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GUEST EDITORIAL

DPSIR as an integrated approach to assess natural resources status and development

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ABSTRACT

Environmental problems included biotic, abiotic, and social problems, therefore, to overcome them, various scientific disciplines are needed as well as the characteristics of environmental science itself. As consequences of population growth, industrial development, and technological progress, environmental problems are more complex. Therefore, appropriate research methods are needed to overcome new problems that arise as a result of these developments. UNEP recommends a research method called the DPSIR (Driving force–Pressure–State–Impact–Response) model that can describe the interactions between various environmental and social factors. This method has been applied as an approach to analyzing environmental problems in many countries around the world, including Indonesia. The Ministry of Environment and Forestry (KLHK) and some researchers in Indonesia have also applied the DPSIR method to assess environmental status both nationally and regionally. So far, the DPSIR method is still quite well applied to analyze environmental problems, although some scientists highlight the need for this method to be supplemented with other models to improve results.

ABSTRAK

Permasalahan lingkungan meliputi permasalahan biotik, abiotik dan sosial, oleh karena itu untuk menanggulanginya diperlukan berbagai disiplin ilmu sebagaimana karaktaristik ilmu lingkungan itu sendiri. Siring dengan pertambahan jumlah penduduk, perkembangan industri dan kemajuan teknologi maka permasalahan lingkungan semakin kompleks. Oleh karena itu, diperlukan metode riset yang dapat mencakup permasalahan-permasalahan baru yang timbul akibat perkembangan pembangunan tersebut. UNEP telah merilis metode riset yang disebut model DPSIR (Pemicu–Penekan–Kondisi sosial–Dampak–Respon) yang dapat mendeskripsikan berbagai interaksi antara faktor lingkungan dan sosial. Model ini telah diterapkan sebagai metode pendekatan untuk menganalisis permasalahan lingkungan pada berbagai negara di dunia, termasuk juga di Indonesia. Kementerian Lingkungan Hidup dan Kehutanan (KLHK) dan beberapa peneliti di Indonesia juga telah menerapkan metode DPSIR untuk mengkaji status lingkungan hidup baik secara nasional maupun regional. Sejauh ini, metode DPSIR masih cukup baik diterapkan untuk menganalisis permasalahan lingkungan, meskipun beberapa ilmuwan mengkritisi perlunya metode ini dilengkapi dengan metode yang lain agar hasilnya lebih bagus.

Keywords: *DPSIR, environment status, integrated methods, UNEP*

NATURAL RESOURCES PROBLEM

Environmental Science

The environment is an ecosystem where human is a central component together with the life sciences of plant, animal, and microbes, and non-life sciences of soil, water, oxygen, and other components in the universe. In the Law on the Protection and Management of the Environment, namely Law No. 32 of 2009, the definition of the environment is given as follows: The environment is a unitary space with all objects, forces, conditions, and living things, including humans and their behavior, which affect the continuity of life and the well-being of humans and other living beings. Scientifically, ecology is based on environmental science or environmental science is the application of ecological science.

Environmental science is broader than ecological science. Environmental science is a group of sciences that try to explain how life on earth is conserved, what causes environmental problems and how these problems can be solved. Many disciplines (science) are important for environmental science, such as biology (ecology), geology, hydrology, climatology, meteorology, oceanology (marine science), and soil science. Environmental science also draws on and works with non-science fields, such as philosophy and economics.

Principally, environmental science involves almost all other fields of science, both natural and social sciences. So, the scope of environmental science is very broad. The study of the physical, chemical, and biological quality of water, air, and soil is part of environmental science. The study of ecosystem types and the impact of human activities on ecosystems is also included in

environmental science. To simplify, the study of all the elements and factors around us in relation to the quality of human life can be included in environmental science. 'That is just from the physical aspect, environmental science also includes social, economic, legal, philosophical, and even religious aspects.

Environmental Problem

Industrialization and economic development have led to population growth and rapid urbanization in over the world recently. On the other hand, this also produced environmental and health problems, due to the deterioration of the environment mainly because of industrial and anthropic activities. The main anthropic impacts, such as urban wastewater discharge, industrial operations, oil leakages, and fertilizer and pesticide residues, have compromised the whole ecosystems worldwide generating health problems for human beings.

Environmental damage, such as global warming, acid rain, depletion of the ozone layer, water pollution, and biodiversity loss, is the result of inappropriate human behavior (Wiryono, 2013). In practice, environmental management involves many components of society so there needs to be laws and regulations under it, so a branch of environmental law has developed very dynamically.

In Law No. 32 of 2009 concerning Environmental Protection and Management, natural resources are defined as elements of the environment consisting of biological and non-biological resources which as a whole form a unified ecosystem. Humans have socio-economic activities that require a lot of natural resources. Natural resources can be grouped into renewable natural resources and non-renewable resources. Renewable natural resources are natural resources that can be recovered after harvesting, while non-renewable natural resources are natural resources that after exploitation cannot be recovered in short periods. In a very long time, millions of years, non-renewable natural resources can also be reclaimed.

Integrated Methodology

Several models have tried to describe and analyze the environmental compartments, but cause-effect relations have been rarely discussed. DPSIR (Driving force–Pressure–State–Impact–Response) model is a causal framework for the description of the interactions between society and the environment. In the case of an extremely compromised site, all the various cause-effect relationships for the development of the DPSIR framework have to be carefully analyzed. However, sometimes environmental changes can hardly be attributed to a single cause. In the literature, many topics of research showed the application of the DPSIR model to understand and plan responses for complex problems (Gari et al., 2018). The DPSIR framework was first proposed by the European Environmental Agency (EEA), which is widely used for analyzing environmental problems (Han et al., 2020).

A systemic approach as the driving forces – pressures – state – impacts – responses (DPSIR) framework, is proved to be a useful tool to manage a complex issue. DPSIR has been created for implementing environmental policies widely used in river basin management. It is an indicator-based approach that allows a systemic explanation of the links between environmental metrics. The application of the DPSIR framework cannot be separated from the decision cycle that is at the basis of the elaboration of environmental policies (Lalande et al., 2014).

In a summary, the different methods stated above could offer useful tools for the sustainability assessment of the water resources system. Also, previous works not considering predicting the water resources in the future, sustainability aspects, and assesses the sustainability of water resources in one approach (Siwailam et al., 2019).

The DPSIR approach presents mechanisms for integrating the natural and social aspects of environmental problems with regard to sustainable development by incorporating cause-effect relationships. Due to its ability to integrate knowledge across different disciplines and help formalize different decision alternatives, the framework has been widely applied to analyze the interacting processes of human-environmental systems and help policymakers identify viable options for managing, protecting, and assessing the progress toward sustainable development (Yu et al., 2020).

This framework evolves from the Pressure-State-Response (PSR) and Driving Force-State-Response (DSR) models and has the advantages of flexibility, comprehensiveness, and integrity. It includes natural, social, and economic information and reflects the causal relationship between environmental health and a series of human activities at different scales. The DPSIR framework includes five subsystems: driving force, pressures, state, impacts, and responses, which explore the interaction between humans and the environment (Han et al., 2020).

Our literature review aims to encourage its use in Indonesia: (1) what the DPSIR method is, and how this method is to be implemented to analyze complex environmental problems; (2) how to improve the quality of research by using the DPSIR model.

DPSIR APPROACH

There are many different types of environmental assessment methods available to support decision-making at global, regional, national, and local levels. UNEP defines an assessment as being the entire social process of undertaking a critical, objective

evaluation and analysis of data and information, designed to meet a user's needs and to support decision-making. Environmental assessment is the process by which the consequences and effects of natural processes and human activities on the environment are estimated, evaluated, or predicted (UNEP, 2015; UNEP, 2019).

DPSIR Components Framework

A variety of conceptual frameworks are used for assessment design and implementation. In many regional and national assessments, variations and derivatives of the Drivers-Pressures-State- Impacts-Responses (DPSIR) framework are used (**Figure 1**).

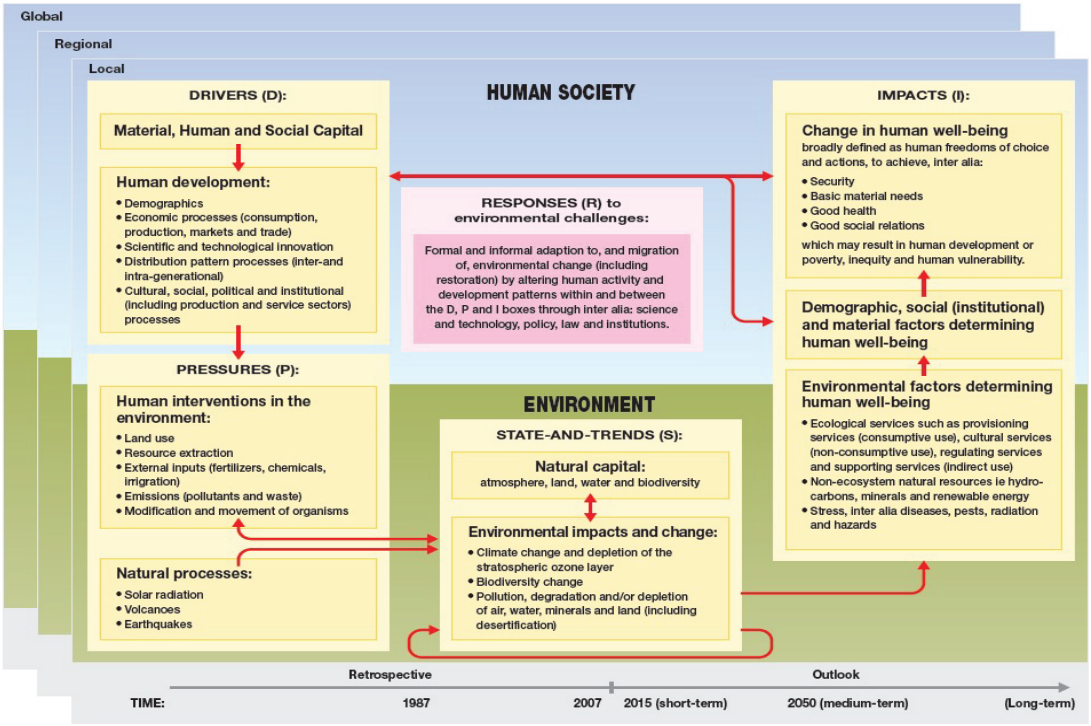

Figure 1. The drivers-pressures-state-impacts-responses framework (UNEP, 2007).

Some of the roles and functions fulfilled by conducting an environmental assessment include: encouraging interdisciplinarity (bringing together diverse branches of knowledge) in a way that is useful for decision-making, strengthening the relationship between science and policy, providing the means through which science informs decision-making, establishing the importance of the issue being assessed, providing an authoritative analysis of policy-relevant scientific questions, demonstrating the benefits of policy options, identifying new research directions, providing options for technical solutions, demonstrating the risks and costs of different policy options, and influencing the goals, interests, beliefs, strategies, resources, and actions of interested parties which can lead to institutional change and to changes in the discourse about the issue being assessed (UNEP, 2015; UNEP, 2019).

The following are examples of key questions to consider when setting out along the assessment pathway:

- What is the scale of the assessment? – i.e., global, regional, national, or local?
- What is the principal ecosystem, habitat, or landscape component to be assessed? – i.e., oceans, freshwater, dry lands, etc.?
- What is the main reason for conducting an assessment? – i.e., a disaster (naturally occurring or induced by human behavior), climate change, land-use change, a new construction or development project?
- What potential impacts could result from 'X', and how will an assessment help in addressing these? – e.g., what will the impacts of climate change be and how will an assessment help in addressing these impacts?
- What is the timeframe in which the assessment needs to take place? – i.e., a rapid assessment is required in order to assess the consequences and implications following a natural disaster such as an earthquake, or if the assessment is forward-looking, it includes scenarios about the future?
- Will the assessment need to be repeated?
- What is the legislative or regulatory requirement?
- Who will be the main user of the results, and what type of information will be most useful to this actor to inform decision-making?

- What sort of policies and decisions will be informed by the assessment?
- What level of certainty is required/how can the uncertainty related to the assessment be communicated?

DPSIR Simple Framework

The DPSIR model is based on a chain of causal links starting from "driving forces" (economic, environmental, and human activities) through "pressures" (emissions, waste, discharges, etc.) leading to "states" (physical, chemical and biological situation of biota and environment) and "impacts" on targets such as ecosystems and human health, eventually giving political or technical "responses". All various cause-effect relationships have to be carefully analyzed when developing a DPSIR framework for an extremely complex case study.

As a first step, all the possible data and information about the five elements of the DPSIR chain need to be identified and collected, describing the relationships between the origins and consequences of environmental problems. In order to understand their dynamics, it is useful to focus on the links between the DPSIR elements. Responses can modify any element of the chain: driving forces through structural interventions, pressures through technological and prescriptive actions, states through remedial actions, and impacts through economic compensation for the damage. Figure 2 shows a schematic representation of the DPSIR framework applied to the case study (Giupponi, 2002; Anonymous, 2022).

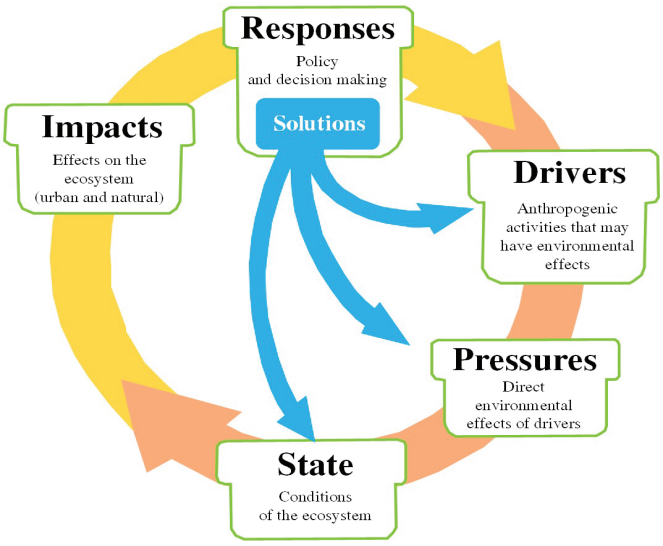

Figure 2. DPSIR Simple Framework (Giupponi, 2002; Anonymous, 2022).

DPSIR IMPLEMENTATION

1. Implementation of the DPSIR Model in Other Countries

We present here a brief review of five examples of research studies that have used the DPSIR model to assess natural resources with the title and topic of research that mostly stressing in water resources. To increase the quality of the research, some researchers used a single model of DPSIR, and other researchers used a model and combined it with other models. The studies cover the micro-mezzo-and macro scale, in Colombia, China, Egypt, and France (**Table 1**).

Table 1. Selected examples of implementation of the DPSIR model globally

No.	Authors	Title	Methods	Research Topic	Scale of research
1	Garia et al., 2018	A DPSIR-analysis of water uses and related water quality issues in the Colombian Alto and Medio Dagua Community Council	DPSIR	Water quality	Located in one river and bay, in Colombia
2	Yu et al., 2020	Sustainability Assessment of Water Resources in Beijing	DPSIR	sustainability assessment of water resources	Located in the megacity of Beijing, located in Northern China
3	Han et al., 2020	Evaluating the Health of an Urban River Combining DPSIR Framework and an Improved Fuzzy Matter-Element Extension Model: a Case Study from the Jinshui	DPSIR + FMEE model	freshwater	Located in in the Jinshui River, located in Zhengzhou city, Henan Province of China

4	Lalande et al., 2014.	Implementing the DPSIR framework to the link water quality of rivers to land use: methodological issues and preliminary field test	DPSIR-LURE	linking land-use indicators to river quality	Located in the Ognon river, the north-eastern area is a tributary of the Saone river that reaches the Rhone river in Lyon, France.
5	Siwailam et al., 2019.	Integrated DPSIR-ANP-SD framework for Sustainability Assessment of Water Resources System in Egypt.	DPSIR-ANP-SD	sustainability of the water resources system by applying the integrated	Managing water resources is located in Egypt.

A summary and conclusion of each research are reported as follows.

1.1. A DPSIR-analysis of water uses and related water quality issues in CC-AMDA Community Council, Colombia

A portion of Colombia's water resources is located on the Pacific coast within the territory of the Community Council of Alto and Medio Dagua (CC-AMDA). Though a harmonious balance between the communities' subsistence activities and nature was maintained for centuries, the appearance of modern modes of resource extraction has negatively affected the environment, especially the water resources. The DPSIR framework was used to analyze water quality problems within this community council (Garia et al., 2018). The DPSIR analysis revealed that agriculture, mining, logging, and infrastructure development constitute the main sectoral drivers, with some lesser contribution from tourism and fisheries. Pressures included inputs of organic matter, sediment, nutrients, and chemical contaminants to the Dagua river, and to the Bay of Buenaventura. These produced corresponding State changes in the water bodies. Impacts on human welfare were poor public health, reduced food and water security, economic loss, and some population displacement. Societal Responses included public protests and campaigns, legal actions, and policy changes for improved governance. As a future policy option, the formation of community-based water resources management was recommended. Though the use of DPSIR was able to link cause-effect relations, further empirical research on these water bodies is necessary to fill in existing gaps in the data set, particularly for public health-threatening contaminants.

Despite data limitations, the DPSIR framework was able to describe the cause-effect relationship in this example to the extent that data were available. The socio-economic activities led to the water quality deterioration of the Dagua River and the Bay of Buenaventura. Moreover, individual activities responsible for the environmental, social, and economic impacts were identified. The impacts on human welfare were manifested as health, economic and social problems. Though a number of responses were taken to alleviate the impacts, they were not effective, necessitating further strong actions. To fill the data gap between the various categories of the DPSIR approach, it is necessary to conduct more empirical research on the pressures emanating from socio-economic activities, and on the state of all the water bodies. This helps to create a clearer link between categories in the DPSIR chain. It also illuminates possible interactions among the categories of DPSIR.

1.2. Sustainability assessment of water resources in Beijing, China

A sustainability assessment of water resources is essential for maintaining regional sustainable development. In this example, a comprehensive assessment of changes in the sustainability of the water resource system in Beijing from 2008 to 2018 was conducted using the DPSIR model (Yu, et al., 2020). To reflect the impacts of humans on water consumption and pollution of water resources, the water footprint was considered. In addition, key factors that affect the sustainability of water resources were filtered. The results indicated that all drivers, pressures, states, impacts, and responses demonstrated increasing tendencies. From these results, it concluded that the sustainability of regional water resources could only be achieved through comprehensive consideration of regional social, economic, and environmental water systems and climate change. Therefore, formulating medium- and long-term urban, economic, and water development plans and adjusting medium- and short-term water utilization programs could contribute to the sustainable utilization of regional water resources.

The results suggested that the specific causal relationship highlighted by the DPSIR model was a feasible and powerful tool for quantitatively evaluating water resource sustainability levels, which can be used not only to determine the critical factors that affect the sustainability of water resources but, also, to develop integrated sustainable water management strategies. However, limited by data availability, only a few socioeconomic and environmental indicators were

considered, while cultural factors, such as the water-saving consciousness of residents, were less involved in this study. Additionally, the application of the DPSIR framework as described in this study needs further exploration under different natural environments and socioeconomic regions. The authors therefore not recommended that a further study that aims to prove the feasibility of the DPSIR model ought to consider comprehensive socioeconomic, environmental, and cultural factors—those that address the consciousness and concept.

1.3. Evaluating the health of an urban river combining DPSIR framework and an improved FMEE Model, in Jinshui River, China

As the key source of freshwater resources, urban rivers are essential for human survival and urban socio-economic development. Increasingly, the functions of urban rivers have been damaged by expanding human activities. A better understanding of the health state of urban rivers is the basis of sustainable urban planning. For this purpose, this study took the Jinshui River as a research area (Han et al., 2020). An indicator system for urban river health evaluation was first established using the DPSIR framework. The health state of the Jinshui from 2008 to 2017 was then assessed based on the urban river health index. The results showed that the overall health status of the Jinshui improved from its unhealthy state in 2008-2016 to a sub-healthy state in 2017. Corresponding response measures achieved certain results that have led to an improvement in the health state of the river. However, its health still faced many problems, including pressure from a rapidly increasing urbanization rate and population density, a large amount of sewage discharge, and serious water pollution. In general, the health of the Jinshui was still on the low side. Therefore, to ensure a sustainable water environment in the region, it is necessary to further govern the water environment and improve the health status of urban rivers. This research analysis can help the government more easily understand an urban river's health state and formulate effective measures in the future.

In conclusion, to further sustainable development in Zhengzhou, the government needs to continue to improve the health of the river. The urban river assessment method used in this study combines the DPSIR framework and the entropy FMEE model. It can identify the sources of driving forces and pressures on the water environment, the factors of impact, and the effectiveness of the response measures, which can provide policymakers with a useful reference for river protection. These assessment methods provide more comprehensive technical support for urban rivers' protection and restoration (Han et al., 2020).

1.4. River quality in micro-meso-macro scale in France

This research study considered three main scales for linking land-use indicators to river quality at a given location, which are usually described as (1) the micro-scale, which concerns land uses in the vicinity of the studied location of a few meters to a few hundred meters. Land uses at this scale influence in-stream habitat (food, physical habitat, thermal conditions, etc.); (2) the mesoscale, which corresponds to land uses on the banks of the river segment upstream. The mesoscale studies are necessary to assess the diversity and the abundance of these local habitats; (3) the macro-scale that describes land uses in the upstream catchment. The macro-scale defines the major environmental characteristics (hydrology, climate, geology, and relief) and thus the major characteristics of rivers (water temperature, energy sources, pH, and flow regime) (Lalande, 2014). The research found that it is possible to implement the DPSIR framework adapted to the interactions between land use and surface water quality (DPSIR-LURE). DPSIR-LURE framework on a medium-sized catchment. It leads to work in close cooperation with water stakeholders and sharing a common conceptual framework for analyzing the impacts of human pressures on the water quality of rivers.

1.5. Integrated DPSIR-ANP-SD framework for sustainability assessment of water resources system in Egypt

Nowadays, freshwater severe scarcity is a global concern, and it is alarming for the future. In order to fully understand the progress of the water system and its impacts, a sustainability assessment of water resources is needed. This accelerates the achievement of sustainability and management of water resources. This work in Egypt by Siwailam et al. (2019) aimed to assess the sustainability of the water resources system by applying a new integrated approach proposed by Xu (2011). This integration approach is based on integrating the DPSIR- Analytic Network Process (ANP)- System Dynamics (SD), in the water resources management field. SD is a computer simulation model to understand the behavior of complex systems over time, while the ANP is a decision-finding method used in modeling complex decision problems that contain feedback connections and loops. DPSIR-ANP-SD is a more integrated approach enabling decision-makers to view the sustainability problems of the water resources system more comprehensively. The results showed that there was an increasing impact on the sustainability of water resource systems in Egypt. This was attributed to the increase in water resource consumption due to the increase in population, agriculture expansion, and an increase in the value of GDP.

Our brief review of five studies from around the world shows that the DPSIR framework facilitates the analysis of water sustainability problems in relation to multiple people-driven activities such as agriculture, mining, logging, and infrastructure development. In the five studies selected, these activities constitute important sectoral drivers, with some impact from tourism and fisheries. Pressures included inputs of organic matter, sediment, nutrients, and chemical contaminants to the river, and to the bay. These pressures produced changes condition in the water bodies. Impacts on human welfare were poor public health, reduced food and water security, economic loss, and some displacement. The sustainability of regional water resources could only be achieved through comprehensive consideration of regional social, economic, and environmental water systems and climate change. Some of the researchers used a combination of DPSIR with other models, such as the DPSIR framework and the improved Fuzzy Matter-Element Extension (FMEE) model, the DPSIR framework adapted to the interactions between land use and surface water quality (DPSIR-LURE), integrating the driving force-pressure-state impact-response (DPSIR)- Analytic Network Process (ANP)- System Dynamics (SD). Communities and government had important roles to implement the results of the research. Even though the authors recognized limitations with the DPSIR framework, it was able to describe the cause-effect relationship between natural and social factors to a useful extent, and they were able to improve data quality through the use of appropriate combinations of DPSIR with other models.

2. Implementation of the DPSIR Model in Indonesia

The DPSIR approach has been adopted to assess natural resources by The Ministry of Environment and Forestry (KLHK) and other researchers in Indonesia. Research topics focused on forest cover, water and air quality, and land use change. The scale of research covered national, regional and district levels (**Table 2**).

Table 2. Selected examples of the implementation of the DPSIR model in Indonesia.

No.	Authors	Title	Methods	Research Topic	Scale of research
1	Kartodihardjo et al., 2020	Status Lingkungan Hidup Indonesia 2020. Kementerian Lingkungan Hidup dan Kehutanan, Republik Indonesia.	DPSIR	Forest cover, water and air quality	National, and 6 ecoregions, i.e., Sumatra, Java, Kalimantan, Bali & Nusa Tenggara,
2	Setiawan and Adnan, 2020	Model driving force, pressure, state, impact, *response* (DPSIR) dalam menilai kualitas udara	DPSIR	Air quality	District scale, West Kalimantan
3	Novira et al., 2015	DPSIR model as a tool to assess land conversion tariff policy in Yogyakarta	DPSIR	Land use change from agricultural land to non-land agricultural	Regional scale, in Yogyakarta Java
4	Pinuji et al., 2018	The dynamics and challenges of land use and utilization on the small island.	DPSIR	the dynamic and land use management in a small island area	Sumenep District, East Java

A summary and the conclusions from each research are reported as follows.

2.1. DPSIR to assess environmental status in Indonesia by KLHK

KLHK published the 2020 Indonesian Environmental Status report to provide a complete portrait of environmental conditions in Indonesia so that it provides the basis for all parties to assess, research, and produce policies that consider environmental aspects in accordance with the principles of sustainable development (Kartodihardjo et al., 2020).

Because the DPSIR method is a universal method adopted by the United Nations Environment Program, KLHK has also adopted this approach. The report used the DPSIR framework to provide a comprehensive discussion of each environmental issue related to Driving Force, Pressure, State, Impact, and Response. The report begins with a literature study of various national

documents and resources, including Law no. 32 of 2009 concerning Environmental Protection and Management; Indonesia's Environmental Status in previous years; the Central Bureau of Statistics website; Publications from the Central Statistics Agency, such as Regional Statistics for each province, Province in number; and some other literatures.

Land use and deforestation

The total land area of Indonesia in 2019 was 187.8 million hectares spread over six large island/archipelagic groups (ecoregions) or 34 provinces. Indonesian geography divided into forested land covering an area of 94.1 million hectares or 50.0% of the total land area; and non-forested land with an area of 93.6 million ha. During the previous five years (2014 – 2019), Indonesia's forested land area had decreased from 95.7 ha in 2014 to 94.1 ha in 2019. Forest damage due to changes in forest function and designation was one of the main factors causing forest loss. Deforestation in Indonesia during the period 2014 – 2019 showed a downward trend, from 1.09 million ha in 2014 to 0.46 million ha in 2019.

Land Cover Quality Index

The land cover quality Index is an index that describes the performance of land cover management including aspects of conservation, rehabilitation, and characteristics the area is spatially presented in a simple way so that it is easy to understand. In principle, this index is obtained by comparing the forest area with the administrative area. UU no. 41 of 1999 stipulates that every province should have at least 30% forest area of its total area. However, what can be utilized is 17.69% of the total available water resources or 691.3 million m^3/year. Around 25.30% of 691.3 million m/year most of it is used as a source of raw water to meet irrigation needs, while the rest is to meet domestic, urban, and industrial needs, as well as a source of renewable energy from water resources, which include: Hydroelectric Power / Hydro Power Plant (5,059 MW), Mini Hydro Power Plant (140 MW), and Micro Hydro Power Plant (30 MW).

Water quality

Water is one of the natural resources that have a very important function for human life and become basic capital and the main factor of development. Indonesia's water quality index in 2015 showed that nationally priority river water was of sufficient quality good with a water quality index number of 65.86, but this then dropped to 58.68 in 2017. River water quality in 2018 improved in most (70.1%) of Indonesia's rivers and was in a good category with an average water quality index of good quality and quite good (water quality index > 70).

Air pollution

Air pollution in urban areas is one of the significant environmental problems faced by Indonesia. A downward trend in air quality in several big cities in Indonesia has been seen in recent years. The rise in transportation and energy, in line with the increasing population, has consequences, escalating air pollution that has potential impacts on the health of both humans and the environment. To recognize environmental status included ambient pollution as suspended particulate matter, nitrogen dioxide (NO_2), and sulfur dioxide (SO2) for six ecoregions of Indonesia (the Sumatra, Java, Kalimantan, Bali ecoregions & Nusa Tenggara, Sulawesi & Maluku, and Papuans) were also monitored by KLHK using schema DPSIR.

2.2. DPSIR to assess water quality in Kutai Barat District

West Kutai Regency with an area of 20,384.6 km^2, and a population of 163,142 people in 2019 is a district rich in natural resources. Using the DPSIR framework, an assessment of air quality was carried out by Setiawan and Adnan (2020). The economic aspect such as the improvement of people's welfare stimulating the competitiveness of investment in industry and infrastructure was predicted as the Drivers force aspect. This is influenced by the increasing of transportation number, industries, and services that impact the production of air pollutants and increase household energy consumption. Implementation of urban air quality control, guidance, and supervision to reduce pollution was essential to serve the people.

2.3. DPSIR to assess land conversion policy in Yogyakarta

Land use change from agricultural land to non-agricultural purposes in Yogyakarta Province (DIY) is the main factor leading to the decrease in agricultural land, as compared with land lost through erosion or other events. The increasing human population growth has led to a higher demand for land for ???, which is contributing to the rapid land use changes. Land scarcity has led to a change in land utilization within the city and in the surrounding area. The DPSIR Model is used by Novira et al. (2015) as the basis for their impact assessment analysis on the tariff policy implementation regarding the controlling of the land use change. The driving force in this model is migration and the pressure is land use change. The state is divided into three categories, state of economic dimension, environmental dimension, and social dimension. These have caused impacts on land degradation, threats to food security, and pollution. As a response to this, the government introduced the policy PERDA No. 53 in the Year 2007 about authorizing land use in DIY. Novira et al. (2015) provide an example of how the DPSIR model is used to assess policy implementation.

Land conversion becomes one of the major issues in a developing country. In the case of Yogyakarta province, implemented land tariff policy could not control this phenomenon. The calculation of the tariff is based on the land price set by the tax office (NJOP: Tax Object Price), which is usually very low in comparison to the market price of the land. This way, the tariff is not a hindrance to converting land use. The following action should be taken to overcome land use conversion: A smaller minimum area that requires a permit for land conversion, a higher land conversion tariff, and the development of land conversion tariff in all Regencies in DIY (Novira et al., 2015).

2.4. DPSIR to assess land use cange of small island in East Java

Small island land resource management has specific characteristics that differ from its larger island management approaches, due to its geographical characteristic. Moreover, small islands are also vulnerable due to climate change. Located in Sumenep District, East Java, Masalembu is one example of an inhabited small island in Indonesia representing the dynamic and land use management in a small island area. This research uses the DPSIR (drivers, pressures, states, impacts, and responses) method to capture those dynamics (Pinuji et al., 2018). The results show that the dynamics of land use and utilization in Masalembu can be described as follows: (i) land use and utilization activities are highly influenced by economic growth, and climate change due to the fluctuation of marine products, and human population growth; (ii) the effect of climate change, together with the exploitation of marine resources, which results in a decrease of marine products, thus drives the local population to cultivate the land to increase their income. Eventually, the products from agriculture and farming sectors become competitive commodities alongside those of their fisheries; (iii) the absence of zonation, strategic, and action plans for land use and utilization control leads to unstructured, unplanned, and unsustainable land use and utilization.

This study is another good example of how the DPSIR method, which comprehensively describes the cause-and-effect relationship between human activities and their effects on the environment, can be used as a tool in formulating policies and strategies. The DPSIR analysis of the pattern of land use and utilization in the Masalembu area shows the following: (i) that population activities on land are strongly influenced by economic growth, and climate change which causes tides of marine fishery products and population growth, both due to births and migration; (ii) climate change which causes erratic sea tides, as well as excessive exploitation of marine resources and causes marine products to be no longer sufficient to meet the economic needs of the community, are factors that encourage people to start using land as an alternative income, and (iii) the absence of zoning plans and strategic plans for land use and utilization which makes land use patterns unstructured and planned, and does not meet the principles of sustainability.

CONCLUSION

The DPSIR method has already been implemented to analyze the environmental problem in some regions in Indonesia and in many other countries globally. The method has been shown to solve complex environmental and social problems that arise in the face of increasing human populations and associated industry growth and over-exploitation of natural resources. The method can be used to analyze environmental and social problems at the national (macro), regional (mezzo), and local (micro) scales. Applications of DPSIR in other countries have adopted and combined DPSIR with another model to improve the analysis in particular situations. This experience was also better if it can be implemented in Indonesia. It is highly recommended that these techniques are adopted more extensively in the field of environmental management and development in Indonesia.

REFERENCES

Anonymous. 2022. DPSIR Model. E Scholarly Community Encyclopedia. https://encyclopedia.pub/entry/1535

Garia, S.R., Guerrero, C.E.O., A-Uribee, B., Icely, J.D., Alice Newton, A. 2018. A DPSIR-analysis of water uses and related water quality issues in the Colombian Alto and Medio Dagua Community Council. ScienceDirect. Water Science 32 (2018) 318–337 journal homepage: www.elsevier.com/locate/wsj.

Giupponi, C. 2002. From the DPSIR reporting framework to a system for a dynamic and integrated decision making process. Mulino Conference on "European policy and tools for sustainable water management" 21-23 November, Venice (Italy): 1-4. https://www.researchgate.net/publication/229047372.

Han, H., Zhang, K., Zhang, J. 2020. Evaluating the Health of an Urban River Combining DPSIR Framework and an Improved Fuzzy Matter-Element Extension Model: a Case Study from the Jinshui River. *J. Environ. Stud. Vol. 29*, No. 3 (2020), 2211-2223. DOI: 10.15244/pjoes/111239.

Kartodihardjo, H., Maulana, F., Hasiholan H., P., Rahman, M.T., Saputro, T., Winastuti R.H., Oktalina, S., Prasodjo O.E., Lukmansjah, D., Satori, M., Iskandar, Rhamdhany, D., Endarini, T., Wiyoga, Muliawan, I., Januwardy, A., Sakina, H., Rivai, P. 2020. Status Lingkungan Hidup Indonesia 2020. Kementerian Lingkungan Hidup dan Kehutanan, Republik Indonesia.

Lalande, N., Cernesson, F., Decherf, A., Tournoud, M-G. 2014. Implementing the DPSIR framework to link water quality of rivers to land use: methodological issues and preliminary field test. *International Journal of River Basin Management*. 12 (3): 201-217.

Novira, N., Dalimunthe, S.A., Wicaksono, A.P., Dewi, N.I.S., and Rahayu, T.S. 2015. DPSIR model as a tool to assess land conversion tariff policy in Yogyakarta. *Jurnal Kependudukan Indonesia*. 10(2), December 2015:101-108.

Pinuji, S., Suhattanto, M.A., Arianto, T. 2018. The Dynamics and Challenges of Land Use and Utilization on Small Island. BHUMI: Jurnal Agraria dan Pertanahan 4(1): 102-114.

Setiawan, Y., and Adnan, F. 2020. Model driving force, pressure, state, impact, response (DPSIR) dalam menilai kualitas udara Kabupaten Kutai Barat. *Jurnal "Teknologi Lingkungan,"* Teknik Lingkungan Universitas Mulawarman 4(2): 31-36.

Siwailam, M., Abdelsalam, H., Saleh, M. 2019. Integrated DPSIR-ANP-SD framework for Sustainability Assessment of Water Resources System in Egypt. *International Journal of Academic Management Science Research (IJAMSR)*. ISSN: 2000-001X, 3(3), March 2019: 1-12

UNEP. 2007. Global Environment Outlook 4 (GEO-4). SBN: 978-92-807-2836-1 (UNEP paperback) DEW/0962/NA 978-92-807-2872-9 (UNEP hardback) DEW/1001/NA, Valletta, Malta. 540 p.

UNEP. 2015. An Introduction to Environmental Assessment. UNEP World Conservation Monitoring Centre (UNEP-WCMC). www.unep-wcmc.org

UNEP. 2019. Guidelines for Conducting Integrated Environmental Assessments Environmental Assessments. UN Environment Programme.

Wiryono. 2013. Introduction to Environmental Science. Widiono, S. (Editor). Bengkulu University, ISBN 9786029071054. 234 p.

Yu, H., Yang, Z., Li, B. 2020. Sustainability Assessment of Water Resources in Beijing. Water 2020, 12, 1999:1-21. doi:10.3390/w12071999. MDPI. www.mdpi.com/journal/water