Reconstruction of the SDGs Measurement Model Based on Socio-Ecological Perspective Technology for a Sustainable Green Economy

Satia Nur Maharani[1], Dhika Maha Putri[2]

{satia.nur.fe@um.ac.id[1], dhika.maha.fe@um.ac.id[2]}

Universitas Negeri Malang[1], Universitas Negeri Malang[2]

Abstract. In 2015, the UN adopted the 2030 Agenda for Sustainable Development Goals (SDGs) for sustainable development, which places sustainability and resilience at the heart of the global development framework. In particular, the agenda focuses on the 17 dimensions of the SDGs (UNDP 2015). The main criticism of this objective grievance process relates to the risk of tradeoffs if the SDGs are treated separately and not as interrelated components of a larger system. Research shows that some of the SDGs are contradictory, inconsistent, or can be synchronized but influence each other's goals. Actions to achieve one goal can hinder the goals of others. For example, reducing poverty (SDG 1) tends to be directly correlated with improving health (SDG 3). Either of the two goals above can be achieved cheaply and relatively quickly by investing in the provision of electricity generation using fossil fuels, but the use of fossil fuels goes against SDG 13 on climate action and adaptation. Using the procedures developed by Jha and Rangarajan (2019), this study seeks to build a SDG measurement technology using a Socio-Ecological Perspective by synergizing the three dimensions of sustainability, namely the economy, society, and biosphere. Through this measurement technology, sustainable development policies do not work partially and negate one dimension from other SDG dimensions. So that a sustainable green economy can be significantly realized

Keywords: SDGs, Socio-Ecological, Measurement Model

1. Introduction

The measurement of SDG topics is a matter of debate among researchers, policymakers, and other stakeholders [1]; [2]. Adoption of the 2030 Agenda and Sustainable Development Goals (SDGs), targets, and indicators increasingly includes this [3]; [4]. The main criticism of the process of achieving these goals concerns the risk of SDG trade-offs being treated separately rather than as interrelated components of a larger system. Research shows that some SDGs conflict, are inconsistent, or can be synchronized but have a negative impact on each other [1]; [2]; [3].

Actions to achieve one goal can hinder the achievement of other goals. For example, tackling poverty (SDG 1) tends to worsen directly with improvements in health (SDG 3). The second goal would be to cheaply and relatively quickly invest in providing electricity generation using fossil fuels, but the use of fossil fuels violates SDG 13 regarding climate change action and adaptation [3]. Another concern is the potential contradiction between some of the goals and SDG 8, which involves an annual GDP growth target of 7% for poor countries [5], GDP is a commonly used proxy for measuring welfare, but for poor countries, it

ICEBE 2023, September 13-14, Bandar Lampung, Indonesia

DOI 10.4108/eai.13-9-2023.2341169

tends to decline with environmental degradation [6]. Another potential problem is the increase in production and consumption, while the levels of these activities are often beyond sustainable activities for the environment [7]. Therefore, performance measurement is needed to exceed the independent goals of each SDG.

One way to ensure consistent and synchronous monitoring of the SDGs is to measure them within a social-ecological perspective (SES) framework, where humans and nature are seen as an integrated whole with various complex connections [7]. This approach reconnects humans with the biosphere by recognizing each other and interacting with and depending on one another. As for several attempts to develop steps to measure the SDGs, namely the proposal [4] through the SDGs Index and elements, The method combines different variables based on SDG indicators into one index to rank countries, with the aim of helping countries identify the most pressing priorities.

However, the SDGs measurement above has limitations when converting various forms of capital, where the indicators assume that human capital can be converted into natural capital [8], thus ignoring that there are natural limits to the use of natural capital so that it does not experience damage [9]. Indonesia itself is slower in developing measurements using partial and composite indicator approaches for economic growth, the Human Development Index, the Environmental Quality Index, and poverty [10]. The partial approach has an impact on the separation of successful perspectives for human and natural welfare, thereby threatening sustainable development policies [11]. Therefore, this article describes the results of research that seeks to develop a conceptual model for measuring SDGs through a social-ecological perspective by synergizing the three dimensions of poverty, namely economy, society, and the biosphere.

This research is important to carry out to ensure that the SDG goals have been achieved, namely protecting the natural foundations of life, the planet, and increasing the chances of living well and well-being for all generations. Social-ecological systems (SES) help to understand the interactions between different dimensions of the SDGs and whether each specific action considers ecosystems as a fundamental part of human well-being and societal development [11]. The 'social' component relates to the human dimension, including economic, political, technological, and cultural. The 'ecological' component relates to the thin layer on planet Earth, called the biosphere, which includes all living things and organisms, including humans, and their dynamic interactions with the atmosphere, air cycles, biochemical cycles, and the dynamics of the earth system as a whole [12]. Socio-ecological systems emerge from multilevel subsystem dynamics where major changes, such as climate change, can direct SES on new trajectories or rapid transitions into different climate situations and configurations [13].

2. Analytical Framework: SDGs In Various Perspectives

There are several analytical frameworks that conceptualize SES. [12] uses a new approach by reframing the SDGs as a wedding cake or layers of a wedding cake. The framework emphasizes the importance of the biosphere for sustainable development by placing the economic dimension of the SDGs as a subsystem of the societal dimension, which in turn is an important part of the subsystem of the biosphere SDGs. The foundation of the biosphere is based on the concept of 'planetary boundaries, where there are nine planetary boundaries that provide guidance for program activities that are safe for humans and nature as a prerequisite for global sustainable development [14]. Measuring the scope of the SDGs to always be linked to the biosphere is very important because the biosphere supports the future

of humanity by providing resources [12]. SDGs consist of 17 dimensions with 109 main elements and 111 additional elements (UN General Assembly 2015). To monitor these targets, the Inter Agency and Expert Group on Sustainable Development Goal Indicators (IAEG-SDGs) has developed an indicator framework, whose 2016 version consists of 241 indicators. The total number of indicators is 230, although some are repeated for different purposes [15].

The country is committed to providing systematic reviews every year and following the implementation of the 2030 Agenda at national and regional levels [16]. However, Resolution 70/1 is not a legally binding document. Political implementation aimed at achieving the SDGs is guided by the goals and principles of the UN Charter by fully respecting national law and other international declarations, such as those on human rights [16]. In achieving these goals, there is room for negotiation and compromise based on the situation and conditions of each country, but they must remain based on universally agreed values [17](17). Therefore, developing appropriate measurement indicators can help in maintaining and monitoring accountability by providing a way to demonstrate progress through relevant measurable indicators and an analytical frame that focuses on challenges and obstacles and has characteristics that can be compared [17]. The initial effort to systematically compile the SDGs was carried out by Donat Raworth by comprehensively synergizing the natural environment, including animal life, and socio-economic order. Depicted in the form of a donut framework, [18] proposes a framework model consisting of concentric circles, where the people-centered core SDGs (SDGs 1, 3, 4, 5, 10) depend on the middle circle of SDGs related to production, distribution, and services (SDGs 2, 6, 7, 8, 9, 11, 12), which then depend on the condition of natural resources and ecosystems such as climate, oceans, biodiversity, and land (SDGs 13, 14, 15), followed by SDG 16 (peace, justice, and strong institutions) and ending with SDG 17 (means of implementation).

Natural resources, with their limited nature, attract attention and have very important characteristics, so the implementation of the entire SDG framework must adopt mitigation strategies to reduce the degradation of natural resources. In a similar way, a model was proposed by the global research institute The World in 2050 [13] , where the SDGs are described as planetary boundaries. At these limits, the global partnerships for sustainable development (SDG 17) and governance (SDG 16) for the purposes of the 2030 Agenda are represented as interrelated groups and are grouped according to five main SDG categories: social and economic development (SDGs 8, 9, 11), universal values (SDGs 4, 5, 10), basic human needs (SDGs 1, 2, 3), and sustainable use of resources (SDGs 6, 7, 12). The common denominator of the models described above is that they not only categorize goals according to individual outcomes but also group them in the same way according to their systemic role. The aim of achieving human basics in the socio-economic aspect is limited by biophysical terms and conditions. The process and results for achieving human welfare are limited by the limits of the planet's capabilities, as illustrated by [19], which explains that the essence of every definition of sustainable development for improving the quality of human life must have the carrying capacity of the ecosystem. However, at the same time, criticism has been directed at the above definitions and concepts because they reflect an anthropocentric interpretation of sustainable development. Anthropocentrism is a current in the philosophical discipline of environmental ethics that views nature as a human habitat where its preservation has instrumental value depending on the extent to which such preservation contributes to the welfare of present and future generations. So it is clear that what is considered worthy of preservation is human welfare rather than the environment [17].

Therefore, it is necessary to adopt a new perspective for the broader ethical foundation of the SDGs [16], [18], where the importance of placing the success of nature at

the top of the priority list in the interconnected relationship between nature and humans (20) at the SDG target level presents the SDGs as a network of related targets by combining network analysis and content analysis methodologies to explore the relationships between the SDGs based on the goals of each target individually. For example: Target 12.4 of SDG 12 (responsible consumption and production) is linked to SDG 3 (good health and well-being) because it aims to "by 2020 achieve environmentally friendly management of chemicals and all waste throughout the life cycle in accordance with the framework agreed upon in international work and significantly reduce its release into air, water, and soil to minimize its adverse impacts on human health and the environment."

3. Discussion Result

Socio-ecological indicators are techniques for measuring the impact of the implementation of activities on nature. These indicators should focus on the determinants that maintain the stability of nature in a sustainable manner. Indicators should also be able to provide some kind of early warning message regarding risks caused by a chain of cause-and-effect activities, such as a project impact analysis for stakeholders [20]. Concern for environmental sustainability in general arises from negative phenomena in nature and the desire to resolve these phenomena and ultimately realize a perspective to prevent them. This process takes place in general for all problems of social and natural life. For example, programs to improve the quality of hospital health services. Even though hospital services are included in the primary needs, great attention is paid to preventing the community from contracting the disease. In contrast to the problem of environmental damage, which has a long-term impact and, in some situations, does not have an immediate. So the problem of environmental damage is often a second-class problem, except when the time bomb has exploded and harmed many lives [16]. This is what makes it difficult to internalize indicators in socio-ecological evaluations. Meanwhile, as previously explained, when the impact of damage is increasingly massive and external, environmental damage is placed on the extreme side, which is very important. Therefore, it can be said that socio-ecological indicators are able to provide information and insight that is much more forward-looking than only focusing on symptoms and problems [21].

Socio-ecological indicators provide environmental standards, a frame of mind, or a group of data as a portrait of several quality aspects of environmental conditions. The indicators are oriented towards social causes, potential damage, and solutions. Indicators are directed at actors and their activities in social life that have a direct impact on the natural environment. For example, pollution disposal to other areas outside of pollution sources, pollution released by export and import shipments, and so on. Therefore, socio-ecological indicators can be related to the effects of pollution disposal from waste production centers to other areas and the accumulation of pollution originating from external activities outside certain areas [22]. The problem of environmental damage tends to be ignored in the economic and social activities of the community. The cost of damage is not a consideration for economic actors. Therefore, one way to solve this is to transform impact activities into an indicator model. These indicators can clarify the impact and what kind of activity adjustments are necessary to minimize risk. SDGs (Sustainable Development Goals) measurement through a socio-ecological perspective is an approach that tries to understand and assess the achievement of sustainable development goals by considering the relationship between social and ecological systems [23]. In this context, the goals of sustainable development are considered a complex system in which social and ecological components interact and influence one another.

4. Integration Between Social And Ecological Dimensions

The socio-ecological approach attempts to address complex and interrelated problems by considering social, economic, and environmental aspects simultaneously. Sustainable development goals cannot be achieved simply by focusing on one aspect without considering its impact on other aspects [24]. In this context, measurement of the SDGs attempts to track and evaluate indicators that reflect the complex interactions between social and ecological systems. The characteristics of these indicators are as follows:

First, the use of multidimensional indicators, where the measurement of SDGs from a socio-ecological perspective requires the use of indicators that cover various social and ecological dimensions. These indicators should reflect the linkages between social and ecological aspects and provide a holistic picture of the progress made in achieving sustainable development goals. First of all, it is important to identify the linkages between the SDG goals. For example, efforts to improve the quality of education (goal 4) could have an impact on poverty reduction (goal 1) through increased skills and economic opportunities. Every action or policy taken to achieve one SDG goal can have positive and negative impacts on other goals. It is important to fully understand how these impacts might occur and how to mitigate them. Effective measurement of the SDGs must identify links and relationships between different goals, both in social and ecological dimensions [25]. This allows for an understanding of how the achievement of one goal can support or hinder the achievement of another. towards the Sustainable Development Goals (SDGs). This approach involves collecting and analyzing data from various dimensions, such as social, economic, environmental, and institutional dimensions, to provide a more comprehensive understanding of developments and challenges in achieving sustainable development goals.

Second, it contains an analysis of socio-ecological impacts. Apart from only tracking the progress of each goal separately, SDG measurement must also analyze the impact of actions and policies on social and ecological aspects [26]. For example, if there is an effort to increase access to education (goal 4), it is important to understand how this might impact the welfare of the community and the surrounding environment. Through impact and linkage analysis, you can develop a better understanding of how the SDGs operate as part of a complex system. This helps avoid narrow approaches and ensures that actions taken take into account the overall effect. Therefore, these indicators stimulate the need to carry out a systemic analysis. Socio-ecological integration in SDG measurement requires a systemic approach that treats sustainable development goals as part of a complex and interrelated system [18]. That is, changes in one aspect can impact other aspects, and this must be considered in measurement and evaluation.

Fourth, stakeholder involvement. Involving various stakeholders from various sectors of society in the SDG measurement process is important to ensure a holistic view and obtain diverse inputs on the social and ecological impacts of development efforts [23]. Involving various stakeholders in data collection and analysis enhances the credibility and relevance of the information obtained.

Fifth, utilize comprehensive data sources. Integrated measurement of the SDGs requires the utilization of relevant and quality social and ecological data. This can include both quantitative and qualitative data collected from various sources and methods. Data can be obtained from a variety of sources, including governments, statistical agencies, international agencies, independent research, and community surveys. It is important to use data from trusted and recognized sources. In addition to collecting new data, existing secondary data can

also be utilized. This includes historical data, data published by relevant agencies, and previously analyzed data. Technologies such as remote sensing, sensors, and big data analysis can help in collecting more accurate and real-time data. This helps to get faster information about developments and trends.

Sixth, continuous evaluation approach evaluation of progress in achieving sustainable development goals is not done just once but on an ongoing basis to ensure positive changes and identify problems that may arise over time [27] . Impact and linkage analysis needs to be carried out on an ongoing basis over time to monitor whether the actions and policies taken have the expected impact or may require adjustments.

Eighth, a holistic approach to measuring the SDGs from a socio-ecological perspective includes efforts to understand thoroughly and in depth how social and ecological systems are interrelated and interact in achieving sustainable development goals [28]. This approach emphasizes the need to treat the SDG goals as part of a complex whole, where changes in one aspect can affect other aspects. The holistic approach recognizes that the goals of sustainable development cannot be achieved in isolation from one another. For example, efforts to achieve poverty alleviation goals (goal 1) could have an impact on health (goal 3), education (goal 4), or environmental sustainability (goal 13) goals. Therefore, measurement must include an analysis of the linkages between these objectives. In addition, a holistic approach requires a focus on systems and dynamics. A holistic approach recognizes that the SDGs operate in a complex and changing environment [27], [28]. Therefore, measurements must pay attention to system dynamics and understand how interactions between social and ecological components can impact the desired results.

5. A Situation Requiring Socio-Economic Indicators

A situation with a global impact where activities caused by certain countries have a systemic impact on other countries [25]. For example, when waste comes from domestic sources but its spread and impact are distributed globally, such as greenhouse gases or other types of gases that damage the ozone layer, Furthermore, waste that is carried by wind, rivers, and seas to pass the boundaries of continents and countries, such as SO2 and NOx, Furthermore, waste that is scattered from several sources that are difficult to distinguish, for example, sources of cadmium emissions (factories), has begun to decrease, but this is not in line with reduced product emissions.

The impact of waste is related to the unlimited time where there are problems that are non-linear and where the prediction of the impact of the waste provides disturbance in the future. This situation is stimulated by the time lag between the implementation of social responsibility and the non-stop impact caused by past and present waste activities that disrupt the future. For example, the capacity of cadmium and chromium in the packaging will have a damaging impact when the packaging is not used or has been used and thrown away [27]. Therefore, the impact of waste requires not only protecting nature in the present but also protecting nature for the future.

Social and natural processes contribute to negative impacts simultaneously, for example, the nitrogen fixation stage in fertilizer production and fixation in plant biology [25]. In addition, there are differences in the contribution of disturbance to social and natural activities, for example, the level of disturbance of nitrogen fixation in food production processes with fixation in communication and transportation. So when social actors provide different levels of disturbance contribution from one another, this is due to methods, attitudes,

thoughts, and lifestyle determinations. For example, the awareness of how to dispose of trash during recreation is very influential for the environment.

The description above describes how the flow of several different substances stimulates different threats, some of which are the same. Each component of a hazardous substance can originate from the same or different activities. For example, the degree of greenhouse gases has different levels, and each greenhouse gas involves the lifestyle of people who have different levels of awareness and behavioral intelligence.

The stages of preparing measurement indicators can be explained as follows:

1. **Identification of Relevant Objectives and Indicators:** Choose SDG goals that are relevant to the social and ecological issues you want to measure. Then, identify appropriate indicators for each of these objectives. Make sure the indicators include social and environmental aspects.
2. **Data collection:** collect data related to identified indicators. This data can come from a variety of sources, such as governments, international organizations, independent research, and community surveys.
3. **Data Normalization:** Some indicators may have different units of measure. Therefore, it is necessary to process data normalization into a uniform unit so that indicators can be used to compare and combine data from various sources.
4. **Indicator Weight and Priority:** Give weight or priority to indicators based on their relevance and relative impact on the social and ecological objectives to be measured. This requires consultation with experts or stakeholders.
5. **Merge Indicator:** Use appropriate formulas or methods to combine these indicators into an index or score that reflects progress towards socio-ecological-based goals. This can involve the use of various statistical techniques, such as linear aggregation or weighting methods.
6. **Data Analysis and Interpretation:** Data analysis to identify trends, interrelationships, and socio-ecological impacts of progress or non-progress towards the goals being measured Furthermore, the process of interpretation is relevant and contextual to the results of the analysis.
7. **Communicate Results:** Present measurement results in a format that is easily understood by different stakeholders, including government, communities, and the private sector. Data visualization in the form of graphs, maps, and reports can aid in effective communication.
8. **Continuous Evaluation and Improvement:** Ongoing evaluation of the constructed measurement approach This process is carried out by identifying deficiencies and potential for improvement to increase the relevance and accuracy of social-ecological-based SDG measurements.
9. **Stakeholder Engagement:** Involve various stakeholders in the entire measurement process, from identifying objectives to communicating results. This will help ensure that the measurements reflect a wide range of views and interests.

Below are several examples of theoretical and practical analysis and observation results from the socio-ecological-based SDG indicator model, which was built based on the stages mentioned above.

Table 1. SDGs Measurement Model

No	Indicator	Formula	Description
1	Multidimensional Poverty Index	MPI = H x A	1. H (headcount ratio): The proportion of the population experiencing multidimensional

No	Indicator	Formula	Description
			poverty. 2. A (intensity of poverty): the intensity or depth of poverty faced by people who experience multidimensional poverty. The MPI combines several social indicators, such as education, health, and standard of living, to measure multidimensional poverty.
2	Human Development Index - HDI	HDI = (GNI per capita + Life Expectancy Index + Education Index) / 3	1. GNI per capita: Gross national income per capita. 2. Life Expectancy Index: Life expectancy at birth. 3. Education Index: A combination of educational participation rate and average years of schooling. HDI measures development which includes social aspects (life expectancy and education) and economic aspects (income)
3	Marine Life Index	Climate Adaptation Index = (Availability of water resources + Disaster-resistant infrastructure) / 2	1. GNI per capita: Gross national income per capita 2. Life Expectancy Index: Life expectancy at the time of birth 3. Education Index: A combination of education participation rate and average years of schooling HDI measures development, which includes social aspects (life expectancy and education) and economic aspects (income)..
4	Resource-based Well-being Index	$W = (\Sigma S_i) / (\Sigma P_i)$	1. W: resource-based welfare index 2. Si: total social value of resource assets (e.g., jobs, education, access to clean water). 3. Pi: total environmental value of resource assets (e.g., water quality, biodiversity). This index tries to measure human welfare by considering social and environmental aspects related to natural resources.
5	Sustainable Well-being Index	$SWB = (\Sigma W_i) / N$	1. SWB: Sustainable Welfare Index 2. Wi: The total value of an individual's well-being (e.g., income, health, education). 3. N: The number of individuals in the population This index attempts to measure sustainable well-being by considering social indicators such as income and health as well as ecological factors such as ecological footprint.
6	Ecosystem Balance Index	$EBI = (\Sigma B_i) / (\Sigma L_i)$	1. 1.EBI: Ecosystem equilibrium index 2. 2.Bi: Total value of biodiversity and ecosystem sustainability 3. 3.SLi: Total value of environmental pressure and ecosystem damage This index attempts to measure ecosystem

No	Indicator	Formula	Description
			health by considering environmental factors such as biodiversity and ecosystem damage.
7	Welfare Sustainability Index	$WSI = (\Sigma S_i - \Sigma D_i) / \Sigma P_i$	1. 1.WSI: Well-being Sustainability Index 2. 2. Si: Total social value of resource assets 3. 3. Di: Total negative social impact value (e.g., unemployment rate, poverty). 4. 4.SPi: total environmental value of resource assets This index tries to measure the sustainability of welfare by considering social aspects, negative social impacts, and environmental aspects.
8	Sustainable Livelihood Index	$SLI = (\Sigma A_i + \Sigma E_i) / N$	1. 1.EQI: Environmental Quality Index 2. 2. Qi: Total value of environmental quality indicators (e.g., air quality, biodiversity). 3. 3.M: Number of environmental quality indicators used This index measures environmental quality by considering various environmental indicators.
9	Multidimensional Poverty Index	MPI = H x A	1. MPI: Multidimensional Poverty Index 2. H (headcount ratio): The proportion of the population experiencing multidimensional poverty. 3. A (intensity of poverty): the intensity or depth of poverty faced by people who experience multidimensional poverty. The MPI combines several social indicators (such as education, health, and standard of living) to measure multidimensional poverty.
10	Sustainable Life Satisfaction Index	$SLSI = (\Sigma L_i - \Sigma D_i) / N$	1. SLSI: Sustainable Life Satisfaction Index 2. SLi: The total value of the positive aspects of life (e.g., social welfare, access to services). 3. Di: The total value of negative aspects of life (e.g., inequality, environmental degradation). 4. N: Number of individuals in the population This index attempts to measure ongoing life satisfaction by considering the positive and negative aspects of life.
11	Human Ecological Footprint Index	$HEFI = (\Sigma AE_i) / N$	1. HEFI: Human ecological index. 2. ΣAE_i Humans total ecological footprint in relation to the consumption and use of natural resources 3. N: Number of related human populations This index tries to measure the ecological impact of humans on the planet by considering the consumption of natural resources.
12	Sustainable Cities and Settlements	[(100% x LRTH + 100% x TP) + (1-Index KU)] / 3	1. Percentage of Green Open Space Area (Ecological Indicator): This reflects the availability of green open space within the city. 2. Percentage of Population Using Public

No	Indicator	Formula	Description
			Transportation (Social Indicator): This reflects the mobility aspect and the environmental impact of using private transportation. 3. Air Quality Index (Ecological Indicator): This reflects urban air quality and its impact on people's health. 4. Different weights are assigned to each indicator according to the importance of each aspect (e.g., giving the ecological indicator a higher weight if environmental conservation is a top priority in the context you are measuring). Next, the process of normalizing the results of this index to get a value between 0 and 1, where 0 represents the worst condition and 1 represents full achievement of the SDGs you are measuring
	Climate Action	ITK= [(1−EGRK+100% x P + ET)] /3	1. Greenhouse Gas Emissions (Ecological Indicator): This reflects the environmental impact of greenhouse gas emissions. 2. Percentage of Population Protected from the Impacts of Climate Disasters (Social Indicator): This reflects the social welfare of the people who are protected from the impacts of climate disasters. 3. Use of Renewable Energy (Ecological Indicator): This reflects the contribution to the reduction of greenhouse gas emissions.

6.Conclusion

Socio-ecological-based measurement of SDGs is a holistic approach that considers social and ecological aspects simultaneously to measure progress towards sustainable development goals (SDGs). Socio-ecological-based measurement of SDGs is a holistic approach that integrates social and ecological aspects to provide a more complete picture of progress towards sustainable development goals (SDGs). This approach recognizes that human welfare and environmental sustainability are interrelated. Therefore, measuring social-ecologically based SDGs takes into account social and environmental indicators to assess the impact of development actions. It is important to give appropriate weight to the social and ecological indicators used according to the relevant priorities and context. Normalization is necessary to ensure measurement results can be compared and assessed within a consistent framework. The selected social and ecological indicators must reflect the aspects that are most relevant in the context of the goals of the SDGs being measured and have reliable data. Measuring SDGs based on socio-ecology can be a complex approach because it involves many indicators and considerations.

Local context and regional sustainability must be taken into account in the analysis. This approach helps measure the long-term impact of development actions and policies because it includes environmental aspects that reflect long-term sustainability. The socio-

ecological-based measurement of the SDGs focuses on a more holistic understanding of how our actions affect the world around us. This reflects the fact that the challenges of sustainable development are systemic and complex. This approach encourages the use of multidimensional data, including social and ecological data, to make better decisions and support more effective planning. In general, measuring social-ecological-based SDGs is a powerful tool for understanding and measuring progress towards sustainable development goals in a way that includes social and ecological aspects simultaneously. In an effort to achieve the SDGs, this approach promotes awareness of the close relationship between human well-being and the sustainability of the natural environment.

References

[1] T. Pogge and M. Sengupta, "Rethinking the Post-2015 Development Agenda: Eight Ways to End Poverty Now," *Global Justice : Theory Practice Rhetoric*, vol. 7, 1970, doi: 10.21248/gjn.7.0.43.

[2] C. Allen, G. Metternicht, and T. Wiedmann, "Initial progress in implementing the Sustainable Development Goals (SDGs): a review of evidence from countries," *Sustainability Science*, vol. 13, no. 5. 2018. doi: 10.1007/s11625-018-0572-3.

[3] V. Spaiser, S. Ranganathan, R. B. Swain, and D. J. T. Sumpter, "The sustainable development oxymoron: quantifying and modelling the incompatibility of sustainable development goals," *International Journal of Sustainable Development and World Ecology*, vol. 24, no. 6, pp. 457–470, Nov. 2017, doi: 10.1080/13504509.2016.1235624.

[4] H. A. H. Dang and U. Serajuddin, "Tracking the sustainable development goals: Emerging measurement challenges and further reflections," *World Dev*, vol. 127, 2020, doi: 10.1016/j.worlddev.2019.05.024.

[5] S. Fritz *et al.*, "Citizen science and the United Nations Sustainable Development Goals," *Nat Sustain*, vol. 2, no. 10, 2019, doi: 10.1038/s41893-019-0390-3.

[6] S. Fukuda-Parr and D. McNeill, "Knowledge and Politics in Setting and Measuring the SDGs: Introduction to Special Issue," *Glob Policy*, vol. 10, 2019, doi: 10.1111/1758-5899.12604.

[7] S. Kapto, "Layers of Politics and Power Struggles in the SDG Indicators Process," *Global Policy*, vol. 10. 2019. doi: 10.1111/1758-5899.12630.

[8] S. E. Merry, "The Sustainable Development Goals Confront the Infrastructure of Measurement," *Global Policy*, vol. 10. 2019. doi: 10.1111/1758-5899.12606.

[9] S. Macfeely and B. Nastav, "You say you want a [data] revolution": A proposal to use unofficial statistics for the SDG Global Indicator Framework," *Stat J IAOS*, vol. 35, no. 3, 2019, doi: 10.3233/SJI-180486.

[10] S. Mair, A. Jones, J. Ward, I. Christie, A. Druckman, and F. Lyon, "A Critical Review of the Role of Indicators in Implementing the Sustainable Development Goals," in *World Sustainability Series*, 2018. doi: 10.1007/978-3-319-63007-6_3.

[11] S. Razavi, "Indicators as Substitute for Policy Contestation and Accountability? Some Reflections on the 2030 Agenda from the Perspective of Gender Equality and Women's Rights," *Global Policy*, vol. 10. 2019. doi: 10.1111/1758-5899.12633.

[12] S. MacFeely, "The Big (data) Bang: Opportunities and Challenges for Compiling SDG Indicators," *Glob Policy*, vol. 10, 2019, doi: 10.1111/1758-5899.12595.

[13] Miola A, Borchardt S, Neher F, and Buscaglia D, "Interlinkages and policy coherence for the Sustainable Development Goals implementation An operational method to identify trade-offs and co-benefits in a systemic way", doi: 10.2760/472928.

[14] P. Hellegers and G. van Halsema, "SDG indicator 6.4.1 'change in water use efficiency over time': Methodological flaws and suggestions for improvement," *Science of the Total Environment*, vol. 801, 2021, doi: 10.1016/j.scitotenv.2021.149431.

[15] O. E. Malay and S. Aubinet, “Improving government and business coordination through the use of consistent SDGs indicators. A comparative analysis of national (Belgian) and business (pharma and retail) sustainability indicators,” *Ecological Economics*, vol. 184, 2021, doi: 10.1016/j.ecolecon.2021.106991.

[16] Ö. Calicioglu and A. Bogdanski, “Linking the bioeconomy to the 2030 sustainable development agenda: Can SDG indicators be used to monitor progress towards a sustainable bioeconomy?,” *N Biotechnol*, vol. 61, 2021, doi: 10.1016/j.nbt.2020.10.010.

[17] A. G. Olabi *et al.*, “Assessment of the pre-combustion carbon capture contribution into sustainable development goals SDGs using novel indicators,” *Renewable and Sustainable Energy Reviews*, vol. 153, 2022, doi: 10.1016/j.rser.2021.111710.

[18] F. Johnsson, I. Karlsson, J. Rootzén, A. Ahlbäck, and M. Gustavsson, “The framing of a sustainable development goals assessment in decarbonizing the construction industry – Avoiding ‘Greenwashing,’” *Renewable and Sustainable Energy Reviews*, vol. 131, 2020, doi: 10.1016/j.rser.2020.110029.

[19] H. Muri, J. Sandstad Næss, and C. M. Iordan, “Potential contribution from bioenergy with CCS to SDG13: an Earth system modelling perspective,” *EGU General Assembly Conference Abstracts*, 2020.

[20] J. D. Sachs, G. Schmidt-Traub, M. Mazzucato, D. Messner, N. Nakicenovic, and J. Rockström, “Six Transformations to achieve the Sustainable Development Goals,” *Nat Sustain*, vol. 2, no. 9, 2019, doi: 10.1038/s41893-019-0352-9.

[21] T. Heimann, “Bioeconomy and SDGs: Does the Bioeconomy Support the Achievement of the SDGs?,” *Earths Future*, vol. 7, no. 1, 2019, doi: 10.1029/2018EF001014.

[22] J. Schweinle, N. Geng, S. Iost, H. Weimar, and D. Jochem, “Monitoring sustainability effects of the bioeconomy: A material flow based approach using the example of softwood lumber and its core product Epal 1 pallet,” *Sustainability (Switzerland)*, vol. 12, no. 6, 2020, doi: 10.3390/su12062444.

[23] P. Schroeder, K. Anggraeni, and U. Weber, “The Relevance of Circular Economy Practices to the Sustainable Development Goals,” *J Ind Ecol*, vol. 23, no. 1, 2019, doi: 10.1111/jiec.12732.

[24] T. Ronzon and A. I. Sanjuán, “Friends or foes? A compatibility assessment of bioeconomy-related Sustainable Development Goals for European policy coherence,” *J Clean Prod*, vol. 254, 2020, doi: 10.1016/j.jclepro.2019.119832.

[25] F. Fuso Nerini *et al.*, “Connecting climate action with other Sustainable Development Goals,” *Nature Sustainability*, vol. 2, no. 8. 2019. doi: 10.1038/s41893-019-0334-y.

[26] R. Fehri, S. Khlifi, and M. Vanclooster, “Disaggregating SDG-6 water stress indicator at different spatial and temporal scales in Tunisia,” *Science of the Total Environment*, vol. 694, 2019, doi: 10.1016/j.scitotenv.2019.133766.

[27] A. A. Wieser, M. Scherz, S. Maier, A. Passer, and H. Kreiner, “Implementation of Sustainable Development Goals in construction industry - A systemic consideration of synergies and trade-offs,” in *IOP Conference Series: Earth and Environmental Science*, 2019. doi: 10.1088/1755-1315/323/1/012177.

[28] A. Moldavska and T. Welo, “Testing and verification of a new corporate sustainability assessment method for manufacturing: A multiple case research study,” *Sustainability (Switzerland)*, vol. 10, no. 11, 2018, doi: 10.3390/su10114121.