Research Paper

Integrating Environmental Carrying Capacity with Social Behavior: Strategies Towards Sustainability and Climate Resilience in Indonesia

M Erick KUSUMA, Indonesian Association of Urban and Regional Planners (IAP), Indonesia

Ayu Sekar MAWARNI, Directorate of Environmental Impact Prevention and Regional and Sector Policy, Ministry of Environment and Forestry, Republic of Indonesia, Indonesia

Haviz KURNIAWAN, Directorate of Environmental Impact Prevention and Regional and Sector Policy, Ministry of Environment and Forestry, Republic of Indonesia, Indonesia

Lintang Sekar Kedaton BARNAD, Indonesian Association of Urban and Regional Planners (IAP), Indonesia

Abstract

The sustainability of the environment, as a fundamental component of sustainable development, is contingent upon not only environmental carrying capacity but also social behaviour. Social behaviour is reflected in consumption patterns of natural resources and demonstrates climate resilience. The objective of this research is to integrate three key elements: environmental supporting capacity, environmental assimilative capacity, and social behaviour, in order to assess environmental sustainability in Indonesia in a holistic manner. This study employs a mixed-method approach to develop an integrative model between environmental capacity and social behaviour. The findings of this study demonstrate that this integration provides a more comprehensive picture of the long-term endurance of the national environment. Moreover, this integration elucidates the national climate resilience conditions based on social behaviour. This integration serves as a crucial input in formulating national climate change adaptation action plans, urban environmental protection and management strategies, and as a recommendation for sustainable urban spatial planning. The study concludes by emphasising the importance of a multidimensional approach in urban environmental policymaking and in optimising natural resources utilisation to achieve genuine sustainability.

Keywords

Environmental carrying capacity, social behaviour, sustainability, climate resilience, Indonesia.

1. Introduction

National development has entered a new phase with the enactment of Law No. 59/2024 on the National Long-Term Development Plan (Rencana Pembangunan Jangka Panjang Nasional/RPJPN) 2025-2045. This period is crucial for the future of the Republic of Indonesia and is characterised by high uncertainty and global issues, including global megatrends (demographic dividend, urbanisation, etc.) (Ministry of National Development Planning/Bappenas, 2023), global risks (World Economic Forum, 2024) such as technological

progress and competition for natural resources in the context of global geopolitics, and global environmental challenges, also known as the triple planetary crisis, which includes climate change, pollution and biodiversity loss (UNEP, 2020). These uncertainties and challenges need to be anticipated in national development planning.

The RPJPN 2025-2045 (Republic of Indonesia, 2024) has been formulated with the expectation that it will serve as a framework for national development towards the nation's enduring vision and mission: to become a sovereign, progressive and sustainable country. The 'sustainable' aspect needs to be elaborated in the context of advancing the environmental, economic, social and governance dimensions of sustainable development. As outlined by the Stockholm Resilience Centre (2016), the economic and social dimensions (including governance) are seen as intrinsically linked to the environmental dimension. This corrects the current understanding of these dimensions as separate entities.

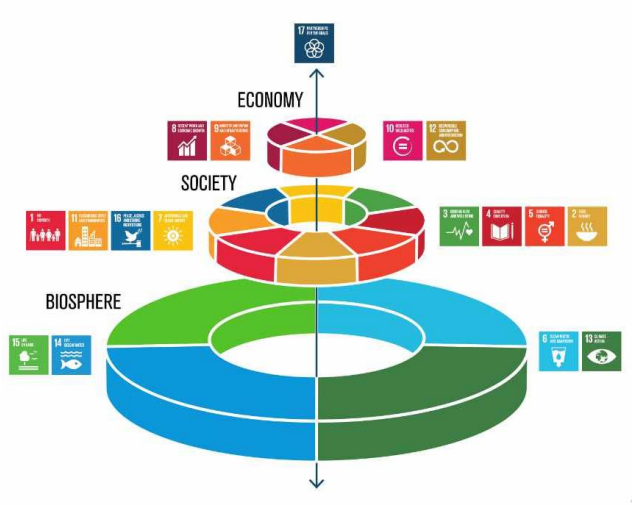

Figure 1. Environmental Aspects as the Basis for Sustainable Development.
Source: Stockholm Resilience Center (2016)

Environmental Carrying Capacity (ECC) is understood as a fundamental tool that represents environmental sustainability in Indonesia. This concept serves as the basis for the sustainable use of natural resources, as required by Law of the Republic of Indonesia No. 32/2009 on Environmental Management and Protection (Republic of Indonesia, 2009), and is applied in various sectors, including spatial planning, agriculture, mining, fisheries, and others. In Indonesia, ECC is divided into two components: carrying capacity, which refers to the number of people the environment can support, and assimilative capacity, which refers to the environment's ability to absorb pollutants or pollutant loads (Khanna et. al, 1999; Republic of Indonesia, 2009).

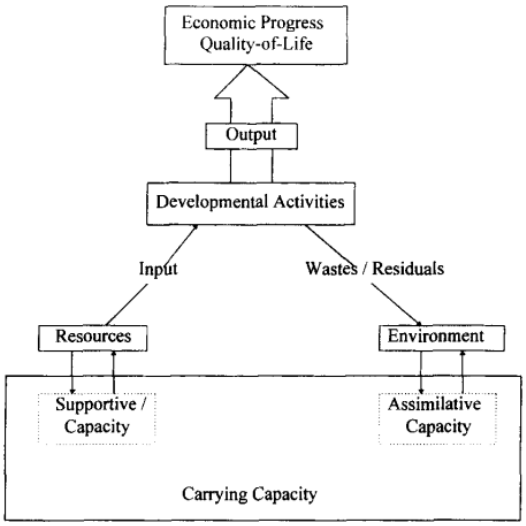

Figure 2. Implementing Environmental Carrying Capacity in Indonesia.
Source: Khanna, et al (1999)

In Indonesia, the concept of Environmental Carrying Capacity (ECC) is typically approached from two perspectives: the supply aspect, which concerns the capacity of the environment, and the demand aspect, which encompasses the utilisation of natural resources by humans, including population size and consumption patterns. If demand exceeds supply, it can be concluded that the ECC has been exceeded, and vice versa (MOEF of the Republic of Indonesia, 2023a). The supply aspect of ecosystem services exerts an influence on the functioning of social and economic factors, thereby underscoring the necessity for environmentally friendly governance efforts to maintain a surpassed ECC (Martin-López, 2014).

Considering the aforementioned explanation, the integration of ECC with social behaviour is of paramount importance to achieve sustainable development. Consequently, this research aims to integrate ECC (environmental supporting capacity and environmental assimilative capacity) with social behaviour to provide a comprehensive assessment of environmental sustainability in Indonesia.

2. Literature Review

Concept of Environmental Carrying Capacity in Indonesia

The concept of Environmental Carrying Capacity (ECC) has been predominantly focused on the notion of "supporting capacity". Edelman (1997) defines carrying capacity as a limit to growth. Lane et al. (2013) posit that a carrying capacity assessment entails the utilisation of modelling techniques to ascertain the extent of natural resources that can be harnessed for the sustenance of life, encompassing food, water, shelter and energy. Meanwhile, Santoso et al. (2014) conceptualise carrying capacity as a threshold or critical level of productive land area required to support human needs. Exceeding this threshold can result in environmental degradation (Kozlowski, 1990). Such degradation is frequently associated with human-ecological systems, manifested in the depletion of natural resources, loss of biodiversity, land degradation, pollution, and other environmental issues (Swiader et al., 2020).

Conversely, the concept of environmental assimilative capacity is well-established and employed in a variety of assessments to advance the objective of sustainable development. In their 2014 study, Fouad

and colleagues define environmental assimilative capacity as the ability of the environment to absorb and process pollutants without compromising its health. This is influenced by two key factors: pollution levels and human intervention efforts. As defined by Khanna et al. (1999), assimilative capacity represents the maximum pollution load that can be discharged into the environment without affecting its designated use. This concept is closely linked to environmental supporting capacity, which encompasses the limits of natural resources and the ecosystem's ability to sustain human activities.

As previously mentioned, ECC in Indonesia is mandated by Law No. 32/2009 on Environmental Protection and Management as the basis for the utilization of natural resources in the absence of an environmental planning framework. ECC includes environmental supporting capacity and environmental assimilative capacity and is derived from an environmental inventory conducted at the ecoregion level. Ecoregions of Indonesia refer to geographical areas that share similar characteristics in terms of climate, soil, water, native flora and fauna, as well as human-nature interactions that represent the integrity of natural systems and the environment (Republic of Indonesia, 2009).

As previously stated, the Indonesian Environmental Protection and Management Act (No. 32/2009) requires the use of the Environmental Considerations Certificate (ECC) as the foundation for the utilisation of natural resources in the absence of an environmental planning framework. ECC encompasses both environmental supporting capacity and environmental assimilative capacity, derived from an environmental inventory conducted at the ecoregion level. Ecoregions of Indonesia are defined as geographical areas exhibiting analogous characteristics in terms of climate, soil, water, native flora and fauna, as well as human-nature interactions, which collectively represent the integrity of natural systems and the environment (Republic of Indonesia, 2009).

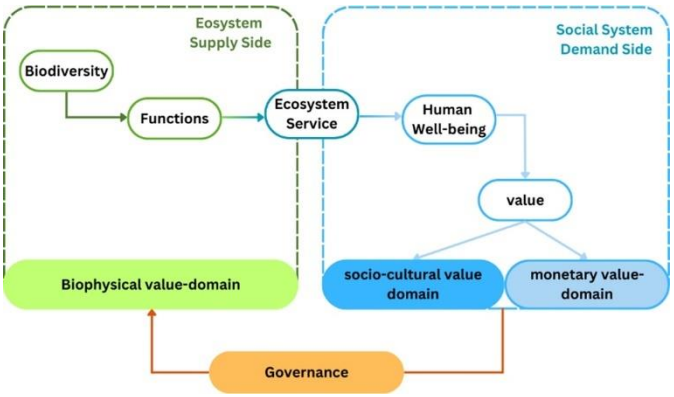

Figure 3. Integrating Ecosystem and Social System with Ecosystem Services
Source: Martin-López (2014), modified.

The ecoregions and ecosystem services of Indonesia place particular emphasis on renewable natural resources. This approach is aligned with the framework proposed by Miller and Spoolman (2016), which defines these natural assets as those that can regenerate themselves through natural processes within a timeframe ranging from hours to centuries. However, this potential for regeneration is contingent upon ensuring that the consumption rate does not exceed the replenishment rate. The renewable resources include freshwater, arable land, biodiversity, oceans, and clean air. These resources are also addressed in the national environmental protection and management plan (MOEF of Republic of Indonesia, 2023b).

In terms of implementation, the initial guideline for calculating environmental carrying capacity (ECC) in Indonesia was set forth in the Ministry of Environment and Forestry of the Republic of Indonesia (MOEF) Regulation No. 17 of 2009 concerning Guidelines for Determining Environmental Carrying Capacity in Regional Spatial Planning. However, this regulation concentrated solely on supportive capacity. In order to promote sustainable natural resource management, the MOEF has taken significant steps, including the establishment of national water carrying capacity in 2019, which was subsequently updated in 2023. Furthermore, in 2023, the MOEF completed the calculation of national arable land carrying capacity. The calculation of both water and arable land carrying capacity is based on a comparison between the availability of natural resources and human needs. These calculations employ specific standards, such as per capita clean water requirements or land requirements for agriculture, as benchmarks.

The availability of carrying capacity data enables the government and relevant stakeholders to develop more measurable and sustainable development plans. This information is crucial for identifying regions that have exceeded their carrying capacity, thereby facilitating the implementation of mitigation and adaptation measures. Furthermore, carrying capacity data can serve as a foundation for establishing more effective natural resource management policies.

Social Behavior Related to Environment

In accordance with the stipulations set forth in Law No. 32 of 2009, the utilisation of natural resources in Indonesia is governed by the principle of Environmental Carrying Capacity (ECC). This principle emphasises the necessity for the sustainability of environmental processes, functions, and productivity, while also ensuring the safety of the public, the quality of life and welfare of the population. This highlights the significance of integrating social considerations and human well-being as determinants of environmental demand.

The 2023 study, conducted by the MOEF, has provided detailed insights into the interrelated concepts of public safety, quality of life, and welfare. The concept of public safety can be understood as a state of health and security. It can be considered healthy when related to life safety and secure when associated with safety from hazards and disasters. The quality of life is associated with cultural advancement (in light of Indonesia's rich cultural heritage) and human development. In contrast, welfare is reflected in economic growth, general price stability, and the open unemployment rate. The study suggests that these three aspects are interlinked with environmental sustainability and the achievement of low-carbon and climate-resilient development (MOEF of the Republic of Indonesia, 2023a).

Social behaviour can be defined as the consequence of a multitude of human experiences and interactions with their environment, manifested in their knowledge, attitude, and practice (Sarwono in Populix, 2023). These three components are commonly referred to as the knowledge-attitude-practice (KAP) framework. The KAP framework is widely used in health education and in developing countries for family planning programmes. It serves as a guideline for understanding the mechanisms of health education in influencing patient behaviour change and health outcomes (Jaccard et al., in Populix, 2023).

Prior research conducted by the government has indirectly explored social behaviours related to climate resilience. The Central Bureau of Statistics (Badan Pusat Statistik/BPS) published a report entitled "Indicators of Pro-Environmental Behavior" (2012), which provided an overview of household behaviors related to environmental concern. The indicators covered a range of areas, including housing facilities, energy use, water use, transportation, waste management, and concern for the surrounding environment.

Subsequently, BPS updated this publication with the "Environment Indifferent Behavior Index Report of Indonesia" (2017), which served as a counterpoint to the previous version. The objective of this report was to measure the level of environmental indifference in various regions of Indonesia. A higher index value indicated a higher level of environmental indifference, while a lower value signified greater environmental concern. Both publications demonstrate that Indonesian society exhibits moderate levels of environmental concern and climate resilience-related behaviors.

3. Methodology

Building upon prior research conducted by the MOEF, this study extends the scope of assessment in order to gain a deeper understanding of the environmental condition (ECC) of Indonesia. While previous studies have primarily focused on the supportive capacity of freshwater and arable land, this research incorporates a wider range of renewable resources, including biodiversity, air quality, and ocean. This comprehensive approach allows for a more holistic view of the environmental condition of Indonesia.

The calculation process of the Indonesia Environmental Sustainability Index is divided into three stages. The initial stage entails the calculation of the supporting and assimilative capacities, which collectively constitute the environmental carrying capacity, leading to the generation of the ECC Index. The subsequent stage involves the calculation of the Social Behaviour Index. The final stage integrates the Indonesia ECC Index with the Social Behaviour Index.

Calculation

The calculation of the ECC Index is conducted through an assessment of the supporting and assimilative capacity for the following five renewable resources:

In this study, the renewable resource of freshwater is calculated for both its supporting capacity and its assimilative capacity. The calculation of water supporting capacity is conducted by means of a comparison between the available water supply and the water demand that is required in order to support the population through the provision of ecosystem services. The calculation of assimilative capacity is performed by measuring a range of parameters, including Total Suspended Solids (TSS), pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Phosphates, NO_3, and Fecal Coliform. Furthermore, the water quality standards for rivers and lakes will be integrated to provide insight into the water's assimilative capacity. The findings of this analysis will elucidate the quantity of water that can be supplied and the extent of pollutant load that can be absorbed, thereby enabling the utilisation of water in a manner that does not exceed the natural assimilative capacity of the aquatic ecosystem.

In this study, arable land is considered a renewable resource, with calculations made for both supporting and assimilative capacity. The calculation of arable land supporting capacity employs a projection of optimal land cover to support a specific population. In contrast, the calculation of arable land assimilative capacity is derived from the land quality index developed by MOEF, which is based on the area of forest and shrubland cover within forest areas and protected zones. This parameter reflects the land's capacity to support human activities without compromising its ecological functions.

In order to assess the supporting and assimilative capacities of marine environments, the Marine Ecological Carrying Capacity approach is adopted. The evaluation of marine supporting capacity is based on a number

of parameters, including the maximum sustainable yield (MSY), seawater quality, and the condition of marine ecosystems such as coral reefs and mangroves. The data is then subjected to analysis in order to ascertain the extent to which the ocean is able to support the food requirements and economic activities of coastal communities. In order to assess the marine assimilative capacity, the parameters include fish biomass, seawater quality, the health of marine ecosystems (comprising coral reefs, mangroves and seagrass), and the level of marine pollution. The results of this analysis will indicate the extent to which the ocean is able to support fisheries and marine tourism activities without resulting in a degradation of marine ecosystem quality or biodiversity.

In regard to air quality, this study will focus on the calculation of the assimilative capacity of the ecosystem. The assimilative capacity is determined by comparing the regulating services of the ecosystem with the actual air quality, using NO_2 and SO_2 as parameters. The results of this calculation will indicate the extent to which the environment is capable of absorbing air pollutant loads.

The assessment of supporting and assimilative capacity is conducted using the Multidimensional Biodiversity Index, developed by the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) (Soto-Navarro et al., 2020). This index broadly measures the contributions of "biodiversity for people" and "biodiversity for nature." This approach integrates the various dimensions of biodiversity, thereby providing a more comprehensive representation of ecosystem health.

The assessment of the social behaviour index is conducted using the knowledge-attitude-practice (KAP) method, which is employed to evaluate patterns of production, consumption, and the associated impact on natural resource pollution. This approach offers insights into the ways in which knowledge and attitudes shape behaviours that contribute to environmental degradation.

Once the ECC Index and Social Behavior Index have been determined, the two indices are integrated to produce the Environmental Sustainability Index, which provides a comprehensive depiction of the ECC. The index values range from 0 to 1, with a value closer to 1 indicating optimal environmental processes, functions, and productivity. This suggests that renewable natural resources, such as water, land, oceans, air, and biodiversity, can adequately support human life and other ecosystems with minimal negative impact from human activities. Conversely, a lower value indicates the opposite.

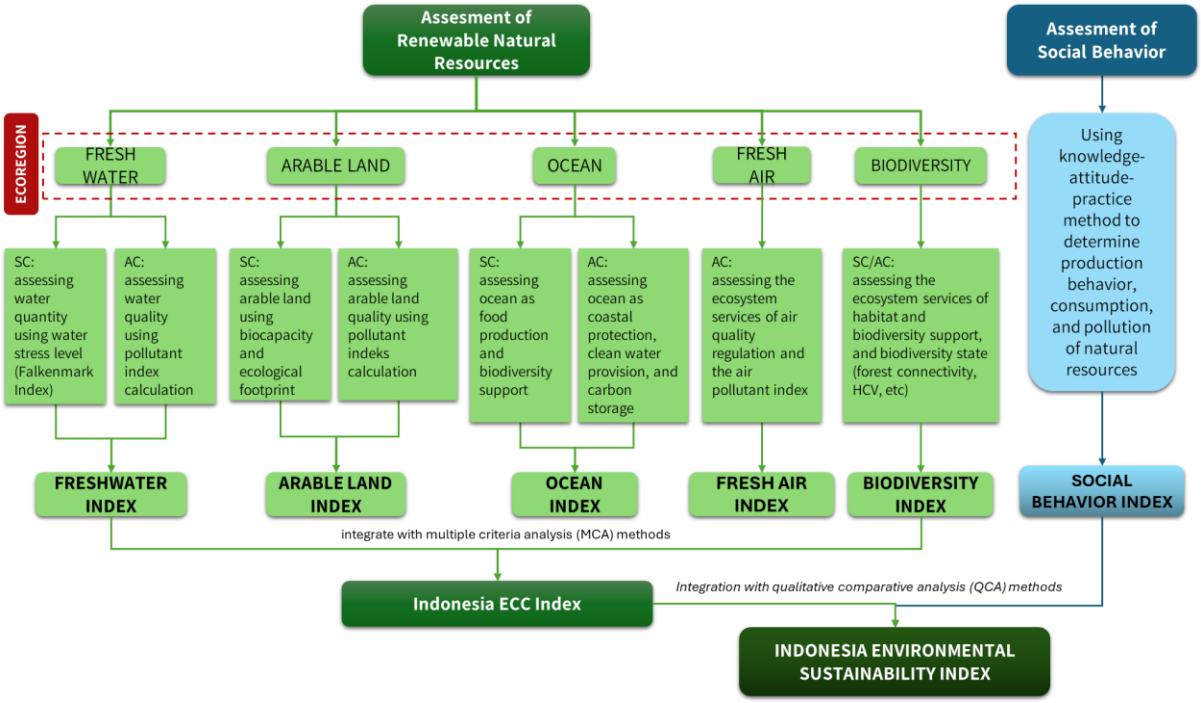

Figure 4. Concept of Integration of ECC and Social Behavior Assessment.
Source: Developed by the author (2024).

Data and Source Data

The data employed in this study is primarily drawn from the MOEF, particularly data pertaining to the five renewable resources. The data utilised in calculating the social behaviour index is the result of a collaborative effort between the MOEF and academic institutions, as well as social and economic research organisations. The calculation process involves the input of experts, practitioners, and policymakers.

4. Findings and Discussion

This study represents an initial exploration of the subject matter, and all findings presented in this article are preliminary drafts that require significant refinement. As a preliminary investigation and for illustrative purposes, this article presents the ECC calculation for the Indonesian province of Bali. Bali was selected due to its status as an internationally renowned tourist destination, known for its rich cultural heritage and tourist appeal, yet facing significant challenges related to overtourism. It is therefore crucial to assess the province's environmental capacity to support its population and tourism activities. Subsequently, this article provides the Environmental Sustainability Index calculations for all regions across Indonesia.

The ecoregion of Bali exhibits a number of characteristics in common with those of Java Island and several surrounding islands. These include distinctive landscape features, natural vegetation characteristics, and land cover. The Province of Bali is characterised by a diverse range of landscapes, predominantly comprising mountains and hills. These landscapes exhibit a variety of ecoregions, including volcanic and structural hill complexes, volcanic mountain complexes (Bali-Lombok and Flores), karst hill complexes, fluvial plains, and coral/organic complexes. This diversity of landforms gives rise to a variety of land slopes and four main morphological features: plains, hills, mountains, and calderas. The Province of Bali has four

lakes that were formed by past volcanic eruptions: Lake Beratan, Lake Buyan, Lake Tamblingan, and Lake Batur. These lakes have nutrient-rich soil from volcanic deposits. At the time of writing, Bali is home to two active volcanoes: Mount Agung and Mount Batur. The topography of Bali, which is characterised by a mountainous landscape, has resulted in the formation of 401 rivers. The longest of these is the Tukad Ayung, which flows for 62.5 km and predominantly empties into the southern coastline. In addition to lakes and rivers, Bali also has significant groundwater resources, with the Denpasar-Tabanan Basin being the largest and most water-abundant. The natural vegetation of Bali is primarily composed of evergreen monsoon lowland forests, particularly in the central and eastern mountainous regions. The diverse forest cover in these areas helps to reduce surface runoff, with a higher density of vegetation leading to greater water absorption. The distribution of land cover in Bali is generally aligned with the topography of the island, with plantations commonly situated between forests and urban areas. Plantations, which may be either mixed or monoculture (such as cacao or coconut), are typically located at the periphery of forests, while shrublands and dry fields are predominant in South Kuta and Nusa Penida due to the thin karst soils with sandy loam textures and carbonate bedrock (MOEF of Republic of Indonesia, 2023c).

Following an assessment of the characteristics of the ecoregion, calculations were conducted to determine the supporting and assimilative capacity of each renewable natural resource in Bali. The results indicate that, overall, the supporting capacity and assimilative capacity of freshwater resources are at a low level. In contrast, the supporting capacity of arable land resources is low, but the assimilative capacity is reasonably good. Marine resources show a fairly good level of both supporting and assimilative capacity. Air quality reflects a moderate level of assimilative capacity, while biodiversity reveals low supporting capacity yet adequate assimilative capacity. It can thus be concluded that the environmental supporting capacity and environmental assimilative capacity of Bali are less than optimal (see Figure 5).

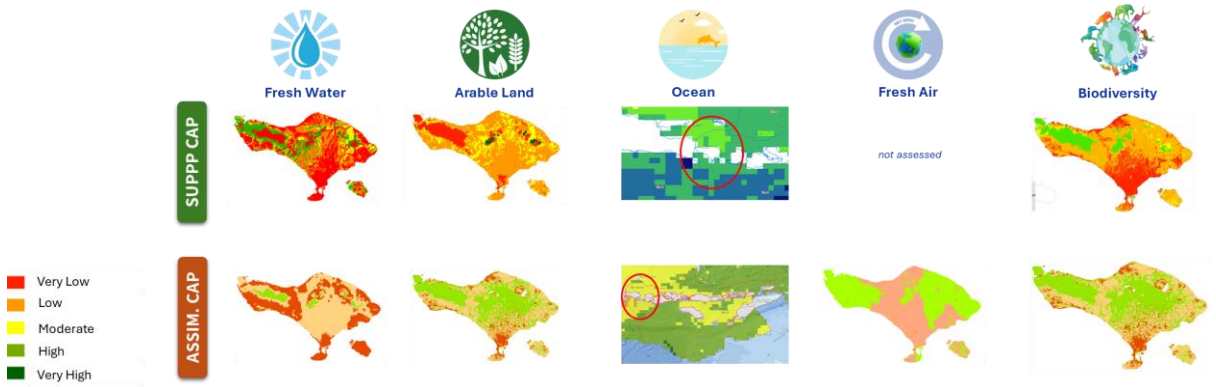

Figure 5. Assessment of Environmental Supporting Capacity and Assimilative Capacity of Bali
Source: Authors' analysis, 2024.

The social behaviour in Indonesia is identified through the knowledge-attitude-practice (KAP) approach to understanding environmentally friendly behaviours. The term "knowledge" encompasses individuals' comprehension of environmental issues, climate change, and the consequences of their actions on the environment. "Attitude" denotes individuals' sentiments or predispositions towards the environment and their sense of obligation to act. "Practice" signifies the tangible behaviors individuals engage in based on their knowledge and attitudes towards the environment and climate change. These elements are interlinked with consumption behaviors and pollution related to the five renewable resources.

The social behaviour observed in Indonesia is generally indicative of a favourable standing, with moderate levels of knowledge, positive attitudes and good levels of practice. This general pattern is consistent across different regions in Indonesia, including the province of Bali. The discussions conducted emphasise the necessity of enhancing "knowledge" in order to further encourage "practice", thus ensuring more environmentally friendly consumption and pollution behaviours in relation to the five renewable resources (Authors' analysis, 2024).

Following an assessment of the ECC in Indonesia (represented visually by the Province of Bali) and an understanding of the social behaviour conditions in the country, the next step is to determine the Indonesia Environmental Sustainability Index. The integration of these two variables into a calculation reveals that the Indonesia Environmental Sustainability Index is at a level of "good" or "high condition." The ECC across various regions in Indonesia is diverse, reflecting the distinct ecoregional characteristics and population concentrations of each region. Currently, Java Island is the most densely populated, with fertile land and moderate clean water availability. Social behaviour plays a significant role in this context, as environmentally friendly practices, responsible consumption, and reduced pollution by the population can effectively mitigate pressure on the environment, allowing the ECC to recover both now and in the future. However, this recovery will depend on the implementation of adequate interventions targeting social behaviour (see Table 1).

Table 1 Indonesia Environmental Sustainability Index

Region	ECC Index	Social Behavior Index	Indonesia Environmental Sustainability Index
Sumatera	High	Moderate	High
Java	Very Low	High	Low
Bali-Nusa Tenggara	Moderate	Moderate	Moderate
Kalimantan	High	Moderate	High
Sulawesi	Very High	Moderate	High
Maluku	Very High	Moderate	High
Papua	High	Moderate	High
INDONESIA	High	Moderate	High

Source: Authors' analysis, 2024.

Table 1 presents a threshold that elucidates the interrelationship between the two variables and the conditions prevailing in diverse regions of Indonesia. The threshold was determined through a process of discussion and agreement, with specific cutoff values established for the ECC Index and the Social Behavior Index. Subsequently, the data was represented in four quadrants, based on the aforementioned threshold. Quadrant I comprises cases where both the ECC Index and the Social Behavior Index exceed the threshold. Quadrant II encompasses instances where the ECC Index falls below the threshold, while the Social Behavior Index surpasses it. Quadrant III represents scenarios where both the ECC Index and the Social Behavior Index are below the threshold. Finally, Quadrant IV includes cases where the ECC Index exceeds the threshold, while the Social Behavior Index falls below it.

The results demonstrate that Indonesia as a whole, along with several regions, is situated within Quadrant IV. In contrast, Java Island and the Bali-Nusa Tenggara Archipelago are positioned in Quadrants II and III, respectively (see Figure 6). This finding highlights the significance of conserving and safeguarding the environment to maintain and enhance the ECC, as well as managing consumption and pollution behaviours to further develop responsible social behaviour.

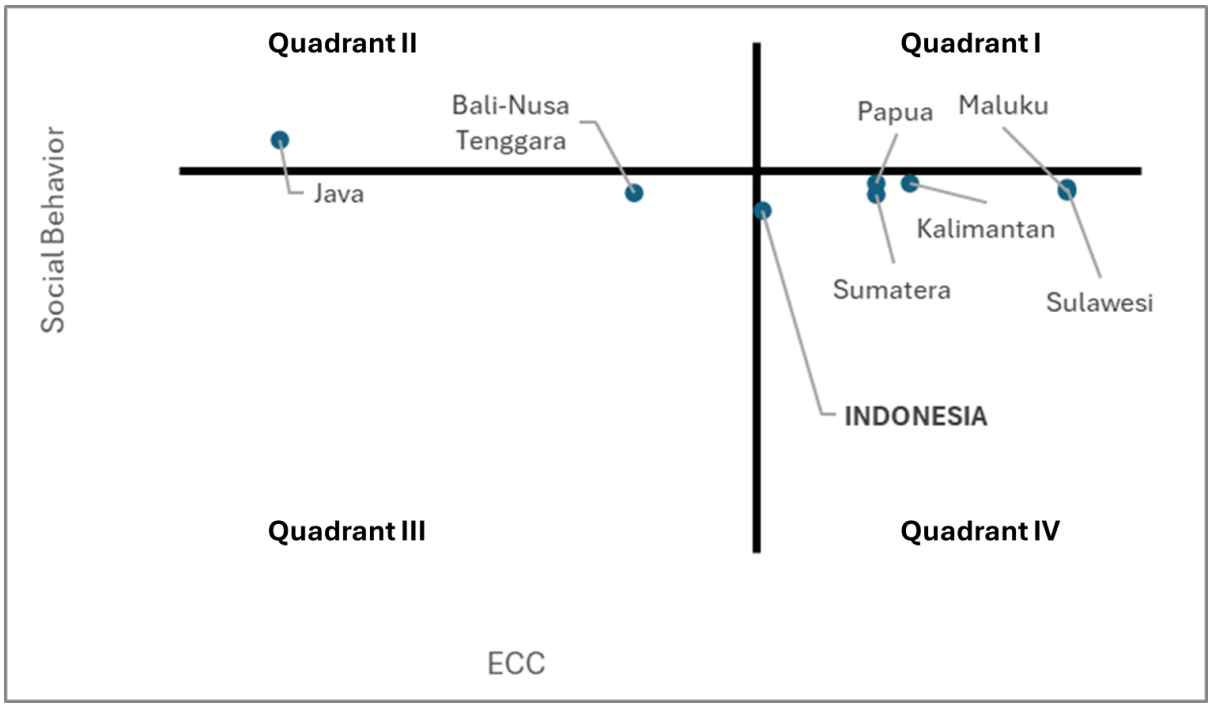

Figure 6. Indonesia Environmental Sustainability Index in Quadrant Visualization
Source: Authors' analysis, 2024.

The integration of environmental, social and economic factors provides a comprehensive perspective on the state of the environment and national climate resilience. The integrated result can be employed in a number of strategic policies in Indonesia, including the formulation of national medium-term development plans, environmental protection plans, climate change action plans, spatial planning, and other sectoral plans. This is with a view to making them more inclusive and sustainable. These findings underscore the critical importance of environmental conservation and protection efforts to sustain and improve the ECC. They also emphasise the need to manage consumption and pollution behaviours in order to foster more environmentally responsible social behaviour.

5. Conclusion

Sustainable development must be grounded in a robust and enduring environmental aspect. This environmental aspect can be indicated, among other things, by a good Environmental Carrying Capacity (ECC). ECC reflects the ability of the environment to support various human activities without diminishing the quality and quantity of available natural resources. Furthermore, it is essential to understand the social behaviour characteristics of the population in utilising natural resources. This understanding is crucial, as community behaviour plays a significant role in the success of sustainable development.

This study seeks to integrate environmental, social and behavioural perspectives in order to gain a more comprehensive understanding of the factors that contribute to environmental sustainability and climate resilience. The findings of the analysis indicate that Indonesia is currently performing at a relatively high level in terms of the index, however, there is an urgent need to promote more responsible social behaviour among the general population. The implementation of more responsible and sustainable social behaviour has the potential to enhance the utilisation of natural resources and mitigate negative environmental impacts. The findings of this integration have the potential to inform and enhance various strategic and sectoral planning efforts, thereby enabling Indonesia to progress towards achieving its Vision of Golden Indonesia 2045 and improving climate resilience in the future.

It is important to note that this is a preliminary study and that various limitations remain to be addressed. These limitations include the necessity for further methodological and analytical development and a more profound elaboration of the methodologies and analyses used. It is recommended that discussions with experts and stakeholders be conducted to gain deeper and more contextual insights. Furthermore, testing the validity and utility of the study's results as inputs for planning is necessary to refine this research. Through these steps, it is hoped that the findings of this study can make a significant contribution to environmental policy and sustainable development in Indonesia.

References

Badan Pusat Statistik/BPS. (2012). *Indikator Perilaku Peduli Lingkungan Hidup 2012*. Jakarta: BPS.

Badan Pusat Statisitik/BPS. (2017). *Laporan Indeks Perilaku Ketidakpedulian Lingkungan Hidup Indonesia 2018*. Jakarta: BPS.

Burkhard, B. and Maes, J. (2017). *Mapping Ecosystem Services. Advanced Books*. Sofia: Pensoft Publishers. https://doi.org/10.3897/ab.e12837

DeepL Write (2024). *AI-powered writing assistant*. Available at: https://www.deepl.com/en/write (Accessed: December 8th 2024)

Edelman. D. (1997). *Carrying capacity-based regional planning by National Institute of Urban Affairs*. New Delhi. Project Paper Institute for Housing and Urban Development Studies. 11. Rotterdam.

Khanna, P., Ram Babu, P., & Suju George, M. (1999). 'Carrying-capacity as a basis for sustainable development a case study of National Capital Region in India'. *Progress in Planning, 52(2), 101–166.* doi:10.1016/s0305-9006(99)00004-5

Kozlowski, J. M. (1990). 'Sustainable development in professional planning: a potential contribution of the EIA and UET concepts'. *Landscape and Urban Planning, 19(4), 307–332.* doi:10.1016/0169-2046(90)90040-9.

Lane, M., Dawes, L., & Grace, P. (2014). 'The essential parameters of a resource-based carrying capacity assessment model: An Australian case study'. *Ecological Modelling*, 272, 220–231. doi:10.1016/j.ecolmodel.2013.10.006.

Martín-López, B., E. Gómez-Baggethun, M. García-Llorente, and C. Montes. 2014. Trade-offs across value-domains in ecosystem services assessment. Ecological Indicators 37:220–228. http://dx.doi.org/10.1016%2Fj.ecolind.2013.03.003.

Millennium Ecosystem Assessment. (2005). *Ecosystems and Human Well-being: Synthesis*. Washington DC: Island Press.

Miller, G. Tyler, and Spoolman, Scott. (2016). *Environmental Science.* 15th edition. Australia: Cengage Learning.

Ministry of National Development Planning/Bappenas. (2023). *Rencana Pembangunan Jangka Panjang Nasional 2025-2045*. Jakarta: Bappenas.

MOEF of Republic of Indonesia. (2023a). *Buku Materi Teknis Penentuan dan Penetapan Daya Dukung Daya Tampung Lingkungan Hidup (D3TLH) Nasional*. Jakarta: Direktorat Jenderal Planologi dan Tata Lingkungan.

MOEF of Republic of Indonesia. (2023b). *Materi Teknis Rencana Perlindungan dan Pengelolaan Lingkungan Hidup (RPPLH) Nasional*. Jakarta: Direktorat Jenderal Planologi dan Tata Lingkungan.

MOEF of Republic of Indonesia. (2023c). *Deskripsi Peta Wilayah Ekoregion Indonesia*. Jakarta: Direktorat Jenderal Planologi dan Tata Lingkungan.

Populix. (2023). *Laporan Riset – Penyusunan Informasi Peduli Lingkungan Hidup Tahun 2023*. Jakarta: Populix.

Republic of Indonesia. (2024). *Law of the Republic of Indonesia No. 59 Year 2014 of National Long-Term Development Plan 2025-2045*. Indonesia.

Republic of Indonesia. (2024). *Law of the Republic of Indonesia No. 32/2009 about Environmental Management and Protection*. Indonesia.

Soto-Navarro et al. 2020. *Building a Multidimensional Biodiversity Index – A scorecard for biodiversity health. Project report*. UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), Cambridge, UK and Luc Hoffmann Institute (LHI), Gland, Switzerland.

Stockholm Resilience Center. (2016). *The SDGs wedding cake*. Available at: https://www.stockholmresilience.org/research/research-news/2016-06-14-the-sdgswedding-cake.html (Accessed: May 23rd 2024).

Świąder, M., Szewrański, S., and Kazak, J.K. (2020). 'Environmental Carrying Capacity Assessment—the Policy Instrument and Tool for Sustainable Spatial Management'. *Front. Environ*. Sci. 8:579838. https://doi.org/10.3389/fenvs.2020.579838

UNEP (United Nation Environment Programme). (2020). *The triple planetary crisis: Forging a new relationship between people and the earth.* Available at: https://www.unep.org/news-andstories/speech/triple-planetary-crisis-forging-new-relationship-between-people-andearth (Accessed: May 23rd 2024).

World Economic Forum. (2024). *The Global Risks Report 2024 19th Edition – Insight Report*. Switzerland: World Economic Forum.