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

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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.

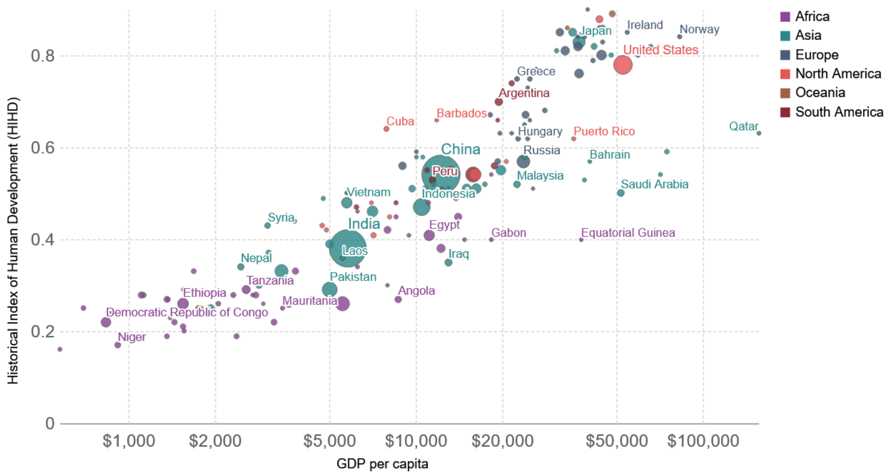

Figure 1.1**.** Human Development Index vs GDP per capita, 2015. Note that the x-axis has a logarithmic scale. Source: Prados de la Escosura (2018), Maddison Project Database 2020 (Bolt and van Zanden (2020))

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.

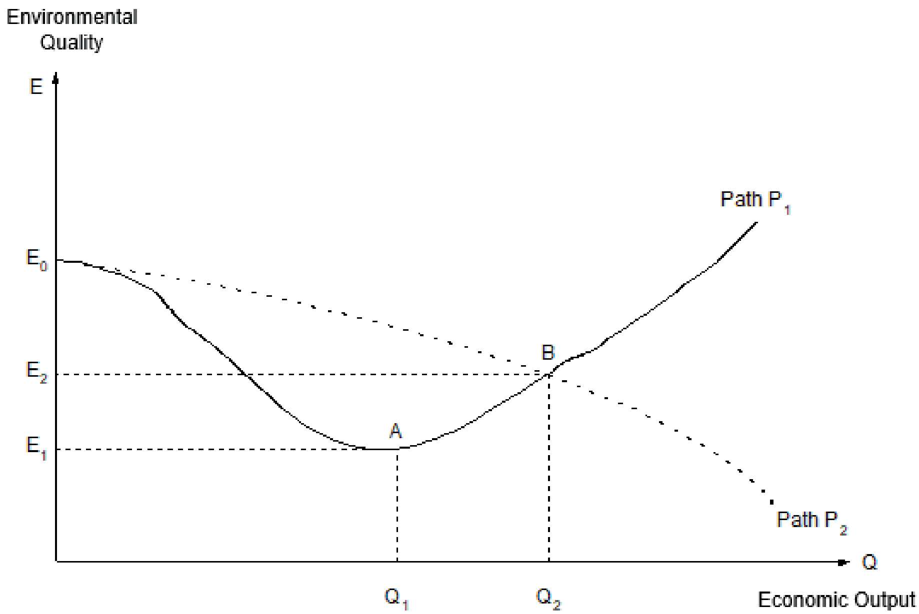

Figure 1.2. Possible trade-offs between output and environmental quality (as output Q grows over time)
Source: Pezzey (1992)

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).

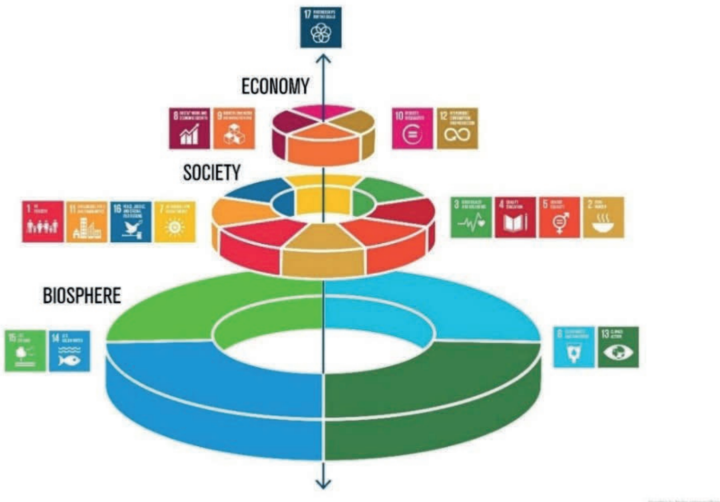

Figure 1.3. The SDGs wedding cake
Source: Stockholm Resilience Center
https://www.stockholmresilience.org/research/research-news/2016-06-14-the-sdgs-wedding-cake.html

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.

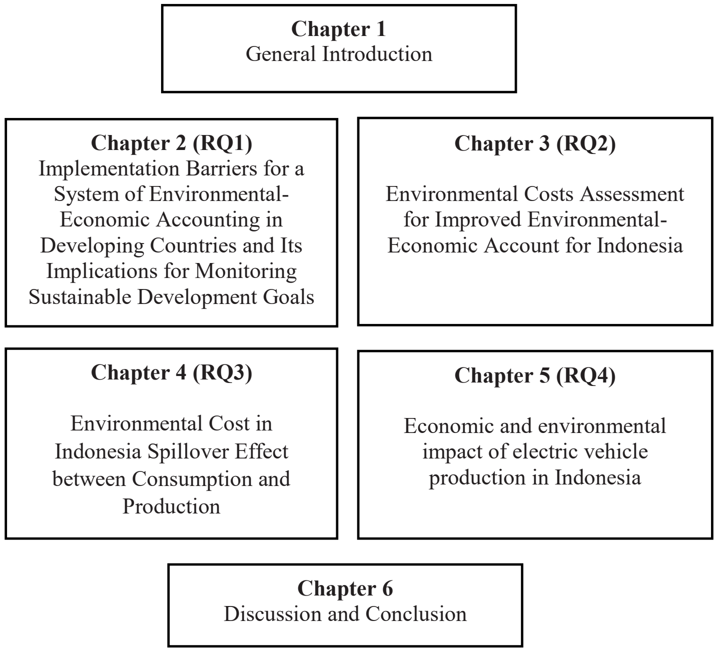

Figure 1.4. Conceptual scheme of the thesis