially have a significant role in supporting the progress and success of SDGs.

Table 2.2. Potential use of the SEEA to monitor the SDG indicators. SNA, Systems of National Account.

Account	Type of account	Goal 2	Goal 6	Goal 7	Goal 8	Goal 9	Goal 11	Goal 12	Goal 14	Goal 15	Goal 17
Land	Asset accounts	√					√		√	√	
Energy	Phisycal Supply-Use Table (PSUT)			√		√					
	Economic accounts			√				√			
	Asset accounts			√							
Water	PSUT + Economic accounts		√								
	Asset accounts		√								
Materials	Material flow accounts				√	√		√	√		
	Emissions accounts		√								
	Air Emissions accounts			√		√					
	Solid Waste accounts						√	√			
Aquatic	Asset accounts								√		
Agriculture, forestry, and fisheries	All	√							√		
Environmental Activities	Environmental Protection Expenditure Account						√		√	√	√
	Resource management expenditure accounts						√				
	Environmental taxes and subsidies accounts							√	√		
Ecosystem	Condition accounts									√	
	Ecosystem extent accounts		√							√	
	Ecosystem services accounts									√	
	Biodiversity accounts									√	
UN-SNA	All	√	√			√		√			
	Value Added			√							
	Tourism				√			√			

Source: Adapted from UN Committee of Experts on Environmental–Economic Accounting (UNCEEA) (2016); notes: for complete results, see Appendix, Table 2.6

Table 2.3. Examples SEEA-relevant SDG indicators

Indicators	Account	Tier
2.4.1 Proportion of agricultural area under productive and sustainable agriculture	Land + Agriculture, Forestry and Fisheries	Tier 2
2.a.1 The agriculture orientation index for government expenditures	SNA + Environmental Activities	Tier 1
6.3.1 Proportion of wastewater safely treated	Water	Tier 2
6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	Water	Tier 1
7.1.1 Proportion of population with access to electricity	Energy	Tier 1
7.3.1 Energy intensity measured in terms of primary energy and GDP	SNA + Energy	Tier 1
8.4.1 Material footprint, material footprint per capita, and material footprint per GDP	Materials	Tier 2
8.9.1 Direct tourism GDP as a proportion of the total GDP and growth rate	SNA	Tier 2
9.4.1 CO_2 emissions per unit of value added	Materials	Tier 1
11.3.1 Ratio of land consumption rate to population growth rate	Land	Tier 2
11.6.1 Proportion of urban solid waste regularly collected and with adequate final discharge out of the total urban solid waste generated by cities	Materials	Tier 2
12.2.1 Material footprint, material footprint per capita, and material footprint per GDP	Materials	Tier 2
12.5.1 National recycling rate; tons of material recycled	Materials	Tier 3
14.4.1 Proportion of fish stocks within biologically sustainable levels	Aquatic Resources	Tier 1

Source: Adapted from: UNCEEA (2016); for a complete picture, see Appendix, Table 2.6. Notes: SDG tier classification taken from the United Nation Statistical Division (UNSD).
https://unstats.un.org/sdgs/files/Tier_Classification_of_SDG_Indicators_22_May_2019_web.xlsx, accessed 27 August 2019.

2.3.3 Assessment survey of the potential for the SEEA to support SDG indicator monitoring

Apart from above literature analysis, this study also offers the results of a survey assessing the possibilities of the SEEA based environmental–economic accounts to support the achievement of SDGs. This survey aims to elicit opinions about the potentials and challenges of the SEEA as a tool for monitoring SDG indicators. The following conclusions can be drawn from the survey results: All respondents from 14 countries agreed that environmental–economic accounting data can support SDG monitoring. Furthermore, they also believed that all of the SEEA accounts could be potentially used as a tool to support the monitoring of SDG indicators. According to this assessment, the accounts with the most potential to support SDG indicator monitoring were water accounts, energy and emission accounts, and forest accounts (Figure 2.2).

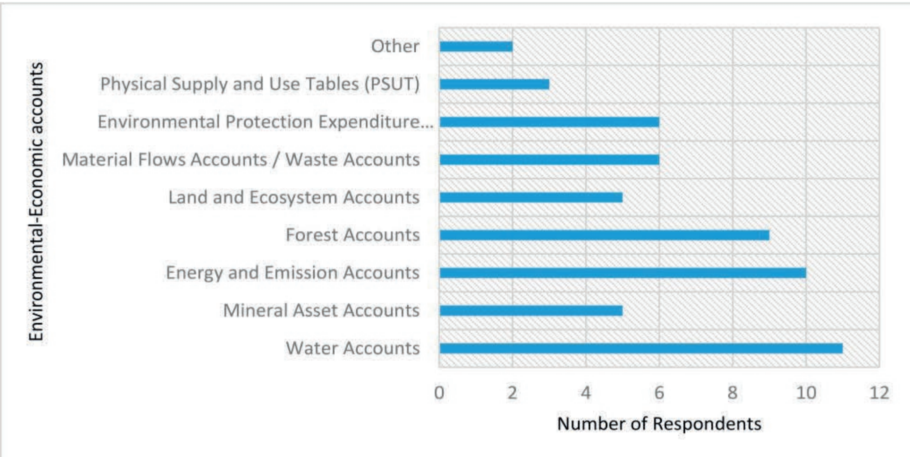


Figure 2.2. Potential accounts to support SDG indicator monitoring (Source: own survey).

The assessment showed that Goal 6, related to the availability and sustainable management of water and sanitation for all, had the most potential to be supported by the existence of environmental-economic accounts, followed by Goal 7 (affordable and clean energy) and Goal 15 (life on land (ecosystem), see Figure 2.3.

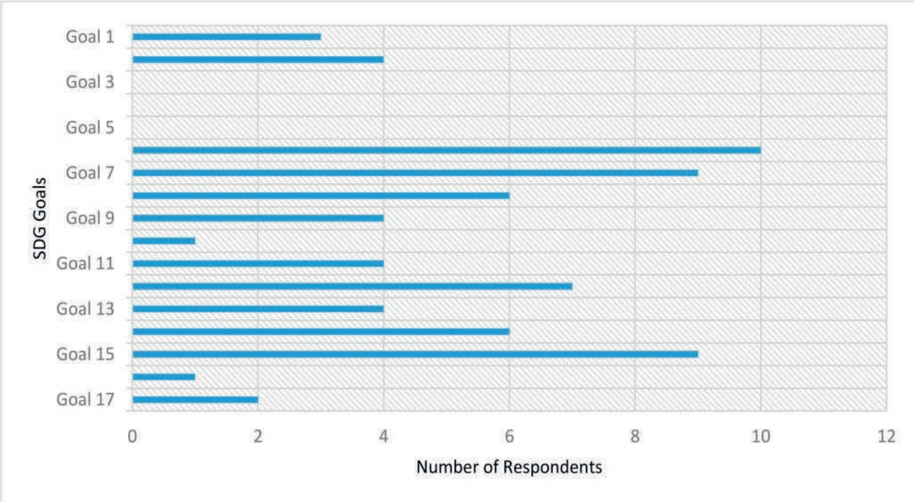


Figure 2.3. Potential goal of SDGs supported by the existence of the environmental-economic accounts (Source: own survey)

2.3.4 Conclusions about the relationship between the SEEA and SDGs

The analysis of this study clearly confirmed that the SEEA, as a standard international statistical framework, has a significant potential to be used as a tool to support the monitoring of SDG indicators. Although not complete and as-yet imperfect, these results suggest that indicators and analytical methods based on the SEEA to support the national SDG process exist. Moreover, based on the analysis results, SDG indicators that were potentially supported by the existence of the SEEA were classified into Tiers 1 and 2 (see Table 2.3). Of the 232 indicators, 50 very important ones were covered by the SEEA. Several indicators, such as 6.4.2 (level of water stress) and 9.4.1 (CO_2 emissions per unit of value added), were conceptually clear, had an internationally established methodology, and could be informed by the existence of the SEEA (see Table 2.3 and Appendix, Table 2.6 for detail). However, the success of the SEEA in supporting SDGs will depend on countries being able to develop their SEEA-based accounts in a way that is internationally comparable. It is, therefore, relevant to analyze the extent of SEEA implementation and if factors such as complexity, data problems, unfamiliarity, and lack of technical capabilities and skills represent obstacles to the SEEA in enabling SDGs at the country level.

2.4 Implementation levels of the SEEA

2.4.1 Introduction to the implementation of the SEEA

A description of the SEEA implementation in this study was derived from the results of our literature survey (e.g., [Sachs et al., 2017; Alfsen and Greaker, 2007; UNSD,2017; Smith, 2007) and surveys conducted by international organizations such as the UN and the World Bank in the context of its WAVES program (World Bank, 2016; Vardon et al., 2016; World Bank, 2017; UNSD, 2007; UNSD, 2012; UNSD, 2015; UNSD, 2018). In addition, as discussed in the Methods Section, we conducted our own survey to obtain more specific details and information on the SEEA implementation compared to the assessment survey conducted by the UN. We discuss the results obtained via these two approaches in the two sections below and end with conclusions.

2.4.2 Literature review and international reports on the SEEA iImplementation

2.4.2.1 General literature review

Several studies focused on the level of implementation of the SEEA in different countries. A comprehensive example is the work of Edens, de Haan, and Schenau (2011), which summarized the environmental accounting experiences by non-EU countries, cross classified by the different chapters of SEEA (Table 2.4). The countries listed in Table 4 are known to have (or have had) environmental accounting programs.

Table 2.4. Experiences outside the EU with environmental accounting.

	Ch3	**Ch4**	**Ch5**	**Ch6**
	Flows a)	**Monetary** b)	**Assets** c)	**Sequence** d)
Australia	x	x	x	x
Botswana			x	
Brazil			x	
Canada	x	x	x	x
China	x			x
Colombia	x	x	x	
India	x		x	x
Indonesia	x		x	x
Japan	x	x	x	x
Jordan	x		x	
Mexico	x		x	x
Namibia			x	
New Zealand	x	x	x	
Philippines	x		x	x
Korea			x	
South Africa	x		x	
USA	x		x	x
EU	x	x	x	x

Source: Edens B., M. de Haan, and Shenau, S (2011);

notes: a) physical flow accounts; b) monetary flow accounts; c) assets accounts; d) sequence of economic accounts (the sequence of economic accounts records a range of transactions between economic units, for example payments of rent on environmental assets that are usefully analyzed from the perspective of institutional sectors rather than by industry or activity).

The overall picture that emerges from Table 2.4 is that outside the EU, interest in natural resource (asset) accounting is high. This tendency could be attributed to environment related policy perspectives. Edens B., M. de Haan, and Shenau, S (2011) noted that policy demands in developing countries should be understood based on the need for resource management of their natural resource endowments and specific security issues related to water and energy. They also stated that the perspective of developing countries differs from that of developed countries, where flow issues of expenditures, economic instruments, resource efficiency, and environmental degradation related economic activities take precedence. Data availability is also an issue for emission accounts because of the need for energy statistics and emission inventories, which may be less readily available in developing countries.

March (2015) reviewed the experiences of three industrialized export nations and offered a spectrum of implementation of the SEEA integration in Germany, Australia, and China. Germany and Australia are classified as developed countries with long histories in the context of environmental accounting, protection, and regulation. China, by contrast, is a developing nation with rapid growth in economic development and endowed with vast natural capital, but limited regulatory regimes concerning the environment.

March (2015) concluded that Germany and Australia, as developed nations, have seen successful adoption and implementation of the SEEA to inform their environmental agendas. Germany has a long history on the SEEA and has been successful in implementing the SEEA. Germany continuously refines its sustainable development indicators and the accounting methods stipulated in its SEEA to inform national policy effectively.

Meanwhile, Australia built a case for policy-makers by educating them about the potential usefulness of the SEEA through its initial report, *Completing the Picture: Environmental Accounting in Practice* (ABS, 2012, in March, 2015). These efforts led to decision-makers seeing an Australian SEEA as useful for informing Australia's environmental policy going forward.

Moreover, Aoki-Suzuki et al. (2012) performed an international comparison of the application of economy wide material flow accounting (EW-MFA) to monitor resource consumption. They found that countries whose policy-makers pay considerable attention to EW-MFA indicators are characterized by large resource imports and large net export of manufactured goods. In developing countries, however, much of the data for constructing EW-MFA are available, but collection is fragmented and access limited. These authors also suggested that ensuring the capacity to develop EW-MFA requires first coordinating a national focal point, raising awareness among government officials, training researchers and experts in EW-MFA, and strengthening institutions collecting relevant data.

2.4.2.2 United Nation Statistical Division global assessment of environmental-economic accounting

The UNSD offers the most authoritative overview of global SEEA implementation [UNSD, 2007; UNSD, 2015; UNSD, 2018). The design of the Global Assessment is to assess the progress made in meeting the targets of the SEEA implementation strategy.

According to the 2017 Global Assessment, the number of countries with an existing program on environmental-economic accounting has increased. Of the 109 surveyed countries, 69 have a program on environmental-economic accounting, corresponding to an increase of about 28 percent compared to the

2014 Global Assessment (Appendix, Figure 2.10). This increase was especially high, about 39 percent, for developing countries, while it was only 19 percent for the developed countries. In terms of geographical region, the largest percentage of respondents with an existing program is in Europe and North America (88 percent). Meanwhile, Africa has the lowest percentage (36 percent).

The order of importance for most compiled accounts differs between developed and developing countries (Appendix, Figure 2.11). In developing countries, the most commonly compiled accounts tend to be energy and water accounts. By contrast, in developed countries, the most commonly compiled accounts are material flow and environmental taxes and subsidies accounts, with a high tendency to focus on energy accounts. Overall, all the global assessments of the UNSD indicated that the most commonly compiled accounts by country do not change for all countries or between developed and developing countries.

Other important findings from the Global Assessment 2017 relate to funding and technical assistance for compiling and developing SEEA. Only 45 of the 69 countries had regular funding for repeat compilation and publication of the accounts (UNSD, 2018). In terms of technical assistance, 65 percent of countries with an environmental–economic accounting program stated that they had received technical assistance from non-governmental organizations, international organizations, or other institutions in compiling and/or developing specific modules.

2.4.2.3 Experiences of the WAVES Program Relevant for SEEA Implementation

The World Bank, one of the institutions that contributed to the SEEA Central Framework, has launched a global partnership to advance natural capital accounting internationally through the Wealth Accounting and Valuation of Ecosystem Services (WAVES) program at the 2010 Convention on Biological Diversity meeting in Nagoya, Japan.

WAVES is intended to implement natural capital accounting using the UN's SEEA in a critical mass of countries, to promote sustainable development by ensuring the normalization of natural resources into development planning and national economic accounts. WAVES works to assist and build the capacity in countries to implement the SEEA and also to demonstrate its benefits to policy-makers (Vardon et al., 2016). Botswana, Colombia, Costa Rica, Madagascar, and The Philippines were the first core implementing countries to start this program. In late 2013, Guatemala, Indonesia, and Rwanda joined WAVES as core implementing countries.

Since its launch in 2010, WAVES has demonstrated the viability of establishing environmental accounts in low and middle income countries, as well as informing national development plans and policies. In the first five WAVES pilot countries, the program contributed positively in the context of environmental–economic policy. Water accounts have been identified as an instrumental tool for water sector reform in Botswana. Mineral accounts have also been a useful tool in helping the Botswanan government develop a fiscal rule on the management of mineral revenues, a major component of gross domestic product and government revenue. Meanwhile, for Guatemala, forest accounts have documented the extent of uncontrolled logging. This account is also used as the basis for formulating the National Strategy for Production and Use of Fuelwood.

Moreover, WAVES (World Bank, 2017) reported that Costa Rica has made a significant investment in conserving its abundant natural resources with great success. More than half (52 percent) of the country's area is now covered with forests. Furthermore, more than 90 percent of the country's electricity is generated from renewable resources. The Central Bank is routinely updating and publishing accounts in parallel with these national accounts, especially on water and energy accounts that they can use as information for policymakers related to environmental policy.

There is also substantive UNSD work underway around the world. UNSD work is essential to the SEEA development through technical cooperation, which is one of the core functions of the UNSD. They provide support to member states and improve statistical services through advice and training.

2.4.3 Assessment of SEEA implementation in selected developing countries via an assessment survey

The assessment survey of this study, as described earlier, also assessed the extent of the SEEA implementation in developing countries, covering general information on their programs of environmental–economic accounting. This survey included questions about institutional infrastructure, subject areas of the account, obstacles to the development and implementation of the programs, and the countries' future plans.

The assessment survey consisted of fourteen experts from fourteen developing countries. Among the fourteen experts, six persons were involved in the WAVES program from the World Bank and eight persons in developing countries without involvement in WAVES. The assessment results showed that energy and emission accounts were the most commonly compiled accounts, followed by water accounts, forest accounts, mineral accounts, and ecosystem and land accounts (Figure 2.4).

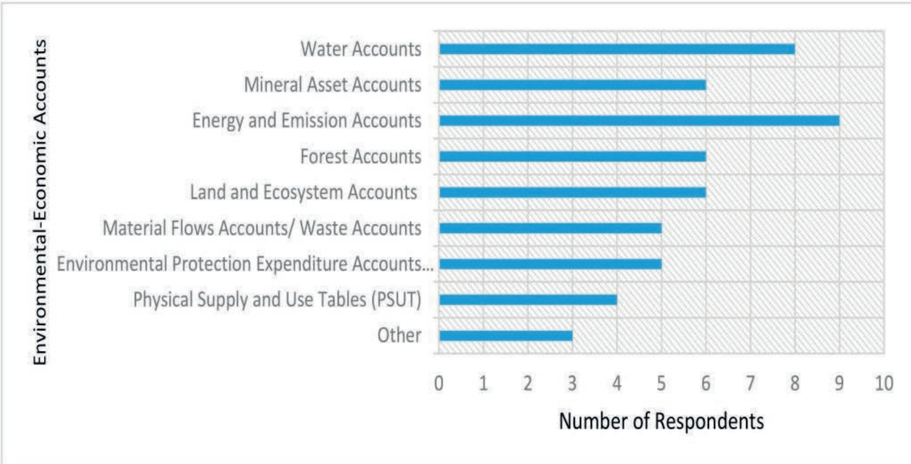


Figure 2.4. Existence of environmental–economic accounting programs in 14 developing countries (Source: Own survey)

The most important results of the survey assessment were related to funding issues for the data collection and development of the SEEA. Most respondents (eight out of 14 respondents) stated that they get funding regularly in collecting and developing the SEEA accounts, but only a small number of countries surveyed in the assessment survey stated that they get regular funding from the government. For example, Guatemala relies on university funds and funds from external sources (WAVES) to finance the collection and development of the SEEA accounts for its country. We can conclude that the problem of routine funding in the collection and development of the SEEA going forward will greatly determine the continuity of program implementation and development for developing countries. Furthermore, the assessment also noted that all respondents whose countries were involved in the collaboration of the WAVES program agreed that international organizations' assistance in the form of funding, technical assistance, and capacity building had a significant role in supporting the progress of the SEEA development in developing countries. They also stated that water accounts, forest accounts, and land and ecosystem accounts are the accounts most strongly impacted by the existence of the WAVES program.

All respondents, except those from Jamaica and Curacao, noted that their countries plan to expand the compilation of their environmental–economic accounts. Moreover, the assessment survey also found that their priorities going forward are water accounts, land and ecosystem accounts, and forest accounts (Figure 2.5). For example, Bangladesh plans to develop water accounts, forest accounts, land and ecosystem accounts, and Environmental Protection Expenditure Accounts (EPEAs).

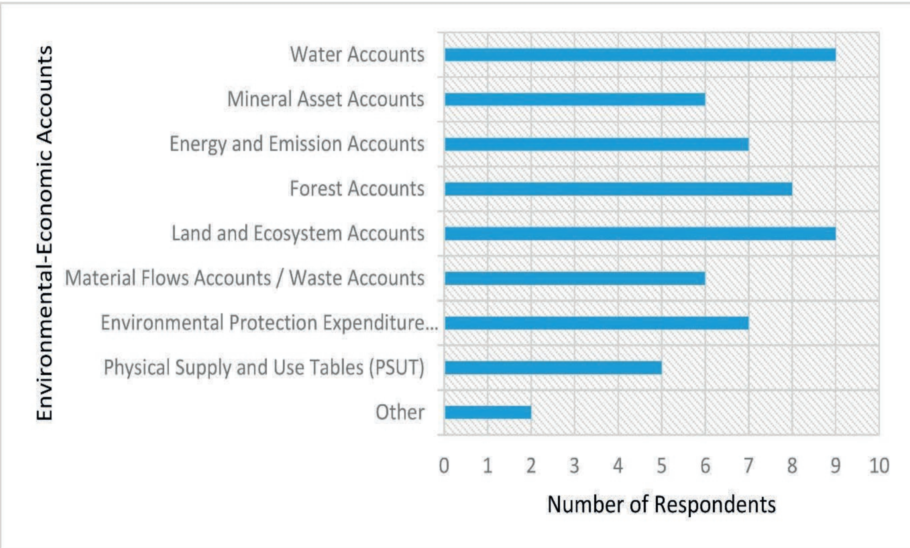


Figure 2.5. Plans to expand the compilation of environmental–economic accounts (Source: own survey)

The Philippines and Indonesia plan to develop several new accounts. Supported by government funding and external funding from international organizations, The Philippines plans to develop water, mineral assets, forest, and land and ecosystem accounts, physical supply and use tables (PSUTs), and recreational accounts. Indonesia, a resource-rich country, plans to develop complete environmental–economic accounts to support policy formulation.

The survey results also indicated that the main limitation of environmental–economic accounts in supporting SDG monitoring indicators in developing countries was the lack of institutional setup and coordination (Figure 2.6).

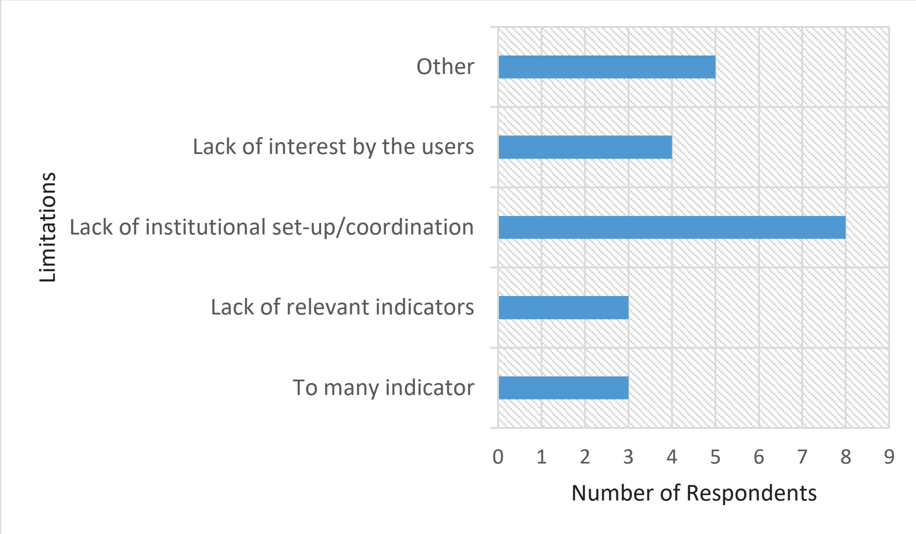


Figure 2.6. Limitations of comprehensive environmental–economic accounts in supporting SDG indicator monitoring (Source: own survey)

2.4.4 Conclusions on the implementation of the SEEA

Based on the literature review, international organization reports, and our own survey, we can draw some conclusions about the SEEA implementation. The topics covered by environmental-economic accounting programs differ between developing and developed countries (mostly EU regions) (UNSD, 2007; Eden, de Haan, and Scheau, 2011; Aoki et al. 2012; UNSD, 2012; UNSD, 2015; Vardon et al., 2016; World Bank, 2017; Naidu, 2017; UNSD, 2018). In developing countries, existing activities and plans should be focused on the management of natural resources and specific security issues (e.g., energy security). Meanwhile, in developed countries, salient issues relate to expenditure flow, economic instruments, resource efficiency, and environmental degradation associated with economic production and consumption.

The WAVES program has proven the possibility of setting up environmental accounts in middle income countries, as well as its use in informing national development plans and policies. Furthermore, our assessment survey indicated that regular funding and international organization assistance programs, such as WAVES, seem to affect the compilation and development of SEEA accounts positively, especially in developing countries, as previously described (UNSD, 2007; UNSD, 2012; UNSD, 2015; Vardon et al., 2016; World Bank, 2017; UNSD, 2018). The survey also indicated that energy and water accounts are the most commonly compiled accounts in developing countries.

2.5 Challenges in Implementing and Expanding of the SEEA

This section highlights the challenges in implementing and expanding the SEEA accounting. This analysis is based on a literature survey and our surveys of experts in developing countries. The studies identified several challenges in compiling and developing the SEEA accounts and will be essential for improving the SEEA implementation, especially in developing countries.

2.5.1 Implementation Challenges from the Literature and Survey

Implementation barriers for the the SEEA in developing countries are related to several issues. The UNSD 2007 Global Assessment asked respondents to identify the major constraints/impeding factors for the compilation of environmental–economic accounting (the UNSD 2014 Global Assessment did not include the question of impeding factors for their compilation of environmental–economic accounting). The Global Assessment noted that the top three impeding factors in the compilation of environmental–economic accounts are data availability, data quality, and lack of human resources, especially in developing countries (Figure 2.7). This conclusion was reported previously (Naidu, 2017) in the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) study for Pacific island nations.

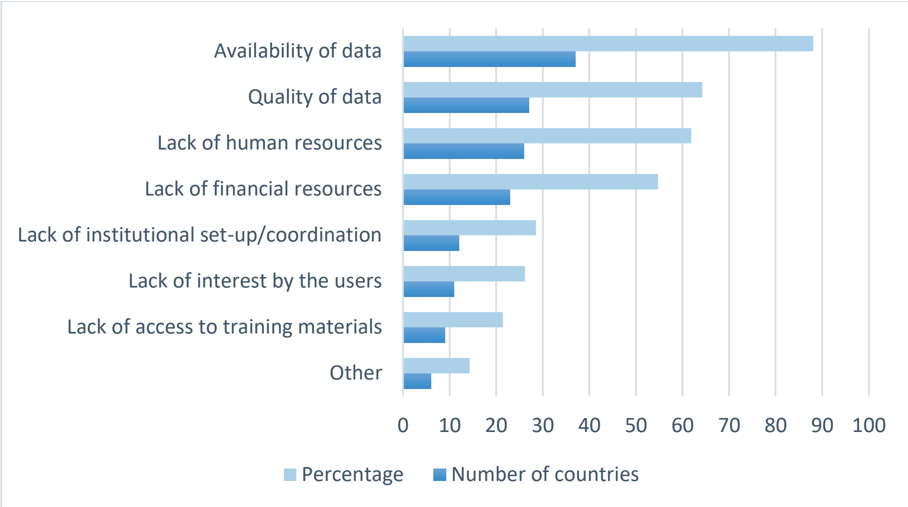


Figure 2.7. Impeding factors in the compilation of the environmental-economic accounting program (Source: adapted from UNSD, 2007)

The same three factors were the top three obstacles to further expanding an environmental–economic accounting program (Figure 2.8).

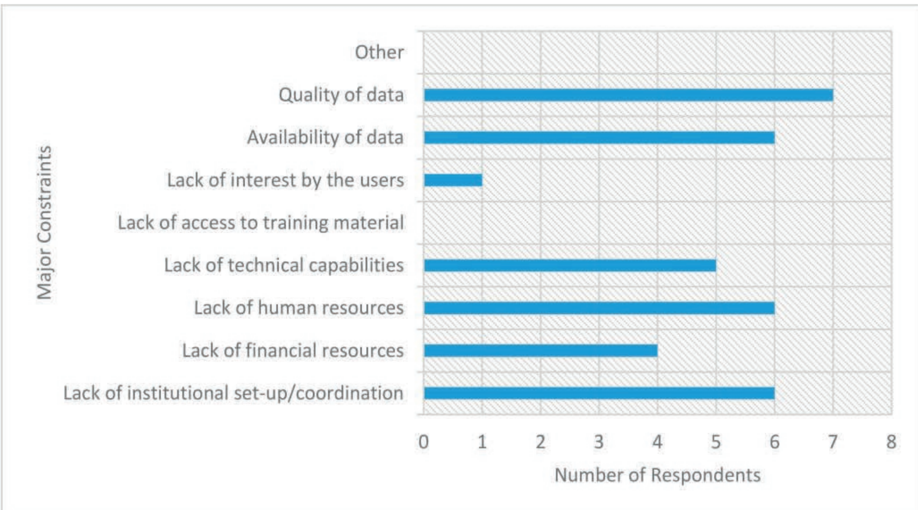


Figure 2.8. The major constraints in starting the compilation of the (current) environmental-economic accounts (Source: Own survey)

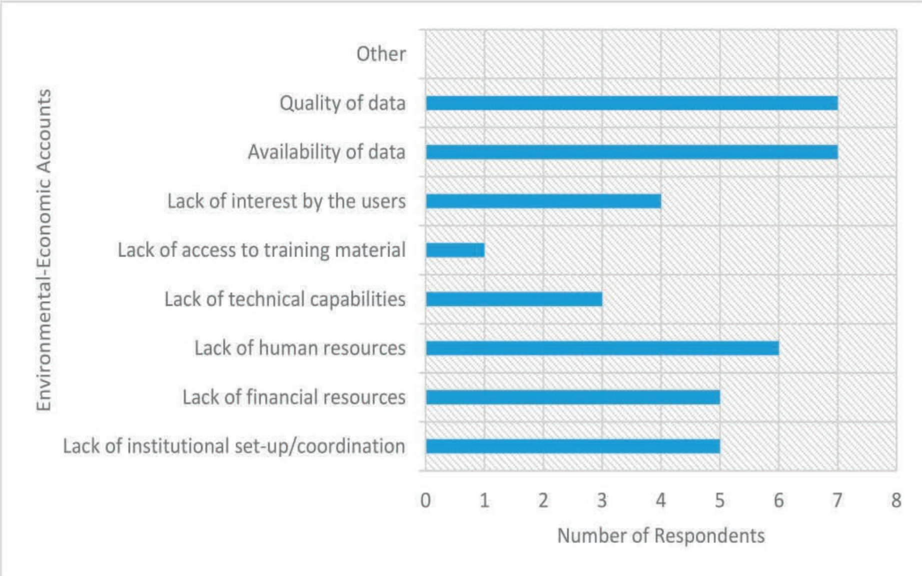


Figure 2.9. The major constraints for further expanding the environmental-economic accounting program (Source: own survey)

2.5.2 Potential approaches to addressing implementation challenges

Barriers to the implementation of the SEEA can be addressed in several ways. Our survey findings indicated that the responding countries with an SEEA program benefit from using training material, methodological guidelines, or country experiences, as well as technical assistance from international organizations in compiling environmental-economic accounts. For example, The Philippines experienced progress in developing and implementing the SEEA, supported by technical assistance from international organizations since the 1990s. From 1990 to 2012, this compilation was assisted by the UN and with USAID funded through the Environmental and Natural Resources Accounting Project (ENRAP); since 2013, the compilation has been assisted by the World Bank through the WAVES program.

Further introduction and awareness of the potential usefulness of the SEEA are required at the national level, especially by educating decision-makers (March, 2015). As noted, Australia built its case for policy makers by educating them via its initial report, Completing the Picture: Environmental Accounting in Practice (ABS, 2012; in March, 2015). Moreover, the unsuccessful SEEA implementation in China confirms that a supportive state (governance) and political structures, leading agencies, collaborative entities, and the influence of decision-makers are instrumental for successful SEEA development and implementation (March, 2015).

Another important aspect that determines the success of the SEEA implementation is the establishment of a multi-stakeholder mechanism to enable coordination in SEEA production and implementation. Financial and technical assistance from international agencies also plays a significant role, especially in developing countries. Our findings from the self-assessment survey indicated that regular funding from the government or an international agency is essential to support successful development and implementation. Countries without regular funding from their governments clearly experience greater obstacles in developing their SEEA accounts.

2.5.3 Implication for SDG monitoring

The importance of the SEEA has grown in the last couple of decades. SEEA development is driven by a desire to present detailed and comprehensive information on the environment and to provide a better understanding of how it interacts with the economy. This study illustrated a strong relationship between SEEA and SDG indicators. The implementation of SDGs requires a solid framework of indicators and statistical data to inform policy-making, monitor progress, and ensure accountability. The SEEA can meet this need by providing an internationally recognized, comparable, and consistent framework (including definitions, classifications, accounting concepts, and methods) for the accounting of natural capital (see the SEEA Brochure at https://unstats.un.org/unsd/envaccounting/Brochure.pdf).

Moreover, the SEEA and SDGs are highly compatible, with a shared purpose and philosophy (Bann, 2016). SDGs provide a policy framework, and the SEEA provides the necessary data to move towards sustainable development. SEEA, as an integrated statistical framework, can facilitate the production of statistics and indicators by national statistical systems, which are of enhanced quality, based on a set of criteria (UNSD, 2015a): (i) policy relevance and utility; (ii) analytical and methodological soundness; and (iii) measurability and practicality.

The SEEA also can be implemented in countries at various stages of development by identifying data gaps and improving consistency. Through the WAVES program, the World Bank has shown that it is possible to produce accounts in middle income countries and inform national development plans and policies. Programs from international agencies can support countries in the compilation and implementation of the SEEA via technical assistance, financial support, training materials, and methodological guidelines, thus improving the efficiency of the statistical output of basic data and other collaborative actions.

Realizing the full potential of the SEEA to support sustainable development and green policies (including supporting SDG implementation) requires cooperation and commitment at the national and international levels. Contributions from international agencies and donors are needed for SEEA implementation, including support from supporting institutions in middle income and low income countries to improve their capacity to establish high quality SEEA accounts and support the SEEA implementation for their sustainable development policy agenda.

2.6 Conclusions

In this study, we provided a brief overview of the current and potential uses of the SEEA to support SDG indicator monitoring. This study also included the results of a small assessment survey of the potential for the SEEA to support this monitoring. From the literature review, we showed that the SEEA is a potential tool that can help monitor SDG indicators and address priority issues in each country. The small assessment survey we conducted confirmed that almost all environmental-economic accounts have the potential to support SDG indicator monitoring. The surveys also showed that Goal 6, regarding the availability and sustainable management of water and sanitation for all, has the most potential to be supported by existing environmental-economic accounts, via water accounts, followed by Goals 7, 12, and 15. Moreover, the overall results from the survey confirmed the literature review analysis of the potential relationship between the SEEA and SDG indicators.

Based on the literature review, we can draw some conclusions about the current SEEA implementation. The topics covered by environmental–economic accounting programs differ between developing and developed countries (mostly from EU regions). In developing countries, activities and plans should be understood from the perspective of requiring the management of natural resource endowments and specific security issues. Meanwhile, in developed countries, the most important issues are expenditure flow, economic instruments, resource efficiency, and environmental degradation related to economic production and consumption.

The results of the literature review and survey indicated that regular funding and programs such as WAVES positively affect the compilation and development of the SEEA accounts, especially in developing countries. Furthermore, according to the survey results, energy and water accounts are the most commonly compiled accounts in developing countries. The survey also showed that data availability, data quality, and lack of human resources are the top three major constraints on starting the compilation of (current) environmental-economic accounts. Finally, the survey results also showed that the same three factors represent the top three obstacles to further expansion of an environmental-economic accounting program.

This study provided an overview and reflection on the possibilities of monitoring SDGs with the SEEA, discussing limits and critical states and offering guidelines and recommendations. However, this study had some limitations in terms of our elaboration of the SEEA literature. In addition, we realize that the survey we conducted still had limitations, especially on the coverage of respondents. However, the survey, especially regarding the potential of the SEEA to support monitoring of SDG indicators, perhaps is the first attempt ever made. We hope this study will trigger the emergence of more comprehensive studies on the potential of the SEEA in supporting the success of the SDGs.

Acknowledgments
Viktor Pirmana acknowledges funding from the Indonesian Endowment Fund for Education (LPDP Scholarship), Ministry of Finance, Republic of Indonesia.

2.7 Appendix

This appendix contains the supporting information for this case study and includes details on the modelled processes, supporting calculations.

Questionnaire on Assessment of Environmental-Economic Accounting in Developing Countries

Introductions
This Assessment has the objectives of:

(a) Assessing the current status of national implementation of Environmental-Economic Accounting Programs in developing countries
(b) Assessing institutional arrangements for the compilation of

Environmental-Economic Accounts in developing countries
(c) Identifying priorities and future plans for the compilation of Environmental-Economic Accounts
(d) Identifying the constraints in starting the compilation and developing Environmental-Economic Accounts
(e) Identifying the role of WAVES program in compiling and developing Environmental-Economic Accounts
(f) Identifying the possibilities of Environmental-Economic Account to support the monitoring of SDG Indicators

You are kindly requested to complete the questionnaire for the country in which you operate. It would be appreciated if you could provide as much information as possible and submit any supporting documents when requested.

Please provide your contact information:
Country:
Name of Institution:
Contact person:
Position:
Email:
Phone:

1. Does country have a program on Environmental-Economic Accounting that is compiling data for, or developing SEEA-based accounting?
   [ ] Yes
   [ ] No → skip to question 18

2. If your country have a program on Environmental-Economic Accounting, is the program is a yearly/routine program?
   [ ] Yes
   [ ] No

3. After 2012, did the program already adopt SEEA-CF 2012 from UN?
   [ ] Yes
   [ ] No

4. Which modules of Environmental-Economic Accounting are compiled by your country?
   [ ] Water Accounts
   [ ] Mineral Asset Accounts
   [ ] Energy and Emission Accounts
   [ ] Forest Accounts

[ ] Land and Ecosystem Accounts
[ ] Material Flows Accounts/Waste Accounts
[ ] Environmental Protection Expenditure Accounts (EPEA)
[ ] Physical Supply and Use Tables (PSUT)
[ ] Other → *Please specify* (*there is no limit in number of characters*): _______

5. In compiling Environmental-Economic Accounts, has your institution/agency made use of the following:

5a. Training material, methodological guidelines or country experiences?
[ ] Yes → *Please specify* (*e.g. 1993 SNA, SEEA 2003, etc.*) : SEEA 2012______
[ ] No

5b. Technical assistance from international organizations or countries?
[ ] Yes → *Please describe* (*e.g. during which period, nature of assistance, etc*): 2016, reviewing the estimates compiled by the Statistics office.
[ ] No

In compiling Environmental-Economic Accounts, your institution/agency funded by:
[ ] Government funding
[ ] External funding → *Please specify* (*e.g. during which period, from which sources, etc*) : _________

6. In compiling Environmental-Economic Accounts, your institution/agency has regular funding?
[ ] Yes → *Please specify* (*e.g. how many professional/supporting staff covered, ranges of funds, government or external sources, etc*) : _2 fulltime staff ______
[ ] No

7. In compiling Environmental-Economic Accounts, is WAVES program has a significant role?
[ ] Yes → *Please give a brief explanation:* ---------------
[ ] No

8. Which modules/accounts is the most impacted by the existence of WAVES program?
[ ] Water Accounts
[ ] Mineral Asset Accounts
[ ] Energy and Emission Accounts
[ ] Forest Accounts
[ ] Land and Ecosystem Accounts
[ ] Material Flows Accounts/Waste Accounts

[ ] Environmental Protection Expenditure Accounts (EPEA)
[ ] Physical Supply and Use Tables (PSUT)
[ ] Other → *Please specify* (*there is no limit in number of characters*): ________

9. If the World Bank stops the WAVES Program, is your institution/agency will continue to compile the Environmental-Economic Accounts?
[ ] Yes
[ ] No

10. Are there plans to continue compiling the current Environmental-Economic Accounts in your institution/agency?
[ ] Yes
[ ] No

11. Are there plans to expand the compilation of Environmental-Economic Accounts in your institution/agency?
[ ] Yes → Which modules?
  [ ] Water Accounts
  [ ] Mineral Asset Accounts
  [ ] Energy and Emission Accounts
  [ ] Forest Accounts
  [ ] Land and Ecosystem Accounts
  [ ] Material Flows Accounts/Waste Accounts
  [ ] Environmental Protection Expenditure Accounts (EPEA)
  [ ] Physical Supply and Use Tables (PSUT)
  [ ] Other → *Please specify* (*there is no limit in number of characters*): -________
[ ] No

12. In relation with SDGs, do your institution/agency think that Environmental-Economic Accounting database is possible to support the SDG Indicators monitoring?
[ ] Yes → Please continue to the next questions
[ ] No → Skip to question 21

13. Which modules/accounts in your view can support SDG Indicators monitoring?
[ ] Water Accounts
[ ] Mineral Asset Accounts
[ ] Energy and Emission Accounts
[ ] Forest Accounts
[ ] Land and Ecosystem Accounts

[ ] Material Flows Accounts/Waste Accounts
[ ] Environmental Protection Expenditure Accounts (EPEA)
[ ] Physical Supply and Use Tables (PSUT)
[ ] Other → *Please specify* (*there is no limit in number of characters*): _______

14. Which goal of SDGs in your view can support by the existence of the Environmental-Economic Accounts?

[ ]	Goal 1	End poverty in all its forms everywhere
[ ]	Goal 2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
[ ]	Goal 3	Ensure healthy lives and promote well-being for all at all ages
[ ]	Goal 4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
[ ]	Goal 5	Achieve gender equality and empower all women and girls
[ ]	Goal 6	Ensure availability and sustainable management of water and sanitation for all
[ ]	Goal 7	Ensure access to affordable, reliable, sustainable and modern energy for all
[ ]	Goal 8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
[ ]	Goal 9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
[ ]	Goal 10	Reduce inequality within and among countries
[ ]	Goal 11	Make cities and human settlements inclusive, safe, resilient and sustainable
[ ]	Goal 12	Ensure sustainable consumption and production patterns
[ ]	Goal 13	Take urgent action to combat climate change and its impacts*
[ ]	Goal 14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
[ ]	Goal 15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
[ ]	Goal 16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
[ ]	Goal 17	Strengthen the means of implementation and revitalize the global partnership for sustainable development

15. Which is the most potential goal of SDGs can support by Environmental-Economic Accounts ?

[ ]	Goal 1	End poverty in all its forms everywhere

[ ]	Goal 2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
[ ]	Goal 3	Ensure healthy lives and promote well-being for all at all ages
[ ]	Goal 4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
[ ]	Goal 5	Achieve gender equality and empower all women and girls
[ ]	Goal 6	Ensure availability and sustainable management of water and sanitation for all
[ ]	Goal 7	Ensure access to affordable, reliable, sustainable and modern energy for all
[ ]	Goal 8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
[ ]	Goal 9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
[ ]	Goal 10	Reduce inequality within and among countries
[ ]	Goal 11	Make cities and human settlements inclusive, safe, resilient and sustainable
[ ]	Goal 12	Ensure sustainable consumption and production patterns
[ ]	Goal 13	Take urgent action to combat climate change and its impacts*
[ ]	Goal 14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
[ ]	Goal 15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
[ ]	Goal 16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
[ ]	Goal 17	Strengthen the means of implementation and revitalize the global partnership for sustainable development

16. What are the limitation of comprehensive Environmental-Economic Accounts to support SDG indicators monitoring?

[ ] To many indicator
[ ] Lack of relevant indicators
[ ] Lack of institutional set-up/coordination
[ ] Lack of interest by the users
[ ] Other → *Please specify* (*there is no limit in number of characters*): __data custodians have limited knowledge of their data. _____

17. What were the major constraints in starting the compilation of the (current) Environmental-Economic Accounts in your country? (*Please check all that apply*)

[ ] Lack of institutional set-up/coordination

[ ] Lack of financial resources
[ ] Lack of human resources
[ ] Lack of technical capabilities
[ ] Lack of access to training material
[ ] Lack of interest by the users
[ ] Availability of data
[ ] Quality of data
[ ] Other → *Please specify* (*there is no limit in number of characters*): ________

18. What have been the major constraints further expanding the Environmental-Economic Accounting Program?
[ ] Lack of institutional set-up/coordination
[ ] Lack of financial resources
[ ] Lack of human resources
[ ] Lack of technical capabilities
[ ] Lack of access to training material
[ ] Lack of interest by the users
[ ] Availability of data
[ ] Quality of data
[ ] Other → *Please specify* (*there is no limit in number of characters*): ________

19. Are there plans to compile any modules of the Environmental-Economic Accounts in your country in the near future?
[ ] Yes → Which modules?
  [ ] Water Accounts
  [ ] Mineral Asset Accounts
  [ ] Energy and Emission Accounts
  [ ] Forest Accounts
  [ ] Land and Ecosystem Accounts
  [ ] Material Flows Accounts/Waste Accounts
  [ ] Environmental Protection Expenditure Accounts (EPEA)
  [ ] Physical Supply and Use Tables (PSUT)
  [ ] Other → *Please specify* (*there is no limit in number of characters*): -________
[ ] No

Please provide additional comments in the box below

Table 2.5. List of Respondent Affiliation and Position

No.	Country	Affiliation	Position
1	Columbia	National Administrative Department of Statistics (DANE)	Coordinator Indicators and Environmental Accounts
2	Chile	Ministry of the Environment	Manager – Unit of Environmental Accounts and Indicators
3	Brasil	Instituto Brasileiro de Geografia e Estatística	técnico em informações geográficas e estatística
4	Curacao	Central Bureau of Statistics (CBS)	Analyst, Head Business and Environmental Statistics
5	Guatemala	Universidad Rafael Landívar / IARNA	Academic research associate / Sr. Environmental Economist WAVES
6	Costa Rica	Banco Central de Costa Rica (BCCR)	Coordinator of Environmental Statistics Unit
7	Bangladesh	Bangladesh Bureau of Statistics (BBS)	Deputy Director
8	Philipines	Resources, Environment and Economics Center for Studies	President/ Resoure Economict
9	Indonesia	Central Bureau of Statistics (CBS)	Head of Sub-directorate on Regional Production Account
10	Iran	Statistical Centre of Iran	Director General, Office of the Head, Public Relations and International cooperation
11	Fiji	Fiji Bureau of Statistics	Government statistician
12	South Africa	Statistics South Africa	Deputy Director: Application of National Accounts
13	Botswana	Ministry of Finance & economic Development	Chief Economist / Coordinator of WAVES Program for Botswana
14	Jamaica	Science and Technology Development Planner/SIDS	Dock National Coordinator Planning Institute of Jamaica (PIOJ)

Table 2.6. Possible SDG Indicators that can be constructed from SEEA databases

Goals and Targets	Indicators	Account	Type of Account	Tier
Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture				
2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment	2.3.1 Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size	Agriculture, Forestry and Fisheries	All	Tier II
2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	2.4.1 Proportion of agricultural area under productive and sustainable agriculture	Land + Agriculture, Forestry and Fisheries	Asset accounts	Tier II
2.a Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries	2.a.1 The agriculture orientation index for government expenditures	SNA + Environmental activities	All	Tier I
Goal 6. Ensure availability and sustainable management of water and sanitation for all				
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water	6.1.1 Proportion of population using safely managed drinking water services	Water	PSUT + Economic Accounts	Tier II

for all				
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	6.2.1 Proportion of population using safely managed sanitation services, including a hand-washing facility with soap and water	Water	PSUT + Economic Accounts	Tier II
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	6.3.1 Proportion of wastewater safely treated	Water	PSUT	Tier II
	6.3.2 Proportion of bodies of water with good ambient water quality	Materials	Emmission Accounts	Tier II
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	6.4.1 Change in water-use efficiency over time	SNA + Water	PSUT + All	Tier II
	6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	Water		Tier I
6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	6.5.1 Degree of integrated water resources management implementation (0-100)	Water	PSUT + Physical asset accounts	Tier I
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	6.6.1 Change in the extent of water-related ecosystems over time	Ecosystems	Ecosystems extent accounts	Tier II

6.a By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies	6.a.1 Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan	Water	PSUT + Economic Accounts	Tier I
Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all				
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Proportion of population with access to electricity	Energy	PSUT+Economic Accounts+Asset accounts	Tier I
	7.1.2 Proportion of population with primary reliance on clean fuels and technology	Energy	PSUT+Economic Accounts+Asset accounts	Tier I
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	Energy	PSUT	Tier I
7.3 By 2030, double the global rate of improvement in energy efficiency	7.3.1 Energy intensity measured in terms of primary energy and GDP	SNA + Energy	PSUT+Value added from SNA	Tier I
7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States and landlocked developing countries, in accordance with their respective programmes of support	7.b.1 Investments in energy efficiency as a percentage of GDP and the amount of foreign direct investment in financial transfer for infrastructure and technology to sustainable development services	SNA + Energy	PSUT+ value added from SNA	Tier III
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all				
8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavor to decouple economic growth from environmental degradation, in accordance with the 10-Year	8.4.1 Material footprint, material footprint per capita, and material footprint per GDP	Materials	Material flow accounts	Tier II

Framework of Programmes on Sustainable Consumption and Production, with developed countries taking the lead				
	8.4.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP	Materials	Material flow accounts	Tier I
8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products	8.9.1 Tourism direct GDP as a proportion of total GDP and in growth rate	SNA	Tourism satellite account	Tier II
	8.9.2 Number of jobs in tourism industries as a proportion of total jobs and growth rate of jobs, by sex	SNA	Tourism satellite account	Tier III
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation				
9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	9.4.1 CO_2 emission per unit of value added	Materials	Air emission accounts +SNA	Tier I
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable				
11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	11.3.1 Ratio of land consumption rate to population growth rate	Land	Asset accounts	Tier II

11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	11.3.2 Total expenditure (public and private) per capita spent on the preservation, protection and conservation of all cultural and natural heritage, by type of heritage (cultural, natural, mixed and World Heritage Centre designation), level of government (national, regional and local/municipal), type of expenditure (operating expenditure/investment) and type of private funding (donations in kind, private non-profit sector and sponsorship)	Environmental activities	Env. Protection expenditure accounts + Resource management expenditure accounts	Tier III
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	11.6.1 Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated, by cities	Materials	Solid waste accounts	Tier II
11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials	11.c.1 Proportion of financial support to the least developed countries that is allocated to the construction and retrofitting of sustainable, resilient and resource-efficient buildings utilizing local materials	Environmental activities	Env. Protection expenditure accounts	Tier III
Goal 12. Ensure sustainable consumption and production patterns				
12.2 By 2030, achieve the sustainable management and efficient use of natural resources	12.2.1 Material footprint, material footprint per capita, and material footprint per GDP	Materials	Material flow accounts	Tier II
	12.2.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP	Materials	Material flow accounts	Tier I
	12.4.2 Hazardous waste generated per capita and proportion of hazardous waste treated, by type of treatment	Materials	Solid waste accounts	Tier III
12.5 By 2030, substantially reduce waste generation through prevention, reduction,	12.5.1 National recycling rate, tons of material recycled	Materials	Solid waste accounts	Tier III

recycling and reuse				
12.c Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities	12.c.1 Amount of fossil-fuel subsidies per unit of GDP (production and consumption) and as a proportion of total national expenditure on fossil fuels	Energy	Energy accounts and Environmental taxes and subsidies accounts	Tier II
Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development				
14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	14.4.1 Proportion of fish stocks within biologically sustainable levels	Aquatic resources	Asset accounts	Tier I
14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information	14.5.1 Coverage of protected areas in relation to marine areas	Land	Asset accounts	Tier I

14.7 By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism	14.7.1 Sustainable fisheries as a percentage of GDP in small island developing States, least developed countries and all countries	Agriculture, Forestry and Fisheries	All	Tier I
14.a Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries	14.a.1 Proportion of total research budget allocated to research in the field of marine technology	Environmental activities	Env. Protection expenditure accounts	Tier II
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss				
15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	15.1.1 Forest area as a proportion of total land area	Land	Asset accounts	Tier I
	15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type	Land	Asset accounts	Tier I
15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral	15.1.3 Proportion of land that is degraded over total land area	Ecosystems	Condition accounts	Tier II

world				
15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development	15.4.1 Coverage by protected areas of important sites for mountain biodiversity	Land	Asset accounts	Tier I
	15.4.2 Mountain Green Cover Index	Land	Asset accounts	Tier I
15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	15.5.1 Red List Index	Ecosystems	Biodiversity accounts	Tier I
15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts	15.9.1 Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011-2020	Ecosystems	Condition accounts + Ecosystem service account + Biodiversity accounts	Tier III
15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems	15.a.1 Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems	Environmental activities	Env. Protection expenditure accounts	Tier I/III
15.b Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation	15.b.1 Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems	Environmental activities	Env. Protection expenditure accounts	Tier I/III
Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development				

17.1 Strengthen domestic resource mobilization, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection	17.1.1 Total government revenue as a proportion of GDP, by source	Environmental activities	Env. Protection expenditure accounts	Tier I
	17.1.2 Proportion of domestic budget funded by domestic taxes	Environmental activities	Env. Protection expenditure accounts	Tier I

Source: Updated and modified from: UNCEEA (2016), "Broad brush analysis of SEEA relevant SDG indicators".
http://unstats.un.org/unsd/envaccounting/ceea/documents/Broad%20Brush_7%20September.xlsx

Notes:

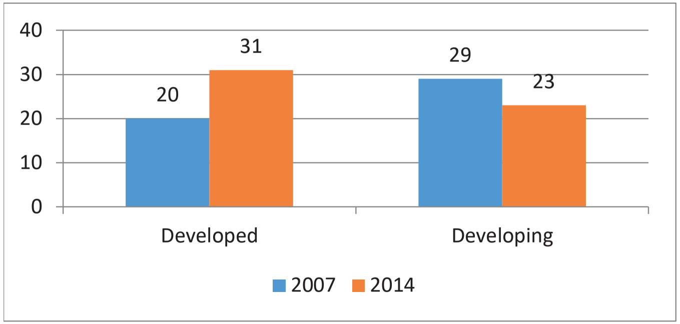
- PSUT : Physical Supply and Use Table
- Broad brush analysis from UNCEEA (2016) and Ruinj et.al (2018) compared with the list of global SDG indicators as approved by UNSC in March 2016. This study use the suggested indicator and Definition updated using the latest version of Revised list of global Sustainable Development Goal indicators (March, 2017), retrieved from https://unstats.un.org/sdgs/indicators/Official%20Revised%20List%20of%20global%20SDG%20indicators.pdf
- This Broad brush analysis is updated and completed with Tier Classification for Global SDG Indicators from United Nation Statistical Division (UNSD) https://unstats.un.org/sdgs/files/Tier_Classification_of_SDG_Indicators_22_May_2019_web.xlsx

Defining 'SEEA Relevant':

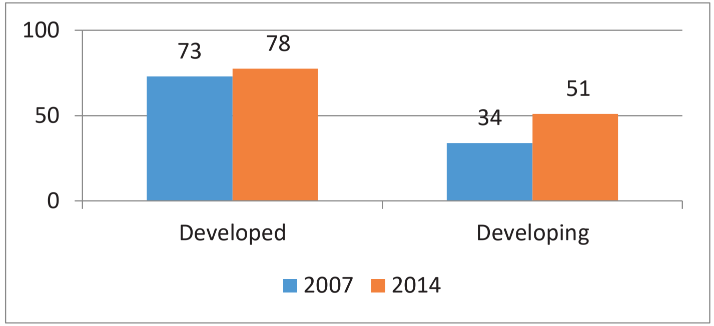
: Indicator as currently proposed can be informed by the SEEA Accounts

: Either current wording and concepts of indicator needs to be aligned to be SEEA compliant; or indicator needs to be further defined to ensure SEEA compliance (i.e. detailed definitions added)

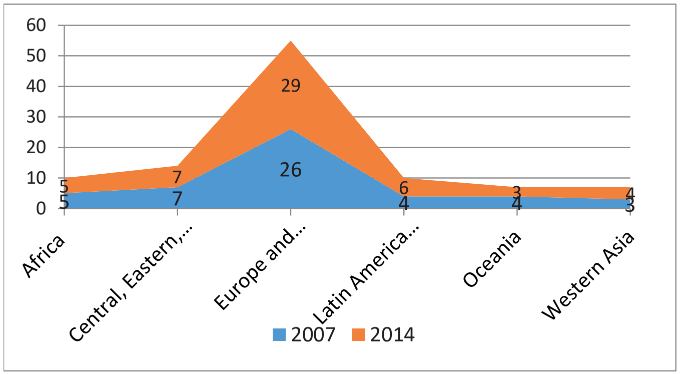
: While the indicator cannot be informed by the SEEA, either; a) the SEEA can provide important contextual information and the indicator should be developed with the SEEA approach in mind; or b) there is some overlap with SEEA methodology which should be considered when formulating this indicator.



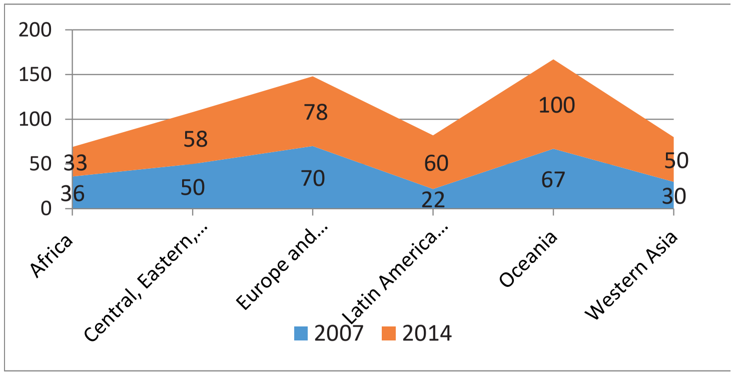
1a. Number of Countries, by Economic Grouping



1b. Percentage of Countries, by Economic Grouping

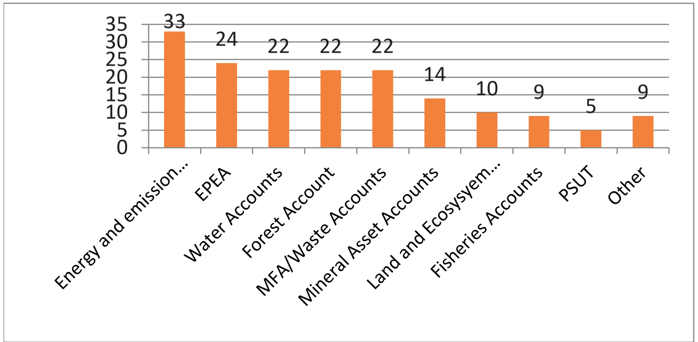


1c. Number of Countries, by Geographical Grouping

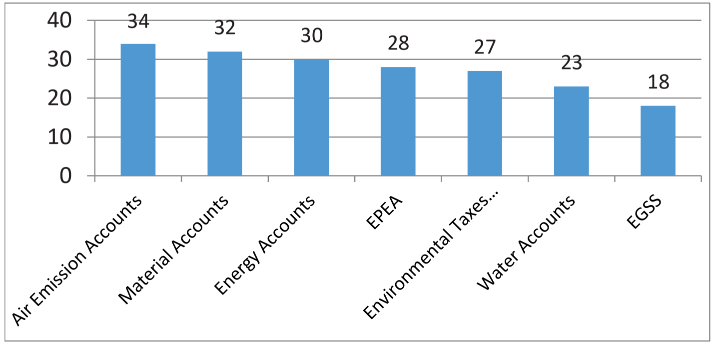


1d. Percentage of Countries, by Geographical Grouping

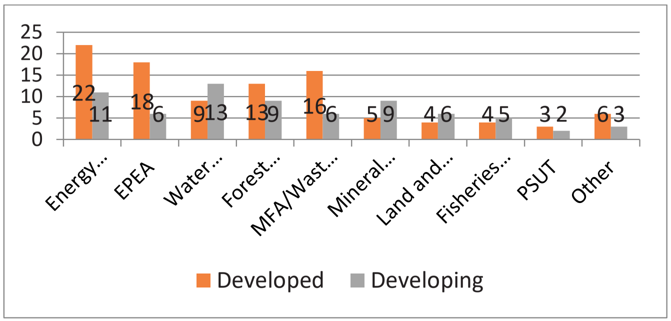
Figure 2.10. Existence of Environmental-Economic Accounting Program in Countries (Adapted from: UNSD, 2007 and UNSD 2014)



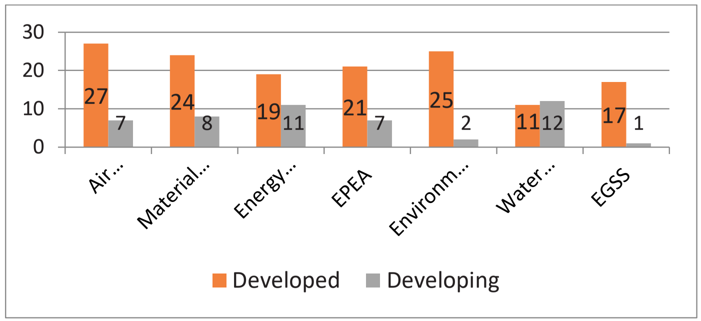
2a. All Countries, 2007



2b. All Countries, 2014



2c. Economic Regions, 2007



2d. Economic Regions, 2014

Figure 2.11. Modules/Accounts Covered in Environmental-Economic Accounting Program by Economic Region (Adapted from: UNSD, 2007 and UNSD 2014)

Chapter 3

Environmental Costs Assessment for Improved Environmental-Economic Accounts for Indonesia

Abstract

The overall purpose of this study is to assess priorities for new environmental accounts in Indonesia. We use environmental costs related to air pollution and resource extraction in Indonesia as a measure for priority. This study uses the damage costs approach to estimate the environmental degradation costs value and the Net Present Value (NPV) approach to obtain the environmental cost of natural resources depletion of several natural resources that are most important for the Indonesian economy. Our estimate of the total environmental costs amounts to around 13% of GDP in 2010. Environmental costs are mostly due to depletion of energy and mineral resources, followed by environmental degradation cost from air pollution, and the use of forestry resources and related depletion of ecosystems. The Indonesian Central Bureau of Statistics (BPS) has already published damage costs data related to resource depletion, which we find is a priority. However, the BPS should consider completing its data with additional information on the depletion costs of ecosystem services related to forestry. Moreover, the BPS could expand Indonesia's economic-environmental accounts by including environmental degradation costs due to air pollution. We found that from a substance perspective, the priorities are SOx, NOx, CO_2, CH_4, and particulate matter. At the same time, from a sector perspective, the priorities are electricity, manufacture of basic iron and steel and of ferro-alloys and first products thereof, mining of coal and lignite, and extraction of peat, because if the national accounts included the external costs of air pollution and the depletion of natural resources, these sectors would create a negative value-added.

Published as Pirmana, V., Alisjahbana,A.S., Hoekstra, R., Yusuf, A.A., and Tukker. A. (2021) Environmental costs assessment for improved environmental-economic accounts for Indonesia, Journal of Cleaner Production, Volume 280, Part 1, 2021, 124521,ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2020.124521.

3.1 Introduction

Achieving the Sustainable Development Goals (SDGs) requires that economic development, particularly in developing countries, ensure that adverse effects of economic activities to the environment are minimized (also compare WCED, 1987 pp.12). For monitoring progress towards SDGs, environmental and economic accounts are needed, but many low-income countries still have problems developing such accounts (Pirmana et al., 2019).

A starting point of proper environmental management concerning economic development is to recognize the cost of environmental impacts due to economic activities and to include them in the decision-making process (World Bank, 1994). Studies have calculated and valued not only the natural resource depletion but also the environmental degradation as a side effect from economic activities (World Bank, 1997; Alisjahbana and Yusuf, 2000a; Bolt et al., 2002; Anielski and Wilson, 2005; Asici, 2013; Obst and Vardon , 2014).

To ensure that the development process proceeds well, Indonesia also needs to develop an accurate and comprehensive environmental-economic account. Indonesia is one of 17 countries with an extraordinary biodiversity (OECD, 2019). Indonesia is well known as the country with the largest area of tropical forests in the world, and it has a very rich coastal and marine ecosystem. The abundance of natural resources has made Indonesia one of the largest producers and exporters of minerals, energy sources, woods, and agricultural products. At the same time, the country still faces challenges in reducing environmental impacts due to economic activities. Indonesia was the fourth-largest emitter of greenhouse gas in the world in 2015 (Chrysolite et al., 2020), due to emissions from deforestation and peat forest fires, as well as from burning fossil fuels for energy. Other challenges comprise unwise behavior in natural resources extraction, high pollution, and environmental degradation.

In Indonesia, the Central Bureau of Statistics (BPS) has conducted several studies on establishing economic-environmental accounts (including the Green GDP measurement). Those publications are still limited to specific accounts, for instance, forest, energy and mineral accounts. Meanwhile, Indonesia is in the process of expanding its work on environmental accounts, for example, on CO_2 emissions. However, since the collection of new environmental statistics can be costly, it is useful to analyze which kind of environmental accounts are relevant to the respective economic sectors.

Generally, the purpose of this study is to assess the priorities for improving and expanding environmental accounts in Indonesia. We used environmental costs related to emissions and resource extraction in Indonesia as a measure for priority. Based on this background, the present study intends to answer the following research questions: (i) How high are the total environmental costs in Indonesia? (ii) What part of these environmental costs is caused by the environmental degradation cost from air pollution? What sectors and types of air pollutants have the highest environmental degradation cost in the Indonesian economy? (iii) What part of these environmental costs is caused by natural resource depletion from resource extraction sectors in Indonesia? (iv) Which sectors and types of environmental interventions are hence of the highest priority to be covered by environmental accounts?

This chapter is broadly structured as follows: Section 2 contains literature reviews on environmental cost accounting methods. Section 3 introduces earlier work on environmental costs accounts for Indonesia and the methodology used throughout this paper. Section 4 presents the results of this study on environmental degradation costs and the costs of natural resource depletion from resource extraction sectors in Indonesia. Section 5 provides a discussion of the findings and the conclusion of the study.

3.2 Methods for environmental cost calculations

Figure 3.1 summarizes the most widely used approaches in environmental cost accounting. Usually, two broad groups of costs are discerned: (a) costs related to environmental degradation caused by emissions (with impacts on the ecosystem and on human health), and (b) costs associated with the use of natural capital and the depletion of natural resources (Alisjahbana and Yusuf, 2004; Wang et al. 2018).

The costs of the first category can be estimated via two main approaches: the damage-based approach and the cost-based approach. The damage-based approach calculates pollution costs due to pollutant discharge, which can cause environmental deterioration (Wang et al., 2018). On the other hand, the cost-based approach calculates the costs required to abate pollutant discharge in the production and consumption processes, the result of which is called maintenance costs.

Cost calculations for the second category usually discern two main types: (1) renewable (biotic) natural resources, such as crops, timber and fish, and (2) non-renewable (abiotic) natural resources, such as metals and non-metal minerals, and fossil energy resources, including water (Hertwich et al., 2010). Renewable natural resources are, in principle, self-regenerating, making use of solar energy. They can be harvested to yield ecosystem goods (such as wood). Non-renewable natural resources cannot be regenerated. Mineral deposits and fossil fuel are the best examples. These resources generally yield no services until extracted. Overexploitation of biotic resources can lead to the collapse of resource stocks (e.g., forests and fisheries) and cause complex environmental problems. Methods for measuring the depreciation/depletion of natural resources can be categorized into three broad groups of approaches: (i) The Market Price Approach, (ii) The Income Approach, and (iii) The Cost Approach.

Environmental cost accounting seeks to monetize the various forms of environmental pressures shown in figure 3.1. Monetization makes it possible to prioritize such pressures and to calculate how environmental costs are related to the Gross Domestic Product (GDP) of a country—for instance, by calculating a "correction" of the GDP. The next section will provide a more detailed discussion of the available methods and approaches for monetizing environmental degradation and natural resource depletion, with an emphasis on the Indonesian context.

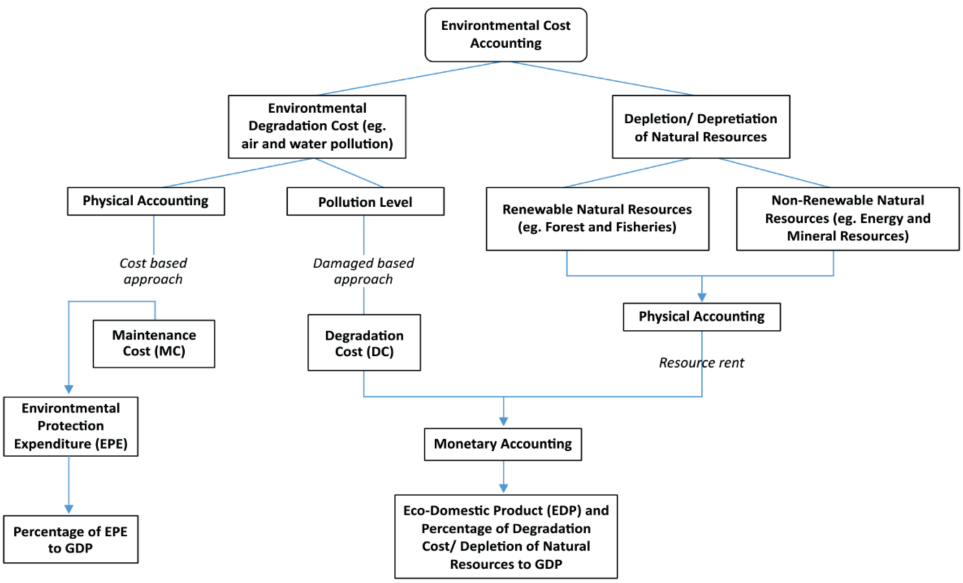


Figure 3.1. Approaches to environmental cost accounting
Source: Authors, inspired by Alisjahbana and Yusuf (2004); Wang et al. (2018)

3.2.1 Environmental degradation cost

Environmental degradation is defined as a decrease in the quality of the environment due to development activities. Its value does not include the actual cost of economic activities under the market economy framework (World Bank, 2006; Perman et al., 2011). There is no consensus on the "best" method of valuing environmental damages from economic activities. In practice, several approaches and methods are used to measure environmental degradation costs.

Among others, (Wang et al., 2018) pointed out that the environmental costs of pollution can be assessed in two ways, namely by calculating the expenditure on environmental protection and by calculating environmental degradation. The first approach calculates the sum needed to reduce pollutant discharge from production and consumption activities with the Best Technology (treatment) currently available (BAT). The United Nations Economic and Environmental Account System (UN SEEA; see UN, 2003; UN, 2012) defines prevention costs such as 'maintenance costs'. The second approach is to calculate what damage is caused by pollutant disposal (e.g., for human health, or environmental degradation). UN SEEA refers to these costs as 'costs of environmental degradation', or 'damage value'.

The damage costs approach is more complicated than the maintenance cost approach (Schoer, 2007). However, the damage costs approach provides a better insight into the dangers of pollution for human health and for the environment (Xia et al., 2006).

Table 3.1 provides an overview of authoritative studies that calculated these damage costs in different contexts. We observed that few studies specifically examine these costs in developing countries. As we will explain further in section 3, we opted for using the studies in Table 3.1 by adjusting them to an Indonesian context, rather than estimating damage costs via complex emission-effect calculations in the Indonesian situation, for which no data are available.

Table 3.1. Publications on Damage/Abatement cost Value for Air Pollutions

	Descriptions	Source/ Institution	Population whose values are considered	Prices	Website	Comments
DAMAGE COST						
1	EPS Impact Assessment Method	Steen (2015)/ Swedish Life Cycle Center	Global	€/Kg (2015)	https://www.lifecyclecenter.se/publications/eps-2015d1-including-climate-impacts-from-secondary-particles/	Including climate impact from secondary particles
2	EPS Impact Assessment Method	Steen (2015)/Swedish Life Cycle Center	Global	€/Kg (2015)	https://www.lifecyclecenter.se/publications/eps-2015d1-excluding-climate-impacts-from-secondary-particles/	Excluding climate impact from secondary particles
3	Environmental Prices Handbook EU28 version	De Bruyn et al (2018) / CE Delft, Netherlands	28 EU country	€/Kg (2015)	https://www.cedelft.eu/en/publications/2191/environmental-prices-handbook-eu28-version	Environmental prices were calculated for over 2,500 pollutants.
4	Environmental Prices Handbook 2017: Methods and numbers for valuation of environmental impacts	De Bruyn et al (2018) /CE Delft, Netherlands	Netherlands	€/Kg (2015)	https://www.ce.nl/en/publications/2113/envionmental-prices-handbook-2017	Environmental prices were calculated for over 2,500 pollutants.
5	Eco-costs 2007 LCA data on emissions and materials depletion	TU Delft, Netherlands	EU countries	€/Kg (2007)	https://ecocostsvalue.com/EVR/img/Ecocosts%202007%20LCA%20data%20on%20emissions%20and%20materials%20depletion.xls	Eco-costs is a measurement tool that shows the amount of environmental burden of a product based on load prevention €2007/kg emission
6	Costs of air pollution from European industrial facilities 2008–2012	European Environment Agency (2014)	EU countries	€/Kg (2007)	https://www.eea.europa.eu/publications/costs-of-air-pollution-2008-2012/download	This publication is an updated version of the earlier assessment of the costs of air pollution from European industrial facilities (2011)
ABATEMENT COST						
7	Industrial Pollution Projection System (IPPS)	World Bank	Global	US$/T on (1994)	https://datacatalog.worldbank.org/dataset/wps1431-ipps-pollution-intensity-and-abatement-cost/resource/7972b102-9c7b-4146-8df2	Abatement costs value limited to manufacturing sectors only.
8	Pollution Abatement Costs and Expenditures (PACE) Survey	U.S. Bureau of the Census (2008)	USA	Million $ (2005)	https://www.epa.gov/environmental-economics/pollution-abatement-costs-and-expenditures-2005-survey	Abatement costs value limited to manufacturing sectors only.

Source: Authors compilation

3.2.2 Depletion of natural resources

The theory and literature on environmental costs accounting generally base the valuation of natural resource depletion on market prices. The assumption is that a market price represents a revealed preference and shows how economic decisions are made and can be compared. Several approaches have been used to estimate the depletion of natural resources (Motta and Amaral, 2000; UN, 2005; Domingo and Lopez Dee, 2007). Domingo and Lopez Dee (2007) categorized these approaches into three categories: (i) the market price approach, (ii) the income approach, and (iii) the cost approach.

3.2.2.1 The market price approach

Environmental assets are tradable, and their value follows the prices prevailing in the market. Domingo & Lopez Dee (2007) pointed out some advantages and limitations of using the market price approach. Data on quantities, prices, and costs are relatively easy to obtain, especially in established markets. On the other hand, one of several limitations of using this approach is the availability or lack of market data for non-traded resources. Due to policy failures or market imperfections, market transactions may not fully reflect the actual economic value of these goods and services. Moreover, researchers must consider factors affecting prices and seasonal variations. Domingo & Lopez Dee (2007) also pointed out that the market price approach may overstate benefits since this measurement does not subtract the market value of other resources that are necessary to bring ecosystem products to market.

3.2.2.2 The income approach

An alternative to the market price approach is the income approach, which is an indirect way of using market value or considered a proxy measure of market value where, in reality, a true market does not exist. Four approaches fall into this income approach group: (1) the Net Price Method, (2) the Net Present Value (NPV) method, (3) the El Sherafy/User Cost method, and (4) the Appropriation method. Each approach has advantages and limitations.

Table 3.2 below presents each approach's advantages and disadvantages for concisely measuring natural resource depletion.

Table 3.2. Methods based on the income approaches to measure depletion/depreciation of natural resources

Approach	General description	Advantages	Limitations
Net Price method	The market price minus all factor costs. (UN, 2005)	Simple	(i) This method is built on the assumption of a perfectly competitive market structure; in reality, the premise that rents will increase along with the discount rate may not apply because of market imperfections. (ii) The rent used may also include other forms of rent. (iii) Global mineral prices are not regulated by perfect market mechanisms. (iv) Overestimates the market value of subsoil assets.
Net Present Value	This approach is commonly used to predict the net income stream of an asset over its entire economic life. This includes forecasting future net income streams that can be generated if mineral resources are exploited optimally and then discounting them using appropriate capital costs.	(i) **The time aspect.** This approach recognizes the notion that dollars earned today are worth more than dollars earned ten years from now. (ii) **Risk**. This approach combines the risks associated with resources via the expected income stream and/or the discount rate. (iii) **Flexibility**. NPV provides resilience and intensity because the equation can adjust for inflation and can be used together with other analytic tools.	(i) it is difficult to specify the Income flow, which reflects the estimated Net Benefits during the natural life of the resource. (ii) In this approach, choosing an appropriate discount rate is crucial. (iii) The calculation is done in a static manner, which does not allow for any future adjustments. (iv) The capital requirements may possibly change over time, requiring decisions along the path that may change the risk profile.
El Sherafy/User Cost method	This approach distinguishes between the "actual income" and the "gross revenue" generated by an asset. In this approach, actual income is defined as "the amount of revenue that will be maintained indefinitely regardless of the actual life of the asset by investing a portion of the gross revenue generated which can be a depletion expense or referred to as a user cost".	One of the strengths of this method is that the user cost (1- (X / R)) can be proxied by a formula involving the discount rate and the ratio of annual production to the total stock of resources (1 / (1 + r)) n +1)	(i) Several assumptions are needed to calculate the user costs. (ii) During the lifetime of the resource, the current level of receipts is held constant. (iii) Until the final exhaustion of the resource, the rate of extraction is also held constant. (iv) Assumes a constant discount rate.
The Appropriation method	This approach is based on the notion that governments theoretically can collect all rents from resource extraction. The government can collect resource rent through taxes, fees, and royalties imposed on companies that extract the natural resources.		(i) The level of payments to the authority may not move with the market price for the extracted product. (ii) In practice, taxes, royalties, and fees tend to underestimate resource rents because they can be determined by the government.

Source: Summarized from Domingo and Lopez Dee (2007)

3.2.2.3 The cost approach

This approach is an alternative measurement for valuing natural resource assets, such as mineral resources. The advantages of this method are reflected in the availability of technical data and specific information on exploration costs (Domingo and Lopez Dee, 2007). On the other hand, the disadvantage of using this method relates to the experience assessments that are needed to distinguish past expenditures that are considered productive from those estimated to make no contribution to the value of the property and to predict what will be reasonable exploration programs and costs in the future.

3.3 Estimation method for Indonesia

Several attempts have been made to measure environmental costs and to adjust the conventional GDP for the case of Indonesia. These attempts have been initiated since the early 1990s, both by individuals and by local and international institutions. Table 3.3 below summarizes the most critical studies on environmental cost measurement for the case of Indonesia.

Table 3.3. Summary of previous studies of environmental cost and related adjustments of Indonesia's GDP

Authors	Coverage	Valuation Methods	Results (Adjustment of GDP,%)
Repetto et al. (1989)	- *Resource depletion:* Oil, soil degradation and forest (including deforestation)	Net price method	17.9 (1984)
Pearce and Atkinson (1993)	- *Resource depletion*: Oil, soil degradation and forest (including deforestation)	Market price	17.9 (1984)
BPS (1996-2011)	- *Resource depletion*: Forest, mineral resources (oil, gas, coal, gold, silver, nickel ore, bauxite)	Net price method	11.7 (1996)
Vincent and Castenada (1997)	*Resource depletion*: several mineral resources, forest, and sub-soil resources.	Hotelling rent	2.5 (1992)
Hamilton (1999)	- *Resource depletion*: oil, gas, broad coverage of minerals, forest; - *Env. degradation*: damage due to emission of CO_2.	Net present Value (NPV) method	14.7 (1994)
Alisjahbana and Yusuf (2000a)	- *Resource depletion:* petroleum, natural gas, several of the most important mineral resources, forest resources - *Env. degradation*: pollution damage from local and global sources	User cost method	5.2 (1995)
Alisjahbana and Yusuf (2000b)	- *Resource depletion:* petroleum, natural gas, several of the most important mineral resources, forest resources *Env. degradation*: pollution damage from	Net price method, the maintenance cost approach	10.5 (1997)

	local and global sources[1]		
Yusuf and Pirmana (2009)	*Resource depletion:* Forest, oil, natural gas, and several of the most important mineral resources *Env. degradation*: pollution damage from local and global sources	Net price method, the maintenance cost approach	4.27 (2007)
Yuniarti, P. Irma (2013)	*Resource depletion:* crude oil, natural gas, forest, several of the most important mineral resources *Env. degradation*: pollution damage from local (NOx) and global sources	Net price method, the maintenance cost approach	4.2 (2007)
BPS (2012-2016)	- *Resource depletion*: forest, crude oil, natural gas, and several of the most important mineral resources - Land cover and land use	Net present Value (NPV) method	6.74 (2016)

Source: Author's compilation

The table shows that in most studies, the measurements of environmental costs only focus on the calculation of natural resource depletion. A few studies attempted to include the calculation of environmental degradation cost caused by emissions, and they usually concentrate on a small number of emissions, such as BOD, CO_2, NO_x, etc. Furthermore, most of these studies are quite dated. There is hence a need to highlight how significant the environmental degradation costs of emissions are in comparison to those of resource extraction. The next section will discuss and elaborate on how environmental costs were estimated in this study.

3.3.1 Estimation procedures

This sub-section will explain in more detail the methodologies used in the present study for calculating environmental costs for the Indonesian context, divided into the procedures for calculating the costs of (i) environmental degradation due to emissions, (ii) destruction of ecosystems, and (iii) depletion of natural resources.

3.3.1.1 Environmental degradation due to emissions

Damage costs usually are calculated by estimating damage cost values per unit discharge of a specific pollutant, multiplied by the volume of emission discharge. The formula used to arrive at environmental degradation costs in this study is as follows:

[1]s All types of pollutants classified into local sources of pollution except for CO_2 emission.

$$ED = \sum_m \sum_n p_{mn} . uc_n \qquad (3.1)$$

Where *ED* is the environmental degradation costs resulting from the sum of environmental degradation costs by type of pollutant and by sector, p_{mn} is the volume of pollutant m produced per unit output of sector n (pollution intensity), and uc_n is the *unit cost* of pollutants m in sector n (environmental price, Rp/kg)

The environmental degradation cost calculation in this study is limited to air pollution. For calculating the environmental degradation costs related to air emissions and resource extractions by sector, two main data sets are needed:

a) The volume of air pollution emissions by type of air pollutants and by economic sector. Due to the limited availability of data from official sources in Indonesia, this study utilizes emission information from a Global Multi-regional Environmentally Extended Input-Output (GMRIO) database, EXIOBASE, which was developed by a consortium consisting of the Institute of Environmental Sciences (CML), the Netherlands Organisation for Applied Scientific Research (TNO), the Norwegian University of Science and Technology (NTNU) and other partners (Stadler et al., 2018). This consortium estimated emissions by sector for a large number of countries, using, for instance, information of the International Energy Agency (IEA) on fuel use by sector in combination with emission factors. While this information is not official, this source provides a good proxy for emission data by type of air pollutants and by economic sectors. A problem is, however, that EXIOBASE uses a different sector classification than the Indonesian system of national accounts.
b) Several studies/ publications are based on environmental prices, primarily obtained from academic institutions and NGOs in Europe (*see* table 3.1). Publications or studies on environmental damage costs of emissions in developing countries are absent or very rare. We conducted an extensive analysis of available studies on damage costs of emissions, including emissions of CO_2, Pb, PM10, and CH_4, and we reported our findings in table 3.1. We decided to base our present study mainly on damage costs as indicated in the Environmental Prices Handbook EU28 publication version CE Delft, the Netherlands (De Bruyn, S. et al., 2018). This decision was based on the consideration that in comparison with other publications, the environmental price data published by this institution are up to date and provide the most detailed data based on the type of air pollutants. This data set is also compatible with the classification of types of air pollutants in EXIOBASE. The use of this data set poses various problems, however.

For instance, the currency is different, and the data are for a different base year (2015) than the year we used in this study (2010). Finally, there may be a different valuation of the same level of damage in Europe than in Indonesia.

To solve the problems posed by using emission data given in the EXIOBASE classification and by using damage cost data that are sourced for the year 2015 in Europe and calculated in Euro, we used the following approach:

1. Align EXIOBASE and Indonesian data. We first created a correspondence between EXIOBASE and the sector classification in the Indonesia Input-Output Table (IIOT). In this study, a mapping of the two-sector classification of the dataset was carried out by making a concordance matrix. The EXIOBASE data are categorized into 163 sectors, while the 2010 IIOT distinguishes between 185 industries. By aggregating both EXIOBASE and the IIOT, both were converted into a standard classification of 86 sectors. Furthermore, EXIOBASE itemizes highly specific emission extensions, differentiating, for instance, CO_2 emissions by fuel type and other sources. We aggregated the original 417 emission extensions to 34 substances.
2. Align the base year for environmental prices (damage costs). The volume data of emissions/air pollutants from the EXIOBASE dataset are for 2010, while the available data on environmental prices are based on other years. We therefore re-priced environmental damage costs according to the year and country of origin using the GDP deflator of the OECD National Accounts Statistics.
3. Convert the 2010 environmental prices by type of air pollutant into Indonesian rupiah. The sources we used reported damage costs in Euro and $ per kg emission. For the present study, it was necessary to convert these values into rupiah/kg. We decided to apply a monetary conversion for 2010 based on Purchasing Power Parity (PPP) rather than just using the market exchange rate. For developing countries, the latter would lead to an underestimation of damage costs, since purchasing power is usually higher than an income calculated via the market exchange rate.
4. Multiply the emission volumes estimated under point 1) with the damage costs per kg calculated under point 3. The last step to calculate the environmental cost value was to multiply the amount of air pollutant discharge for each sector with the environmental price value for each type of air pollutant.

These conversion steps are shown in detail in an extensive spreadsheet added as Supplementary Information (SI). Table 3.4 shows the resulting damage costs in Rupiah (Rp)/kg per pollutant for Indonesia for 2010. The total damage costs of emissions by sector in Indonesia are discussed in section 4.

Table 3.4. Damage cost value by type of air pollutant

No	Air Pollutants	Environmental prices/kg (in Thousand Rp,2010)
1	CO_2	0.12
2	CH_4-Methane	4.33
3	N_2O	36.82
4	SO_x	61.95
5	NO_x	36.82
6	NH_3	43.54
7	CO	0.13
8	Benzo (a) pyrene	13.16
9	Benzo (b) fluoranthene	0.50
10	Benzo (k) fluoranthene	0.50
11	Indeno (1,2,3-cd) pyrene	1.53
12	PCBs-Polychlorinated biphenyls	0.04
13	PCDD_F -polychlorinated dibenzo-p-dioxin and dibenzofuran	70,78*)
14	HCB-Hexachlorobenzene	4.63
15	NMVOC	2.86
16	PM10	66.18
17	PM2.5	96.29
18	TSP	35.56
19	As-Arsenic	2,144.73
20	Cd-Cadmium	1,465.48
21	Cr-Chromium	1.24
22	Cu-Copper	9.65
23	Hg	85,813.91
24	Ni	213.23
25	Pb	13,353.53
26	Se	87.58
27	Zn	16.57
28	PAH	18.77
29	SF6	3,309.15
30	HFC-Hydrofluorocarbons	2,650.72
31	PFC-Perfluorocarbons	-
32	Nitrogen	7.74
33	Phosphorus	11.82
34	Emissions n.e.c – Waste	-

Source: Author's calculation based on various sources of the damage cost values by types of air pollutants, see supporting information. In short, data on damage costs were taken mostly from the Environmental Prices Handbook for the EU28, produced by CE Delft in 2018, and were adjusted to the Indonesian context. For other types of air pollutants, we used values from other sources. The value for CO_2 was taken from the US EP, the value for PCDD_F was taken from EEA publication (EEA, 2014), and the values for TSP, Se and HFC were taken from the Eco-cost 2007 LCA data, the only source providing them. Data for PAH were taken from the EPS Impact Assessment Method dataset of the Swedish Life Cycle Center.
Notes: *) in Billion rupiah

3.3.1.2 Value loss of ecosystems

To estimate the value of ecosystems, or more particularly in this study, of forest resources, we covered two primary sources of destruction: (i) Net depletion of renewable resources (timber resources), often referred to as "excess felling" and defined as the volume of wood produced that exceeds its natural growth. (ii) The loss of ecosystem services from tropical forests due to deforestation.

To compute (i), the net depletion of timber resources, we use the main sources available in Indonesia on physical forest accounts published by the BPS, which cover two types of timber: teak wood and deep forest roundwood.

The stocks (both opening and closing stocks) of timber resources are the stocks of products assessed at a certain period. Additions to the stocks of this type of resources include both plantation and natural growth, whereas the decrease in stocks of these assets covers damages and harvesting or production. We assume that log values destructed by fires constitute a part of destroyed forests.

In constructing the monetary account for timber resources, a unit rent has to be estimated. Data of the physical account is then multiplied by its unit rent to arrive at a monetary account for forest resources.

$$D^R = \sum_j s_j (h_j - g_j) \qquad (3.2)$$

Where DR is depletion/depreciation of renewable natural resources; sj is unit rent of renewable natural resources j; hj is the quantity of a renewable natural resource j, and gj is the natural growth of that renewable resource j.

Equation (3.2) shows how to calculate the depletion or depreciation value of renewable natural resources. Based on this equation, rather than multiplying the unit rent by the number of resources obtained, the authors of this study considered it better to multiply the unit rent by the net depletion or the quantity of the resource obtained (hj) minus its natural growth (gj).

To calculate (ii) the loss of ecosystem service value of tropical forests, we multiplied the area of primary forest cover loss (ha) with the unit values of ecosystem services from tropical forests. Due to the limited availability of data from official sources, we utilized data for primary forest cover loss for 2010 from Margono et al. (2014). The estimated value per ha of ecosystem services from tropical forests was taken from Costanza et al. (2014). Since the unit value data is only available for 1997 and 2011, with values in int.$/ha/year in 2007 constant prices, we converted the data in the following steps: we first converted the unit value $2007/ha/year into unit value $2010/ha/year using the US CPI data. Next, we calculated the loss of value of ecosystem services of tropical forests by multiplying the unit value with the number of ha of forest cover loss. We finally converted the value into Indonesian rupiah using the PPP. The SI shows these calculation steps in detail.

3.3.1.3 Depletion of natural resources

This study estimated the value of non-renewable resources depletion for the essential mineral and energy resources in the Indonesian economy, i.e., crude oil, natural gas, bauxite, tin, coal, nickel ore, gold, and silver, in terms of monetary accounts, based on a physical accounts dataset from the BPS publication on SISNERLING. After considering and comparing the strengths and limitations of each of the natural resource depletion measurement methods in section 2, we decided to use the NPV approach to assess the costs of resource depletion for non-renewable resources. The use of this approach is also recommended by the SEEA-CF 2012 (United Nations, 2014).

The formula used to estimate the depletion/depreciation of non-renewable natural resources in this study is as follows:

$$D^{NR} = \sum_i r_i q_i \quad (3.3)$$

Where DNR is depletion/depreciation of non-renewable or exhaustible natural resources; i is the type of non-renewable natural resources; ri is the unit rent (or value) of non-renewable natural resources type i, and qi is the extracted quantity of non-renewable natural resources type i.

Data on the extracted quantity of each of these natural resources (qi) was obtained from the publication "Statistics of Oil and Gas Mining" and "Statistics of Non-Oil and Gas Mining" published by the BPS. For each resource, the unit rent (ri) is estimated by subtracting the extraction costs per unit from the price.

3.4 Findings on environmental cost calculation for Indonesia

3.4.1 Total environmental costs

The environmental costs estimated in this study consist of two main components, i.e. (1) environmental degradation caused by air pollution; (2) natural resource depletion. Using the approach explained in the earlier sections, we estimated the total environmental costs at Rp. 915,11 trillion, broken down into Rp 348,35 trillion (38.07%) due to environmental degradation by air pollution, Rp 61.43 trillion (6.71%) due to the depletion of renewable resources (split up into Rp. 33.09 trillion for the value of excess felling of wood, and Rp 28.35 trillion for the loss of ecosystem service value) and Rp 505.33 trillion (55.22%) due to non-renewable resource depletion, see table 3.5.

Table 3.5. Breakdown of environmental costs by type of natural assets (Rp trillion)

Components	Environmental Costs (Rp trillion)	Percentage
1. Environmental degradation costs (air	**348.35**	**38.07**
2. Destruction of Ecosystem (forest)	**61.43**	**6.71**
- Net depletion/excess felling of wood	33.09	3.62
-Loss of eco-services Value of tropical	28.35	3.10
3. Non-renewable resources (Energy and	**505.33**	**55.22**
Environmental costs	**915.11**	**100.00**

Source: Author's calculation

Table 3.5 shows that the principal source of imputed environmental costs in Indonesia were energy and mineral resource depletion, for which the BPS already has good statistics. However, the table and figure also illustrate the major contribution of environmental degradation costs from air pollutants, for which the BPS has less elaborated statistics.

Table 3.6 shows the top 10 sectors with the highest Total Environmental Cost /Value-Added Ratio in Indonesia in 2010. The table shows that eight sectors have total environmental costs that are larger than their value-added (VA): Waste management and recycling; Other livestocks; Fertilizer; Sea and coastal water transport; Manufacture of basic iron and steel and of ferro-alloys and first products thereof; Mining of coal and lignite; extraction of peat; Extraction of crude petroleum and services related to crude oil extraction, excluding surveying; Inland water transport. The fact that total environmental costs exceed value-added implies that if the national accounts included the external costs of air pollution and the depletion of natural resources, these sectors would create a negative value- added.

Table 3.6. Top 10 sectors with total environmental cost (TEC) / value-added (VA) ratio

No	Sector	Total Environmental Costs (Rp. trillion)	Value-Added	TEC/VA
1	Waste management and recycling	0.26	0.08	3.17
2	Other livestocks (meat nec)	2.94	1.62	1.82
3	Fertilizer	13.75	7.77	1.77
4	Sea and coastal water transport	29.00	18.93	1.53
5	Manufacture of basic iron and steel and of ferro-alloys and first products thereof	35.85	28.81	1.24
6	Mining of coal and lignite; extraction of peat	185.10	156.02	1.19
7	Extraction of crude petroleum and services related to crude oil extraction, excluding surveying	196.20	177.46	1.11
8	Inland water transport	7.29	6.70	1.09
9	Cultivation of sugar cane, sugar beet	5.71	5.86	0.97
10	Manufacture of cement, lime and plaster	17.85	18.52	0.96
	Other sectors	**421.17**	**6,261.92**	**0.07**
	Total	**915.11**	**6,683.68**	**0.14**

Source: Authors calculation

Estimating environmental costs allows us to make adjustments to the GDP. Such an adjusted GDP is commonly known as "Eco-Domestic Product" (EDP), where EDP is defined as a GDP that includes elements of degradation of natural resources and the environment (Li and Lang, 2010). Subtracting the value of the environmental costs from Net Domestic Product (NDP) yielded an EDP of Rp. 4,678.54 trillion. The environmental costs constituted 16.36% of the Net Domestic Product or 13.33% of the Gross Domestic Product, see figure 3.2.

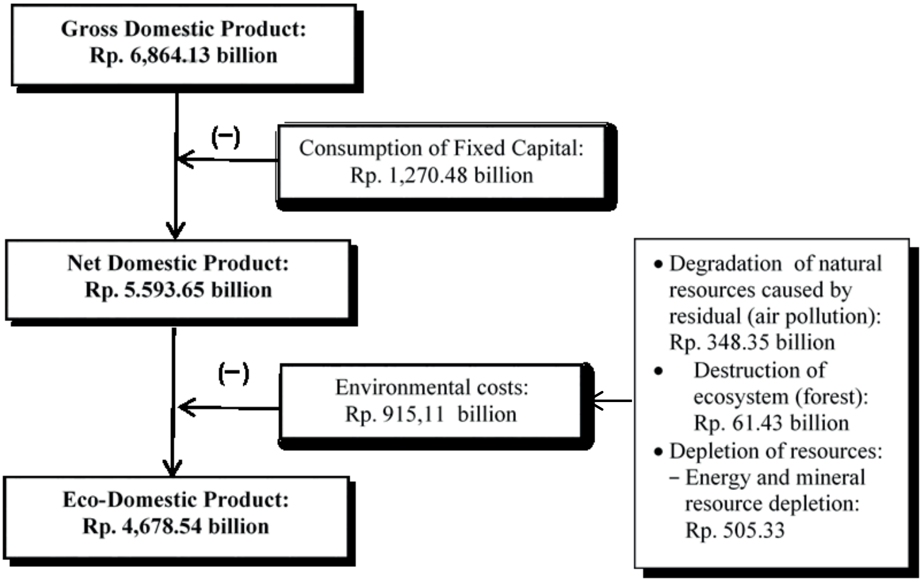


Figure 3.2. The 2010 Indonesian Eco Domestic Product
Source: Author's Calculations

3.4.2 Environmental degradation cost by type of air pollutant

As indicated, environmental damage costs due to air emissions are an important part of the total damage costs in Indonesia. In Table 3.7 and 3.8, we present the value of environmental degradation cost by sector and by type of air pollutant. The profile helps to identify the sectors and pollutants with the highest value in environmental degradation costs, which can be considered a priority for inventorying improved data on emissions for the Indonesian situation. Such data also will allow calculating a more accurate Green GDP by, for instance, identifying the priority sectors whose data must be obtained by the BPS or related official institutions, such as the ministry of the environment and forestry.

As was already shown in Table 3.5, the total environmental costs related to air emissions in 2010 for Indonesia were about 348.35 trillion rupiahs or 5.07% of the total GDP. Table 3.7 shows the ten sectors with the highest environmental degradation cost value in Indonesia. Based on table 3.7, these ten sectors contributed about 73.11% of Indonesia's total environmental degradation costs in 2010. The electricity sector was the sector with the highest costs of environmental degradation in the economy: about 47.86 trillion rupiah's, or 13.74% of the total value of environmental degradation costs.

The following priorities are the manufacture of basic iron and steel and of ferro-alloys and first products thereof, including re-processing of secondary steel into new steel (10.39%); mining of coal and lignite and extraction of peat (8.33%); Sea and coastal water transport (8.32%); Cultivation of paddy rice (7.38%). The remaining five of the ten highest contributors were accountable for 25.23% of the total environmental degradation costs in Indonesia for 2010.

Table 3.7. Ten highest environmental degradation costs values by sectors

No	Sector	Environmental Degradation Cost (Rp trillion)	Percentage
1	Electricity	47.86	13.74
2	Manufacture of basic iron and steel and ferro-alloys and first products thereof & Re-processing of secondary steel into new steel	35.85	10.29
3	Mining of coal and lignite; extraction of peat	29.02	8.33
4	Sea and coastal water transport	29	8.32
5	Cultivation of paddy rice	25.72	7.38
6	Manufacture of rubber and plastic products	24.49	7.03
7	Livestock and their results	18.43	5.29
8	Manufacture of cement, lime, and plaster	17.85	5.12
9	Fertilizer	13.75	3.95
10	Construction	12.7	3.65
	Other sectors	93.69	26.89
	Total	348.35	100%

Source: Author's calculation (see appendix for detailed results)

Looking at pollutants, the ten types of air pollutants with the highest costs of environmental degradation in Indonesia are accountable for 326.41 trillion rupiahs or 93.70% of the total environmental degradation cost value (table 3.8). SOx has the highest environmental degradation cost of about 74.56 trillion rupiahs or 21.40% of the total environmental degradation cost value, followed by NOx (16.44%), CO_2 (13.60%), andCH4 (10.41%).

Table 3.8. Ten air pollutants with the highest environmental degradation costs values

No	Pollutants	Environmental Degradation Costs (Rp trillion)	Percentage
1	SO_X	74.56	21.40
2	NO_X	57.27	16.44
3	CO_2	47.39	13.60
4	CH_4	36.28	10.41
5	NH_3	30.50	8.75
6	TSP	20.69	5.94
7	Pb	18.03	5.18
8	PM10	17.01	4.88
9	PM2.5	14.86	4.27
10	Nitrogen	9.83	2.82
	Other pollutants	**21.94**	**6.30**
	Total	**348.35**	**100%**

Source: Author's calculation (see appendix 3 for detailed results)

Table 3.9 and 3.10 show a matrix of the top 10 sectors and pollutants in terms of environmental degradation cost value. The ten sectors and the ten types of pollutants are the sectors and types of pollutants that must be prioritized, both in terms of data availability, as well as in terms of industrial policy-making in the context of sustainable development. The ten sectors are as follows: Electricity; Sea and coastal water transport; Manufacture of rubber and plastic products; Pulp & Paper; Mining of coal and lignite; Extraction of peat; Manufacture of cement, lime and plaster; Other non-ferrous metal production; Petroleum Refinery; Manufacture of basic iron and steel and of ferro-alloys and first products thereof & Re-processing of secondary steel into new steel; and Chemical. The ten pollutants are SO_x, NO_x, CO_2, CH_4, NH_3, TSP, Pb, PM10, PM2.5, and Nitrogen.

Table 3.9. Matrix of the top 10 sectors and pollutants contributing to environmental degradation costs in Indonesia (Rp trillion)

No.	Sectors/Pollutants	SOx	NOx	CO_2	CH_4	NH_3	TSP	Pb	PM10	PM2.5	Nitrogen	Total*)
1	Electricity	21,119	5,874	11,458	46	6	4,135	251	2,948	1,579	-	**47,416**
2	Manufacture of basic iron and steel and of ferro-alloys and first products thereof & Re-processing of secondary steel into new steel	3,132	1,447	416	4	1	7,455	16,806	2,781	2,461	-	**34,503**
3	Mining of coal and lignite; extraction of peat	6,583	1,605	3,096	11,398	0	2,896	116	2,247	869	-	**28,810**
4	Sea and coastal water transport	8,343	8,352	1,749	6	15	667	11	1,209	1,662	-	**22,014**
5	Cultivation of paddy rice	5	102	14	16,849	5,628	6	-	11	15	2,491	**25,120**
6	Manufacture of rubber and plastic products	8,333	4,135	7,247	57	17	1,872	342	1,429	817	-	**24,250**
7	Livestock and their results	43	2,742	113	3,952	9,458	50	0	89	122	344	**16,914**
8	Manufacture of cement, lime and plaster	4,741	2,970	3,666	1	1	1,743	127	2,276	2,258	-	**17,783**
9	Fertilizer	527	3,919	201	4	2,423	21	1	38	47	2,108	**9,289**
10	Construction	126	5,934	4,602	18	178	1	53	590	724	-	**12,229**
	Other sectors	**21,604**	**20,186**	**14,828**	**3,943**	**12,770**	**1,844**	**328**	**3,389**	**4,304**	**4,886**	**88,082**
	Total *	**74,556**	**57,266**	**47,391**	**36,278**	**30,496**	**20,693**	**18,034**	**17,007**	**14,859**	**9,830**	**326,409**

Source: Author's calculation

Notes:

*) Total value of top 10 sectors

Colour	Range
(red)	>10,000
(orange)	3,000-9,999
(yellow)	346-2,999
(green)	<346

Table 3.10. Matrix of the top 10 sectors and pollutants contributing to environmental degradation costs in Indonesia (%)*

	Sectors/Pollutants	SOx	NOx	CO_2	CH4	NH3	TSP	Pb	PM10	PM2.5	Nitrogen	Total
1	Electricity	6.06	1.69	3.29	0.01	0.00	1.19	0.07	0.85	0.45	-	13.61
2	Manufacture of basic iron and steel and of ferro-alloys and first products thereof & Re-processing of secondary steel into new steel	0.90	0.42	0.12	0.00	0.00	2.14	4.82	0.80	0.71	-	9.90
3	Mining of coal and lignite; extraction of peat	1.89	0.46	0.89	3.27	0.00	0.83	0.03	0.64	0.25	-	8.27
4	Sea and coastal water transport	2.39	2.40	0.50	0.00	0.00	0.19	0.00	0.35	0.48	-	6.32
5	Cultivation of paddy rice	0.00	0.03	0.00	4.84	1.62	0.00	-	0.00	0.00	0.71	7.21
6	Manufacture of rubber and plastic products	2.39	1.19	2.08	0.02	0.00	0.54	0.10	0.41	0.23	-	6.96
7	Livestock and their results	0.01	0.79	0.03	1.13	2.72	0.01	0.00	0.03	0.04	0.10	4.86
8	Manufacture of cement, lime and plaster	1.36	0.85	1.05	0.00	0.00	0.50	0.04	0.65	0.65	-	5.10
9	Unspecified activities	0.15	1.13	0.06	0.00	0.70	0.01	0.00	0.01	0.01	0.61	2.67
10	Construction	0.04	1.70	1.32	0.01	0.05	0.00	0.02	0.17	0.21	-	3.51
	Other sector	6.20	5.79	4.26	1.13	3.67	0.53	0.09	0.97	1.24	1.40	**25.29**
	Total	15.20	10.64	9.35	9.28	5.09	5.41	5.08	3.91	3.03	1.42	**68.42**

Source: Author's calculation

Notes:

*) Percentage value to total emission in the economy

**) Total of top 10 sectors

Colour	Range
(red)	>4%
(orange)	1%-3.9%
(yellow)	< 1%
(green)	<0.09%

3.4.3 Loss of ecosystem services from deforestation

The environmental costs of the extraction of forest resources and the related ecosystem depletion consist of excess felling of timber above its natural growth, forests damage and conversions, but also include the loss of eco-services of forests due to economic activities[2]. In Indonesia, many economic activities involve the conversion of forest areas to commercial areas, such as estates and transmigration areas. Also, there is a large amount of forest damage due to both human activities and natural causes. This forest damage and the effects of conversion should not be neglected in estimating the environmental costs since they contribute to the reduction of forest products in the future. Table 3.11 provides an overview of the estimated results of the net depletion (excess felling) of timber resources. The value of environmental costs is equal to Rp. 61.43 trillion, almost half of which, Rp. 33.09 trillion, is due to net depletion (excess felling) of forest resources, calculated as growth minus felling, conversion, and damages. Meanwhile, the value of destruction of the ecosystem due to the loss of eco-services of tropical forests amounted to Rp. 28.35 trillion (calculation details provided in supplementary information).

Table 3.11. Environmental cost from the depletion of forest resources, 2010

1. Net depletion (excess felling)			
Description	Teak wood	Deep forest roundwood on Java	Deep forest roundwood outside Java
Growth (000 M3)*	4,779.74	16,669.30	26,957.10
Conversion and	440.80	385.30	248,573.60
Felling ((000 M3)	450.03	439.40	53,550.90
Excess felling ((000	-3,888.91	-15,844.60	275,167.40
Unit rent Rp/cubic	190,137.50	13,381.80	120,237.70
Excess felling in (Rp	-0.74	-0.21	33.09
2. Loss of Eco-services Value			
Unit value $2010/ha/year			5,568.45
Forest cover loss (ha)			560,000.00
Loss of eco-services Value from the tropical forest ($ million)			3,118.33
Loss of eco-services Value from the tropical forest (Rp trilion)			28.35
Environmental Cost from depletion of Forest Resources (1+2) (Rp			61.43

Source: Author's calculation
Notes : *) Thousand cubic meters

Most of the destruction resulted from forest fires, either caused by humans or

[2] excess felling also known as depletion of forest resources

by nature. Human-caused forest damage is the result of shifting cultivation practices, logging damage, or land clearing. Some of the forest fires were exacerbated by nature (wind, dry temperature, etc.). In this case, it was not possible to obtain a more detailed account of forest damage due to each of these causes.

3.4.4 Depletion of natural resources

This study covers the depletion of non-renewable resources such as minerals and energy carriers. Table 3.12 shows the depletion value from energy and mineral resources: the depletion value from oil resources amounts to Rp. 190.40 trillion, the depletion value from natural gas is about Rp. 125.84 trillion, and coal depletion is equal to Rp. 156.09 trillion. Moreover, the depletion value from bauxite is equal to Rp. 1.36 trillion, followed by tin (Rp.5,01 trillion), gold (Rp. 25.30 trillion), silver (about Rp. 0.97 trillion), and nickel ore (Rp. 0.36 trillion). Environmental costs due to the depletion of energy and mineral resources in 2010 amounted to Rp 505.33 trillion. The largest contributors to the high value of environmental costs from the depletion of energy and mineral resources are oil, natural gas, and coal, which together contribute around 93% (see table 3.12).

Table 3.12. Depletion of energy and mineral resources, 2010

Energy and Mineral Resources	Depletion (Rp trillion)	Percentage (%)
Oil	190.40	37.68
Natural Gas	125.84	24.9
Coal	156.09	30.89
Bauxite	1.36	0.27
Tin	5.01	0.99
Gold	25.30	5.01
Silver	0.97	0.19
Nickel Ore	0.36	0.07
Total	505.33	100%

Source: Author’s calculation

3.5 Conclusions

This chapter reports on an initial effort to assess environmental costs for the purpose of priority setting and as an instrument for assimilating the most relevant environmental aspects into a framework of sustainable socio-economic development. Moreover, compared to other studies on environmental costs in Indonesia, our research provides the most detailed coverage of emissions type data for each economic sector. This study will be beneficial in supplementing Indonesia's existing Environmental-Economic Accounts, as official publications of the BPS Indonesia are still limited to measuring depreciation of natural resources, without including measurements of environmental costs due to environmental degradation.

In order to answer the research questions, two main conclusions can be drawn from our analysis of the environmental costs in Indonesia. Firstly, the environmental costs of environmental degradation, destruction of the ecosystem, and depletion of natural resources in Indonesia for 2010 amounted to Rp. 915.11 trillion, constituting 16.36% of the Net Domestic Product (NDP) or 13,33% of the conventional Gross Domestic Product (GDP). These results do not differ much from the results found in earlier studies, see Table 3.3.

Second, the environmental cost calculation indicates that natural resources are essential in the context of Indonesia's sustainable development. The environmental cost structure shows that the largest contributor to Indonesia's total environmental cost value is the depletion of natural resources from non-renewable resources (mineral and energy resources), which constitutes around 55.22% of the total environmental costs. The second contributor to Indonesia's environmental costs, amounting to 38.07%, is the cost of environmental degradation, which in this study was only from air pollution. In third place, the destruction of the ecosystem contributes to 6.71% of Indonesia's total value of environmental cost.

Based on the calculation results, it can be concluded that the BPS is on the right track by prioritizing the compilation and publication of the economic-environmental account, which includes regular energy, mineral, and forest resources accounts. However, the BPS publication on the forest resources account is still limited to timber resources. The BPS should consider a complete compilation and publication of this forest account, besides including the costs of loss of ecosystem services.

Third, we found that the value of environmental cost due to air pollution also constitutes a significant contribution to the total environmental costs value, as it is the second largest contributor to the total environmental costs value after non-renewable resources depletion. The cost of environmental degradation from air pollution alone, excluding water and waste pollution, amounts to Rp. 348.35 trillion or 38.07% of the total value of environmental costs, and to around 6.23% of the total NDP.

The BPS has not yet compiled and published a comprehensive economic-environmental account that includes the environmental costs due to environmental degradation. If the BPS plans to expand the scope of Indonesia's economic-environmental accounts by including data on environmental degradation costs due to air pollution, we recommend to prioritize at least the top ten sectors and polluters in terms of the amount of environmental degradation costs they generate in Indonesia. The ten sectors contributing the most to the costs of environmental degradation related to air pollution in Indonesia accounted for around 73.11%. These ten sectors comprise electricity; manufacture of basic iron and steel and of ferro-alloys and first products thereof & re-processing of secondary steel into new steel; mining of coal, lignite, and extraction of peat; sea and coastal water transport; cultivation of paddy rice; manufacture of rubber and plastic products; livestock and their result; manufacture of cement, lime, and plaster; fertilizer and construction. The ten most prominent air pollutants that together generate 93.70% of the cost of environmental degradation from air pollution are SO_X, NO_X, CO_2, CH_4, NH_3, TSP, PB, PM10, PM2.5 and Nitrogen.

This study's results can be used as a guide for policymakers in formulating environmentally sound economic development policies. However, there certainly is a need for a follow-up study aiming to overcome the limitations and weaknesses of this study, including those of the methods used in this study, but yet able to keep the technique simple, which is especially important for developing countries like Indonesia.

Acknowledgments
This research was funded by the Lembaga Pengelola Dana Pendidikan (LPDP), grant number PRJ-1461/LPDP.3/2016, Ministry of Finance, Republic of Indonesia. It is part of the first author's PhD scholarship at the Institute of Environmental Sciences (CML), Faculty of Science, Leiden University, Netherlands.

3.6 Appendix

This appendix contains the supporting information for this case study and includes details on the modelled processes, supporting calculations.

Table 3.13. Environmental degradation cost value by sector

No	Sector	Environmental Degradation Cost (Rp trillion)	Percentage
1	Cultivation of paddy rice		7.38
2	Cultivation of cereal grains n.e.c.	2.62	0.75
3	Cultivation of vegetables, fruit, nuts	9.03	2.59
4	Cultivation of oil seeds	8.26	2.37
5	Cultivation of sugar cane, sugar beet	0.33	0.10
6	Cultivation of plant-based fibers & Crop n.e.c.	5.71	1.64
7	Livestock and their results	18.43	5.29
8	Meat animals n.e.c.	2.94	0.84
9	Animal products including Wool, silk-worm cocoons n.e.c.	0.93	0.27
10	Raw milk	0.74	0.21
11	Forestry, logging and related service activities	0.02	0.01
12	Fishing, operating of fish hatcheries and fish farms; service activities incidental to fishing	0.01	0.00
13	Mining of coal and lignite; extraction of peat	29.02	8.33
14	Extraction of crude petroleum and services related to crude oil extraction, excluding surveying	5.80	1.67
15	Extraction of natural gas and services related to natural gas extraction, excluding surveying	2.64	0.76
16	Mining of iron ores	0.18	0.05
17	Mining of copper ores and concentrates	0.10	0.03
18	Mining of nickel ores and concentrates	0.05	0.01
19	Mining of aluminium ores and concentrates	0.01	0.00
20	Mining of precious metal ores and concentrates	0.00	0.00
21	Mining of lead, zinc and tin ores & other non-ferrous metal ores and concentrates	0.22	0.06
22	Mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c.	1.75	0.50
23	Production of meat products n.e.c.	0.03	0.01
24	Processing vegetable oils and fats	0.02	0.01
25	Processing of dairy products	0.00	0.00
26	Processed rice	0.07	0.02
27	Sugar refining	0.11	0.03
28	Processing of Food products n.e.c.	0.20	0.06
29	Manufacture of beverages	0.02	0.01
30	Manufacture of fish products	0.18	0.05
31	Manufacture of tobacco products	0.37	0.11
32	Manufacture of textiles	1.06	0.30
33	Manufacture of wearing apparel; dressing and dyeing of fur	0.32	0.09

34	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	0.11	0.03
35	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials including Re-processing of secondary wood material into new wood material	0.10	0.03
36	Pulp & Paper	9.90	2.84
37	Publishing, printing and reproduction of recorded media	0.02	0.01
38	Petroleum Refinery	6.47	1.86
39	Plastics, basic	0.61	0.18
40	N-fertiliser	13.75	3.95
41	Chemicals n.e.c.	3.37	0.97
42	Manufacture of rubber and plastic products	24.49	7.03
43	Manufacture of glass and glass products	0.38	0.11
44	Manufacture of ceramic goods, including bricks, tiles and construction products, in baked clay	0.55	0.16
45	Manufacture of cement, lime and plaster	17.85	5.12
46	Manufacture of other non-metallic mineral products n.e.c.	4.65	1.33
47	Manufacture of basic iron and steel and of ferro-alloys and first products thereof & Re-processing of secondary steel into new steel	35.85	10.29
48	Precious metals production	0.00	0.00
49	Casting of metals	0.02	0.01
50	Manufacture of fabricated metal products, except machinery and equipment	0.11	0.03
51	Manufacture of machinery and equipment n.e.c.	0.03	0.01
52	Manufacture of office machinery and computers	0.01	0.00
53	Manufacture of electrical machinery and apparatus n.e.c.	0.02	0.01
54	Manufacture of radio, television and communication equipment and apparatus	0.23	0.07
55	Manufacture of medical, precision and optical instruments, watches and clocks	1.26	0.36
56	Manufacture of motor vehicles, trailers and semi-trailers	0.06	0.02
57	Manufacture of other transport equipment	0.06	0.02
58	Manufacture of furniture; manufacturing n.e.c.	2.24	0.64
59	Electricity	47.86	13.74
60	Manufacture of gas; distribution of gaseous fuels through mains	0.00	0.00
61	Collection, purification and distribution of water	0.00	0.00
62	Construction	12.70	3.65
63	Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessoiries	0.00	0.00
64	Wholesale trade and commission trade, automotive fuel except of motor vehicles and motorcycles	1.65	0.47
65	Hotels and restaurants	0.06	0.02
66	Transport via railways	0.13	0.04
67	Other land transport	3.01	0.86
68	Sea and coastal water transport	29.00	8.32
69	Inland water transport	7.29	2.09
70	Air transport	3.18	0.91
71	Supporting and auxiliary transport activities; activities of	0.75	0.21

	travel agencies		
72	Post and telecommunications	0.69	0.20
73	Financial intermediation, except insurance and pension funding	0.11	0.03
74	Insurance and pension funding, except compulsory social security	0.21	0.06
75	Activities auxiliary to financial intermediation	0.04	0.01
76	Real estate activities	0.03	0.01
77	Renting of machinery and equipment without operator and of personal and household goods	0.02	0.01
78	Computer and related activities	0.04	0.01
79	Research and development	0.03	0.01
80	Other service activities	0.21	0.06
81	Public administration and defence; compulsory social security	0.05	0.01
82	Education	1.38	0.40
83	Health and social work	0.54	0.15
84	Waste water treatment	0.26	0.07
85	Recreational, cultural and sporting activities	0.09	0.03
86	Private households with employed persons	0.02	0.01
	Total	**348.35**	**100.00**

Source: Author's calculation

Table 3.14. Environmental degradation cost value by type of air pollutant (Rp trillion)

No	Pollutants	Value	Percentage
1	CO_2	47.39	13.60
2	CH4	36.28	10.41
3	N_2O	3.75	1.08
4	Sox	74.56	21.40
5	NOx	57.27	16.44
6	NH_3	30.50	8.75
7	CO	0.34	0.10
8	Benzo(a)pyrene	0.00	0.00
9	Benzo(b)fluoranthene	0.00	0.00
10	Benzo(k)fluoranthene	0.00	0.00
11	Indeno(1,2,3-cd)pyrene	0.00	0.00
12	PCBs	0.00	0.00
13	PCDD_F	0.03	0.01
14	HCB	0.00	0.00
15	NMVOC	2.24	0.64
16	PM10	17.01	4.88
17	PM2.5	14.86	4.27
18	TSP	20.69	5.94
19	As	2.82	0.81
20	Cd	0.14	0.04
21	Cr	0.00	0.00
22	Cu	0.01	0.00
23	Hg	6.13	1.76
24	Ni	0.05	0.01
25	Pb	18.03	5.18
26	Se	0.01	0.00
27	Zn	0.01	0.00
28	PAH	0.03	0.01
29	SF6	0.14	0.04
30	HFC	-	-
31	PFC	-	-
32	Nitrogen	9.83	2.82
33	Phosphorus	6.24	1.79
34	Emissions n.e.c. - Waste	-	-

Source: Author’s calculation

Chapter 4

Environmental Cost in Indonesia Spillover Effect between Consumption and Production

Abstract

Reducing environmental costs is a significant concern for Indonesia's future. This paper explores Indonesia's environmental costs from emissions and forest resources and identifies the priority sectors in terms of economic and environmental performance. We use environmentally extended input-output analysis for calculating the environmental costs and further extension with linkages analysis to identify the priority sectors. The study finds that the total environmental costs of emissions due to final demand is around 7 % of GDP. This environmental cost is significantly due to domestic products, with household consumption being the largest contributor. The top ten sectors in the Indonesian economy are responsible for about 70% of the total environmental costs of emissions. Based on pollutants source, SOx, NOx, CO_2, and CH4 contribute more than half of emissions' environmental costs. We also find that forest resources' environmental cost is only 7.5% of the total environmental cost. Lastly, this study finds that key sectors of economic and sustainability points of view are textile manufacturing; publishing, printing, and reproduction of recorded media; chemicals n.e.c; manufacture of other non-metallic mineral products; Construction; other land transport. Finally, this paper discusses the policy options for Indonesia to promote sustainable consumption and production in terms of reducing environmental costs while managing economic development.

Published as Pirmana, V., Alisjahbana, A. S., Yusuf, A. A., Hoekstra, R., & Tukker, A. (2021) Environmental Cost in Indonesia. Spillover Effect between Consumption and Production. Frontiers in Sustainability, 73.

4.1 Introduction

Environmental issues, for the first time, began to garner global attention at the Stockholm United Nations Conference on the Environment in Sweden in 1972. The conference, known as the Stockholm Conference, is the first international conference to discuss the environment as a major issue in response to various cases of environmental damage that are increasingly widespread and threatening the life of the world. Furthermore, in 1987, the World Commission on Environment and Development submitted its report titled “Our Common Future,” also known as the Brundtland report, which became a milestone for the concept of sustainable development (Borowy, 2014).

Since the publication, the concept of sustainable development has become a popular discourse. Attention at the world level toward sustainable development continues to increase, most recently with the UN Sustainable Development Summit in September 2015 in New York in the United States. At that conference, all the countries jointly adopted the new development agenda “Transforming Our World: the 2030 Agenda for Sustainable Development,” better known as sustainable development goals (SDGs), which include 17 goals with a total of 241 achievement indicators. Of the 17 goals, one of the SDGs is the 12th goal, namely, responsible consumption and production. Goal 12 implies that all parties should endeavor, for example, not to use hazardous materials in consumption and production activities. Goal 12 can provide an example of how the interests of all countries are represented in the SDGs. The existence of international regulations and bilateral agreements that prohibit using specific materials in export and import activities is one concrete example. Therefore, many development goals in the SDGs should be interpreted as a shared global vision that represents the interests of all parties, including Indonesia (Alisjahbana et al., 2018).

Wackernagel and Beyers (2019) group Indonesia into countries experiencing bio-deficit conditions, i.e., having an ecological footprint1 exceeding its bio-capacity. As shown in Figure 4.1, Indonesia's bio-capacity decreases over time, and the ecological footprint tends to increase. Based on data for 2016 from the Global Footprint Network, the percentage of ecological footprint exceeding bio-capacity deficit reaches 32% or around 0.4 gha per capita. Today, Indonesia is one of the top 10 countries with the highest ecological footprint in the world along with China, India, the United States, Russia, Brazil, Japan, Germany, Mexico, and the United Kingdom (Pata et al., 2021).

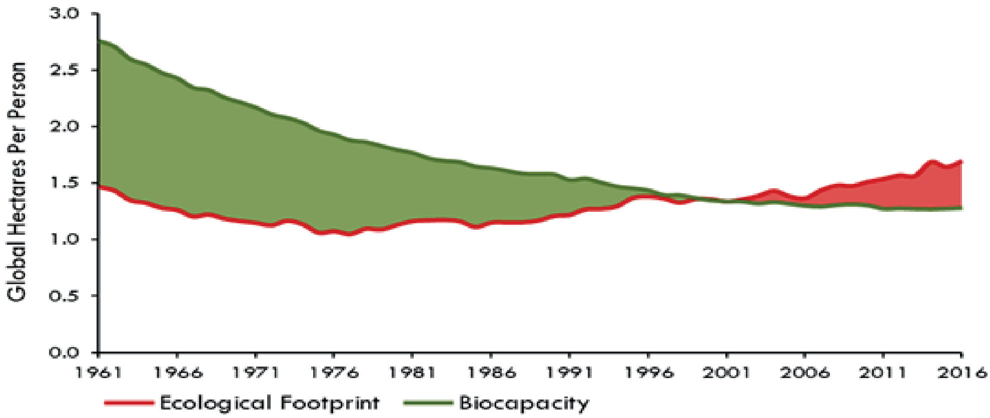


Figure 4.1. Ecological footprint and Bio Capacity Trend in Indonesia
Source: Global Footprint Network, 2019, https://www.footprintnetwork.org/licenses/public-data-package-free/

Numerous studies analyze factors affecting environmental deterioration due to increasing human activities. Danish et al. (2020) indicate that trends in economic progress accelerate the consumption and extraction of natural resources while increasing the ecological footprint. Hassan et al. (2018) underline that economic growth increases the need for natural resource use, which leads to environmental degradation in Pakistan. Other studies (e.g., Galli et al., 2012; Bello et al., 2018; Zall'e, 2018; Hanif et al., 2019; Pata, 2020) indicate similar results that environmental degradation might increase due to economic expansion. However, if sustainable development management practices are applied, the rate of resource depletion decreases, and resources are allowed to regenerate (Pata et al., 2021).

One option to reduce pressure related to environmental degradation and resource use is adjusting consumption patterns and shifting production toward more environmentally friendly sectors and technologies. According to Wiedmann et al. (2007), Watson et al. (2013), Peters et al. (2016), Tukker and Vivanco (2018), and Wiedmann and Lenzen (2018), environmental impacts from the economic system can be viewed from two complementary perspectives: production and consumption. The production perspective considers the direct environmental pressures caused by economic activities in a country. The consumption perspective focuses on the indirect environmental pressures driven along value chains by a country's final demand.

In the past decades, various studies discuss the environmental impact of both perspectives of production and consumption; see for instance Haas et al. (2005), Tukker et al. (2006), Tukker and Jansen (2006), Weisz and Schandl (2008), United Nations Environment Programme (2010, 2015), Jungbluth et al. (2011), Kitzes et al. (2007), Akenji and Bengtsson (2014), Ivanova et al. (2016), and Castellani et al. (2019).

This study aims to provide a comprehensive analysis of Indonesia's environmental costs. This study also tries to identify key sectors where economic and environmental performance are considered. Specifically, this study aims to answer the following questions: (i) How much are the environmental costs for each final demand component? (ii) How much is the ratio of environmental costs to value added by the economic sector? (iii) Which sectors and emissions are most responsible for pressures driven by final demand? (iv) How much is the value of environmental costs embodied in import due to final demand? (v) What are the economic sectors that perform best when both economic performance and environmental costs are considered simultaneously?

In answering these questions, we use the input–output (IO) analysis approach. This approach can link, in a comprehensive way, how consumption via value chains drives production and, in
turn, emissions, resource use, and related external environmental costs or so-called "external cost" (Miller and Blair, 2009; United Nations Environment Programme, 2010, 2015; Jungbluth et al., 2011; Akenji and Bengtsson, 2014).

This study is structured as follows—section 2 reviews (environmentally extended) IO studies for Indonesia and related environmental cost accounts. Section 3 describes in more detail the methodology used in this study to answer the research questions. Section 4 provides the results. Section 5 ends with the conclusion and policy considerations.

4.2 Input output tables and environmental cost accounting for Indonesia

Indonesia's Central Bureau of Statistics has published IO tables for various years between 1971 and 2010 (see Appendix Table 4.8). In this study, we use the latest published IO table, the Indonesian IO table 2010. We realize that this IO database seems to be outdated; we decided to use this database with the following considerations:

(i) In analyzing the economic and environmental impacts from the production and consumption perspectives in detail, theory and empirical studies suggest using life cycle analysis or IO models.

(ii) The IO can be expanded to EE IO. IO tables, to our knowledge, contain comprehensive and detailed data not found in other databases, such as economic structure, sectoral added value, distribution of goods and services, and sectoral export-import structure.

(iii) During the 2010–2020 period, the sectoral contribution to the economy in Indonesia remained unchanged, and it is still dominated by three sectors: manufacturing; agriculture, fishery, and forestry; and wholesale and retail trade, car and motorcycle repair.

Based on these considerations, we conclude that, even though the data is outdated, they are still relevant to current conditions in Indonesia and have practical significance for today's policymaking.

There are no publications from official sources in Indonesia that present detailed information on resource extraction, emissions, and related external cost data by economic sector. To our knowledge, Pirmana et al. (2021) provide the first detailed description of environmental costs for each economic sector. Information on extraction of non-renewable resources and forestry products, including their external cost, can be obtained from Indonesian sources. Emissions by sector are, however, not available from Indonesian sources. Pirmana et al. (2021), therefore, utilize emission estimates for each sector in Indonesia provided in the Global Multi-regional Environmentally Extended Input-Output (GMRIO) database EXIOBASE (Stadler et al., 2018). By creating a common classification of 86 sectors between the 163 sectors of EXIOBASE and the 185 sectors of the Indonesian IO table (IIOT) and some other conversions, emissions for 86 sectors in Indonesia can be estimated. Pirmana et al. (2021) also estimate the external costs of these emissions based on the concept of damage costs related to human health and the environment.

This approach resulted in an EE IOT for Indonesia including extensions (E) and external costs (P) by sector (Figure 4.2), which was placed on the n + 1 line of the aggregated 86-sector version of the IIOT as an extension (outside the system of the goods/services flow matrix, where n is the number of sectors).

Sector of production	Sector of (intermediate) consumption				Final Demand	Total Output
	1	2	…	N		
1	x_{11}		…	x_{1n}	f_{11}	X_1
2	x_{21}		…	x_{2n}	f_{21}	X_2
.	.		.	.	.	.
.	.		.	.	.	.
	x_{ni}			…	f_{ni}	X_n
Value-Added	v_1	v_2	…	v_n		
Import	m_1	m_2	…	m_n		
Total Input	X_1	X_2	…	X_n		
Environmental extensions: - natural resource use - emissions	E_1	E_2	…	E_n		
External costs	P_1	P_2	…	P_n		

Figure 4.2. Structure of the Indonesian Environmentally Extended Input-Output Table

4.3 Methodology

4.3.1 Leontief approach to calculate consumption based external costs

As indicated in the previous section, EEIO is used to calculate the environmental costs driven by various components of final demand in Indonesia. The components are household consumption, consumption of non-profit institutions, government consumption, gross fixed capital formation, and exports (see Appendix Table 4.9 for detail).

We decided to limit ourselves to the external costs from emissions and the forestry sector and not to include non-renewable resource extraction.

The basic IO relationship developed by Leontief gives the relationship between the total output x and final demand y (Miller and Blair, 2009; Brolinson et al., 2010) by the following formula:

$$x = (I - A)^{-1} y \qquad (4.1)$$

Where $(I - A)^{-1}$ is the inverse matrix or so-called Leontief matrix. By applying an environmental coefficient matrix F (environmental cost per unit of economic output) on equation (4.1), the total environmental cost can be calculated. This is show in equation (4.2), as follow:

$$E = F(I - A)^{-1}y \quad (4.2)$$

To assess the environmental costs embodied in imported products, various approaches can be followed. In the ideal case, one would use a GMRIO, such as EXIOBASE, GTAP, or EORA (Tukker and Dietzenbacher, 2013; Wood et al., 2019) to estimate the emissions and resource use embodied in Indonesian imports. However, none of the available GMRIOs include external cost estimates for these emissions and resource uses. Trying to develop such external costs for the many countries included in such GMRIOs falls outside the scope of this study. Therefore, we fall back on a simplifying assumption called the domestic technology assumption despite the fact that this can lead to less accurate results (e.g., Tukker et al., 2013). We estimate data on the import IO coefficient matrix (direct import requirements) from total IO transaction data minus domestic transaction IO data. Because, as we show later, the externalities in imports are relatively small compared with the externalities in domestic production, our approach still is a reasonable proxy of reality. Based on this approach, we can modify the input coefficient matrix A in Equations (4.1) and (4.2) by creating a direct import requirement matrix:

$$A^d + A^m = A^{tot} \quad (4.3)$$

Where A^d is the direct domestic requirement (domestic input-output coefficient matrix), A^m is the direct import requirement (import input-output coefficient matrix), and A^{tot} is direct total requirement (total input-output coefficient matrix). Likewise, to obtain the total final demand, we can add final demand for domestic products and imported product:

$$y^d + y^m = y^{tot} \quad (4.4)$$

To calculate environmental costs associated with final demand, equation (4.2) then can be rewritten:

$$E = f(I - A^{tot})^{-1}y^{tot} \quad (4.5)$$

To assess the embodied environmental cost from imported products, the above equation can be rewritten in such a way that domestic technology assumption is made explicit by replacing A^{tot} and y^{tot} by their domestic and import shares:

$$E = F(I - (A^d + A^m)^{-1}y^d + F(I - (A^d + A^m)^{-1}y^m \quad (4.6)$$

4.3.2 Prioritizing sectors based on economic and environmental performance

It is essential to identify priority sectors when the economic and environmental performance takes into account. This identification of priority sectors approached with a linkage analysis between sectors or what is commonly known as backward and forward linkages (Sonis et al., 2000; Dietzenbacher, 2002; Shmelev, 2010; Nguyen, 2018; Peng et al., 2020).

This study identifies the key sectors from an economic view by calculating an index of backward and forward linkages of economic sectors' value added. The formula to estimate these backward and forward linkages is as follows:

$$BL_j = \sum_{i=1}^{n} \alpha_{ij}^{d} \quad (4.7)$$

$$FL_j = \sum_{i=1}^{n} \beta_{ij}^{d} \quad (4.8)$$

Where $\sum_{i=1}^{n} \alpha_{ij}^{d}$ and $\sum_{i=1}^{n} \beta_{ij}^{d}$ are the i-th row and j-th column elements of the matrix $(I\text{-}A^d)^{-1}$ and $(I\text{-}B^d)^{-1}$, respectively. We can standardize the BL_j and FL_j to obtain the unified backward linkage (UBL) and forward linkage (UFL) into the following equations:

$$UBL_j = \frac{BL_j}{\frac{1}{n}\sum_{j=1}^{n} BL_j} \quad (4.9)$$

$$UFL_j = \frac{FL_j}{\frac{1}{n}\sum_{j=1}^{n} FL_j} \quad (4.10)$$

The key sectors in the economy are the sectors that have a backward and forward linkage index higher than one, which are sectors with high potential to drive value-added growth in the upstream and downstream sectors. From an economic view, policies aimed at influencing the amount of economic output are sufficiently focused on these key sectors so that the government can save the development costs. By adopting Equations (4.9) and (4.10), we can formulate an index of the backward and forward linkage of emissions and forest resources' environmental costs as follows (Peng et al., 2020):

$$BLE_j = \sum_{i=1}^{n} EI_i \alpha_{ij}^d \qquad (4.11)$$

$$FFE_j = \sum_{i=1}^{n} EI_i \beta_{ij}^d \qquad (4.12)$$

Where BLE is adjusted backward linkage of the environmental cost, FLE is the forward linkage of the environmental cost, and EI is environmental cost intensity. If this index is greater than 1, this implies that this sector has a greater influence than other sectors in increasing air pollution and related environmental costs in its upstream/downstream sectors. Based on the linkage indices for value-added and environmental costs, we can now identify four classes of sectors with different relevance for economic and sustainability policies as follows:

(i) Encouraged sectors: sectors with high linkages for value-added, and low linkages for external costs – sectors that should be stimulated by policy from a sustainability and economic point of view.
(ii) Slightly encouraged sectors: sectors with high value-added linkages, characterized mainly by low linkages in external costs.
(iii) Slightly constrained sectors: sectors with characterized mainly by low linkages for value-added, and high linkages in external costs.
(iv) Constrained sectors: sectors with low linkages for value-added and high linkages for external costs – sectors that are no priority for economic stimulation.

The detailed classification of the economic sectors in terms of potential for reducing environmental costs is summarized in appendix, table 4.9.

4.4 Results

4.4.1 Environmental costs driven by Indonesian final demand

This first result section analyses environmental cost induced by final demand in Indonesia. We discuss environmental costs of emissions (4.4.1.1), forestry resources (4.4.1.2), the total consumption based environmental costs and the ratio of environmental costs of value-added by consumption category (4.4.1.3).

4.4.1.1 Environmental cost from emissions driven by Indonesian final demand

Table 4.1 shows the total environmental costs of emissions resulting from Indonesia's final demand in 2010, which amounted to Rp. 449.41 trillion. Most of this environmental cost value comes from domestic production of final demand of Rp. 419.55 trillion (93.4%), while the environmental cost from import sources is only around Rp. 29.86 trillion (6.6%). According to the final demand component, both domestic and imported, household consumption is the largest contributor to the total environmental cost created in the economy, amounting to Rp. 196.26 trillion (43.67%), followed by environmental cost from the gross fixed capital formation of Rp 124.07 trillion (27.6%), and export of Rp. 101.81 (22.7%)

Table 4.1. Environmental cost from emission due to final demand in Indonesia (Trillion Rp)

Component	**Domestic**	**Import**	**Total**
Households Consumption	172.89 *(41.2)*	23.37 *(78.3)*	196.26 *(43.67)*
Consumption of Non-Profit Institutions	2.56 *(0.6)*	0.21 *(0.7)*	2.77 *(0.62)*
Government Consumption	13.81 *(3.3)*	0.08 *(0.3)*	13.89 *(3.09)*
Gross Fixed Capital Formation (GFCF)	119.09 *(28.4)*	4.98 *(16.7)*	124.07 *(27.61)*
Changes in Inventory	9.39 *(2.2)*	1.22 *(4.1)*	10.61 *(2.36)*
Export	101.81 *(24.3)*	- -	101.81 *(22.65)*
Total Final Demand	419.55 *(100)*	29.86 *(100)*	449.41 *(100)*

Source: Author’s calculation
Notes: Number in parentheses shows the percent

Tables 4.2-4.3 show the product environmental costs from emission by final demand category. Driven by final demand, the top ten sectors are responsible for approximately 70.4% of the total environmental costs of emissions. Almost 50% of the total environmental cost of these emissions comes only from the top five sectors. Manufacture of basic iron and steel and of ferro-alloys and first products thereof is the sector with the highest environmental costs, amounting to Rp. 70.50 trillion (15.7%). Furthermore, in second place is the electricity sector with an environmental cost value of Rp. 53.95 trillion (12.%), followed by the sea and coastal water transport sector amounting to Rp. 31.62 trillion (7%); manufacture of rubber and plastic products of Rp. 30.98 trillion (6.9%); and the fifth position is coal mining, lignite, and extraction of peat amounting to Rp. 30 trillion (6.7%).

SO_x, NO_x and the greenhouse gases CO_2 and CH_4 contribute to over 50% of the external costs. Also, here we see that emissions within Indonesia are most important; only for CO_2 and the contribution of imports to external costs is slightly over 10% (see appendix table 4.12-4.14 for details). We see further that for most emissions there is no major difference in how the type of final demand drives contribution to external costs. For SO_x we see that Government consumption and exports has a somewhat higher than average external costs compared to total final demand, whereas for lead this is the case for Gross fixed capital formation (see appendix table 4.15).

Table 4.2. Top ten of total environmental cost from emissions by sector in Indonesia in 2010 (Trillion Rp)

No	Sector products	Households Consumption	Consumption of Non-Profit Institutions	Government Consumption	Gross Fixed Capital formation	Export	Changes in Inventory	Total
1	Man. of basic iron, steel, ferro-alloys, and first products thereof	6.22	0.10	0.78	47.92	11.93	3.55	70.50
2	Electricity	38.90	0.75	1.86	6.52	5.48	0.44	53.95
3	Sea and coastal water transport	20.63	0.14	0.30	2.61	7.69	0.25	31.62
4	Man. of rubber and plastic products	9.38	0.08	0.64	7.71	12.40	0.76	30.98
5	Mining of coal lignite; and extraction of peat	2.13	0.04	0.14	2.79	24.74	0.15	30.00
6	Cultivation of paddy rice	22.73	0.23	1.70	0.36	0.59	1.27	26.88
7	Fertilizer	12.14	0.20	0.61	2.41	5.19	0.45	21.00
8	Livestock and their results	14.98	0.09	0.32	2.48	0.52	1.07	19.46
9	Manu. of cement, lime and plaster	1.10	0.02	0.17	16.07	0.75	0.41	18.50
10	Paper & pulp	4.38	0.10	2.50	1.55	4.57	0.16	13.26
	Other sectors	63.69	1.03	4.85	33.63	27.95	2.10	133.25
	Total	196.26	2.77	13.89	124.07	101.81	10.61	449.41

Source: Author's calculation

Table 4.3. Top ten of total environmental cost from emissions by sector in Indonesia in 2010 (percent)

No	Sector Products	Households Consumption	Consumption of Non-Profit Institutions	Government Consumption	Gross Fixed Capital formation	Export	Changes in Inventory	Total
1	Man. of basic iron, steel, ferro-alloys, and first products thereof	3.17	3.50	5.64	38.63	11.72	33.48	15.69
2	Electricity	19.82	27.12	13.37	5.26	5.38	4.19	12.00
3	Sea and coastal water transport	10.51	4.93	2.17	2.10	7.55	2.40	7.04
4	Man. of rubber and plastic products	4.78	2.92	4.61	6.21	12.18	7.19	6.89
5	Mining of coal and lignite; extraction of peat	1.08	1.35	1.03	2.25	24.30	1.41	6.67
6	Cultivation of paddy rice	11.58	8.18	12.27	0.29	0.58	11.98	5.98
7	Fertilizer	6.19	7.33	4.38	1.95	5.10	4.22	4.67
8	Livestock and their results	7.63	3.35	2.33	2.00	0.51	10.06	4.33
9	Man. of cement, lime and plaster	0.56	0.57	1.24	12.95	0.73	3.82	4.12
10	Paper & pulp	2.23	3.57	18.01	1.25	4.49	1.50	2.95
	Other sectors	32.45	37.16	34.94	27.11	27.45	19.76	29.65
	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Author's calculation

4.4.1.2 Environmental cost of forest resources driven by Indonesian final demand

Pirmana et al. (2021) estimate that the environmental costs derived from forest resources in 2010 in Indonesia are Rp. 61.45 trillion, caused by the depletion of forest resources (wood resources) of 33.09 trillion (including conversions and damages), from the loss of eco-services value from the tropical forest of Rp. 28.35 trillion, and those caused by domestic emissions of Rp. 22.94 billion, meanwhile from this study, including emissions from import activities, it becomes Rp. 25.4 billion.

This study attempts to trace the environmental costs of these forest resources from a consumption perspective. The estimation results may overestimate because it only accumulates in the forestry, logging, and related service activities sector. This situation occurs because the responsibility for conversion and damage to forest resources may also be caused by activities in other sectors such as sector groups in plantations and agriculture.

After the calculation and analysis of environmental costs originating from emissions in the previous section, which includes those from the forestry sector, table 4.4 below shows the results of the estimated calculation of environmental costs from timber resources from the consumption perspective. Total environmental costs of timber resources reach Rp. 36.66 trillion. Gross fixed capital formation and household consumption and export are final demand components with the highest environmental cost, each amounting to Rp. 18.02 trillion (49.2%) and Rp. 9.79 trillion (26.7%), and from export around Rp. 6.51 trillion (17.8%).

Table 4.4. The environmental cost of timber resources due to final demand in Indonesia in 2010 (Trillion Rp)

Components	**Environmental costs (trillion Rp)**	**Percentage of total environmental costs**
Household Consumption	9.79	26.71
Consumption of Non-Profit Institutions that serve Households	0.13	0.35
Government Consumption	0.99	2.69
Gross Fixed Capital formation	18.02	49.15
Total Export	6.51	17.75
Changes in Inventory	1.23	3.35
Total	36.66	100.00

Source: Author's calculation

4.4.1.3 Total environmental costs/value-added driven by Indonesian final demand and comparison with value-added creation

In this section we combine the external costs from emissions and the use of forestry resources driven by Indonesian final demand (table 4.5). The total environmental cost from a consumption perspective is 486.04 trillion, with details of environmental costs originating from emissions amounting to 449.39 (92.5%) and environmental costs derived from forest resources of 36.66 trillion (7.5%). The external costs related to forest resources are fully allocated to consumption of forestry products. This leads to a total environmental cost from a consumption perspective for forestry products of Rp. 36.66 trillion[3], of which the costs related to timber resources is Rp. 36.63 trillion (99.9%), and the costs related to emissions created in the value chain of forestry products is only Rp. 25.4 billion (0.07%).

Table 4.5. Total environmental costs due to final demand in Indonesia in 2010 (Trillion Rp)

Component	Environmental Cost from emission (trillion Rp)	Environmental Cost from forest resources (trillion Rp)	Total Environmental Costs (trillion Rp)
Households Consumption	196.26	9.79	206.05
Consumption of Non-Profit Institutions	2.77	0.13	2.9
Government Consumption	13.89	0.99	14.88
Gross Fixed Capital formation	124.07	18.02	142.09
Changes in Inventory	10.61	6.51	17.12
Export	101.81	1.23	103.04
Total Final Demand	449.41	36.66	486.04

Source: Author's calculation

We also calculated the ratio the total environmental costs, combination of environmental cost form emission and forest resources as a fraction of added value in Indonesia in 2010. This ratio appeared to be 0.07. Table 4.6 shows the top ten sectors with the highest ratio in Indonesia in 2010. The table shows that the environmental costs of emissions resulting from the consumption of

[3] Pirmana et al. (2021) include environmental costs from the loss of eco-services value from the tropical forest in calculating the forestry sector's environmental costs. In this study, we calculate environmental costs from a consumption perspective and not include the environmental costs due to loss of eco-services value from the tropical forest.

products in these ten sectors have a greater value than value-added (except electricity). The fact that total environmental costs exceed value-added implies that if the national accounts had included air pollution's external costs, these production outputs would create a negative value-added (Pirmana et al. 2021).

Waste management and recycling sector is sector with the highest ratio, with a ratio of 3.17, this means that the environmental cost contained in this sector is 3.17 times greater than its value-added. The second position was the fertilizer, with a ratio value of 2.70, followed by product from manufacture of basic iron, steel, ferro-alloys, and first products thereof (2.45); other livestock's product (2.18); and product from manufacture of medical, precision, and optical instruments, watches, and clocks in with a ratio of 1.70. Meanwhile, the other five products in the top ten group's has a ratio between 0.92 and 1.67.

Table 4.6. Top ten ratio of total environmental cost compared to value-added

No	Sector	Environmental Cost (EC) (Trillion Rp)	Value-Added (VA) (Trillion Rp)	EC/VA
1	Waste management and recycling	0.26	0.08	3.17
2	Fertilizer	21.00	7.77	2.70
3	Man. of basic iron, steel, ferro-alloys, and first products thereof	70.50	28.81	2.45
4	Other livestocks	3.52	1.62	2.18
5	Man. of medical, precision and optical instruments, watches and clocks	2.62	1.53	1.70
6	Sea and coastal water transport	31.62	18.93	1.67
7	Cultivation of sugar cane, sugar beet	8.57	5.86	1.46
8	Inland water transport	7.96	6.70	1.19
9	Man. of cement, lime and plaster	18.50	18.52	1.00
10	Electricity	53.95	58.87	0.92
	Other sectors	260.38	6,534.99	0.04
	Total	486.04	6,683.68	0.07

Source: Author's calculation

4.4.2 Priority sector based on linkage analysis

Using the method discussed in section 3.2., table 4.7 shows a calculation of forward and backward linkages for both value-added as environmental costs. As mentioned in the previous section, sectors are classified into four groups: (i) encouraged sectors; (ii) slightly encouraged sectors; (iii) slightly discouraged sectors; and (iv) discouraged sectors. Of the 86 sectors, 6 sectors are classified as "encouraged sectors", 42 sectors as "slightly encouraged sectors", 34 sectors as "slightly constrained sectors", and 4 sectors are grouped as "constrained sectors". From a policy perspective the following categories are most relevant:

(i) Encouraged sectors. These include manufacture of textile; publishing, printing, and reproduction of recorded media; chemicals; manufacture of other non-metallic mineral products; Construction; other land transport. Stimulation of economic activity in these sectors hence will have a more than proportional positive impact on Indonesian economic development, with a less than proportional rise of external costs.
(ii) Constrained sectors. Apart from not having a significant pulling and pushing effect on the development of other sectors, these sectors' activities also have a significant negative impact on environmental damage. Sectors included in the "constrained sectors" are the cultivation of sugar cane, sugar beet; other livestock; raw milk; and inland water transport. These sectors hence seem less of a priority for stimulation, from an economic and environmental perspective.

Table 4.7. Classification of sectors in the Indonesian economy, 2010, in terms of the potential of environmental costs reduction

No	Sectors	UBLj	UFLj	UBLEj	UFLEj
Encouraged sectors					
1	Manufacture of Textile	1.118	1.075	0.318	0.138
2	Publishing, printing and reproduction of recorded media	1.065	1.196	0.252	0.003
3	Chemicals nec	1.007	1.78	0.345	0.606
4	Manufacture of other non-metallic mineral products n.e.c.	1.109	1.096	0.663	0.337
5	Construction	1.177	1.787	0.645	0.172
6	Other land transport	1.006	1.631	0.228	0.235
Constrained sectors					
1	Cultivation of sugar cane, sugar beet	0.903	0.814	6.676	7.285
2	Other livestocks (meat nec)	0.788	0.61	11.352	11.376
3	Raw milk	0.961	0.631	2.494	2.488
4	Inland water transport	0.98	0.649	3.473	3.547

Source: author's calculation
Notes:
- (UBL: unified backward linkage of production; UFL: unified forward linkage of production; UBLE: unified backward linkage of environmental costs; UFLE: unified forward linkage of environmental costs).
- See Appendix for complete results

4.5 Conclusion and recommendation

This study is an initial attempt to provide an overview of the environmental cost of emissions and the associated environmental cost of forest resources from a consumption perspective and Indonesia's priority sectors when economic and environmental performance are considered. This study results can be used as a guide for policymakers in formulating sustainable development policies, especially in sustainable consumption and production (SCP) policies.

We found that the total environmental cost from emissions due to the final demand is around 7.3% of GDP. The environmental cost of emissions mostly comes from domestically produced final consumption, with household consumption as the largest contributor to total emissions environmental cost.

This study also found that driven by final demand; the top five sectors account for nearly half of the environmental costs of emissions. These sectors are manufacturing basic iron and steel and iron alloys and their first products; electricity; the sea and coastal water transportation; manufacture of rubber and plastic products; coal mining, lignite, and peat extraction. Efforts to reduce Indonesia's emission environmental costs should focus on these sectors.

SOx, NOx, CO_2, and CH_4 are the main contributors to Indonesia's environmental costs based on pollutant sources. Strategies to reduce environmental costs from emissions can be focused on these four pollutant sources. The results further show that, for most emissions, there are no significant differences in how the types of final demand drive contribute to environmental costs.

Regarding the environmental costs to value-added ratio, nine sectors have a higher environmental cost value than their value-added, with waste management and recycling is the sectors with the highest environmental cost to value-added ratio. Meanwhile, the total environmental costs derived from forest resources are about 7.54% of the total environmental cost.

Finally, the results from linkage analysis pointed out that key sectors for Indonesia from a sustainability and economic point of view (encouraged sectors) are: manufacture of textile; publishing, printing, and reproduction of recorded media; chemicals n.e.c; manufacture of other non-metallic mineral products n.e.c; Construction; other land transport.

Based on the study findings, in order to reduce environmental costs and shift to more sustainable consumption and production, the following policy options and instruments can be considered by policymakers:

- Change consumer behavior. There are three different ways to influence consumer behavior. Firstly, raising consumer awareness via mandatory or voluntary labeling schemes, information campaigns, information websites, and eco-benchmarking tools. Secondly, making sustainable consumption easy by providing attractive offers to consumers and limit the range of non-sustainable products on the market. Thirdly, greening the market by improving products' environmental performance, prohibiting products with a harmful environmental performance, and increasing the market share of environmentally friendly products.
- Adopt a green public procurements system. The government with large public funds can regularly behave as a sustainable consumer to procure public goods and services. The application of green public procurement will benefit the government itself as a public organization, society, and the economy. On the other hand, government plays a vital role in reducing negative impacts on the environment.
- Stimulate the adoption of cleaner production. There is a wide range of economic and policy instruments that government may use to promote cleaner production. Tax, fees, and charges can be useful tools to promote cleaner production practices by raising the cost of harmful products or promote more efficient use of natural resources. Other instruments such as liability rules, financial subsidies, innovative financing for certain industries can be used as direct economic incentives to move away from polluting production technologies and unsafe products.

Lastly, from an economic point of view, sectors development to increase value-added growth, besides focusing on key sectors with strong linkages to the upstream and downstream sectors, can also be expanded to sectors with at least have a strong backward or forward linkage. The effective policy instruments to stimulate strong backward linkage sectors are demand-side policies. Otherwise, the supply-side is expected to be more effective in targeting strong forward linkage sectors. Some examples of policy instruments that can be applied to stimulate targeted sectors include:

- Demand-side policies. Changing fiscal policies (via government expenditure or taxes) concerning specific consumer commodities, improvement of the attractiveness of specific areas (which includes the provision or improvements of industrial sites and public utilities)
- Supply-side policies. Subsidies to certain sector activities, small business grants, wage subsidies, privatization, and lower-income tax rates.

Acknowledgments
Viktor Pirmana acknowledges funding from the Indonesian Endowment Fund for Education (LPDP Scholarship), Ministry of Finance, Republic of Indonesia.

4.6 Appendix

This appendix contains the supporting information for this case study and includes details on the modelled processes, supporting calculations.

Table 4.8. Indonesia's Input-Output Tables

Year	Sector/Industry Classification	Description	Reference
1971	179		BPS (1977), "Tabel Input-Output Indonesia, 1971.
1975	179		BPS (1980), "Tabel Input-Output Indonesia, 1975.
1980	171		BPS (1985), "Tabel Input-Output Indonesia, 1980.
1983	66	IO updating*)	
1985	169		BPS (1990), "Tabel Input-Output Indonesia 1985.
1990	161		BPS (1994), "Tabel Input-Output Indonesia 1990.
1993	66	IO updating	
1995	172		BPS (1999), "Tabel Input-Output Indonesia 1995.
1998	66	IO updating	
2000	175		BPS (2002), "Tabel Input-Output Indonesia 2000
2003	66	IO updating	BPS (2004), "Tabel Input-Output Indonesia Updating 2003.
2005	175		BPS (2008), "Tabel Input-Output Indonesia 2005.
2008	66	IO updating	BPS (2009), "Tabel Input-Output Indonesia Updating 2008.
2010	185		BPS (2015), "Tabel Input-Output Indonesia 2010.

Source: Indonesia's Central Bureau of Statistics (BPS)
Notes: The IO updating is the IO table constructed using the non-survey method based on the previous IO table publication.

Table 4.9. Classification of sectors in term of the potential of environmental cost reduction

Group	Sector Group	Sector Indices				Relevant characteristics
		UBLj	**UFLj**	**UBLEj**	**UFLEj**	
I	Encouraged sector	High	High	Low	Low	Key sector. Low environmental cost
II	Slightly encouraged sector	High	High	High	Low	Key sector. Increase environmental cost by inputs
		High	High	Low	High	Key sector. Self-polluter and related environmental cost by demand
		High	Low	Low	Low	Backward linkage sector. Non-self-polluter and related environmental cost
		Low	High	Low	Low	Forward linkage sector. Non-Self-polluter and related environmental cost
		High	High	High	High	Key sector. Self-polluter by inputs and demand
III	Slightly constrained sector	Low	Low	High	Low	Self-polluter and related environmental cost by inputs
		Low	Low	Low	High	Self-polluter and related environmental cost by demand
		High	Low	High	High	Backward linkage sector. Self-polluter and related environmental cost by inputs and demand
		Low	High	High	High	Forward linkage sector. Self-polluter and related environmental cost by inputs and demand
		High	Low	Low	High	Backward linkage sector. Self-polluter and related environmental cost by demand
		Low	High	Low	High	Forward linkage sector. Self-polluter and related environmental cost by demand
		High	Low	High	Low	Backward linkage sector. Self-polluter and related environmental cost by inputs
		Low	High	High	Low	Forward linkage sector. Self-polluter and related environmental cost by inputs
		Low	Low	Low	Low	Non-polluter and related environmental cost
IV	Constrained sector	Low	Low	High	High	Self-polluter and related environmental cost by demand and inputs

Source: Adopted from Nguyen 2018, and Peng et al, 2020

Table 4.10. Top ten of domestic environmental cost from emission by sector in Indonesia (Trillion Rp)

No	Sector products	Households Consumption	Consumption of Non-Profit Institutions	Government Consumption	Gross Fixed Capital formation	Export	Changes in Inventory	Total
1	Man. of basic iron, steel and ferro-alloys, and first products thereof	5.37	0.09	0.78	46.41	11.93	3.02	67.60
2	Electricity	37.39	0.74	1.84	5.66	5.48	0.37	51.48
3	Sea and coastal water transport	19.80	0.13	0.30	2.49	7.69	0.24	30.65
4	Mining of coal and lignite; extraction of peat	1.99	0.04	0.14	2.69	24.74	0.14	29.74
5	Man. of rubber and plastic products	7.76	0.08	0.64	7.06	12.40	0.64	28.57
6	Cultivation of paddy rice	22.02	0.22	1.70	0.34	0.59	1.26	26.13
7	Fertilizer	10.79	0.19	0.61	2.34	5.19	0.41	19.52
8	Livestock and their results	14.17	0.09	0.32	2.47	0.52	1.06	18.63
9	Man. of cement, lime and plaster	1.01	0.01	0.17	15.99	0.75	0.39	18.33
10	Construction	0.53	0.01	0.12	11.70	0.31	0.16	12.83
	Other sectors	52.09	0.97	7.19	21.94	32.20	1.69	116.08
	Total	172.89	2.56	13.81	119.09	101.81	9.39	419.55

Source: Author’s calculation

Table 4.11. Top ten of emission embodied in import by sector in Indonesia (Trillion Rp)

No	Sector products	Households Consumption	Consumption of Non-Profit Institutions	Government Consumption	Gross Fixed Capital formation	Export	Changes in Inventory	Total
1	Recycling of waste and scrap	6.48	0.06	0.00	0.03	-	0.00	6.57
2	Manufacture of basic iron and steel and of ferro-alloys and first products thereof	0.85	0.00	0.01	1.52	-	0.53	2.91
3	Electricity	1.51	0.01	0.01	0.86	-	0.07	2.47
4	Manufacture of rubber and plastic products	1.63	0.00	0.00	0.65	-	0.12	2.41
5	Cultivation of sugar cane, sugar beet	1.49	0.00	0.00	0.06	-	0.05	1.60
6	Fertilizer	1.35	0.02	0.00	0.08	-	0.04	1.49
7	Sea and coastal water transport	0.83	0.01	0.00	0.12	-	0.01	0.97
8	Petroleum Refinery	0.84	0.01	0.00	0.10	-	0.02	0.97
9	Cultivation of vegetables, fruit, nuts	0.82	0.02	0.00	0.02	-	0.01	0.87
10	Livestock and their results	0.81	0.00	0.00	0.01	-	0.01	0.84
	Other sectors	6.75	0.06	0.04	1.54	-	0.36	8.77
	Total	23.37	0.21	0.08	4.98	-	1.22	29.86

Source: Author's calculation

Table 4.12. The top ten environmental cost from emission due to final demand by the substance in Indonesia (Trillion Rp)

No	Emissions	Domestic	Imported	Total
1	SOx	87.62	4.90	92.52
2	NOx	65.72	4.96	70.68
3	CO_2	54.90	6.58	61.48
4	CH4	38.85	1.45	40.30
5	NH3	33.34	2.64	35.98
6	Pb	33.07	1.45	34.52
7	TSP	28.49	1.26	29.75
8	PM10	20.84	0.98	21.82
9	PM2.5	18.35	0.93	19.28
10	Nitrogen	11.44	1.11	12.56
	Other emissions	26.94	3.60	30.54
	Total	419.55	29.86	449.41

Source: Author’s calculation

Table 4.13. Total environmental cost of emission due to final demand by type of emission in Indonesia (Trillion Rp)

No	Pollutants	Households Consumption	Consumption of Non-Profit Institutions	Government Consumption	Gross Fixed Capital formation	Export	Changes in Inventory	Final Demand
1	SOx	38.63	0.63	4.06	22.91	24.75	1.53	92.52
2	NOx	33.86	0.43	2.05	18.59	14.51	1.23	70.68
3	CO_2	26.95	0.41	1.98	16.77	14.44	0.93	61.48
4	CH_4	21.48	0.22	1.45	3.03	12.88	1.24	40.30
5	NH_3	25.32	0.32	1.02	3.72	4.45	1.17	35.98
6	Pb	3.40	0.05	0.42	22.93	6.02	1.69	34.52
7	TSP	7.35	0.13	0.62	13.47	7.24	0.94	29.75
8	PM10	6.89	0.12	0.61	8.30	5.39	0.50	21.82
9	PM2.5	6.40	0.12	0.64	7.69	3.99	0.45	19.28
10	Nitrogen	8.72	0.13	0.41	1.20	1.78	0.31	12.56
	Other Emissions	17.27	0.21	0.63	5.45	6.37	0.61	30.54
	Total Emissions	196.26	2.77	13.89	124.07	101.81	10.61	449.41

Source: Author’s calculation

Table 4.14. Environmental cost of emission due to final demand for domestic source by type of emission in Indonesia (Trillion Rp)

No	Pollutans	Households Consumption	Consumption of Non-Profit Institutions	Government Consumption	Gross Fixed Capital formation	Export	Changes in Inventory	Total
1	SOx	35.23	0.59	4.04	21.71	24.75	1.29	87.62
2	NOx	29.85	0.40	2.04	17.84	14.51	1.08	65.72
3	CO_2	21.40	0.36	1.97	15.95	14.44	0.79	54.90
4	CH_4	20.19	0.21	1.44	2.92	12.88	1.20	38.85
5	NH_3	22.83	0.30	1.01	3.64	4.45	1.12	33.34
6	Pb	2.95	0.05	0.42	22.19	6.02	1.44	33.07
7	TSP	6.72	0.12	0.62	12.98	7.24	0.80	28.49
8	PM10	6.28	0.12	0.61	8.01	5.39	0.43	20.84
9	PM2.5	5.78	0.11	0.63	7.44	3.99	0.39	18.35
10	Nitrogen	7.68	0.12	0.40	1.17	1.78	0.29	11.44
	Other	13.99	0.18	0.63	5.23	6.37	0.55	26.94
	Total	172.89	2.56	13.81	119.09	101.81	9.39	419.55

Source: Author's calculation

Table 4.15. Top ten of emission embodied in import by substance in Indonesia (trillion Rp)

No	Pollutants	Households Consumption	Consumption of Non-Profit Institutions	Government Consumption	Gross Fixed Capital formation	Export	Changes in Inventory	Total
1	CO_2	5.55	0.05	0.01	0.82	-	0.15	6.58
2	NOx	4.01	0.03	0.01	0.76	-	0.15	4.96
3	SOx	3.41	0.03	0.03	1.20	-	0.24	4.90
4	NH_3	2.49	0.02	0.00	0.08	-	0.05	2.64
5	CH_4	1.28	0.01	0.00	0.12	-	0.04	1.45
6	Pb	0.45	0.00	0.00	0.74	-	0.25	1.45
7	TSP	0.63	0.00	0.00	0.49	-	0.14	1.26
8	Nitrogen	1.05	0.01	0.00	0.03	-	0.02	1.11
9	Phosphorus	0.95	0.01	0.00	0.03	-	0.02	1.01
10	PM10	0.61	0.01	0.00	0.29	-	0.07	0.98
	Other	2.94	0.03	0.01	0.44	-	0.11	3.52
	Total	23.37	0.21	0.08	4.98	-	1.22	29.86

Source: Author’s calculation

Table 4.16. Classification of sectors in the Indonesian economy, 2010, in terms of the potential of environmental costs reduction

Code	Sector	UBLj	UFLj	UBLEj	UFLEj	Criteria
1	Cultivation of paddy rice	0.726	1.262	1.219	1.903	III
2	Cultivation of cereal grains nec	0.742	0.783	0.804	0.681	III
3	Cultivation of vegetables, fruit, nuts	0.725	0.880	0.739	0.626	III
4	Cultivation of oil seeds	0.806	1.560	0.622	0.693	II
5	Cultivation of plant-based fibers & crop nec	0.756	0.975	0.334	0.051	III
6	Cultivation of sugar cane, sugar beet	0.903	0.814	6.676	7.285	IV
7	Livestock and their results	0.957	1.031	0.960	1.439	III
8	Other livestocks (meat nec)	0.788	0.610	11.352	11.376	IV
9	Animal products nec	1.202	0.949	0.502	0.109	II
10	Raw milk	0.961	0.631	2.494	2.488	IV
11	Forestry, logging and related service activities	0.741	1.088	5.164	9.398	III
12	Fishing, operating of fish hatcheries and fish farms; service activities incidental to fishing	0.742	1.144	0.177	0.001	II
13	Mining of coal and lignite; extraction of peat	0.832	0.999	1.080	1.660	III
14	Extraction of crude petroleum and services related to crude oil extraction, excluding surveying	0.842	1.603	0.283	0.771	II
15	Extraction of natural gas and services related to natural gas extraction, excluding surveying	0.787	1.781	0.164	0.391	II
16	Mining of iron ores	0.962	0.634	0.450	0.314	III
17	Mining of copper ores and concentrates	0.834	0.618	0.120	0.012	III
18	Mining of nickel ores and concentrates	0.887	0.643	0.160	0.042	III
19	Mining of aluminium ores and concentrates	0.655	0.618	0.034	0.014	III
20	Mining of precious metal ores and concentrates	0.821	1.046	0.064	0.000	II
21	Mining of lead, zinc and tin ores and concentrates	0.726	0.804	0.125	0.103	III
22	Mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c.	0.774	1.325	0.157	0.244	II
23	Production of meat products nec	1.395	0.650	0.310	0.034	II
24	Processing vegetable oils and fats	1.181	0.927	0.348	0.001	II
25	Processing of dairy products	1.393	0.716	0.421	0.000	II
26	Processed rice	1.189	0.747	0.886	0.003	II
27	Sugar refining	1.309	0.848	1.317	0.029	II
28	Processing of Food products nec	0.726	2.150	0.348	0.013	II
29	Manufacture of beverages	1.236	0.676	0.340	0.003	II
30	Manufacture of fish products	1.140	0.632	0.151	0.034	II
31	Manufacture of tobacco products	0.942	0.693	0.166	0.026	III
32	Manufacture of Textile	1.118	1.075	0.318	0.138	I
33	Manufacture of wearing apparel; dressing and dyeing of fur	1.051	0.628	0.204	0.020	II
34	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	1.021	0.665	0.294	0.023	II
35	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1.099	1.061	1.221	0.010	II
36	Paper & pulp	1.154	1.445	0.955	1.160	II
37	Publishing, printing and reproduction of recorded media	1.065	1.196	0.252	0.003	I
38	Petroleum Refinery	0.974	2.320	0.257	0.587	II
39	Plastics, basic	0.994	1.059	0.280	0.148	II

40	Fertilizer	1.032	0.803	5.194	7.327	III
41	Chemicals nec	1.007	1.780	0.345	0.606	I
42	Manufacture of rubber and plastic products	1.174	1.104	1.058	1.620	II
43	Manufacture of glass and glass products	1.085	0.658	0.401	0.103	II
44	Manufacture of ceramic goods	1.151	0.675	0.538	0.095	II
45	Manufacture of cement, lime and plaster	1.173	0.699	2.659	2.649	III
46	Manufacture of other non-metallic mineral products n.e.c.	1.109	1.096	0.663	0.337	I
47	Manufacture of basic iron and steel and of ferro-alloys and first products thereof	1.199	0.994	3.122	5.939	III
48	Precious metals production	1.184	0.607	0.426	0.007	II
49	Casting of metals	1.104	0.609	0.739	0.125	II
50	Manufacture of fabricated metal products, except machinery and equipment	1.122	0.910	0.758	0.009	II
51	Manufacture of machinery and equipment n.e.c.	0.892	0.988	0.184	0.015	III
52	Manufacture of office machinery and computers	0.873	0.778	0.175	0.007	III
53	Manufacture of electrical machinery and apparatus n.e.c.	1.053	0.898	0.253	0.004	II
54	Manufacture of radio, television and communication equipment and apparatus	0.991	0.833	0.229	0.029	III
55	Manufacture of medical, precision and optical instruments, watches and clocks	1.087	0.624	2.957	2.771	III
56	Manufacture of motor vehicles, trailers and semi-trailers	1.073	0.912	0.120	0.007	II
57	Manufacture of other transport equipment	0.970	0.939	0.173	0.005	III
58	Manufacture of furniture; manufacturing n.e.c.	1.157	0.875	0.615	0.275	II
59	Electricity	1.637	2.131	2.637	4.708	III
60	Manufacture of gas; distribution of gaseous fuels through mains	0.965	0.822	0.121	0.000	III
61	Collection, purification and distribution of water	0.774	0.816	0.093	0.000	III
62	Construction	1.177	1.787	0.645	0.172	I
63	Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessories	0.878	1.227	0.128	0.000	II
64	Retail sale of automotive fuel	0.921	3.354	0.152	0.073	II
65	Hotels and restaurants	1.149	0.965	0.263	0.002	II
66	Transport via railways	1.265	0.620	0.500	0.163	II
67	Other land transport	1.006	1.631	0.228	0.235	I
68	Sea and coastal water transport	1.159	0.712	3.669	4.159	III
69	Inland water transport	0.980	0.649	3.473	3.547	IV
70	Air transport	0.930	0.779	0.404	0.280	III
71	Supporting and auxiliary transport activities; activities of travel agencies	1.005	0.874	0.456	0.146	II
72	Post and telecommunications	0.906	1.391	0.120	0.043	II
73	Financial intermediation, except insurance and pension funding	0.848	1.422	0.097	0.011	II
74	Insurance and pension funding, except compulsory social security	0.830	0.926	0.087	0.038	III
75	Activities auxiliary to financial intermediation	0.890	0.976	0.071	0.006	III
76	Real estate activities	0.786	0.737	0.080	0.001	III
77	Renting of machinery and equipment without operator and of personal and household goods	0.942	1.220	0.157	0.003	II
78	Computer and related activities	0.995	0.900	0.142	0.013	II

79	Research and development	0.985	0.936	0.159	0.004	III
80	Other services activities	1.112	0.923	0.143	0.023	II
81	Public administration and defence; compulsory social security	0.972	0.896	0.153	0.001	III
82	Education	0.931	0.664	0.183	0.037	III
83	Health and social work	1.121	0.719	0.311	0.033	II
84	Waste Management and recycling	1.246	0.606	8.648	8.429	III
85	Recreational, cultural and sporting activities	1.050	0.617	0.325	0.082	II
86	Private households with employed persons	0.950	0.630	0.197	0.028	III

Source: Author's calculation

Notes: Notes:

Encouraged sectors :

Slightly encouraged sectors :

Slightly constrained sectors :

Constrained sectors :

(UBL: unified backward linkage of production; UFL: unified forward linkage of production; UBLE: unified backward linkage of environmental costs; UFLE: unified forward linkage of environmental costs).

Chapter 5

Economic and environmental impact of electric vehicle production in Indonesia

Abstract

The use of fossil fuel-based vehicles may gradually be replaced by electric vehicles in the future. The trend indicates that the number of users of electric vehicles, especially electric cars, continues to increase. Indonesia is well-positioned to take advantage of this opportunity as it has the world's largest nickel reserves, an essential raw material for making electric vehicle batteries (EVB). The study examines the economic and environmental implications if Indonesia were to successfully set up electric vehicle (EV) production rather than exporting such raw materials overseas. We use an input-output model to estimate the economic and environmental impacts of electric vehicle production in Indonesia. This study assumes that nickel, which is usually exported, is absorbed by domestic economic activities, including being used in manufacturing batteries and electric vehicles in Indonesia. Our estimates include direct and indirect output, value-added, and employment changes. The same model is also used to estimate changes in emissions' environmental costs. It is evident from the results that batteries and EV production are economically beneficial. Additional value-added is Rp. 100.57 trillion, 1.5% of GDP in 2010. At the same time, 538,658 additional jobs were created, which is about a 0.5% increase. Lastly, EV production will have extra environmental costs of emissions, around Rp. 2.23 trillion, or an increase of about 0.6%. Based on these findings, it is concluded that electric vehicle production increases productivity, gross added value, and job creation with a relatively small impact on the environment. A limitation of this study is that we assumed EVs were produced for export only, and we did not assume a reduction in economic activities in the supply chain of conventional vehicles.

Under review as: Pirmana, V., Alisjahbana, A. S., Yusuf, A. A., Hoekstra, R., & Tukker, A. (2022) Economic and environmental impact of electric vehicle production in Indonesia

5.1 Introduction

A transition from fossil fuel vehicles to electric-based vehicles in the last decade clearly gained momentum. This transition is essential to make the road transport system carbon-neutral. Several countries worldwide have experienced a rapid increase in sales of electric vehicles over the last decade, especially in North America, Europe, and Asia. One of the determining factors for the success of electric vehicles in penetrating the market is the existence of policy support from the government (Yang et al., 2016).

Electric batteries are a critical component of an electric vehicle. They are the sources of energy to run the engine. This energy source is what distinguishes electric vehicles from conventional petrol-based vehicles. Electric vehicles do not generate direct air emissions and, if charged with electricity from renewable sources, also have no indirect air emissions. There are two types of electric batteries that are widely used today, namely Lithium-ion (Li-ion) and Nickel Metal Hydride (NiMH). Li-ion batteries use the metal elements lithium and cobalt as electrodes, while NiMH uses nickel. A global shift from petrol-based vehicles to electric vehicles will require a massive growth in the use of these metals. The EU released a detailed study (by Roskill, in Fraser et al. 2021) which projected that EVs would be the most significant driver of nickel demand over the next two decades, and the amount of nickel used in EV batteries will rise exponentially. In numerical terms, nickel demand for EVs is projected to rise from 92kt in 2020 to 2.6 Mt in 2040 globally. Karabelli et al. (2020) show that global e-mobility demand will boost battery production by 2030 to around 1725 GWh, with Ni being the dominant raw material in lithium-ion batteries. Currently, nickel use in batteries' represents 4% of the annual global production. Karabelli et al. (2020) expect nickel demand for batteries would rise to 34% of current mining production in 2030.

Table 5.1 presents ten countries with the world's largest nickel resources and reserves. According to CIM (2014), mineral resources are the concentration or presence of economically valuable solid materials in or on the earth's crust in such form, grade, quantity, and quality that there are reasonable prospects for eventual economic extraction. Meanwhile, mineral reserves are economically mineable portions of indicated or measured mineral resources shown by at least a preliminary feasibility study, including diluent and allowance for losses that may occur when the material is mined. The table shows that the ten countries have 77 percent of the global nickel resources and 90 percent of the world's nickel reserves. It also shows that Indonesia has an important position as having the world's second-largest resource and the country with the largest reserves in the world. Indonesia's nickel reserves are around 24% of the world's total, of which 70% are in the form of nickel limonite.[4] Indonesia is rich in these raw materials, an essential raw material in the EVs supply chain.[5] This condition indicates that Indonesia has the potential to be superior in the global EV supply chain, especially in providing raw materials for the production of EV batteries.

Table 5.1. World Nickel Resources and Reserves (in million tons)

Global Resources			**Global Reserves**		
Country	Value	Percentage	Country	Value	Percentage
Australia	43,4	15%	Indonesia	21,0	24%
Indonesia	33,3	11%	Australia	19,0	21%
South Africa	33,2	11%	Brazil	11,0	12%
Rusia	24,4	8%	Rusia	7,6	9%
Canada	21,9	7%	Cuba	5,5	6%
Philipines	18,0	6%	Philipines	4,8	5%
Brazil	16,4	6%	South Africa	3,7	4%
Cuba	16,2	5%	China	2,8	3%
New Caledonia	15,0	5%	Canada	2,7	3%
China	6,0	2%	Guatemala	1,8	2%
Rest of the World	68,4	23%	Rest of the World	8,9	10%
Total	296,2	100%	Total	88,8	100%

Source: Nickel Institute, 2019 in Revindo and Alta, 2020

To support its electric vehicle (EV) ambition and encourage the production of value-added products, including processing minerals such as nickel ore, the government has issued a policy through Presidential Decree No. 55/2019 regarding the acceleration of the program for battery electric vehicles for road transportation. This Presidential Decree was followed by the Ministry of Energy and Resources Regulation No. 11/2019 concerning the nickel ore export ban with the content below 1.7% Ni, which, combined with a ban on exports of high grade nickel in 2014, brought all exports of nickel ore to a halt

[4] There are two types of nickel ore, nickel sulfide and nickel oxide (commonly called nickel laterite). Nickel sulfide is generally found in the subtropical hemisphere, while nickel laterite is located at the equator. Nickel laterite is divided into two types, saprolite and limonite. Various products such as ferronickel, Ni- matte, and nickel pig iron (NPI) are the saprolite processed products. Those kinds are intended for the export market as well as used for local stainless steel production. Meanwhile, nickel limonite is one of the essential raw materials in manufacturing batteries for electric vehicles.

[5] Indonesia has not been able to downstream nickel, which causes this type of nickel to have not been processed and appropriately utilized. This condition is unfortunate, considering that each tonne of nickel-based processed products on the world market can reach more than 200 times the price of nickel which is still in the form of ore (Revindo & Alta, 2020).

by Indonesia. These documents show that Indonesia is ambitious to become Asia's production hub for electric vehicles.

With this background in mind, it is important to analyze the impact of this EV production in the Indonesian context. Therefore, we conducted a study to analyze the economic and environmental impacts of EV production. This study simulates that all nickel ore produced is absorbed for further processing in domestic economic activities consisting of battery and EV production while assuming all produced EVs are destined for export.

This chapters's structure is organized as follows—section 2 first reviews earlier studies on the environmental and economic impacts of EV production. Section 3 explains that we used an input-output approach in this paper and describes the construction of the required database. Finally, section 4 presents the results of this study, and section 5 ends with a discussion and conclusions.

5.2 Literature review

The scientific literature gives various earlier studies on electric vehicle production's economic and environmental impact. Winebrake and Green (2009) tried to estimate the macroeconomic impact of reducing petrol use induced by plug-in electric vehicles in the US. The study found that plug-in electric vehicles on a large scale would reduce gasoline demand by more than 41 billion gallons per year, reduce the household gasoline spending by approximately \$118 billion, and save household fuel costs by \$86 billion overall. This effect would increase the US economic output by \$23 to \$94 billion and create around 162 to 863 thousand jobs. A more recent study by Winebrake et al. (2017) focused on adopting plug-in vehicles' economic and employment impacts, concluding that the transition from gasoline to electric vehicles brings positive economic and job creation effects.

Mase (2020) evaluated the impacts of producing electric vehicles on Japan's industrial output using the Leontief input-output production model. The study indicates that the positive and negative impacts of producing electric vehicles rather than internal combustion engine (ICE) vehicles on Japanese industrial output mainly depend on whether the suppliers of electrical machinery with electric vehicles are sourced domestically or overseas. The total impact on Japanese industrial output increased by 1.1 trillion yen in the case of producing the component electrical machinery in Japan; on the other hand, the impact decreased by 4.9 trillion yen when electrical component items were produced overseas. A study from Ribeiro (2020) for the case of the European Union shows that in the long term, investing in electric vehicles is beneficial, both economically and environmentally. Such a shift will reduce dependence on fossil fuels, increase GDP, and improve air quality. Generally, the literature finds that the economic and environmental impacts of electric vehicle production and adoption are positive (Hawkins et al., 2012; Melaina et al. 2016; ERIA, 2020; Kim & Mishra, 2021, Chen et al., 2021).

However, the adoption of electric vehicles will not necessarily reduce emissions when the whole life cycle is considered. Several studies conclude that the environmental impact of electric vehicle development will depend on the power generation mix and its carbon intensity (Karplus et al., 2020). Hawkins et al. (2013) conclude that electric vehicles powered by coal-based electricity may reduce emissions like PM2.5 but enhance CO_2 emissions. Doucette and McCulloch (2011) found that countries like India and China will not benefit from electric vehicle penetration unless they decarbonize their power generations. Meanwhile, ERIA (2020) found that deploying electric vehicles in Thailand, Malaysia, and Vietnam significantly reduces emissions. But not in the case of Indonesia. Investing in electric vehicles will reduce fuel import bills. However, this will not significantly reduce overall carbon emission as the current, carbon-intensive electricity mix is used.

5.3 Methodology and data

5.3.1 Rationale for choosing an input-output approach

This study uses an input-output model to evaluate the economic and environmental impacts of the production of electric vehicles in the Indonesian context. Currently, there are at least three main approaches used to estimate the broad or general socio-economic impact of economic change: the input-output (I-O) model, the Social Accounting Matrix (SAM) model, and the Computable General Equilibrium (CGE) model. The IO approach is the most commonly used of these models and the least expensive but suffers from the constraints of fixed prices, fixed coefficients for inputs, outputs, and extensions which can only be assumed in short-term time frames. SAM is an extension of the IO model but relates, amongst others, income paid to employees at different skill levels to final consumption, which allows assessing distributional impacts. The use of CGE models allows for overcoming many of the constraints of the IO model. Such models allow for assessing multi-directional sectoral impacts and can capture dynamic effects by taking into account a.o. Price and substitution elasticities (White & Patriquin, 2003). Using a CGE model would give a complete insight into economic change. CGEs have more extensive data requirements, such as price and substitution elasticities for the new battery and EV production sectors. Such data are difficult to obtain, and our more straightforward IO approach, which is much easier to implement, still gives a good, static first-order analysis of the implications for the Indonesian economy.

5.3.2 Principles of the input-output approach

In input-output analysis, a fundamental assumption is that the inter-industry flows from sector i to sector j in a specific period (usually a year) depends entirely on the total output of sector j for that same period. (Miller and Blair, 2009; Heinuki, 2017). With the set of fixed technical coefficients, the balanced equation for the input-output model is expressed as;

$$z = Az + y \qquad (5.1)$$

where z is the gross output vector, A is the input coefficients matrix, and y is the final demand vector. The input coefficients aij are obtained as $a_{ij} = d_{ij}/z_j$, where d_{ij} denotes the domestic intermediate supply of intermediate inputs i (in million rupiahs) to industry j.

Equation (5.1) can be rewritten to be $(I - A)\,X = y$, where I denotes the identity matrix. Expressing the gross outputs in terms of final demands yields $X = (I - A)^{-1}\,y$ as the solution of the input-output model. Where $(I - A)^{-1}$ is the Leontief inverse (L). Since the model is linear, we can rewrite it as $\Delta X = (I - A)^{-1}\Delta y = L\Delta y$ giving the extra gross outputs corresponding to an arbitrary vector Δy of extra final demand (e.g., electric vehicles).

Value-Added (VA) is the primary input in which part of the overall input. Following the basic assumptions used in preparing the I-O table, the relationship between VA and output is linear. It implies that an increase or decrease in output will be followed proportionally by an increase and decrease in VA. The relationship can be described in the following equation:

$$V = \hat{V}X \qquad (5.2)$$

Where V is value-added, and $\hat{V}$ is the diagonal matrix of value-added.

To see the impact of Δy on employment creation, the employment coefficient vector (e) is constructed as e_j/x_j, where e_j denotes the employment opportunity provided by the sector j, and we get the change in employment due to the change in domestic final demand as follows;

$$\Delta e = e\ L\ \Delta y \quad (5.3)$$

Similarly, the impact on pollution and related external costs can be calculated. If emissions per unit output of a sector and the external costs of each emission are known and combined to a pollution coefficient (p), the changes in external cost from such emissions can be calculated as follows;

$$\Delta p = p\ L\ \Delta y \quad (5.4)$$

5.3.3 Construction of the basic Indonesian extended Input-Output Table

In estimating the economic and environmental impact of electric vehicle production, we used the Indonesian Input-Output Table (IIOT) of 2010 from the Indonesian Central Bureau of Statistics (BPS). Since the IIOT has no environmental extensions, we used emission information on Indonesia from EXIOBASE, a comprehensive Global Multi-regional Environmentally Extended Input-Output (GMRIO) database developed by a European research consortium[6]. We mapped this emission data on the common, aggregated version of IIOT and EXIOBASE of 86 sectors and aggregated the highly detailed emission set from EXIOBASE to emissions of 34 individual substances. We further calculated the external costs related to the emissions of each sector and will in this study further express environmental impacts as externalities. This procedure has been described in detail in Pirmana et al. (2021), and we refer further to this reference.

5.3.4 Addition of a battery and EV production sector to the Indonesian Input-Output Table

We want to analyze the economy-wide impact of a diversion of raw materials exported to the production of car batteries and EVs in Indonesia. However, the IIOT (nor EXIOBASE) contains specific production sectors. We, therefore, constructed two new sectors in the 86 sector IIOT. The input and output coefficients of these sectors were estimated as follows. Details are provided in Appendix. We concentrate here on the coefficients of monetary inputs, including value-added creation, labor input, and environmental extensions of

[6] Institute of Environmental Sciences (CML), Netherlands Organization for Applied Scientific Research (TNO), the Norwegian University of Science and Technology (NTNU) and other partners.

battery and EV production, assuming these sectors will have only batteries and EVs as output.

Input coefficients

1. The initial input structures for the electric vehicle sector and the battery for electric vehicles are taken from the conventional vehicle sector and conventional battery industries from the original IIOT.
2. Next, modifications were made to the input structure by utilizing information from the results of studies/publications related to the input structure of the two new sectors.
3. For the motor vehicle industry, modification of the input structure of conventional vehicles is carried out by utilizing information on the cost structure of electric vehicle production from a study conducted by ERIA (2020) (see figure 5.2). Based on ERIA (2020) information, we estimate the electric vehicle industry's input structure by mapping the sector classification related to the cost structure of the electric vehicle industry in the 86 IIOT classification and put the input structure values into the related sectors.
4. The modification of the input coefficient from the conventional battery industry to the input structure of the electric vehicle battery is carried out by utilizing some information from various relevant sources (e.g., Sakti, 2015; Qnovo, 2016; Tsiropoulos et al., 2018; Campbell, 2019).
5. According to Tsiropoulos et al. (2018), the breakdown of the total cost of EV batteries consists of material costs, operating surplus, capital, and labor cost. The material costs consist of raw materials and other materials costs. To obtain an estimate of the input coefficient for each raw material, we multiply the share of each input by the proportion of the total raw material cost for producing the EV battery, using information from Campbell (2019) with assumptions for the raw material cost per 64 kWh EV battery. As for the proportions of other materials, the distribution of the input coefficients is based on the classification of sectors related to the production of EV batteries from the study of Sanfelix et al. (2016). The study contains a detailed list of inventory components to the industrial sector in the manufacture of cells, battery control units, and modules (see appendix for details).
6. As for the output row, the final demand is only accounted for, assuming there is no intermediate demand for electric vehicles and batteries for electric vehicles by each industry.
7. The input coefficients include imports. To accurately determine the inducement of domestic production, we deducted the inducement of

imports by subtracting the input structure in the total transaction table from the inputs originating from imports.

8. The electric vehicle body is assumed to be the same as a conventional vehicle

Labor input

Since the IIOT does not contain employment tables, we created an employment table for each sector based on the National Labor Force Survey (Sakernas) from the Indonesian Central Bureau of Statistics. However, the statistics on the number of employees are categorized into only 63 industries. Therefore, to split into 88 industries in the input-output tables in this study, generally, we estimate them with the following procedure (see the detailed procedure in appendix).

1. The total labor income in the input-output table is divided by the number of employees of the Sakernas database statistics to calculate income per employee.
2. We estimate the income per employee in the Sakernas and the input-output category based on the Indonesia employment table with the more detailed industry category. By multiplying the income per capita in the Sakernas category by the income ratio amongst industries in Indonesia, we get the income by sector, reflecting wage differences amongst industries.
3. Next, we divide the labor income by the income per employee to calculate the number of employees in the input-output category.
4. Lastly, we treated them by multiplying the adjustment factor so that the total number of employees in the input-output category matches the number in the Sakernas category. Then, the employment intensities are calculated based on the estimated employment table. Furthermore, the changes in employment induced by final demand are measured by multiplying those of production by employment intensities.
5. The employment intensities for the new sectors are assumed to be the same as the employment intensities of conventional vehicles and the conventional battery sector.

Environmental extensions

Besides input and employment coefficients, to estimate the environmental impact of battery and EV production, the study also needs the coefficient of the external cost from emissions. As mentioned above, the procedure to estimate the external cost value has been described in Pirmana et al. (2021), and we refer further to this reference. The value of the coefficient of external costs of emissions for the two new sectors is assumed to be the same as the coefficient of the conventional vehicle and the conventional battery industry.

5.3.5 Scenario assumptions

With an Input-Output table now available for Indonesia that includes a battery and EV production sectors, the economic and environmental impacts of the production of electric vehicles are carried out using the following assumptions:

- In line with the government's policy prohibiting nickel ore export, this study assumes that this nickel ore is 100% absorbed by domestic economic activities.
- The electric vehicle batteries produced are assumed to be of the NCA type (the type of battery with the highest nickel content)
- In this study, the production of electric vehicles is assumed only to be exported and not to substitute the use of conventional vehicles in the country, so there is no reduction in the production of conventional vehicles and petrol use.
- The analysis is limited to the production phase. The modeling in this study does not involve an impact analysis on the use phase of the produced EVs since it is assumed that all EVs are exported, and we focus on impacts in Indonesia.

5.4 Results

The general results of the economic and environmental impact of EV production are summarized in figure 2. To absorb the nickel output into domestic activities, i.e., all exported nickel is used for EVs, the final demand for EVs that the economy must create is around Rp. 135.35 trillion. Moreover, assuming the electric vehicle to be produced is a Tesla Model 3 with a unit cost of $23,300 or Rp. 212 million (converted using the exchange rate of $/Rp for 2010), the number of electric vehicles that can be produced is around 639.672 units per year[7].

[7] Kosak (2018) mentioned that the unit cost of producing a Tesla Model 3 is currently estimated at $23,300.

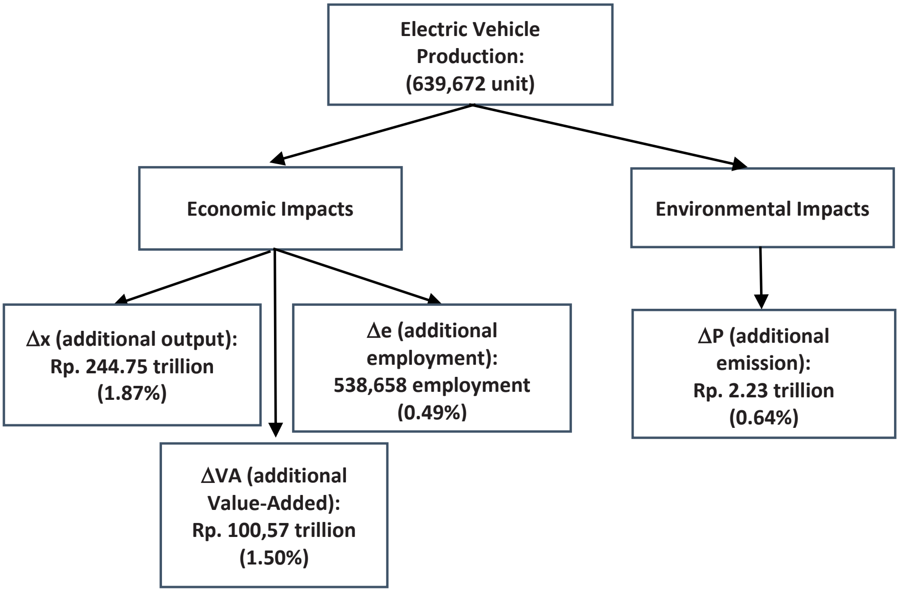


Figure 5.1. Economic and environmental impact of electric vehicle production
Source: Authors calculation.

Based on the calculation results, using nickels in new economic activities in Indonesia; in our case, battery and EV production has a positive economic impact on the Indonesian economy. Since our modeling essentially assumed that Indonesia would expand its economic activities, this is a logical outcome.

The following sectors would benefit the most from using nickel for battery and EV production: The manufacturing sector of motor vehicles, trailers, and semi-trailers.[8]; Mining of aluminum ores and concentrates; and the mining of chemical and fertilizer minerals, production of salt, and other mining and quarrying sectors. The Manufacturing sector of motor vehicles, trailers, and semi-trailers will see a growth in outputs of 22 %. Meanwhile, the mining of aluminum ores and concentrates is about 19.6%; and the mining of chemical and fertilizer minerals sector is around 4.2%.

8 The growth of this sector might occur because one of the inputs in electric vehicle production, the vehicle body, comes from this sector.

Table 5.2. The ten sectors that benefit the most from electric vehicle production

No	Description	Sector growth
1	Manufacture of motor vehicles, trailers and semi-trailers	22.05
2	Mining of aluminium ores and concentrates	19.56
3	Mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c.	4.24
4	Manufacture of rubber and plastic products	2.74
5	Insurance and pension funding, except compulsory social security	2.36
6	Computer and related activities	2.16
7	Plastics, basic	2.09
8	Renting of machinery and equipment without operator and of personal and household goods	2.02
9	Activities auxiliary to financial intermediation	1.89
10	Manufacture of gas; distribution of gaseous fuels through mains	1.84

Source: Author's calculation

The additional output created in the economy due to the final demand of the electric vehicle sector is Rp. 244.75 trillion (1.88%). The highest additional output in the economy from the final demand for the electric vehicle sector is the electric vehicle sector itself and the sectors directly related to the EV production chain (table 5.3).

The ten sectors with the highest additional output account for about 86% of the total additional output in the economy. More than half of the additional output came from the EV sector, contributing 135.35 trillion or almost 55% of the total additional output. Electric Vehicle Battery is the second largest sector, with an additional output of 10% of the total additional output, followed by the manufacture of motor vehicles, trailers, and semi-trailers sector of 9.2%; manufacture of rubber and plastic products of 2.8%; and mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c., about 2.3%.

Table 5.3. Top ten sectors creating additional output due to electric vehicle production

No	Sector activities	Additional output (trillion rp)	Percentage
1	Electric Vehicles	135.35	55.30
2	Electric Vehicle Battery	24.77	10.12
3	Manufacture of motor vehicles, trailers and semi-trailers	22.45	9.17
4	Manufacture of rubber and plastic products	6.73	2.75
5	Mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c.	5.59	2.28
6	Wholesale trade, except of motor vehicles and motorcycles	4.65	1.90
7	Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessories [a)]	3.84	1.57
8	Other land transport	2.68	1.09
9	Electricity	2.13	0.87
10	Renting of machinery and equipment without operator and of personal and household goods	2.09	0.85
	Others	34.50	14.10
	Total	244.75	100

Source: Author's calculation

Notes: [a)] Including sale of car and motorcycle along with vehicles and motorcycles parts and accessories

In terms of added value, driven by the final demand for the EV sector, the additional value-added in the Indonesian economy was Rp. 100.57 trillion, or approximately 1.5%. Looking at the changes in value-added by sectors in table 5.4, it can be seen that over 88 sectors, almost 75% of the additional value-added come from the top ten sectors. The electric vehicle sector contributes about 47% of the additional value-added created in the economy, followed by the manufacture of motor vehicles, trailers, and semi-trailers sector at 11%; electric vehicle battery about 9%; Mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c. of 4.5%. Other sectors in the top ten contribute a small percentage between 1-3%.

Table 5.4. Top ten sectors creating additional value-added due to electric vehicle production

No	Sector activities	Additional value-added (trillion rp)	Percentage
1	Electric Vehicles	47.37	47.1
2	Manufacture of motor vehicles, trailers and	10.99	10.93
3	Electric Vehicle Battery	9.04	8.99
4	Mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c.	4.56	4.53
5	Wholesale trade, except of motor vehicles and motorcycles	3.15	3.13
6	Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessories[a)]	2.61	2.59
7	Manufacture of rubber and plastic products	1.78	1.77
8	Cultivation of plant-based fibers & crop nec	1.41	1.4
9	Other land transport	1.31	1.31
10	Renting of machinery and equipment without operator and of personal and household goods	1.29	1.28
	Others	17.06	16.96
	Total	100.57	100

Source: Author's calculation

Notes: [a)] Including sale of car and motorcycle along with vehicles and motorcycles parts and accessories

Another economic impact of EV production is employment creation. EV production drives additional jobs in the economy by 538,658 employment or an increase of about 0.5%. Approximately 85% of the additional employment comes from the ten sectors with the highest additional employment (table 5.5). The electric vehicle battery and the electric vehicle sector contributed to additional employment in the economy by 8% and about 6%, respectively.

Table 5.5. Top ten sectors creating additional employment due to electric vehicle production

No	Sector activities	Additional employment (thousand person)	Percentage
1	Cultivation of plant-based fibers & crop	100.64	18.68
2	Renting of machinery and equipment without operator and of personal and	80.49	14.94
3	Wholesale trade, except of motor vehicles and motorcycles	73.14	13.58
4	Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and	71.24	13.23
5	Electric vehicle Battery	43.93	8.15
6	Electric vehicles	31.32	5.82
7	Mining of chemical and fertilizer minerals, production of salt, other	23.13	4.29
8	Transport via railways	12.74	2.37
9	Manufacture of rubber and plastic	12.04	2.24
10	Tanning and dressing of leather; manufacture of luggage, handbags,	10.17	1.89
	Others	79.81	14.82
	Total	538.66	100

Source: Author's calculation

Notes: [a)] Including sale of car and motorcycle along with vehicles and motorcycles parts and accessories

Sectors such as the sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motorcycles parts and accessories, and the wholesale trade, except for the motor vehicles and motorcycles sector, are in the top ten sectors with additional output, added value, and labor, as a result of the production of electric vehicles in Indonesia. However, if we look at the percentage of the total effect, it is only small on the overall impact. Moreover, in this study, the production of electric vehicles is intended only for export purposes and not intended to replace the use of conventional domestic vehicles. So the addition of the electric battery and electric car industries does not significantly change the economic structure, especially when viewed from the technical coefficient of the Indonesian economy, as indicated by the distribution of technical coefficients before the addition of the two sectors. The existence of a new sector does not significantly impact other sectors. In addition, the magnitude of the export of electric vehicles is still relatively small compared to the entire economy.

The main motivation for developing electric vehicles in Indonesia is to reduce emissions and the number of fuel imports, as outlined in the release of the 2019 Presidential Decree (ERIA, 2020). However, this study only estimates the environmental impacts of emissions in the production phase expressed as external costs in relation to the assumption that all EVs are exported. The final demand for the EV sector turned out to cause additional external costs from emissions with a monetary value of Rp. 2.2 trillion or about 0.6%. The top ten sectors with additional external costs from emissions account for about 89% of the total additional external costs due to the final demand for the EV sector (table 5.6). Of the ten highest sectors, the top three consecutively are rubber and plastic products, the manufacturing of basic iron and steel and ferro-alloys and first products thereof, and the electricity sector contributes to almost 75% of the total additional external costs. The six sectors in the top ten additional external costs from emissions in table 6 are also in the ten sectors with the highest external costs in the economy due to final demand before the electric vehicle and electric vehicle battery sectors existed (see Pirmana et al. 2021). Meanwhile, the activities of the two new sectors also generated external costs from emissions, from the electric vehicle sector of 78.60 billion (3.5%) and the electric vehicle battery industry of 7.76 billion (0.4%).

Table 5.6. Top ten sectors creating additional emissions (expressed as external costs) due to electric vehicle production

No	Sector activities	Additional external cost (billion rp)	Percentage
1	Manufacture of rubber and plastic products	670.55	30.04
2	Manufacture of basic iron and steel and of ferro-alloys and first products thereof	637.64	28.56
3	Electricity	357.92	16.03
4	Electric Vehicles	78.60	3.52
5	Mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c.	74.12	3.32
6	Sea and coastal water transport	39.56	1.77
7	Fertilizer	39.34	1.76
8	Paper & pulp	36.48	1.63
9	Other land transport	28.75	1.29
10	Chemicals nec	26.03	1.17
	Others	243.51	10.91
	Total	2,232.50	100

Source: Author's calculation

If we break down this additional emission based on the type of pollutant, SOx, CO2, and NOx are the primary sources of additional emissions due to the final demand in the EV sector (table 5.7). The additional emissions from these three sectors accounted for 58% of the total additional emissions, with SOx contributing around 26%, CO2 at 18%, and NOx at 14%.

Table 5.7. Top ten externalities due to additional external cost from emissions due to electric vehicle production by emission type

No	Emission types	Changes in external costs (billion Rp)	Percentage
1	SOx	569.87	25.53
2	CO_2	402.26	18.02
3	NOx	320.10	14.34
4	Pb	311.61	13.96
5	TSP	226.97	10.17
6	PM10	134.01	6.00
7	PM2.5	104.73	4.69
8	NMVOC	43.37	1.94
9	Hg	29.51	1.32
10	CH_4	26.95	1.21
	Others	62.66	2.81
	Total	2,232.04	100

Source: Author's calculation

5.5 Discussion and conclusions

This study is an initial attempt to analyze the economic and environmental impacts of electric vehicle production in Indonesia. In conclusion, we found that electric vehicle production positively boosts output, value-added growth, and job creation. Based on the calculation results, additional output, value-added, and labor due to the final demand for the electric vehicle sector, respectively, amounted to 1.87%, 1.5%, and 0.5%. Note, however, that we did the simulation with an input-output model for 2010. The Indonesian economy's current outputs and value-added generated is about 2.25 times higher than in 2010. Stimulating EV production in Indonesia would still make a significant contribution to economic growth, given that it comes just from one sector. The ambition of the Indonesian government to use its large Nickel reserves to stimulate fast-growing upstream user industries, like battery and EV production, to locate themselves in Indonesia hence makes sense.

On the negative side, this study finds that additional battery and EV production leads to additional external costs from emissions, albeit in insignificant amounts. This is related to our assumption that all produced EVs will be exported. Using EVs domestically, may lead to lower production of traditional vehicles and lower the gains in jobs and value-added. EVs have no direct emissions, which, if they replace traditional vehicles domestically, can potentially lead to the reduction of external costs, depending on the carbon intensity of electricity used. Such wider use of EVs is foreseen in Indonesia's electric vehicle roadmap. More detailed studies are needed that estimate the economic and environmental impacts of EV production both from the production phase and the usage phase.

Acknowledgments

This research was funded by the Lembaga Pengelola Dana Pendidikan (LPDP), grant number PRJ-1461/LPDP.3/2016, Ministry of Finance, Republic of Indonesia, is part of the first author's doctoral scholarship at the Institute of Environmental Sciences (CML), Faculty of Science, Leiden University, Netherlands.

5.6 Appendix

This appendix contains the supporting information for this case study and includes details on the modelled processes, supporting calculations.

5.6.1 Information to adjust input coefficient of electric vehicle sector

The following are the steps in calculating the electric vehicle input coefficient (See detail in Supplementary Information):

1. The new coefficients for the electric vehicle sector are derived from existing input coefficients of the conventional motor vehicle manufacturing sector from the Indonesian input-output table for 86 sectors.
2. The domestic share is taken from the ratio of the domestic inputs to total inputs from the cost structure of the conventional vehicle industry, where the input is divided into inputs from domestic sources and imports.
3. Adjustment of the input coefficients column is carried out by utilizing information on input structure for electric vehicles from ERIA (2020) in figure 5.2 below or see SI in worksheet EV Cost structures cell A8.

Based on ERIA (2020), the electric vehicle sector's input structure consists of about 65% intermediate inputs, and primary input (VA) is about 35%. Figure 5.2 shows the breakdown of these EV input structures.

4. Next, an adjustment is made from the total intermediate input of the conventional vehicle industry to the intermediate input of the electric vehicle industry by changing the share of the total intermediate input of the conventional vehicle industry to the total intermediate input of the electric vehicle industry. The same is also done for the intermediate input component originating from imports. The consequence is that there is a change in the share of the intermediate input component of conventional vehicles, which is the basis for the cost structure of the Indonesian electric vehicle industry.

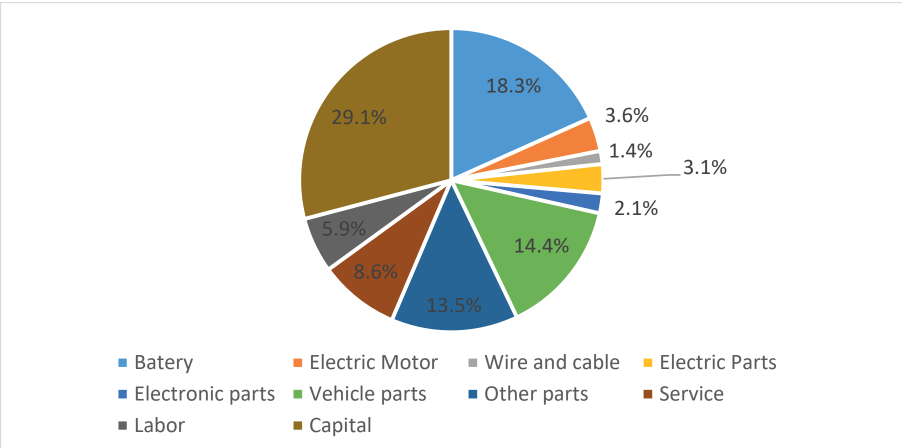


Figure 5.2. Input structures for electric vehicle sectors
Source: Adopted from ERIA, 2020

5.6.2 Information to adjust input coefficient of electric vehicle battery sector

The following are the steps for calculating the input EVB structure in this study:

1. Domestic share is taken from the ratio of domestic inputs to total inputs from the cost structure of the conventional battery industry in table IIOT 86.

2. Information to structure the EVB input is obtained from several sources. Initial information is taken from the study of Tsiropoulos et al. (2018). Based on their study, the breakdown of the total cost of the battery for intermediate inputs (materials) is 64%, and for primary inputs is 36% (see figure 5.3). However, in Tsiropoulos et al. (2018) study, the intermediate inputs from raw materials and other materials are not separated. In this study, we utilize the information from studies conducted by Lowe et al. (2010), Roland Berger (2012), Sakti et al. (2015), and Pilot (2015, which state that the proportion of raw materials is 50-52% of the total cost of producing an EV battery. Meanwhile, detailed information regarding the composition of raw materials for producing EV batteries is taken from Campbell (2019), as shown in Table 5.8.
3. After we know the share of each raw material cost to the total costs structure, adjustments are made from the total intermediate input of the conventional battery to the intermediate input of the electric vehicle battery industry. The adjustment is made by changing the share of the total intermediate input of the conventional battery industry to the total intermediate input of the electric vehicle battery industry. The same steps are also performed for the intermediate input components from imports. Consequently, there is a change in the share of the intermediate input components of a conventional battery. This result is the basis for the cost structure of the electric vehicle battery industry in Indonesia.

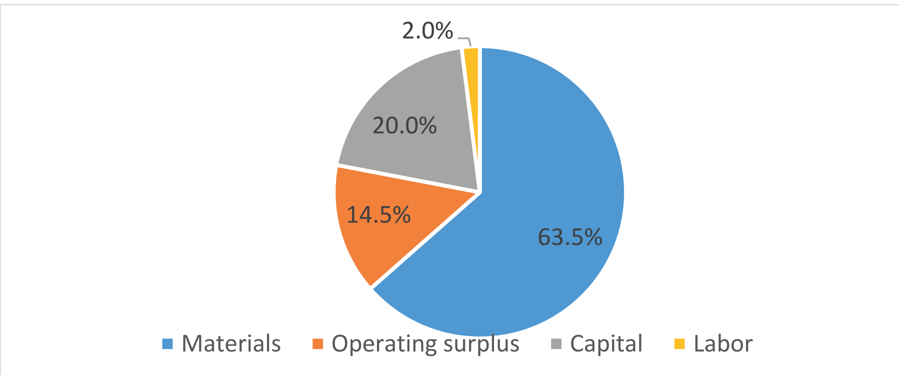


Figure 5.3. Breakdown of the total cost of battery in key components
Source: Adopted from Tsiropoulos et al (2018)

Table 5.8. Raw material costs per 64kWh EV Battery

Materials	Approx Cost per 64kWh EV Battery	Share to total raw material cost	Share of raw material cost to total costs structure
Copper	\$320	0.080	0.041
Aluminum	\$340	0.085	0.044
Nickel	\$1,650	0.411	0.214
Cobalt	\$700	0.175	0.091
Lithium	\$1,000	0.249	0.130
Total	\$4,010	1.000	

Source: Modified from Campbell (2019)

5.6.3 Creating an employment table

Employment tables (the number of employees in each industry sector) should be prepared to analyze the ripple effect on employment. We create an employment table for each sector based on the International Labour Organization's (ILO) ILOSTAT database since IIOT does not contain employment tables. However, the number of employees is categorized into only 63 industries. Therefore, to split into 88 industries in the input-output tables in this study, we estimate them with the following procedure. First, for each industry (i) in the ILO category, the total labor income (Yij) in the input-output table is divided by the number of employees (Li) of the ILO statistics to calculate income per employee (wi).

$$W_i = \sum(Y_{ij})/L_i \qquad (5.5)$$

Next, we estimate the income per employee in the ILO category (w_i^J) and the input-output category (w_{ij}^J) based on the Indonesia employment table with the more detailed industry category. By multiplying the income per capita in the ILO category by the ratio of income amongst industries in Indonesia, we get the income (wij), reflecting wage differences amongst industries.

$$W_{ij} = W_i * W_{ij}^J / W_i^J \qquad (5.6)$$

Then, we divide the labor income by the income per employee to calculate the number of employees (Lij) in the input-output category.

$L_{ij} = Y_{ij}/W_{ij}$ (5.7)

Finally, we treated them by multiplying the adjustment factor (ai) so that the total number of employees in the input-output category matches the number in the ILO category. In this study, we use Leij as the number of employees in the ILO category.

L^{e}_{ij}=$L_{ij} * a_{ij}, \sum(L_{ij} * a_i) = L_i$ (5.8)

Then, the employment intensities are calculated based on the estimated employment table. The changes in employment induced by final demand are measured by multiplying those of production by employment intensities.

Chapter 6

Conclusions and general discussion

This thesis is an illustration of how the System of National Accounts (SNA), combined with data from the System of Environmental-Economic Accounting (SEEA), can be used to analyze simultaneously the economic and environmental pillars of sustainable development (and therefore, the Sustainable Development Goals (SDGs)). Focusing on developing countries, it first analyses the problems in creating accounts in these countries. It then explores detailed case studies for Indonesia calculating environmental damage costs (one of the indicators in SEEA) in part using Environmentally Extended Input-Output Analysis (EEIOA) as the primary analytical tool. The main aim is to measure the environmental costs incurred due to economic development activities, particularly the environmental costs due to environmental degradation from air pollution and the destruction of cultivated forest resources. This study's measurement of environmental costs is also intended to complement and expand the scope of environmental costs calculated by Indonesia's Central Bureau of Statistics (BPS), which is currently limited to measuring environmental costs in terms of resource depletion. The results of this thesis will be beneficial as a guide for policymakers to identify possible measures and policy options in response to future environmental-economic challenges.

This thesis starts in Chapter 2 with an assessment of the potential of the SEEA to contribute to monitoring SDG-related indicators and analyze the current level of the SEEA implementation in developing countries and barriers to its adoption. Next, Chapter 3 assesses the priorities for improving and expanding environmental accounts in Indonesia. We used environmental costs related to emissions and resource extraction in Indonesia to assess priorities. Chapter 4 analyzes the environmental costs of emissions and the environmental costs associated with forest resources from a consumption perspective. In addition, it analyzes Indonesia's priority sectors when economic and environmental performance are measured simultaneously. We use EEIOA to calculate environmental costs of consumption and further analyze backward and forward linkages to identify the priority sectors. Finally, in Chapter 5, we use EEIOA to evaluate the economic and environmental impacts of the production of electric vehicles (EVs) in Indonesia. The analysis assumes that all Indonesian nickel ore will be absorbed for further processing in domestic economic activities consisting of battery and EV production, assuming all produced EVs are for export purposes only.

This concluding chapter will first answer the research questions defined in Chapter 1, followed by a discussion and recommendations for future research and final remarks.

6.1 Answer to research questions

6.1.1 Question 1. Focusing on developing countries in general: what is the potential of the SEEA in supporting the monitoring of SDGs indicators, what is the current state of SEEA implementation, and what are the barriers for a comprehensive SEEA implementation?

To address this question, Chapter 2 provided a brief preview of the current and potential uses of the SEEA to support the success of SDG indicator monitoring. It also reviews the current level implementation of the SEEA and identifies the main factors hindering the implementation of the SEEA through literature reviews and small assessment surveys.
The results confirmed that the SEEA is a very useful accounting system to cover SDGs. As a standard international statistical framework, the SEEA has a great potential to support the monitoring of SDG indicators and address priority issues in each country. Indicators and analytical methods based on SEEA support the national SDG process exist. In addition, SDG indicators that were potentially supported by the existence of the SEEA were classified into Tiers 1 and 2. Of the overall indicators, 50 indicators have a high potential to be covered by the SEEA. Several indicators were conceptually clear, had an internationally established methodology, and could be informed by data collected via the SEEA. However, the success of the SEEA in supporting the SDGs will largely depend on the ability of countries to develop their SEEA-based accounts in an internationally comparable manner.

The topics covered by environmental-economic accounting programs vary between developing and developed countries. In most developing countries, the existing activities and plans should focus on natural resources management and specific issues such as energy security. Meanwhile, for most developed countries (mainly European Union countries), the salient issues are expenditure flows, economic instruments, resource efficiency, and environmental degradation related to economic production and consumption activities.

Barriers to the SEEA implementation, particularly in developing countries, are related to several issues. An inquiry among practitioners and a literature survey indicate that data availability, data quality, and lack of human resources are the three main obstacles at the compilation stage and further development of the environmental-economic accounts. There are indications that financial and technical assistance from international institutions plays an essential role in supporting the successful development and implementation of the SEEA, especially for developing countries. For instance, the WAVES program has demonstrated that it is possible to produce internationally standardized environmental accounts in middle-income countries. International organizations' support concerning technical assistance, financial support, methodological guidelines, and training materials seem to significantly improve the compilation and development of the SEEA accounts, especially in developing countries. Countries without regular government funding experience greater obstacles in developing their SEEA accounts.

6.1.2 Question 2. How can we enrich the Indonesian SNA with environmental costs accounts and what are the sectors and types of environmental interventions for which such accounts have to be developed with the highest priority? (Chapter 3)

Indonesia has good economic accounts but limited accounts for environmental extensions such as emissions and resource extraction by sector. In order to find out what environmental accounts should be an improvement priority in Indonesia, we made a rough estimate of emissions and resource extractions by sectors from a variety of sources and calculated the environmental costs associated with them. This allowed for a priority setting of environmental pressures and sectors for which the need for having good quality data is most prominent. The total environmental costs in this study are divided into three categories: (i) environmental degradation due to emissions, (ii) ecosystem damage (value loss of ecosystem), and (iii) depletion of natural resources.

Based on the calculation results, the total environmental costs in Indonesia were around Rp. 915.11 trillion or 13% of GDP in 2010. The total environmental costs in Indonesia are mainly due to the depletion of energy and mineral resources, which account for around 55% of the total environmental costs. It has to be noted, though, that these costs are not damage costs but represent the value of resource stocks that have been sold. These environmental costs are a logical consequence for any country with mining activities in its economy. The remaining 38% came from environmental costs due to environmental degradation from air pollution, and almost 7% due to environmental costs caused by the destruction of the ecosystem.

It can be concluded that the BPS is on the right track by prioritizing the compilation and publication of environmental-economic accounts related to resources, which includes energy, minerals, and forest resources accounts. However, BPS publications on forest resource accounts are still limited to timber resources. BPS should consider the complete compilation and publication of these forest accounts, including loss of ecosystem services value.

In addition, BPS has not yet included environmental accounts related to environmental degradation due to emissions. Suppose BPS would invest in expanding the scope of Indonesia's economic-environmental accounts. In that case, it is highly recommended to include at minimum data on air pollution emissions from the top ten sectors and top ten polluters that are the main contributors to Indonesia's environmental costs of emissions. The top ten sectors cover 73% of the environmental degradation due to air pollution. These ten sectors comprise electricity; manufacture of basic iron and steel and ferro-alloys and first products thereof & re-processing of secondary steel into new steel; mining of coal, lignite, and extraction of peat; the sea and coastal water transport; cultivation of paddy rice; manufacture of rubber and plastic products; livestock and their result; manufacture of cement, lime, and plaster; fertilizer and construction. At the same time, the ten most prominent air pollutants cause 93.70% of the cost of environmental damage due to air pollution and hence also are a priority. They include SOX, NOx, CO2, CH4, NH3, TSP, PB, PM10, PM2.5, and Nitrogen.

6.1.3 Question 3 - Using the SNA enriched with environmental cost accounts, what final demand components drive most external costs and hence would be priorities for consumption-based policies? How much are the environmental costs for each final demand component in Indonesia, what are the economic sectors which perform best when both economic and environmental performance are considered simultaneously?

The environmental impact of an economic system can be viewed from two complementary perspectives: production and consumption. Chapter 4 provides an overview of these impacts by measuring the environmental costs of emissions and forest resources from a consumption perspective and identifying Indonesia's priority sectors when economic and environmental performance is considered. Environmental Extended Input-Output (EEIO) Analysis is employed for this purpose. The EEIO approach can relate, in a comprehensive manner, to how consumption through the value chain drives production and, in relation, to how consumption drives emissions, resource use, and the associated external environmental costs. The EEIO approach further allows us to calculate backward and forward linkages to identify priority sectors when economic and environmental performance are taken into account.

Based on the calculations, the environmental cost of emissions generated by final demand is roughly 7% of GDP. The environmental costs of emissions value in this chapter have been adjusted to include the environmental costs of emissions embodied in imported products, resulting in a higher value than the environmental costs of emissions in Chapter 3, which are sourced only from domestic production activities (total environmental costs are 13% of GDP, of which 5% comes from the environmental costs of emissions, see chapter 3)

The findings of the calculations demonstrate that the environmental costs of emissions due to final demand are primarily derived from domestically produced final consumption, with household consumption accounting for the majority of total environmental costs of emissions. Meanwhile, the environmental cost of forest resources accounts for just 7.5% of overall final consumption environmental costs, with gross fixed capital formation and household consumption being the primary final demand components that contribute to forest resource environmental costs.

Finally, findings from a backward and forward linkage analysis pointed out that key sectors for Indonesia from a sustainability and economic point of view that must be prioritized in the Indonesian economy are: the manufacture of textile; publishing, printing, and reproduction of recorded media; chemicals n.e.c.; manufacture of other non-metallic mineral products n.e.c.; construction; and other land transport. Stimulation of economic activity in these sectors will have a more than proportional positive impact on Indonesia's economic development, with a relatively limited increase in external costs.

6.1.4 Question 4 - How can we use the SNA enriched with environmental cost accounts to assess the economic and environmental implications of investment in new economic activities, illustrated by the potential use of Indonesian natural resources to produce electric vehicle batteries and electric vehicles? (Chapter 5)

The Indonesian government has ambitions to become a production hub for electric vehicles (EV) in Asia. The ambitions are motivated by the fact that Indonesia has the largest nickel reserves in the world, 70% of which is in the form of nickel limonite, an essential raw material in the global EV supply chain, especially in the supply of raw materials for EV battery production. To support this ambition and encourage the production of value-added products, including mineral processing such as nickel ore, the government has issued a policy through Presidential Regulation Number 55 of 2019 concerning the Acceleration of the Electric Vehicle Battery Program for road transportation. This Presidential Decree then was followed up with the Minister of Energy and Mineral Resources Regulation No. 11/2019 concerning a ban on exporting nickel ore with a content below 1.7% Ni, which, combined with a ban on exports of high-grade nickel in 2014, brought all exports of nickel ore to a halt by Indonesia. Hence, it is interesting to analyze the Indonesian context's economic and environmental impact of such an enhanced EV production. Chapter 5 simulates the economic and environmental impacts of EV production in Indonesia. For this purpose, we use the EEIO model discussed in chapter 4 and section 6.1.3 and simulate what economy-wide changes would occur in value-added, jobs, and external costs if Indonesia developed an electric vehicle battery (EVB) and an EV production sector. In simulating this impact, several assumptions are applied: 100% of the previously exported nickel ore is absorbed by domestic economic activities, and the production of electric vehicles is assumed to be only for export and does not substitute for the use of conventional vehicles in the country. This implies that the analysis is only limited to the production phase. We assume no substitution of vehicles in the use phase in Indonesia and assume no reduction in the production of conventional vehicles and the use of fuel in Indonesia.

In order to analyze the economic and environmental impacts of the production of electric vehicles, two new sectors were added to the EEIO model, i.e., the battery sector for EVs and the electric vehicle sector. Estimates of two new sectors were made by estimating their input and output coefficients, including value-added creation, labor inputs, and emissions/external cost. The input coefficients for the electric vehicle sector were derived from the input-output tables for 86 industries in Indonesia that already exist for conventional vehicles. Adjustments were made using input structure information for electric vehicle production from various relevant studies. Similar steps were also taken to build coefficient input data for the electric vehicle battery sector. Since the Indonesian IOT does not contain employment tables, we created employment tables based on the National Labor Force Survey (SAKERNAS) data from the BPS for all sectors following the sector classification in this study. The employment intensity for the new sectors is assumed to be the same as the employment intensity for conventional vehicles and the conventional battery sector. Meanwhile, to estimate the external cost coefficient of emissions, we use detailed emission data based on economic sectors from the EXIOBASE dataset and damage cost value by type of air Pollutant from several relevant studies. The two new sectors' direct external costs per unit of output are assumed to be the same as the coefficient value for conventional vehicles and the conventional battery industry.

The simulation results indicate that the production of electric vehicles positively increases output, value-added growth, and job creation. Compared to the Indonesian economy, additional output, value-added, and labor due to final demand for the electric vehicle sector were 1.87%, 1.5%, and 0.5%, respectively. However, it should be noted that the simulation using the input-output model is for 2010, while the output and value-added generated by the Indonesian economy is currently around 2.25 times higher than in 2010. Having said this, stimulating EV production in Indonesia will still significantly contribute to economic growth, considering that GDP gains are realized by expanding only one sector. This finding forms the defensible justification for the Indonesian government's ambition to use its large nickel reserves to stimulate fast-growing upstream user industries, such as battery and EV production. The simulation also found that EVB and EV production creates additional external emissions costs. The amounts are, however, insignificant. The extra value-added created due to the formation of new sectors in the economy, the EV and EVB sectors, was Rp. 100.57 trillion, and the extra external cost of emissions was only Rp. 2.23 trillion. Alternatively, to put it another way, the extra external cost from emissions to the extra GDP attributable to the existence of these two industries is only about 2.2%. Note further that the simulation assumes that all produced EVs will be exported. Using EVs domestically can reduce the production of traditional vehicles and, therefore, lower job gains and value-added. EVs do not have direct emissions, which, if they replace traditional vehicles domestically, have the potential to lead to reduced external costs, depending on the carbon intensity of the electricity used.

6.1.5 Answer on overall RQ - How can we set up environmental-economic accounts in developing countries such as Indonesia, and how can such accounts support both development as environmental policies?

In order to deal with the challenges of sustainable development, the availability of appropriate and high-quality data is crucial to inform policy decisions. Sustainable development challenges need to be answered with consistent data that uses the same standards, definitions, classifications, units, assumptions, and history of standardized data to achieve development goals.

This thesis shows that the SEEA's role in supporting and managing sustainable development programs is critical.

As shown in chapter 2, many economic and environmental indicators relevant for measuring progress to the SDGs at the national or global level can be measured via integrated environmental-economic accounting systems. Therefore, The EEA data as part of a comprehensive accounting database consisting of the SNA and its satellite systems EEA (SEEA) is relevant for analyses in the context of scientific policy advice. We can see in each chapter that the SEEA plays an essential role in supporting sustainable development and the green economy agenda, which is very relevant for countries with abundant natural resources like Indonesia.

The SEEA can be applied for different types of analysis. In general, SEEA data can be used to calculate adjusted and better indicators of macroeconomic aggregates such as Green GDP, the productivity of energy and raw materials, emissions of greenhouse gases, environmental costs from resources depletion, and economic and environmental impact analysis.

The SEEA covers both environmental and economic SDGs well. In chapters 3-5, we demonstrated how the SEEA is a powerful tool for setting priorities and analyzing environmental priorities and the impacts of economic development on SDGs. As we saw in chapter 2, implementation is complex, but it can be overcome with financial resources and technical assistance. That suggests that the SEEA is vital.

Efforts to advance the SEEA can be initiated by conducting a scoping exercise to assess institutional readiness and capacity to expand the SEEA through priority accounts. This includes evaluating the relevance and importance of policies, access to data, and the availability of institutional and financial frameworks, as well as the technical resources needed to implement priority accounts. Using such an assessment, the government can develop a national outline that can be used to determine initial priorities for implementing the different types of accounts, collecting/allocating funds, and establishing the necessary institutional arrangements for their implementation.

6.2 Discussion and policy recommendations

Designing and managing development programs becomes impossible if we cannot measure the achievements or progress of development itself. The stages of development management, such as planning, budgeting, implementation, control, and evaluation, become inappropriate and ineffective when their progress cannot be measured correctly. Against this backdrop, data plays an important role. Accurate, up-to-date, complete, and open data so that it can be widely accessed are prerequisites for quality development management and community involvement in participatory management.

Sustainable development includes the interaction between economic and environmental dimensions. The United Nations developed a System of Environmental-Economic Accounting (SEEA), which builds on the System of National Accounts (SNA) to respond to the weakness of conventional national accounts that ignore problems related to natural resource scarcity, degradation, and environmental degradation damage. Measuring macroeconomic aggregates without considering environmental costs can potentially provide misleading information about sustainable development. In this case, the SEEA offers more comprehensive statistical information because it considers an aspect that was previously often overlooked, the environment. Even now, after the SDGs have been agreed upon as a global development agenda, there is a strong impetus to explore the possibility of a broader account that extends beyond GDP, where the SEEA role becomes very strategic. Chapter 2 provides a clear picture of the potential of the SEEA in supporting the monitoring of SDG indicators; there are even indications that all the SEEA accounts are useful as a tool for monitoring most of the SDGs indicators.

The SEEA is an important vehicle for coherent monitoring of progress towards SDGs and sustainable development. The development of The SEEA implies standardization and coherence of the concept, definition, clarification, and accounting of development data agreed upon by statistical offices in countries that have agreed on the SDGs as the main development agenda. This aligns with the principle of one sustainable development data set and one data standard. The construction of the SEEA will enable us to generate useful policy implications relating to natural resource utilization for development and the environment. In general, policy-related issues of the SEEA concern how it helps policy formulation as well as the kind of change it brings once it is implemented.

The experience of Indonesia in developing the SEEA may give important lessons on how developing countries can proceed with further developing this accounting system. Since 1997, the Central Statistics Agency (BPS) has developed an Integrated System for Indonesia's Environmental and Economic Accounts, including external cost accounts, known as SISNERLING. However, a main limitation of SISNERLING is the coverage since it currently only includes natural resource depletion, while environmental costs caused by environmental degradation and damage have not been included (Tasriah, 2021). Several challenges include data availability and quality, low resource support, limited knowledge, and methodological challenges.

Moreover, the data is spread across various institutions, with unclear coordination mechanisms. SISNERLING also has not been appointed as a resource supporting information in formulating public policies and evidence-based development planning. Hence, more effort is needed for data collection activities related to data confirmation, methodologies, and units (UKP-PPP, 2014). This thesis also identifies similar problems in compilation and expanding the SEEA (see chapter 2).

Important issues that need further consideration are what should be covered in the indicators, as sustainability is a broad concept. Data and methodological limitations could become the critical constraint in developing and applying sustainable development measurement. Better data and statistics would help policymakers track the progress and make sure that decision-making is evidence-based and can strengthen accountability (Burov et al., 2016). Due to these issues, we now turn to the recommended direction for the future.

Build linkages between sustainability measurement and policy implication. One important feature to be developed in terms of sustainability measurement is not limited to the issues and its measurement per se, but more importantly, how to develop the necessary linkage between measurement result and policy implication. The sustainability measurement results best include an analysis component in their routine report and built-in feedback to the relevant stakeholders (Alisjahbana & Yusuf, 2004). In terms of the SEEA/EEA, BPS can strengthen the current system of environmental-economic accounts (SISNERLING) by establishing priority accounts based on policy needs to address national policy priorities, including green economy and monitoring SDGs. In addition to the mineral and the forest accounts that BPS has carried out, the account that should be prioritized is the air emissions accounts, which in this study is the second contributor to the total environmental costs in Indonesia.

Enhance integration/coordination across institutions and at the level of government. Data with high integrity is born from integrated data management, not from data scattered across various ministries, institutions, technical units, or individuals. Data with high integrity results from good coordination between data producers and data users or between data producers and data users. Data integrity is born from the coordination process, both between and within ministries and government agencies, where data and information centers each play an important and substantial role in supporting the overall activities of ministries and agencies. With such coordination, the right combination between the substance of the data (what is the content and what is the data for) and the methodological side of the data (how the data is generated) is possible and, in turn, leads to reliable and accountable sustainable development data. The coordination mechanism must be regulated in the provisions and regulations related to data so that the coordination procedure is clearly described. This would embed the sustainable development measurement such as the SEEA within the regulatory framework of enhancing the National Statistical System for information on environment-economy linkages.

Enhance training and capacity building in environmental-economic accounting. Institutional and personnel capacity building within BPS, academicians, and departments such as the Ministry of National Development Planning (Bappenas), Ministry of Environment and Forestry (KLHK), and Ministry of Finance are essential components for improving the quality of the environmental-economic accounting output. Capacity building provides a better understanding of the concepts and engages experts in professional development through collaborative activities, staff exchanges, and training on data compilation, analysis, and evaluation (UN, 2015).

Enhance partnerships and coordination with International and donor agencies. Partnerships and coordination accelerate implementation. Indonesia can use various international initiatives to help build capacity regarding the implementation and development of their current environmental-economic account through technical assistance, financial support, training materials, and methodological guidelines. For example, to support the sustainable development agenda, the aforementioned global partnership, WAVES (Wealth Accounting and Valuation of Ecosystem Services). Specifically, WAVES aims to develop environmental accounts using internationally agreed standards and develop a standardized approach to environmental services accounts. In Indonesia, WAVES involves the ministry of national development planning (Bappenas) as the principal partner, together with BPS and relevant ministries/agencies, and started in 2014 through piloting accounts for selected commodities. The WAVES global partnership is the operationalization of the SEEA so that standardization and coherence of concepts, definitions, classifications, and data accounting rules are the keys to implementing the partnership.

Develop a data quality assurance mechanism. Specific mechanisms along the chain of statistical activities need to guarantee data quality, from data collection to presentation. In the case of Indonesia, this mechanism has not been implemented in some ministries/agencies. Together with the relevant policy departments, BPS can allocate their staff specifically to support this data quality assurance system, such as a dedicated SEEA unit.

This thesis is one effort to continue the previous Indonesia SEEA estimation conducted by BPS (SISNERLING) by extending it to a broader scope. The EEA measurement in this thesis is carried out by considering the environmental costs caused by the depletion of natural resources and expanding its scope to include the calculation of environmental costs caused by environmental degradation and damage in the Indonesian context. In chapter 3, it can be seen that BPS is on the right track by prioritizing the preparation and estimation of the EEA, which includes a mineral and forest resource balance regularly, both physical and monetary accounts. However, there are indications that the environmental costs of environmental degradation are also significant. In this thesis, environmental degradation only includes information on air emissions as an additional environmental stream in Indonesia's EE-IOT framework. Although it only includes air emissions in the calculation, the environmental costs of these air emissions are the second contributor to the total environmental costs in Indonesia. The environmental costs exercise in this thesis can be used as initial consideration for BPS to expand its SISNERLING coverage. The coverage includes environmental flows from air emissions and even other environmental flows such as water pollution, energy use, water use, and waste generation.

In addition, this thesis uses the EEIO model as the primary approach in measuring environmental costs in Indonesia. EEIOT provides a unified framework for analyzing the interconnections between economic sectors and environmental flows. Chapters 4 and 5 show how the EEIO approach can be used as a powerful and valuable analytical tool concerning the measurement of environmental costs based on detailed sector classifications, which will be of great use to policymakers in formulating evidence-based sustainable development policies. Considering the potential of this EEIO approach in measuring EEA, we suggest the BPS compile data on such flows of emissions and resource extractions using the SEEA framework. They can be integrated directly into standard input-output tables to build a comprehensive Indonesian EEIOT.

6.3 Final Remarks

Indonesia's current national development should focus on achieving sustainable development goals. In measuring long-term economic development related to environmental aspects, the presentation of GDP figures should be expanded to take into account the depletion of natural resource availability and environmental damage in order to be able to provide a more comprehensive picture of sustainable economic development. Efforts towards improving data quality, unifying data, and opening data access for the wider community, can be started by doing what we might do together in stages and measurably. The first step of these efforts is to identify data management issues in the context of Indonesia's institutions and public policies and consider the progress that has been made and the limitations faced. This includes paying attention to the possibilities available to rejuvenate what Indonesia already has established, improve what Indonesia is currently doing, and leave behind what tends to hinder, limit or slow down Indonesia's efforts in establishing a sound System of Environmental and Economic Accounts. However, due to its limitations, this thesis is not intended to answer all problems in measuring sustainable development indicators such as Indonesia's environmental-economic accounting (EEA). It is just one exercise in, hopefully, other major endeavors in the future and can be seen as a message which shows that improvements of this kind in the national accounting system are feasible and should be warmly supported. From a methodological perspective, this thesis provides a perspective on the potential and usefulness of the EEIOA to be used as a valuable tool in measuring sustainable development indicators. Such an approach can significantly support future research to refine and expand the scope of the EEA. Furthermore, the calculation of the SEEA helps countries conduct analyses and design and implement policies that would bring about environmentally sound and sustainable economic growth and development. Therefore, further studies to improve the SEEA estimation and address the gaps and limitations of previous SEEA studies are needed.

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Summary

Indonesia is experiencing various environmental challenges related to its fast economic growth. Therefore, it is necessary to have measurable and applicable indicators to obtain accurate data and information regarding the costs of adverse environmental impacts arising from economic activities to support more effective and targeted decision-making. Therefore, this thesis aims to answer how we can set up environmental-economic accounts in developing countries such as Indonesia and how such accounts can support both development as environmental policies. So, the overall objective of this PhD thesis can be formulated as follows: *how can we set up environmental-economic accounts in developing countries such as Indonesia, and how can such accounts support both development as environmental policies?*

This overall aim will be supported by answering the following research questions:

1. Focusing on developing countries in general: what is the potential of the SEEA in supporting the monitoring of SDGs indicators, what is the current state of the SEEA implementation, and what are the barriers for a comprehensive SEEA implementation? (Chapter 2)

2. How can we enrich the Indonesian SNA with environmental costs accounts and what are the sectors and types of environmental interventions for which such accounts have to be developed with the highest priority? (Chapter 3)

3. Using the SNA enriched with environmental cost accounts, what final demand components drive most external costs and hence would be priorities for consumption-based policies? How much are the environmental costs for each final demand component in Indonesia, what are the economic sectors which perform best when both economic and environmental performance are considered simultaneously? (Chapter 4)

4. How can we use the SNA enriched with environmental cost accounts to assess the economic and environmental implications of investment in new economic activities, illustrated by the potential use of Indonesian natural resources to produce electric vehicle batteries and electric vehicles? (Chapter 5)

The starting point of this thesis illustrates how the System of National Accounts (SNA) as expanded in the System of Environmental and Economic

Accounts (SEEA) can be used to analyze the economic and environmental pillars of sustainable development and those related to the Sustainable Development Goals (SDGs) (question 1). Afterward, an exploration is carried out to assess the priorities for improving and expanding environmental accounts in Indonesia, utilizing environmental costs related to emissions and resource extraction in Indonesia to measure priority (question 2). We then combine such environmental cost accounts with the Indonesian input-output table of 2010 to explore Indonesia's environmental costs related to emissions and the use of forest resources from a consumption perspective, and identify priority sectors in terms of economic and environmental performance using linkages analysis (question 3). Finally, a simulation is conducted to analyze the economic and environmental impacts of electric vehicle (EV) production in Indonesia (question 4).

Chapter 2 assesses the potential of the SEEA to contribute to monitoring SDG-related indicators. This chapter also analyzes the current level of the SEEA implementation and barriers to implementation of the SEEA, with a special focus on developing countries. The findings confirmed that the SEEA is a very useful accounting system to cover SDGs. As a standard international statistical framework, the SEEA has a great potential to support the monitoring of SDG indicators and asses priorities with regard to development and environment in each country. Indicators and analytical methods based on SEEA exist already that can support the national SDG processes. Indicators relevant for monitoring progress to the SDGs in general are conceptually clear, can be based on an internationally established calculation methodology, and can be calculated by information that is can be derived from the SEEA. However, the success of the SEEA in supporting the SDGs will largely depend on the ability of countries to develop their SEEA-based accounts in an internationally comparable manner.

The SEEA aims to cover environmental and economic aspects in general. Due to a difference in economic structure however, emphasis of what is relevant for developing and developed countries may differ. In most developing countries, natural resources management and energy security are important issues to be covered in such accounting programs. But in most developed countries, the focus is more on expenditure flows, economic instruments, resource efficiency, and environmental degradation related to economic production and consumption activities. Barriers to the SEEA implementation, particularly in developing countries, are related to several issues. An inquiry among practitioners and a literature survey showed that data availability, data quality, and lack of human resources are the three main obstacles at the compilation stage and further development of the environmental-economic accounts. There are strong indications that financial and technical assistance from international institutions plays an essential role in supporting the successful development and implementation of the SEEA, especially for developing countries. Countries without regular government funding experience greater obstacles in developing their SEEA accounts.

Chapter 3 focuses on research question 2. The chapter describes an initial effort to assess environmental costs related to emissions and resource extraction by economic sector in Indonesia. This exercise had as goal to identify priority sectors, emissions and resource extractions for which more precise data are desirable. According to the calculation results, the total environmental costs in Indonesia were around 13% of GDP in 2010. Indonesia's total environmental costs are mainly due to the depletion of energy and mineral resources, which account for about 55% of the total environmental costs. The remaining 38% came from environmental costs due to environmental degradation from air pollution, and almost 7% due to environmental costs caused by the destruction of the ecosystem. We can conclude that the Indonesian Central Bureau of Statistics (BPS) is on the right track by prioritizing mineral and forest accounts in its compilation and publication of the environmental-economic accounts. However, BPS has not yet been able to include environmental accounts related to environmental degradation caused by air emissions, while chapter 3 shows air emissions contribute significantly to external costs in Indonesia. If BPS would invest in setting up emission accounts, it highly recommended to include data on air pollution emissions from electricity sector; manufacture of basic iron and steel and of ferro-alloys and first products thereof & re-processing of secondary steel into new steel; mining of coal, lignite, and extraction of peat, and 7 other sectors that contribute the most to Indonesia's environmental costs. These top ten sectors cover 73% of the environmental degradation due to air pollution. The top ten air pollutants are responsible for 93.70% of the external costs related to air emissions, with SOx, NOx, and CO_2 being most important.

Chapter 4 examines Indonesia's environmental costs from emissions and forest resources from a consumption perspective and identifies the priority sectors in terms of economic and environmental performance. Environmentally Extended Input-Output (EEIO) analysis is used for this purpose. For this purpose, the environmental extensions and external costs by sector as identified in Chapter 3 were linked to the Indonesian Input-Output table. Based on the calculation results, it is estimated that the environmental cost of emissions driven by final demand are about 7% of the Indonesian GDP. The environmental costs of these emissions arise primarily from domestically produced final consumption, with household consumption becoming the most significant contributor to total environmental costs of emissions, followed by environmental cost from the gross fixed capital formation, and export. On the other hand, the environmental cost of forest resources is only about 7.5% of the total environmental cost, with gross fixed capital formation and household consumption being the main final demand components that contribute to environmental costs from forest resources. Finally, a forward and backward linkage analysis was done to assess how growth in economic activity in a specific sector would influence overall value added and external cost generation in Indonesia. This analysis pointed out that stimulating economic activity in the following sectors would maximize economic growth with minimal additional external costs: manufacture of textile; publishing, printing, and reproduction of recorded media; chemicals n.e.c.; manufacture of other non-metallic mineral products n.e.c.; construction; and other land transport. Stimulation of economic activity in these sectors will hence have a more than proportional positive impact on Indonesia's economic development, with a relatively limited increase in external costs.

Chapter 5 answers question 4. A simulation is conducted to analyze the economic and environmental impact of electric vehicle (EV) production in Indonesia. The impacts are analyzed by a simulation scenario that assumes that all the nickel ore currently exported by Indonesia will be absorbed for further processing in new domestic economic activities. These new activities are assumed to consist the production of electric vehicle batteries (EVB) and electric vehicles (EVs), assuming that all EVs produced are destined for export. The simulation results indicate that the production of electric vehicles positively increases output, value-added growth, and job creation of the Indonesian economy with respectively 1.87%, 1.5%, and 0.5%. This finding forms the defensible justification for the Indonesian government's ambition to use its large nickel reserves to stimulate fast-growing upstream user industries, such as battery and EV production. The simulation also found that EVB and EV production create additional external costs of emissions. The amounts are, however, insignificant. The extra external costs as a percentage of the extra GDP generated by these two sectors is only around 2.2%. It should be stressed that the simulation assumes that all produced EVs will be exported. Using EVs domestically can reduce the production of traditional vehicles and, therefore, lower job gains and value-added. EVs do not have direct emissions, which, if they replace traditional vehicles domestically, have the potential to lead to reduced external costs, depending on the carbon intensity of the electricity used.

Chapter 6 concludes that the SEEA plays an essential role in supporting sustainable development and a green policy agenda, also for countries with abundant natural resources like Indonesia. This thesis shows that many economic and environmental indicators relevant for measuring progress to the SDGs at the national or global level can be measured via integrated environmental-economic accounting systems. Therefore, data that are included in comprehensive accounting databases combining the SNA and environmental satellite systems (SEEA) are very relevant for analyses in the context of scientific policy advising. Information from SEEA can primarily be used as a basis for policy approaches to integrate environmental concerns into sector policies or - more broadly - for policies towards sustainable development. The SEEA covers both environmental and economic SDGs well. In chapters 3-5, we demonstrated how the SEEA is a powerful tool for setting priorities, analyzing environmental priorities, and assessing the impacts of economic development on SDGs. That suggests the SEEA is vital. As we saw in chapter 2, implementation can be complex, but it can be overcome with financial resources and technical assistance. Finally, this thesis gives several recommendations to overcome obstacles in the implementation of the SEEA, both at the preparatory stage and in the further development of the environmental-economic account. The first one is to build linkages between sustainability measurement and policy implication. The sustainability measurement results best include an analysis component in their routine report and built-in feedback to the relevant stakeholders. In Indonesia, its statistics office (BPS) is recommended to strengthen the current system of environmental-economic accounts by establishing priority accounts based on policy needs to address national policy priorities, including green economy, and monitoring SDGs. In addition to the mineral and the forest accounts that BPS has carried out, the account that should be prioritized is the air emissions accounts, which in this study is the second contributor to the total environmental costs in Indonesia. Next to this, it is recommended to enhance integration/coordination between different institutions that have environmental and economic data available. The coordination mechanism must be regulated in the provisions and regulations related to data so that the coordination procedure is clearly described. Third, it is recommended to enhance training and capacity building with regard to environmental-economic accounting. Such capacity building provides a better understanding of the concepts and engages experts in professional development through collaborative activities, staff exchanges, and training on data compilation, analysis, and evaluation. Fourth, partnerships and coordination should be enhanced with International and donor agencies. Lastly, a data quality assurance mechanism should be developed.

Samenvatting

Indonesië wordt geconfronteerd met diverse milieu-uitdagingen die samenhangen met zijn snelle economische groei. Daarom is het noodzakelijk om over meetbare en toepasbare indicatoren te beschikken die inzicht geven in de nadelige milieueffecten en hieraan gerelateerde externe kosten veroorzaakt door economische activiteiten. Dit bevordert een meer doeltreffende en kwalitatief betere besluitvorming. Daarom wil deze dissertatie een antwoord geven op de vraag hoe we milieu-economische rekeningen kunnen opzetten in ontwikkelingslanden zoals Indonesië en hoe dergelijke rekeningen zowel sociaaleconomische ontwikkeling als milieubeleid kunnen ondersteunen. De algemene vraagstelling van dit proefschrift kan dus als volgt worden geformuleerd: *hoe kunnen we milieu-economische rekeningen opzetten in ontwikkelingslanden zoals Indonesië, en hoe kunnen dergelijke rekeningen zowel het ontwikkelings- als het milieubeleid ondersteunen?*

Deze algemene vraagstelling zal worden beantwoordt door het onderzoeken van de volgende deelvragen:

1. Gericht op ontwikkelingslanden in het algemeen: wat is het potentieel van het System of Economic and Environmental Accounts (SEEA) bij de ondersteuning van het monitoren van indicatoren gerelateerd aan de Sustainable Developmet Goals (SDG's), wat is de huidige stand van zaken ten aanzien van de implementatie van SEEA, en wat zijn de belemmeringen voor de implementatie van het SEEA? (Hoofdstuk 2)
2. Hoe kunnen we het Indonesische System of National Accounts (SNA) verrijken met informatie over externe milieukosten en wat zijn de sectoren en soorten milieu-interventies waarvoor inzicht in externe kosten met de hoogste prioriteit moet worden ontwikkeld? (Hoofdstuk 3)
3. Gebruik makend van deze informatie over externe kosten in het SNA, wat zijn de elementen in de finale vraag in Indonesië die de meeste externe kosten veroorzaken en dus prioritair zijn voor op consumptie gebaseerd beleid? Hoe hoog zijn de milieukosten voor elke component van de finale vraag in Indonesië, en wat zijn de economische sectoren die het best presteren wanneer zowel de economische als de milieuprestaties tegelijkertijd worden bekeken? (Hoofdstuk 4)
4. Hoe kunnen we het SNA, verrijkt met externe kosten, gebruiken om de economische en milieugevolgen van investeringen in nieuwe economische activiteiten te beoordelen, geïllustreerd door het potentiële gebruik van Indonesische natuurlijke hulpbronnen voor de

productie van batterijen voor elektrische voertuigen en elektrische voertuigen? (Hoofdstuk 5)

Deze dissertatie illustreert hoe het SNA, zoals uitgebreid via het SEEA, kan worden gebruikt om de economische en milieu aspecten van duurzame ontwikkeling te analyseren, en in verband te brengen met de SDGs (vraag 1). Daarna wordt nagegaan wat de prioriteiten zijn voor de verbetering en uitbreiding van milieurekeningen in Indonesië, waarbij de prioriteit wordt gemeten aan de hand van de milieukosten gerelateerd aan emissies en de winning van natuurlijke hulpbronnen in Indonesië (vraag 2). Vervolgens worden die milieukostenrekeningen gecombineerd met de Indonesische input-outputtabel van 2010 om de Indonesische milieukosten gerelateerd aan emissies en het gebruik van natuurlijke hulpbronnen uit de bosbouw vanuit het perspectief van de finale vraag te onderzoeken, en met behulp van zogenaamde forward- en backward linkages te analyseren hoe groei in een specifieke sector de totale toegevoegde waarde en externe kosten in Indonesië als geheel zou beïnvloeden (vraag 3). Tenslotte wordt een simulatie uitgevoerd om de economische en milieueffecten van de productie van elektrische voertuigen (EV) in Indonesië te analyseren (vraag 4).

Hoofdstuk 2 beoordeelt het potentieel van het SEEA om bij te dragen tot het monitoren van indicatoren relevant voor de SDGs. Dit hoofdstuk analyseert ook het huidige niveau van implementatie van het SEEA en de belemmeringen voor die implementatie, in het bijzonder in ontwikkelingslanden. De bevindingen bevestigen dat het SEEA een zeer nuttig boekhoudsysteem is om de SDG’s te monitoren. Als internationale statistische standaard heeft het SEEA een groot potentieel om de monitoring van SDG’s te ondersteunen en de prioriteiten met betrekking tot ontwikkeling en milieu in landen te bepalen. Er bestaan reeds op het SEEA gebaseerde indicatoren en analysemethoden die de nationale SDG-processen kunnen ondersteunen. Indicatoren die relevant zijn voor het monitoren van de vorderingen ten aanzien van de SDG’s zijn in het algemeen conceptueel duidelijk, kunnen worden gebaseerd op een internationaal vastgestelde berekeningsmethode, en kunnen worden berekend aan de hand van informatie die kan worden afgeleid uit het SEEA. Het succes van het SEEA bij de monitoring van de SDG's zal echter grotendeels afhangen van het vermogen van landen om het SEEA op een vergelijkbare manier te implementeren.

Het SEEA beoogt zowel milieu- en economische aspecten omvatten. Door een verschil in economische structuur kan wat relevant is voor ontwikkelingslanden en ontwikkelde landen echter verschillen. In de meeste ontwikkelingslanden zijn het beheer van natuurlijke hulpbronnen en energie belangrijke thema's. Maar in de meeste ontwikkelde landen ligt de nadruk meer op milieu-uitgaven, economische instrumenten, het efficiënt gebruik van grondstoffen, en milieuverontreiniging als gevolg van productie- en consumptieactiviteiten. De implementatieproblemen rond SEEA, met name in ontwikkelingslanden, houden verband met verschillende punten. Uit literatuurstudie en een enquête onder praktijkmensen bleek dat de beschikbaarheid van gegevens, beperkingen in de kwaliteit van de gegevens en het gebrek aan personele middelen de drie belangrijkste belemmeringen zijn voor de verdere ontwikkeling van milieu-economische rekeningen. Er zijn duidelijke aanwijzingen dat financiële en technische bijstand van internationale instellingen een essentiële rol heeft gespeeld in ontwikkelingslanden die het SEEA succesvol wisten te implementeren. Landen zonder zulke steun of goede eigen financiering hebben het veel lastiger SEEA in te voeren.

Hoofdstuk 3 is toegespitst op onderzoeksvraag 2. Het hoofdstuk geeft een eerste poging om de milieukosten in te schatten die verband houden met emissies en extractie van natuurlijke hulpbronnen per economische sector in Indonesië. Deze exercitie had tot doel vast te stellen welke sectoren, emissies en grondstofonttrekkingen prioritair zijn en waarvoor nauwkeuriger gegevens wenselijk zijn. Het blijkt dat totale milieukosten in Indonesië in 2010 ongeveer 13% van het bruto binnenlands product (bbp) bedroegen. De totale milieukosten van Indonesië zijn voornamelijk te wijten aan de uitputting van energetische en minerale hulpbronnen. Deze uitputting is goed is voor ongeveer 55% van de totale milieukosten. Hiernaast wordt 38% van de milieukosten veroorzaakt door luchtverontreiniging, en bijna 7% van milieukosten door aantasting van ecosystemen. We kunnen concluderen dat het Indonesische Centraal Bureau voor de Statistiek (BPS) op de goede weg is door bij het opstellen van milieu-economische rekeningen prioriteit te geven aan uitputting van grondstoffen. Het BPS is er echter nog niet in geslaagd milieurekeningen te ontwikkelen die betrekking hebben op door luchtemissies veroorzaakte milieuschade, terwijl dus blijkt dat luchtemissies aanzienlijk bijdragen tot de externe kosten in Indonesië. Indien het BPS zou investeren in het opstellen van milieurekeningen voor emissies, hebben de volgende sectoren prioriteit: de elektriciteitssector; de primaire productie van ijzer, staal en ferrolegeringen; de herverwerking van secundair staal tot nieuw staal; de winning van steenkool, bruinkool en turf, en 7 andere sectoren die het meest bijdragen aan Indonesië‘s milieukosten. Deze tien sectoren zijn goed voor 73% van de milieuverontreiniging ten gevolge van luchtverontreiniging. Slechts tien luchtverontreinigende stoffen zijn verantwoordelijk voor 93,70% van de externe kosten in verband met luchtemissies, waarbij SOx, NOx en CO2 het belangrijkst zijn.

In hoofdstuk 4 worden de milieukosten van Indonesië vanuit een consumptieperspectief onderzocht. Daarnaast wordt geanalyseerd welke economische sectoren direct en indirect het meest kunnen bijdragen aan economische ontwikkeling bij de laagste externe kosten. Hiervoor wordt gebruik gemaakt van een milieugerichte input-outputanalyse (EEIO). Daartoe zijn de milieu-extensies en externe kosten per sector, zoals berekend in hoofdstuk 3, gekoppeld aan de Indonesische Input-Outputtabel van 2010. Hiermee kon worden berekend dat milieukosten door emissies gerelateerd aan de finale vraag van producten in Indonesië ongeveer 7% van het Indonesische bbp is. De milieukosten van deze emissies zijn vooral gerelateerd aan binnenlandse productie, waarbij de finale vraag van huishoudens de belangrijkste bijdrage levert aan de totale milieukosten van emissies, gevolgd door investeringen in kapitaalgoederen en export. De milieukosten van het gebruik van producten uit de bosbouw maakt slechts 7,5% uit van de totale milieukosten. Hieraan leveren investeringen in kapitaalgoederen en consumptie door huishoudens het belangrijkste aandeel. Tenslotte werd een forward- en backward linkage-analyse uitgevoerd om na te gaan hoe de groei van de economische activiteit in een specifieke sector de totale toegevoegde waarde en de externe kosten in Indonesië als geheel zou beïnvloeden. Deze analyse wees uit dat het stimuleren van de economische activiteit in de volgende sectoren de economische groei zou maximaliseren met minimale extra externe kosten: vervaardiging van textiel; uitgeverijen, drukkerijen en reproductie van opgenomen media; chemische producten, n.e.g.; vervaardiging van andere niet-metaalhoudende minerale producten, n.e.g.; bouw; en overig vervoer over land. De stimulering van de economische activiteit in deze sectoren zal dus een meer dan evenredig positief effect hebben op de economische ontwikkeling van Indonesië, met een minder dan evenredige stijging van de externe kosten.

In hoofdstuk 5 wordt vraag 4 beantwoord. Er wordt een simulatie uitgevoerd om de economische en milieu-impact van de productie van elektrische voertuigen (EV) in Indonesië te analyseren. Het hoofdstuk maakt een simulatie waarin wordt verondersteld dat al het nikkelerts dat momenteel door Indonesië wordt geëxporteerd, zal worden gebruikt in nieuwe economische activiteiten in Indonesië. Aangenomen is dat het nikkel wordt ingezet voor de productie van batterijen voor elektrische voertuigen (EVB’s) en elektrische voertuigen (EV's). Verder wordt aangenomen dat alle geproduceerde EV's voor de export bestemd zijn. De simulatie geeft aan dat in dit scenario het productievolume, de toegevoegde waarde en de werkgelegenheid in Indonesië toenemen met respectievelijk 1,87%, 1,5% en 0,5%. Dit resultaat is een rechtvaardiging voor de ambitie van de Indonesische regering om haar grote nikkelreserves te gebruiken in snel groeiende sectoren, zoals de productie van batterijen en EV's, te stimuleren. Uit de simulatie blijkt ook dat de productie van EVB's en EV's extra externe kosten door emissies met zich meebrengt. De omvang is echter heel beperkt. Ten opzichte van het extra bbp dat productie in de twee nieuwe sectoren oplevert, bedragen de additionele externe kosten slechts 2,2%. Benadrukt moet worden dat de simulatie aanneemt dat alle geproduceerde elektrische voertuigen zullen worden uitgevoerd. Gebruik van EV's in Indonesië kan tot gevolg hebben dat de productie van traditionele voertuigen afneemt, met een afname van werkgelegenheid en toegevoegde waarde als gevolg. EV's hebben geen directe emissies. Indien EV's gebruik van traditionele voertuigen zou vervangen, leidt dit mogelijk tot lagere externe kosten, afhankelijk van de koolstofintensiteit van de gebruikte elektriciteit.

In hoofdstuk 6 wordt geconcludeerd dat het SEEA een essentiële rol kan spelen in het bevorderen van duurzame ontwikkeling en de ondersteuning van het bereiken van de SDG's. Dit proefschrift toont aan dat veel economische en milieu-indicatoren die relevant zijn voor het monitoren van de SDG's op nationaal of mondiaal niveau, kunnen worden gemeten via geïntegreerde milieu-economische boekhoudsystemen. Daarom zijn gegevens die zijn opgenomen in databases waarin het SNA en milieusatellietsystemen (SEEA) worden gecombineerd, zeer relevant voor analyses in het kader van wetenschappelijke beleidsadvisering. Informatie uit het SEEA kan in de eerste plaats worden gebruikt om milieuoverwegingen meet te wegen in sectoraal beleid of - meer in het algemeen - in beleid gericht op duurzame ontwikkeling. Het SEEA bestrijkt zowel de ecologische als de economische SDG's goed. In de hoofdstukken 3-5 hebben wij aangetoond dat het SEEA een krachtig instrument is voor het stellen van milieuprioriteiten, en het beoordelen van de effecten van economische ontwikkeling op de SDG's. Dit geeft aan dat het SEEA van groot belang is. Zoals we in hoofdstuk 2 zagen, kan de uitvoering complex zijn, maar zulke problemen kunnen worden overwonnen met financiële ondersteuning en technische bijstand.

Tot slot worden in dit proefschrift verschillende aanbevelingen gedaan om belemmeringen voor de implementatie van het SEEA weg te nemen. De eerste is het verbinden van beleid en monitoring van duurzaamheid. De resultaten van die monitoring moeten directe feedback kunnen geven aan beleidsmakers en relevante stakeholders. We bevelen het Indonesische bureau voor de statistiek (BPS) daarom aan om het huidige systeem van milieu-economische rekeningen uit te breiden gericht op het ondersteunen van belangrijke nationale beleidsagenda's, zoals het streven naar een groene economie en de implementatie van de SDG's. BPS heeft al milieurekeningen rond de onttrekking van biotische en abiotische grondstoffen, maar wordt aanbevolen ook prioriteit te geven aan milieurekeningen ten aanzien van emissies.

Emissies blijken na grondstofonttrekking de belangrijkste bijdragen te geven aan de externe milieukosten in Indonesië. Verder wordt aanbevolen de integratie en coördinatie te versterken tussen de verschillende instellingen die over milieu- en economische gegevens beschikken. Die coördinatie moet worden geregeld in de regelgeving en verordeningen die over het verzamelen van statistische gegevens gaan. Ten derde wordt aanbevolen training en capaciteitsontwikkeling met betrekking tot het SEEA te organiseren. Dit zorgt voor een beter begrip het SEEA-concept en zorgt voor verdere professionele ontwikkeling van experts door middel samenwerkingsactiviteiten, uitwisseling van personeel, en opleiding in het vergaren, analyseren en evalueren van gegevens. Ten vierde moet de samenwerking met internationale en donororganisaties worden verbeterd. Tenslotte moet een mechanisme voor kwaliteitsborging van gegevens worden ontwikkeld.

Acknowledgements

It has been a long journey for me to get to this stage. What has supported me through this journey is the encouragement and help from many people. I want to express my gratitude to them.

I could not be more grateful for the guidance of Prof. Dr. Arnold Tukker and Prof. Dr. Armida S. Alisjahbana, and Dr. Ir. Rutger Hoekstra. I feel very lucky to have them as my Ph.D. supervisors. They were always there to provide insightful feedback and valuable advice that inspired me to conduct scientific research and, more importantly, how to deal with unexpected challenges in my scientific career. This thesis would not have been possible without their expertise and patience in guiding me to become an independent researcher. I am also very grateful for the encouragement and support from Prof. Arief Anshory Yusuf, who has provided invaluable help and advice for the completion of this dissertation.

I appreciate the last few years I have spent in my doctoral studies in the Netherlands and Indonesia because I have always been surrounded by a delightful group of colleagues and friends. Special thanks to my best friends in the economics department Bagdja Muljarijadi, Wawan Hermawan, M. Purnagunawan, Megananda, Pipit Pitriyan, Ahmad Komarulzaman, Achmad Maulana, Tisa, Irlan Adiyatma Rum, Adiyatma Manogar Siregar, Wiartini Citrasari, who always helped and encouraged me in completing my doctoral journey. Special thanks to Kurniawan Saefullah for his help and very good friendship, especially when I just arrived in the Netherlands; without your help, I might have gotten lost in the Netherlands. I also thank my neighbors in Marienpoelstraat, especially Ayu Swaningrum, Kusnandar, Aditya Budiarsa, Nurmaya, Raini, Weni, Maya, Rully, Ucok, Hera, Arfiansyah, for their friendship. Thank you to for Wa Atik, Wa Agrar, Teh Meira, who are always friendly and open for me to visit.

Last but not least, I would like to thank my Mother for her generous love, unconditional support, and prayers. My wife Ria Mariani, and my two daughters, Alesha and Bila, thank you for your love and affection. To my brothers and sisters, thank you for the supports and prayers.

Curriculum Vitae

Curriculum Vitae

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Viktor Pirmana's research interest are in the area of Environmental Economics, Sustainable development measurement, labor market development, poverty and inequality, and regional economics. As a researcher, he has been involved in various research projects, among others, under the Indonesian Ministry of National Development Planning (Bappenas), Bank Indonesia, Ministry of Finance, Ministry of Environment and Forestry, International Labor Organization (ILO), SEADI-USAID.