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Cover Photo : The white-throated kingfisher (*Halcyon smyrnensis*) in the mangrove forest of Muara Kambas, Way Kambas National Pak, Lampung, Indonesia. It was photographed in April 2021.
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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**).

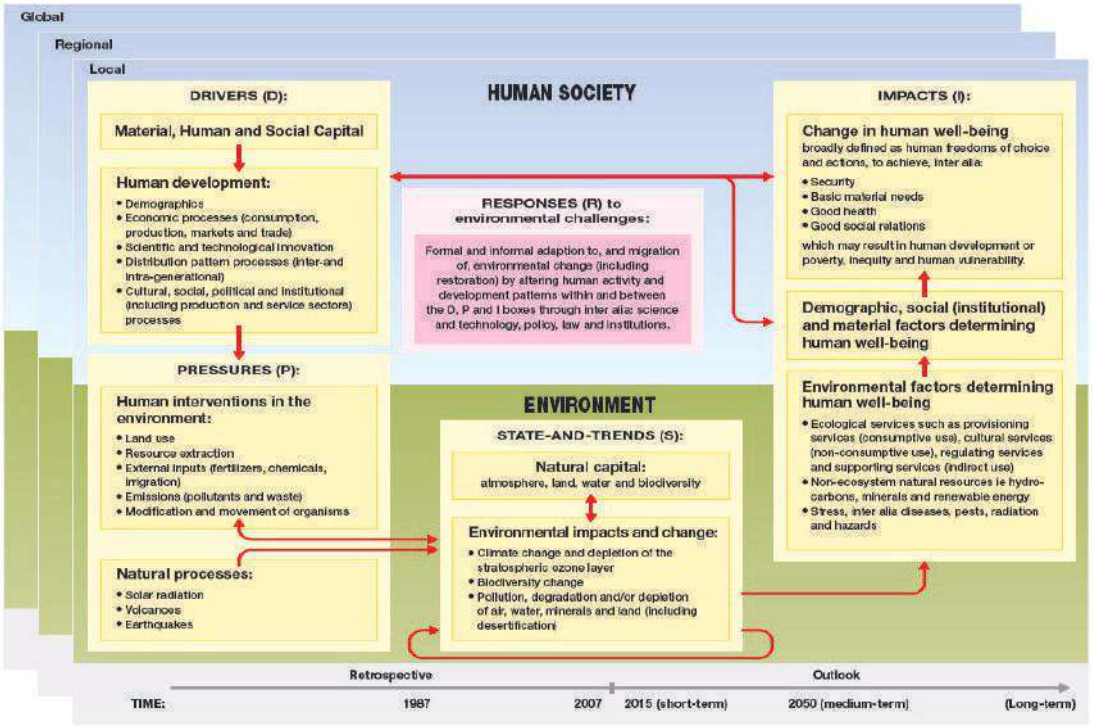

Figure 1. The drivers-pressures-state-impacts-responses framework (UNEP, 2007).

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).

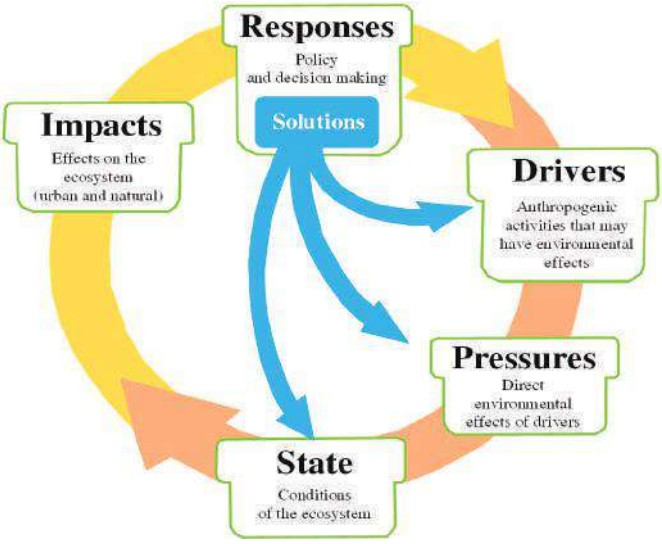

Figure 2. DPSIR Simple Framework (Giupponi, 2002; Anonymous, 2022).

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.

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NEWS, NOTES, & EVENTS

The role of the academic community in combating wildlife trafficking

DOLLY PRIATNA and **KATHRYN A. MONK**(Eds.)

This latest edition of InJAST (Volume 3, Number 2) reflects the diverse nature of environmental management to tackle overexploitation of our natural resources. Our guest editorial highlights the methodology adopted by UNEP to assess the status of natural resources, and other papers focus on topics ranging from seawater quality and mangrove restoration to forest plant tissue culture research for the purpose of saving endangered species. In addition, both the last edition of InJAST and this current one contain articles on the illegal and unsustainable wildlife trade in Indonesia. As the long delayed UN Biodiversity Conference (COP 15) finally draws near – on 7-19 December 2022 - in Montreal, Canada, we want to explore this issue of poaching of endangered species for the wildlife trade here.

By its very nature of being illegal, precise facts and figures are difficult to come by. However, estimates from expert wildlife trade monitoring networks and law enforcement agencies around the world indicate that illegal wildlife trafficking is, shockingly, the fourth most profitable organised criminal activity in the world, after the trafficking of weapons, narcotics and people. . Every year, the losses due to illegal wildlife trade in the world may reach US$ 23 billion and involve the trade of thousands of endangered species of flora and fauna. In Indonesia, the value of the illegal trade in wildlife reaches more than US one million per year. Apart from being a source country, Indonesia also has a significantly growing home market for illegally traded wildlife as pets, skins, and medicines.

The illegal wildlife trade uses various modus operandi, directed by organized criminal groups and carried out by a variety of perpetrators on the ground, often very poor locals from rural communities. Whilst this trading activity is a transnational crime, that is, across national and continental borders, and may use the same supply routes usually associated with other crimes such as weapons, drugs and people trafficking, it is usually only the poachers on the ground who are caught and prosecuted.

In the last three years in Indonesia, some 187 cases have been reported of crimes against protected wildlife, with confiscation evidence of about 13,000 live animals, in addition to more than 10,200 dried animal body destined for "medicinal" purposes. . The losses borne by the government, however, are in no way compensated for by the penalties imposed on convicted perpetrators of wildlife crimes in Indonesia. In many cases, these local perpetrators of illegal trade in protected wildlife are only sentenced to eight months to one year, with a fine of only US$ 150 - 700[1]. Middlemen, international criminals, and the purchasers usually go unchecked.

Whilst we might believe the international face of wildlife trafficking is too complex and embedded for us to improve things, all sectors of society, particularly in Indonesia, can play a role according to their duties and functions, to combat or minimize the illegal trade of protected wildlife. Governments can carry out a supervisory function to suppress and/or control the trade in endangered species, both preventively and repressively. Preventive supervision can be in the form of awareness or outreach to the public regarding the importance of efforts to conserve protected wildlife. Repressive efforts can be carried out by the government through strict law enforcement against the perpetrators of the crime of wildlife trafficking.

The public can report to the relevant government agencies or police if they find any ongoing illegal protected wildlife trade, whether they are found in offline or online transactions. They can also ensure that any legally allowed live pet animals are purchased from fully licensed suppliers. To meet the legal market demands for live pet animals, the public can also make an effort to buy such animals that have been bred in captivity and from breeders who are fully abiding by and highlighting the legal requirements for such activities. Environmental watchdog organizations or NGOs can support the efforts of the government and forest-margin communities through joint activities in carrying out protection, as well as other real actions on the ground in the context of conserving protected wildlife.

Academics in Indonesia are obliged to carry out the "Tridarma Perguruan Tinggi", three pillars that cover the activities of teaching, research, and community service. In accordance with those duties and functions, we would like to encourage more Indonesian academics to help reduce the illegal wildlife trade through all three pillars:

1. in teaching activities, lecturers of relevant subjects such as ecology, law, ethics, health, and social science should deliver materials that can provide students with an understanding of the problems that exist, as well as those that will be caused by the illegal wildlife trade.

[1]https://kumparan.com/pandangan-jogja/perdagangan-satwa-liar-dunia-nilainya-rp-341-t-setahun-indonesia-rp-15-t-1yKmbVHqn5z/full

2. as researchers, academics must also be encouraged to conduct relevant research, especially in developing methodologies for effective monitoring, and especially by utilizing technology that can be applied by law enforcers, so that cases of crimes against wildlife can be detected much more rapidly and effectively. Just as importantly, however, two fields of research need emphasizing. The contribution of universities can also be in the form of academic studies that will inform and encourage government policies that are effective, efficient, and in favor of (a) the conservation of endangered wildlife and (b) rural community development.
3. by conducting public awareness activities, which can be aligned with PKM (Community Service), KKN (Real Work of Lectures), or MBKM (Freedom Learns, Freedom Campus).

In summary, universities and their researchers have a significant role in the fight against the illegal and unsustainable wildlife trade, in monitoring wildlife populations and poaching activity, and in changing people's behavior, so that the activities of hunting, trading, or owning protected wildlife become unattractive and unacceptable to all communities. This role draws on disciplines across the sciences, social sciences, arts, and humanities, encouraging those interdisciplinary behaviours so important for effective environmental management that delivers for the long-term health and well-being of people.

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NOTES

Megafauna extinctions produce idiosyncratic Anthropocene assemblage

The "trophic downgrading of planet Earth" refers to the systematic decline of the world's largest vertebrates. However, our understanding of why megafauna extinction risk varies through time and the importance of site- or species-specific factors remain unclear. Here, we unravel the unexpected variability in remaining terrestrial megafauna assemblages across 10 Southeast Asian tropical forests. Consistent with global trends, every landscape experienced Holocene and/or Anthropocene megafauna extirpations, and the four most disturbed landscapes experienced 2.5 times more extirpations than the six least disturbed landscapes. However, there were no consistent size- or guild-related trends, no two tropical forests had identical assemblages, and the abundance of four species showed positive relationships with forest degradation and humans. Our results suggest that the region's megafauna assemblages are the product of a convoluted geoclimatic legacy interacting with modern disturbances and that some megafauna may persist in degraded tropical forests near settlements with sufficient poaching controls.

Amir, Zachary et al. (**2022**). Megafauna extinctions produce idiosyncratic Anthropocene assemblage. *Science Advances*, 8, eabq2307
https://www.science.org/doi/10.1126/sciadv.abq2307

Restoring the orangutan in a Whole- or Half-Earth context

Various global-scale proposals exist to reduce the loss of biological diversity. These include the Half-Earth and Whole-Earth visions that respectively seek to set aside half the planet for wildlife conservation or to diversify conservation practices fundamentally and change the economic systems that determine environmental harm. Here we assess these visions in the specific context of Bornean orangutans *Pongo pygmaeus* and their conservation. Using an expert-led process we explored three scenarios over a 10-year time frame: continuation of Current Conditions, a Half-Earth approach and a Whole-Earth approach. In addition, we examined a 100-year population recovery scenario assuming 0% offtake of Bornean orangutans. Current Conditions were predicted to result in a population c. 73% of its current size by 2032. Half-Earth was judged comparatively easy to achieve and predicted to result in an orangutan population of c. 87% of its current size by 2032. Whole-Earth was anticipated to lead to greater forest loss and ape killing, resulting in a prediction of c. 44% of the current orangutan population for 2032. Finally, under the recovery scenario, populations could be c. 148% of their current size by 2122. Although we acknowledge uncertainties in all of these predictions, we conclude that the Half-Earth and Whole-Earth visions operate along different timelines, with the implementation of Whole-Earth requiring too much

time to benefit orangutans. None of the theorized proposals provided a complete solution, so drawing elements from each will be required. We provide recommendations for equitable outcomes.

Meijaard, Erik et al. (**2022**). Restoring the orangutan in a Whole- or Half-Earth context. *Oryx*, 56(5): 1-12. https://www.cambridge.org/core/journals/oryx/article/restoring-the-orangutan-in-a-whole-or-halfearth-context/95C49E3F747CF09704C0E5E274D80B64

Land-use choices follow profitability at the expense of ecological functions in Indonesian smallholder landscapes

Smallholder-dominated agricultural mosaic landscapes are highlighted as model production systems that deliver both economic and ecological goods in tropical agricultural landscapes, but trade-offs underlying current land-use dynamics are poorly known. Here, using the most comprehensive quantification of land-use change and associated bundles of ecosystem functions, services and economic benefits to date, we show that Indonesian smallholders predominantly choose farm portfolios with high economic productivity but low ecological value. The more profitable oil palm and rubber monocultures replace forests and agroforests critical for maintaining above- and below-ground ecological functions and the diversity of most taxa. Between the monocultures, the higher economic performance of oil palm over rubber comes with the reliance on fertilizer inputs and with increased nutrient leaching losses. Strategies to achieve an ecological-economic balance and a sustainable management of tropical smallholder landscapes must be prioritized to avoid further environmental degradation.

Clough, Yann et al. (**2016**). Land-use choices follow profitability at the expense of ecological functions in Indonesian smallholder landscapes. *Nature Communications*, 7: 13137. https://www.nature.com/articles/ncomms13137

Perception and Awareness of Local Community to A "Green Wall" Forest Restoration Programme in the Gunung Gede Pangrango National Park, Indonesia

Forest restoration activities have been being carried out across the globe in order to improve degraded forest ecosystem. For Indonesia context, forest restoration in conservation areas need to consider both ecological aspects and regulating access for the community. A study on perceptions and awareness of local community towards restoration program was conducted from April to May 2021 in Cihanyawar Village, Sukabumi District, West Java, Indonesia. The village located adjacent to the Gunung Gede Pangrango National Park (GGPNP), one of Indonesia's conservation area that has been gazeted as UNESCO's biosphere reserve since 1982. The objective of this study is to assess perception and awareness of local community towards "Green Wall" restoration program in the GGPNP. We employed questionnaires method for assessing socio-economic of community. Socio-economic analyses of 100 respondents show that they are at the age range between 30 -50 years (48%), low education level (73%), the majority work as farmers (96%), with the income ranging from 1 to 3 million Rupiah (US$ 69 to 207) per month (83%). Based on respondents' age, education level, occupation, and income level, they have a moderate level of perception and awareness of green wall restoration program. Chi-square test shows that the level of community perception is not influenced by age and education levels but influenced by occupation and income levels. While the community awareness level is not influenced by age, occupancy and income level, but influenced by the education level. The results of the study provide evidence that restoring ecosystem is important for the social and economic aspects of communities around conservation area.

Priatna, Dolly et al. (**2022**). Perception and Awareness of Local Community to A "Green Wall" Forest Restoration Programme in the Gunung Gede Pangrango National Park, Indonesia. *Asian Journal of Conservation Biology*, 11(1): 77-83. https://www.ajcb.in/journals/full_papers_july_2022/AJCB-Vol11-No1-71349_Priatna%20et%20al.pdf

Safeguarding imperiled biodiversity and evolutionary processes in the Wallacea center of endemism

Wallacea—the meeting point between the Asian and Australian fauna—is one of the world's largest centers of endemism. Twenty-three million years of complex geological history have given rise to a living laboratory for the study of evolution and biodiversity, highly vulnerable to anthropogenic pressures. In the present article, we review the historic and contemporary processes shaping Wallacea's biodiversity and explore ways to conserve its unique ecosystems. Although remoteness has spared many Wallacean islands from the severe overexploitation that characterizes many tropical regions, industrial-scale expansion of agriculture, mining, aquaculture and fisheries is damaging terrestrial and aquatic ecosystems, denuding endemics from communities, and threatening a long-term legacy of impoverished human populations. An impending biodiversity catastrophe demands collaborative actions to improve community-based management, minimize environmental impacts, monitor threatened species, and reduce wildlife trade. Securing a positive future for Wallacea's imperiled ecosystems requires a fundamental

shift away from managing marine and terrestrial realms independently.

Struebig, Matthew J. et al. (2022). Safeguarding imperiled biodiversity and evolutionary processes in the Wallacea center of endemism. *BioScience*, Vol. XX No. XX.
https://www.researchgate.net/publication/364750065_Safeguarding_Imperiled_Biodiversity_and_Evolutionary_Processes_in_the_Wallacea_Center_of_Endemism#fullTextFileContent

Rainforest conversion to smallholder cash crops leads to varying declines of beetles (*Coleoptera*) on Sumatra

Southeast Asian arthropod biodiversity is in rapid decline, but the variability of responses within taxa has received little attention. Using canopy fogging, we collected ~50,000 beetles (Coleoptera) in (1) lowland rainforest, (2) jungle rubber (rubber agroforest), and smallholder monoculture plantations of (3) rubber and (4) oil palm in Sumatra, across two landscapes and seasons. On average, beetle abundance was more than 50%, and biomass over 75%, lower in rubber and oil palm plantations than in rainforest and jungle rubber. This pattern was influenced by landscape and season. Abundance and biomass declines were similar in *Chrysomelidae*, *Elateridae*, and *Staphylinidae*, but differed in *Curculionidae*, which were most abundant in oil palm due to the introduced oil palm pollinator *Elaeidobius kamerunicus*. Across beetle families, species richness in monocultures was reduced by at least 70% compared to rain- forest, with beetle richness in jungle rubber being similar to rainforest. Community composition in oil palm plantations differed markedly from the other land-use systems for *Chrysomelidae* and *Curculionida*e, but less for *Elateridae* and *Staphylinidae*. Turnover contributed more to overall beta diversity than nestedness for all families and land-use systems. Likely undersampling of the beetle community in rainforest suggests that declines of beetle density and diversity are much more severe than reported here, especially for beetle families with many concealed species, such as Staphylinidae. This study provides first evidence that negative responses of beetles to tropical land-use change vary among families, and is the first report of its kind from heavily understudied Sumatra.

Kasmiatun et al. (2022). Rainforest conversion to smallholder cash crops leads to varying declines of beetles (*Coleoptera*) on Sumatra. *Biotropica*, 00:1-13.
https://onlinelibrary.wiley.com/doi/full/10.1111/btp.13165

Sumatra-wide assessment of spatiotemporal niche partitioning among small carnivore species

Niche partitioning is a result of interspecific competition between closely-related species to allow co-existence. Multiple species of small carnivores co-occur throughout their ranges in Sumatra, but they are among the lesser studied group of mammal species. This study aimed to collate occurrence records of small carnivores, model their island-wide spatial distribution, and assess their spatio-temporal niche partitioning in Sumatra. We collated camera trap records of small carnivores that were mainly bycatch data from widespread tiger surveys. We used Maxent to predict suitable habitat for nine small carnivore species in response to environmental variables, calculated pairwise spatial niche overlap, and then assessed temporal overlap using Kernel density estimation. In total, we detected 16 of the 21 small carnivore species known to occur in Sumatra. We predicted the suitable habitat of nine species that were found in≥20 locations. Species with the smallest extent of predicted suitable habitat were the Malay civet (*Viverra tangalunga*) and short-tailed mongoose (*Herpestes brachyurus*). Of 36 pairwise comparisons, five species pairs had high overlaps and four species pairs had low overlap on spatiotemporal niche. High overlaps did not necessarily indicate high competition pressure because these species have different behaviour to allow coexistence, such as food preference and arboreality. Camera trap surveys are commonly conducted for species-specific studies, yet they also yield abundant records of non-target species. We therefore encouraged collaboration among institutions working in the same region to use bycatch data to fill the knowledge gaps in the ecology of other lesser known species.

Sibarani, Marsya C. et al. (2022). Sumatra-wide assessment of spatiotemporal niche partitioning among small carnivore species. *Mammalian Biology*, s42991-022-00315-6
https://link.springer.com/article/10.1007/s42991-022-00315-6#citeas

Drivers of three most charismatic mammalian species distribution across a multiple-use tropical forest landscape of Sumatra, Indonesia

Tropical Rainforest Heritage sites of Sumatra are some of the most irreplaceable landscapes in the world for biodiversity conservation. These landscapes harbor many endangered Asiatic mammals all suffering multifaceted threats due to anthropogenic activities. Three charismatic mammals in Sumatra: *Elephas maximus sumatranus, Pongo abelii*, and *Panthera tigris sumatrae* are protected and listed as Critically Endangered (CR) within the IUCN Red List. Nevertheless, their current geographic distribution remains unclear, and the impact

of environmental factors on these species are mostly unknown. This study predicts the potential range of those species on the island of Sumatra using anthropogenic, biophysical, topographic, and climatic parameters based on the ensemble machine learning algorithms. We also investigated the effects of habitat loss from current land use, ecosystem availability, and importance of Indonesian protected areas. Our predictive model had relatively excellent performance (Sørensen: 0.81–0.94) and can enhance knowledge on the current species distributions. The most critical environmental predictors for the distribution of the three species are conservation status and temperature seasonality. This study revealed that more than half of the species distributions occurred in non-protected areas, with proportional coverage being 83%, 72%, and 54% for *E.m. sumatranus*, *P. abelii*, and *P.t. sumatrae*, respectively. Our study further provides reliable information on places where conservation efforts must be prioritized, both inside and outside of the protected area networks, to safeguard the ongoing survival of these Indonesian large charismatic mammals.

Rahman, Dede A. et al. (2022). Drivers of three most charismatic mammalian species distribution across a multiple-use tropical forest landscape of Sumatra, Indonesia . *Animals*, 12: 2722.
https://www.mdpi.com/2076-2615/12/19/2722

Empirically grounded technology forecasts and the energy transition

Rapidly decarbonizing the global energy system is critical for addressing climate change, but concerns about costs have been a barrier to implementation. Most energy-economy models have historically underestimated deployment rates for renewable energy technologies and overestimated their costs. These issues have driven calls for alternative approaches and more reliable technology forecasting methods. Here, we use an approach based on probabilistic cost forecasting methods that have been statistically validated by backtesting on more than 50 technologies. We generate probabilistic cost forecasts for solar energy, wind energy, batteries, and electrolyzers, conditional on deployment. We use these methods to estimate future energy system costs and explore how technology cost uncertainty propagates through to system costs in three different scenarios. Compared to continuing with a fossil fuel-based system, a rapid green energy transition will likely result in overall net savings of many trillions of dollars—even without accounting for climate damages or co-benefits of climate policy.

Way, Rupert et al. (2022). Empirically grounded technology forecasts and the energy transition. *Joule*, 6(9): 2057-2082.
https://www.sciencedirect.com/science/article/pii/S2542435122004 10X

Deforestation projections imply range-wide population decline for critically endangered Bornean orangutan

Assessing where wildlife populations are at risk from future habitat loss is particularly important for land-use planning and avoiding biodiversity declines. Combining projections of future deforestation with species density information provides an improved way to anticipate such declines. Using the critically endangered Bornean orangutan (*Pongo pygmaeus*) as a case study we applied a spatio-temporally explicit deforestation model to forest loss data from 2001 to 2017 and projected future impacts on orangutans to the 2030s. Our projections point to continued deforestation across the island, amounting to a potential loss of forest habitat for 26,200 orangutans. Populations currently persisting in forests gazetted for industrial timber and oil palm concessions, or unprotected forests outside of concessions, were projected to experience the worst losses within the next 15 years, amounting to 15,400 individuals. Our analysis indicates the importance of protecting orangutan habitat in plantation landscapes, maintaining protected areas and efforts to prevent the conversion of logged forests for the survival of highly vulnerable wildlife. The modeling framework could be expanded to other species with available density or occurrence data. Our findings highlight that species conservation should not only act on the current information, but also anticipate future changes to be effective.

Voigt, Maria et al. (2022). Deforestation projections imply range-wide population decline for critically endangered Bornean orangutan. *Perspective in Ecology and Conservation*, 20:240-248.
https://www.perspectecolconserv.com/en-deforestation-projections-imply-range-wide-population-articulo-resumen-S2530064422000372

EVENTS

UN Biodiversity Conference (CBD COP 15)

December 7 - 19, 2022 in Montreal, Canada, governments from around the world will come together to agree on a new set of goals to guide global action through 2030 to halt and reverse nature loss.

Nature is critical to meeting the Sustainable Development Goals and limiting global warming to 1.5 degrees. Adoption of a bold global biodiversity framework that addresses the key drivers of nature loss is needed to secure our own health and well-being alongside that of the planet.

What needs to happen at COP 15:

- Adoption of an equitable and comprehensive framework matched by the resources needed for implementation
- Clear targets to address overexploitation, pollution, fragmentation and unsustainable agricultural practices
- A plan that safeguards the rights of indigenous peoples and recognizes their contributions as stewards of nature
- Finance for biodiversity and alignment of financial flows with nature to drive finances toward sustainable investments and away from environmentally harmful ones

UN Climate Change Conference 2022 (UNFCCC COP 27) - Sharm El-Sheikh, Egypt 6-18 November 2022

The 2022 United Nations Climate Change Conference, more commonly referred to as Conference of the Parties of the UNFCCC, or COP27, will be the 27th United Nations Climate Change conference, to be held from 6 to 18 November 2022 in Sharm El Sheikh, Egypt. It will take place under the presidency of Egyptian Minister of Foreign Affairs Sameh Shoukry, with more than 90 heads of state and representatives of 190 countries expected to attend.

The conference has been held annually since the first UN climate agreement in 1992. It is used by governments to agree action to limit global temperature rises associated with climate change. The selection of Egypt as a host country attracted controversy ahead of the summit due to the country's human rights record.

International Conference on Human-Wildlife Conflict and Coexistence
Oxford, UK: 30th March-1st April 2023.

The IUCN Species Survival Commission (SSC) Human-Wildlife Conflict & Coexistence Specialist Group, the Global Environment Facility-funded and World Bank-led Global Wildlife Program and the Wildlife Conservation Research Unit at Oxford University's Department of Zoology are co-hosting this International Conference on Human-Wildlife Conflict and Coexistence in Oxford, UK, on 30th March-1st April 2023. The conference is organised in collaboration with the IUCN Commission on Environmental, Economic and Social Policy (CEESP), the Food and Agriculture Organization (FAO) of the United Nations, the United Nations Development Programme (UNDP) and several more organisations.

Human-wildlife conflict is one of the most pressing threats to biodiversity conservation and achievement of sustainable development. These conflicts threaten the healthy co-existence of people and wildlife and undermine conservation efforts. Collaboration across disciplines and sectors is needed in this to address human-wildlife conflicts world-wide.

"Human-wildlife conflict is one of the most pressing threats to biodiversity conservation and achievement of sustainable development."

This conference provides a major opportunity to do so. For the first time at this scale, we are bringing together representatives from several major sectors, including governments, NGOs, intergovernmental organisations, academic and business sectors, and indigenous and local communities, to discuss and debate insights and solutions for human-wildlife conflict management.

It will be an interdisciplinary event, actively seeking participation from presenters and discussants from fields such as ecology, animal behaviour, psychology, law, conflict analysis, mediation, peacebuilding, international development, economics, anthropology and others, to understand human-wildlife conflict through various viewpoints, learn from each other, and build new links and collaborations.

The International Conference on Human-Wildlife Conflict and Coexistence aims to

1. Facilitate dialogue and peer-to-peer learning across sectors and actors on the topic for partnerships and collaboration across people and institutions working on human-wildlife conflict.
2. Generate interdisciplinary and shared understanding of the latest insights, technologies, methods, ideas, and information from the field of human-wildlife conflict, coexistence and interactions.
3. Mainstream human-wildlife conflict as one of the top global priorities in biodiversity conservation and the Sustainable Development Goals for the next decade, catalysing opportunities for working together on national, regional or global policies and initiatives.
4. Identify and develop a collective way forward for addressing knowledge and implementation gaps for effective efforts to reduce and manage human-wildlife conflict.

Call for hosts of the 10th International Conference on UNESCO Global Geoparks in 2023

This call to host the 10th International Conference on UNESCO Global Geoparks in 2022 is open to countries or regions that already have functional UNESCO Global Geoparks, whose contribution will be essential for the success of the event. If your organization or country is interested in hosting the 2022 Conference, you are kindly invited to submit a well-developed technical proposal specifying the offer.

ICBEE 2023: 17. International Conference on Biodiversity and Ecological Engineering
January 09-10, 2023 in Bali, Indonesia

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The International Research Conference is a federated organization dedicated to bringing together a significant number of diverse scholarly events for presentation within the conference program. Events will run over a span of time during the conference depending on the number and length of the presentations. With its high quality, it provides an exceptional value for students, academics and industry researchers.

International Conference on Biodiversity and Ecological Engineering

Aims to bring together leading academic scientists, researchers and research scholars to exchange and share their experiences and research results on all aspects of Biodiversity and Ecological Engineering. It also provides a premier interdisciplinary platform for researchers, practitioners and educators to present and discuss the most recent innovations, trends, and concerns as well as practical challenges encountered and solutions adopted in the fields of Biodiversity and Ecological Engineering.

Call for Contributions

Prospective authors are kindly encouraged to contribute to and help shape the conference through submissions of their research abstracts, papers and e-posters. Also, high quality research contributions describing original and unpublished results of conceptual, constructive, empirical, experimental, or theoretical work in all areas of Biodiversity and Ecological Engineering are cordially invited for presentation at the conference. The conference solicits contributions of abstracts, papers and e-posters that address themes and topics of the conference, including figures, tables and references of novel research materials.

Guidelines for Authors

Please ensure your submission meets the conference's strict guidelines for accepting scholarly papers. Downloadable versions of the check list for Full-Text Papers and Abstract Papers.

Please refer to the Paper Submission Guideline, Abstract Submission Guideline and Author Information before submitting your paper.

Conference Proceedings

All submitted conference papers will be blind peer reviewed by three competent reviewers. The peer-reviewed conference proceedings are indexed in the Open Science Index, Google Scholar, Semantic Scholar, Zenedo, OpenAIRE, BASE, WorldCAT, Sherpa/RoMEO, and other index databases. Impact Factor Indicators.

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We are proud to host our next World Conference in Darwin, Australia September 26-30, 2023. SER2023 will be the Society's 10th World Conference since 2005 and 26th meeting since our founding in 1988.

The SER World Conference brings delegates from every continent representing a range of professional backgrounds including natural and social sciences, environmental engineering, urban and regional planning, public policy, landscape architecture, natural resource management, and more. Attendees include:

- Professors, researchers, and students
- Staff scientists from research institutes and governmental agencies specializing in restoration, conservation, and land management
- Environmental consultants and contractors ranging from independently owned small business to national and multinational companies
- Local, national, and international nonprofit organizations
- Staff from botanic gardens, zoos, engineering and landscape firms, and mining and extraction industries
- Individuals and entities from the financial sector
- We always feature *Make a Difference* field trips as part of the conference program, giving participants a chance to learn about local management challenges and have hands-on participation in restoration implementation.
- Our conferences are hosted around the world to highlight the diverse landscapes our community work in and facilitate the exchange of knowledge among our global network of over 4,000 members. We hope to see you soon!

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Influence of exogenous NAA in *Calophyllum inophyllum* micro-environment seeds germination

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ABSTRACT

Throughout Indonesia, more than a hundred million ha of degraded forest and lands are still to be rehabilitated. High-quality tree seedlings are a key component of landscape restoration. The limited supply of quality seeds has been an obstacle so far. *C. inophyllum* is a tropical tree species that grow well under harsh environmental conditions. It can be used as an alternative tree species for degraded land rehabilitation. We present an efficient and reproducible protocol for improving seed quality with exogenous NAA hormones. The Murashige and Skoog (MS) medium was supplemented with NAA hormones (0 mg/l, 1 mg/l, 2 mg/l, and 3 mg/l of NAA) for observation of the influence of the exogenous NAA on seeds germination in micro-environment controlled. After seven weeks of incubation in axenic culture, the highest concentration of NAA (3 mg/l) showed the fastest average seed-breaking time of *C. inophyllum* (2.0 weeks), After three weeks, the roots were nearly five times longer (4.9 ± 0.1 cm) than the control (1.1± 0.1 cm), and the shoots were nearly three times longer (4.9 ± 0.1 cm) than the control (1.1± 0.1 cm). This research needs to be tested on a larger scale of cultivation.

ABSTRAK

Di seluruh Indonesia, lebih dari seratus juta ha hutan dan lahan terdegradasi masih harus direhabilitasi. Bibit pohon berkualitas tinggi adalah komponen kunci dari restorasi lanskap. Terbatasnya pasokan benih berkualitas menjadi kendala selama ini. *C. inophyllum* adalah spesies pohon tropis yang tumbuh dengan baik di bawah kondisi lingkungan yang keras. Ini dapat digunakan sebagai jenis pohon alternatif untuk rehabilitasi lahan terdegradasi. Kami menyajikan protokol yang efisien dan dapat direproduksi untuk meningkatkan kualitas benih dengan hormon NAA eksogen. Media Murashige dan Skoog (MS) dilengkapi dengan hormon NAA (0 mg/l, 1 mg/l, 2 mg/l, dan 3 mg/l NAA) untuk pengamatan pengaruh NAA eksogen terhadap perkecambahan biji di lingkungan mikro dikendalikan. Setelah tujuh minggu inkubasi dalam kultur axenic, konsentrasi NAA tertinggi (3 mg/l) menunjukkan rata-rata waktu pemecahan benih tercepat *C. inophyllum* (2,0 minggu), Setelah tiga minggu, akar hampir lima kali lebih panjang (4,9 ± 0,1 cm) dari kontrol (1,1± 0,1 cm), dan tunas hampir tiga kali lebih panjang (4,9 ± 0,1 cm) dari kontrol (1,1± 0,1 cm). Penelitian ini perlu diuji pada skala budidaya yang lebih besar.

Keywords: *C. inophyllum, NAA, micro-environment, seeds, rehabilitation*

INTRODUCTION

Calophyllum inophyllum is a species of the family Guttifereae (Clusiaceae), native to East Africa, Australia, India, Southeast Asia, and the South Pacific. Usually, it is called as 'Indian laurel', Alexandrian Laurel, Pannay tree, Beach Calophyllum, Beauty leaf, Sweet Scented Calophyllum (in English), Burmese, Pongnyet, Hawaii, Sultan Champa, Surpan (in Hindi), Kokani, Nagachampa (in Marathi), Nagam, Pinmai, Pinnay, Namere, Punnagam, Punnai, (in Tamil) (Susanto, et al, 2020) *C. inophyllum* has very wide natural distribution in Indonesia, from Sumatera in the west to Papua in the east, and from Java in the south to Kalimantan in the north. It can survive and grow well in a wide range and is also highly tolerant to harsh environmental conditions; therefore, the species is suitable for the conservation and land rehabilitation in several locations in Indonesia (Leksono, et al, 2021).

C. inophyllum is a tropical tree species that grow well under harsh environmental conditions on unproductive land (Friday & Okano, 2006). The species produces flowers and fruit in profusion all year round, and its seeds can be harvested repeatedly from trees aged 4 to 5 up to 50 years old (Leksono, et al, 2017). The trees generally grow in warm temperatures under wet or moderate conditions and tolerate wind, salt spray, drought, and brief periods of waterlogging (Friday & Okano, 2006). Due to its high tolerance to harsh environmental conditions, since more than 50 years ago, the species has been planted for conservation and land rehabilitation purposes in southern regions of the island, Indonesia (Leksono, et al, 2021). Reports on tamanu performance in mineral soils in Indonesia have shown it grows well in coastal areas (Putri, et al, 2019), on marginal land

(Windyarini, E., & Hasnah, T. M., 2014), rocky soils (Windyarini & Hasnah, 2014) and burnt land (Toungos & Dahiru, 2018).

Several alternatives to tree planting have been implemented in several regions of the world by direct seeding (Bonilla-Moheno & Holl, 2010; Haryjanto et al, 2020). This method can be quickly applied to large areas, costs less than transplanting seedlings, and has better root system development and structure (Bonilla-Moheno & Holl, 2010). However, the lack of information on the initial variability, germination duration, and the effect of hormones that trigger the initiation of optimal *C. inophyllum* seed roots has not been widely reported. On the other hand, seedlings for land rehabilitation projects are strongly influenced by time or planting season (Klavina et al, 2015). Observing the effect of plant hormones on root initiation by utilizing biotechnology in an *in vitro* axenic environment can minimize the influence of abiotic and biotic factors on plant hormone requirements. Exogenous hormone application can also be better controlled. Auxin, such as Naphthalene Acetic acid (NAA), the most extensively used commercial synthetic auxin for promoting root formation, stimulates adventitious root growth (Omar & Ahmed, 2015). Auxin, carbohydrates, and nitrogen in plant material can induce the formation of roots (Djamhari, 2010). Although each plant can produce its hormones, using hormones from the environment can stimulate metabolic processes in plant growth and development (Ramakhrisna & Ravishankar, 2011). Based on this, the purpose of this study was to determine the effect of the biotechnology application of exogenous NAA in *C. inophyllum* micro-environment seed germination. Hormones could improve the percentage of radicals and reduce propagation time (Ramakhrisna & Ravishankar, 2011). Plant hormones are naturally produced by plants that control plant functions and development, such as root growth (Anfang, M., Shani, E., 2021).

METHODS

Sterilization of Seedlings

The *C. inophyllum* seeds were obtained from the Center for Forest Biotechnology and Tree Improvement, Ministry of Forestry, Indonesia. Several modifications of the sterilization method by (Putri et al, 2019; Putri et al., 2020) were used in this study. Sterilization modifications were carried out on the outside and the inside of the laminar airflow (LAF). Sterilization on the outside of the LAF is to immerse the seeds in distilled water overnight. After soaking in distilled water containing detergent for 1 minute and soaking with a fungicide for 3 minutes, rinsing with tap water for 20 minutes, then soaking in hot water (80 ~ 90° C) for 5 minutes to break seed dormancy. Sterilization on the outside of LAF is by immersing the seeds in 15% (v/v) in anti-microbial compound BI (biocide isothiazolone), which contains 5.25% sodium hypochlorite, hydrogen peroxide, sodium perborate, and sodium percarbonate solution. A few drops of Tween™ 80 were added to the solution for 40 minutes, and 70% ethanol for 1 minute. The seeds were rinsed with sterile distilled water for each sterilization. The percentage of axenic culture in each treatment (one seed per tube) was observed.

Seeds Culture

The research was carried out at the tissue culture laboratory at the Center for Forest Biotechnology and Tree Improvement in Yogyakarta, Indonesia (7040'20" S and 110023'30"), 600 meters above sea level, with the highest temperature being 32 degrees Celsius and the lowest temperature being 18 degrees Celsius and a mean humidity of 95%. Researchers observed for six months in the laboratory, from January 2019 to June 2019. The equipment used in this study met tissue culture laboratory standards. The seeds were cultured under micro-environment controlled, 16-hour photoperiod (50~70 µmol/m^2/s) light, with 20 degrees Celsius and a mean humidity of 80%, sub-cultured once a month for three months. Surface-sterilized seeds were cultured on MS (Murashige & Skoog, 1962) medium with no hormones supplemented, and after seven weeks with NAA (1-Naphthaleneacetic acid) (1000 ppm solution) 0 ml/l, 1 ml/l; 2 ml/l and 3 ml/l, 3% sucrose and 0.2% agar, whose pH was adjusted to 5.7 ± 0.1. To examine the effects of NAA hormone, 20 seed replicates for each NAA treatment were prepared from the best growth of the axenic culture. To fulfill the number of axenic cultures for each NAA treatment (20 cultures per treatment consisting of four treatments), the sterilization of seeds was divided into four blocks of 50 seeds each so that a total of 200 seeds were needed to obtain 80 the best growth of the axenic culture. Seed-breaking time in root formation, root length, and height of shoot were used as a parameter of *C. inophyllum* seeds roots regeneration *in vitro*.

RESULT AND DISCUSSION

Axenic Cultures

Micro-environment seeds rooting culture *in vitro* was defined as the axenic culture of any part of one organism under controlled conditions in a culture medium (**Figure 1**). Sterile conditions in axenic cultures were needed so that nutrients are provided only for target seeds, not used for contaminants. *C. inophyllum* seeds sterilization was carried out immediately after about one week of harvesting from the natural environment to the tissue culture laboratory. This sterilization was one of the causes of high contamination and reduced the acquisition of axenic cultures. Prevention of microorganism contamination in plant tissue culture is

essential. Plants growing *in vitro* are under stress and may be predisposed to direct infection, even by non-pathogenic bacteria (Habib et al, 2002).

Figure 1. Axenic culture of *C. inophyllum* seeds in micro-environment condition.

The graph in Fig. 2 shows a tendency for the number of contaminated cultures to increase at the beginning of incubation until week 4, but there was no increase in contaminated cultures until week 7. The value still requires better sterilization techniques. However, the source of seeds from the natural environment will cause contamination.

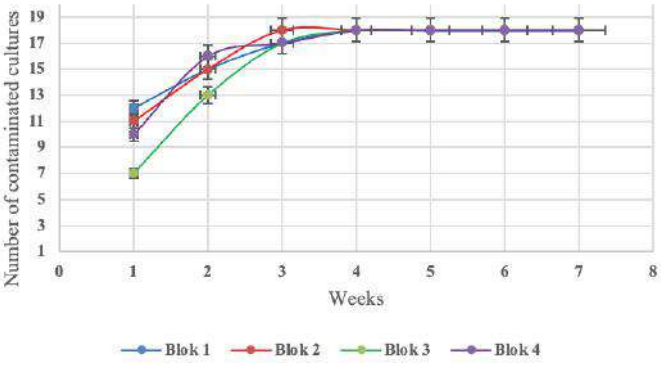


Figure 2. Number of contaminated cultures in 7 weeks incubation (n = 50 cultures/block).

Although the culture medium in which the plant tissue is cultured is a good source of nutrition for contaminant growth, an endogenous contaminant *in vitro* can remain undetected in the micro-environment because the concentration of salts and/or sucrose is not ideal or the pH and/or temperature are not optimal for contaminant growth. When the culture conditions change, as they do during normal plant growth, they can become more favorable to contaminant growth previously undetectable and multiply and even damage the growing plants (Wojtania et al, 2005). The endogenous contaminant can also be difficult to isolate and may only survive or grow well inside the plant. The total contaminated cultures obtained for seven weeks of the observation were 72 cultures from 200 cultures tested (36%), so 128 cultures (64%) were obtained, which could be used for 80 cultures for hormone treatment.

Seed-breaking Time

The NAA treatment with the highest concentration (3 mg/l) showed the fastest average seed-breaking time of *C. inophyllum* (2.0 weeks) compared to the concentration of 2 mg/l (4.6 weeks), concentration 1 (5.1 weeks) and control (6.3 weeks) (**Figure 3**). Seeds of many species do not germinate immediately upon exposure to conditions generally favorable for plant growth, but require a "seed break" of dormancy, which may be related to changes in the seed coat or to the state of the embryo itself. Generally, the embryo has no innate dormancy and will develop after the seed coat is removed or damaged to allow water to enter (Heslop-Harrison & John, 2022). In the observation of bud-breaking, the initial response of *C. inophyllum* seeds showed root growth in all concentrations of NAA treatment (**Figure 4**). Two weeks after seven weeks of root growth, simultaneously shoots grew in all treatments (**Figure 4**). Germination in such cases depends on rotting or abrasion of the seed coat in the soil. Germination inhibitors must be removed with water or the tissue containing them destroyed before germination can occur. Mechanical restriction of embryo growth is only common in species with thick, hard seed coats. Germination then depends on the weakening of the mantle by abrasion or decomposition (Heslop-Harrison & John, 2022).

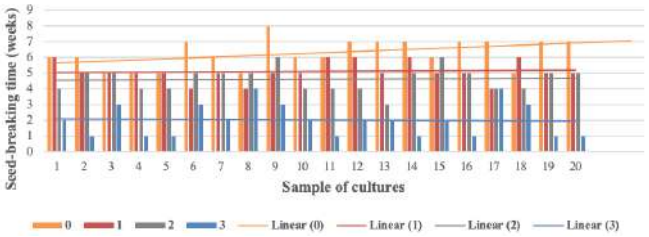


Figure 3. Seed-breaking time of *C. inophyllum* in MS media with 1 mg/l, 2 mg/l, 3 mg/l of NAA added and control at micro-environment.

As in many seeds, the *C. inophyllum* embryo cannot germinate even under suitable conditions for some time. The effect of the micro-environment with conditions of temperature, light, humidity, and light intensity on media containing the NAA hormone, which is measurable, is needed to observe seed development under controlled conditions that are difficult to do directly in nature. This effect can be used as the basis for the required finishing process after "maturation", which is still unclear. Ambient temperature also affects germination, it will fail to grow very late, or growth is not normal. The

micro-environment study showed the suitability of conditions up to the emergence of rooting and shoots of *C. inophyllum in vitro*. The sensitivity of light and temperature interactions for *C. inophyllum* is not widely known; light needs can be completely lost at a certain temperature.

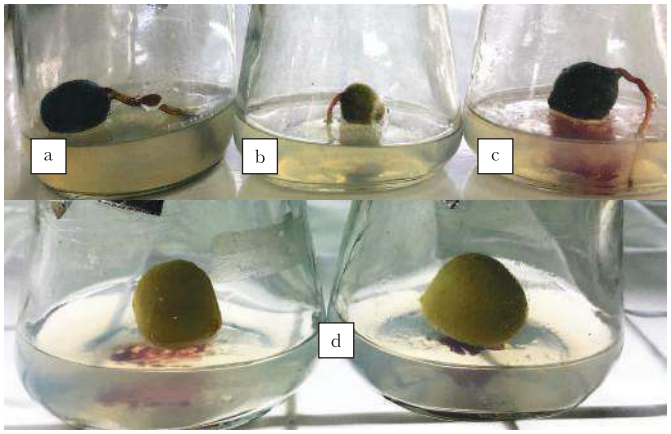


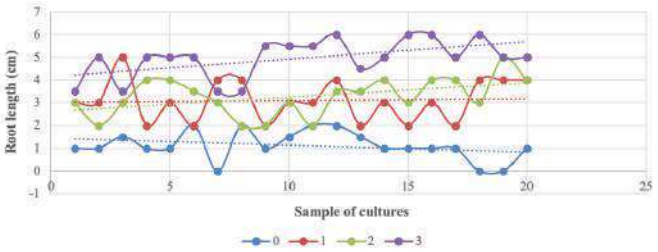
Figure 4. *C. inophyllum* seeds break in 1 mg/l (a), 2 mg/l (b), 3 mg/l (c) of NAA added and control (d) after seven weeks incubation at micro-environment.

C. inophyllum seed appears to have a "critical moisture content", a characteristic feature of a recalcitrant seed. *C. inophyllum* seed can retain viability for an appreciable period (> 8 months) if stored in warmer and slightly humid environments without removing the endocarp, and the seeds appear to be sensitive to low temperatures (Hathurusingha & Ashwath, 2012).

Root and Shoot Length

For three weeks of incubation in the micro-environment at the tissue culture laboratory, the NAA hormone treatment gave a growth response to both root and shoot lengths of *C. inophyllum* seeds. Figure 5, Figure 6, and Figure 7 show the effect of NAA on root and shoot elongation during three weeks of incubation after seven weeks of axenic culture selection and two weeks of seed-breaking maturation. During the 12-week study in this micro-environment, sub-cultures were carried out every month with the same media in each treatment to maintain the availability of *C. inophyllum* nutrients.

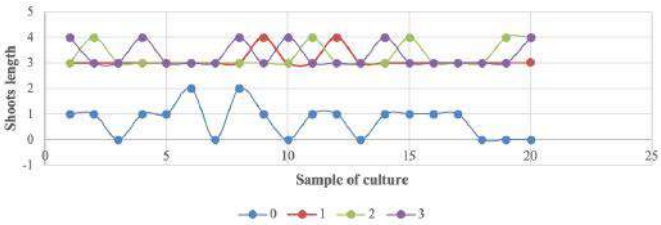
The average addition of root length also followed high exogenous NAA concentrations, the highest at concentrations of 3 mg/l (4.9 ± 0.1 cm), 2 mg/l (3.2 ± 0.1 cm), 1 mg/l (3.1 ± 0.1 cm) and control (1.1± 0.1 cm). In this study, the highest concentration of NAA increased root length almost five times higher than the control. However, Figure 5 shows that all additions of NAA tend to be positively correlated to the increase in the addition of NAA to the culture media. It is also possible that the physical and biochemical microenvironment is suitable for germinating *C. inophyllum* seeds.



Each value is a mean of twenty replicates, significantly different from each other at 0.05 probability level by the Duncan multiple range test. The results of ANOVA showed significant differences (p ± 0.05) between NAA concentration treatment for 200 axenic seeds.

Figure 5. Roots length of *C. inophyllum* in MS media with 1 mg/l, 2 mg/l, 3 mg/l of NAA added and control at micro-environment

In contrast to the exogenous effect of NAA on the root growth of *C. inophyllum* seeds, the response of shoot elongation with all concentration treatments did not show any significant difference. However, NAA still increased shoot elongation three times higher than the control (0.76 ± 0.1 cm). The average elongation of shoots with the addition of 3 mg/l (3.3 ± 0.1) NAA was not significantly different with the addition of 2 mg/l (3.2 ± 0.1 cm) and 1 mg/l (3.1± 0.1 cm).



Each value is a mean of twenty replicates, significantly different from each other at 0.05 probability level by the Duncan multiple range test. The results of ANOVA showed significant differences (p ± 0.05) between NAA concentration treatment for 200 axenic seeds.

Figure 6. Shoots length of *C. inophyllum* in MS media with 1 mg/l, 2 mg/l, 3 mg/l of NAA added and control at micro-environment

Environmental factors play an important part in determining the orientation of the seedling during its establishment as rooting or shooting of a plant and in controlling some aspects of its development. When seeds germinate below the soil surface, plumules may appear and are only visible when light exposure. Correspondingly, the young leaves of the plumules do not expand and turn green unless exposed to light. This adaptive response is regulated by the role of light-sensitive pigment phytochrome reactions. The shoots generally show a strong attraction to light or positive phototropism. Combined with a response to gravity, this positive phototropism maximizes the likelihood that the plant will achieve the most favorable environment for photosynthesis (Hathurusingha & Ashwath, 2012). In a micro-environment with a

completely controlled environment, there is a triggering power for seeds to germinate faster; roots and shoots are expected to be healthier and stronger. These seeds can also be used as a source of material for vegetative propagation explants through *in vitro* multiplication.

Figure 7. *C. inophyllum* roots and shoots length after 12 weeks incubation in micro-environment.

Inadequate supply and quality of tree seeds and seedlings is a major obstacle to the success of rehabilitation (Sacco et al, 2021; Duguma et al, 2021), especially in terms of the lack of consideration of which species to choose and where and how seeds are obtained. Despite the importance of the genetic quality of planting material for restoration efforts, existing recommendations for seed collection are not consistently integrated. Poor growth and survival of seedlings also increase restoration costs and results (Roshetko et al, 2018). Therefore, increasing the supply of seeds quantity and quality is very important to ensure that it can deliver the desired benefits and contribute to the rehabilitation of degraded lands and the climate crisis. The research is one of the initial efforts to obtain seeds as a source of quality genetic material.

CONCLUSION

As an alternative to the mass production of quality seeds for land rehabilitation, we developed a micro-environment technique by observing the effect of the exogenous hormone NAA on the germination of *C. inophyllum* seeds. The study is a new high-efficiency innovation technique with a mutually reinforcing effect on seedling growth. The highest concentration of NAA in this study increased root length by around five times higher than the control and shoots length by around three times higher than the control. This protocol can be used to spread *C. inophyllum* seeds on a large scale; however, it needs to be tested on a larger scale of cultivation.

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AUTHOR CONTRIBUTIONS

All authors had read and agreed to the published version of the manuscript and had an equal role as main contributors in discussing the conceptual ideas and the outline, providing critical feedback for each section and writing the manuscript.

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The illegal trade of the Sumatran serow *Capricornis sumatraensis sumatraensis* for traditional medicine in Indonesia

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ABSTRACT

Mainland serow are in decline in Southeast Asia with poaching for illegal trade being a major driver. In Indonesia, where this species is found only on the island of Sumatra, the illegal wildlife trade is widespread and impacts numerous species and it is therefore not surprising to find serow in trade. Using seizure and prosecution data from 2014 to 2021, a total of 13 seizure records were obtained, involving an estimated minimum of 32 mainland serow (*Capricornis sumatraensis*). While legislation is in place in Indonesia to protect serow from poaching and illegal trade, meaningful penalties are seldom handed down. In an absence of effective deterrents, illegal trade will continue to be a threat to the conservation of this species.

ABSTRAK

Kambing hutan daratan utama mengalami penurunan di Asia Tenggara yang mana perburuan untuk perdagangan ilegal menjadi pendorong utama. Di Indonesia, di mana spesies ini hanya ditemukan di Pulau Sumatra, perdagangan satwa liar secara ilegal terjadi dimana-mana dan berdampak pada banyak spesies, oleh karena itu tidak mengherankan jika ditemukan kambing hutan dalam perdagangan ilegal tersebut. Dengan menggunakan data penyitaan dan penuntutan mulai tahun 2014 hingga 2021, diperoleh total 13 catatan penyitaan, dengan perkiraan minimal terdapat 32 ekor kambing hutan (*Capricornis sumatraensis*). Meski undang-undang telah ada di Indonesia untuk melindungi kambing hutan dari perburuan dan perdagangan ilegal, namun hukuman yang dijatuhkan jarang sepadan. Tanpa adanya pencegahan yang efektif, perdagangan ilegal akan terus menjadi ancaman bagi upaya pelestarian spesies ini.

Keywords: *Caprinae, poaching, Southeast Asia, Sumatra, wildlife trade*

INTRODUCTION

One group of species in Southeast Asia that few people have heard of is the serow (*Capricornis* spp). Based on recent taxonomy re-assessments the IUCN Red List of Threatened Species (hereafter the IUCN Red List) recognises four species of serow: the Japanese serow (*Capricornis crispus*) restricted to Japan; the red serow (*C. rubidus*) restricted to Myanmar, India and southwest China; the Formosan serow (*C. swinhoei*) restricted to Taiwan; and the mainland serow (C. *sumatraensis*) which includes the following subspecies – (*C. s. sumatraensis*) found in Indonesia, Malaysia and Thailand, (*C. s. mildneedwardsii*) found in Cambodia, China, Lao PDR, Myanmar, Thailand and Vietnam, and (*C. s. thar*) found in the Himalayan range (Phan et al, 2020).

Serows are threatened by widespread poaching and illegal trade almost everywhere they occur, yet surprisingly little attention has been given to their plight and conservation needs. Perhaps this is because specific trade-related research involving serows is extremely limited, and likely due to the limited attention this species receives from government and non-government conservation efforts overall. They are mainly hunted for their meat and parts (including horns, bones, feet, blood, teeth, innards) which are used in traditional medicines (Duckworth et al, 2008a; Duckworth et al, 2008b; Duckworth & Than Zaw, 2008). Serow horns and heads are also traded as decorations and trophies. Surveys of wildlife markets in Southeast Asia show that serows are one of region's most utilised group of species, despite being totally protected across their range (Lekagul, 1965; Shepherd & Krishnasamy, 2014; Krishnasamy et al, 2019; Leupen et al, 2017; Nijman & Shepherd 2017; Shepherd, 2021). In some parts of their range, they have been extirpated due to poaching, sometimes in combination with habitat destruction (Shepherd & Krishnnasamy, 2014).

Indonesia is home to one species of serow, (*C. s. sumatraensis*) also known as the Sumatran serow and is the only native species of the Caprinae family in the country. It occurs only on the island of Sumatra and is largely found throughout the Bukit Barisan mountains, especially in the Aceh highlands in the north of the island, the Kerinci highlands in the centre and the Barisan Selatan area in the south (Shackleton, 1997; Whitten et al, 2000; Phan et al, 2020). Assessed as Vulnerable by the IUCN Red List, the Sumatran serow is believed to be in significant decline due to over-hunting and habitat loss (Phan et al. 2020). While targeted poaching of serow is not uncommon, they are more

frequently caught in indiscriminate snares set for other species (Shackleton, 1997).

The Sumatran serow has been legally protected in Indonesia since 1932 under the Nature Protection Ordinance No. 1967 of 1932 (Shackleton, 1997). It is currently protected under the "Act of the Republic of Indonesia No.5 of 1990 concerning conservation of living resources and their ecosystems", widely known as the "Conservation Act (No.5) 1990", which is the principal legislation regulating wildlife trade in Indonesia. Under this Act, protected species are listed under "Government Regulation No.7, 1999, Concerning the preservation of flora and fauna". Protected species may not be "caught, injured, killed, kept, possessed, cared for, transported, or traded whether alive or dead". Exceptions are permitted by the Government for the purposes of research, science and/or safeguarding a species. Violation of this Act may result in a prison term of a maximum of five years and a fine of up to IDR100 million (~USD6,952). This species is also included in the revised list of protected species that was issued in 2018 by the Ministry of Environment and Forestry (P.106/MENLHK/SETJEN/KUM.1/12/2018).

Considering its protected status in Indonesia, and the dearth of information regarding the scale of poaching, uses, illegal trade and the efforts to counter this crime, we attempt to shed light on the illegal trade of serows based on an analysis of seizure data to identify the drivers behind the trade and the legal actions taking place to reduce the demand. We then make recommendations for further actions to be taken to better protect serow in Indonesia from illegal exploitation.

METHODS

To better understand the illegal trade of serow in Indonesia for the period 2014-2021, we collected seizure data from various sources including from media reports, published literature and unpublished literature and the government website, Sistem Informasi Penelusuran Pekara (SIPP)/case tracking system (an open access information database of the courts for each district). Online searches for seizures of Sumatran serow, known in Indonesian as *kambing gunung*, were conducted in both English (search terms: *Seizure of Sumatran serow, Sumatran serow smuggling, Sumatran serow illegal trade, Sumatran serow conservation*) and Indonesian (search terms: *BKSDA*[1] *kambing gunung/kambing hutan sumatera, penyelundupan kambing gunung/kambing hutan sumatera, perdagangan kambing gunung/kambing hutan sumatera, polisi satwa kambing gunung/kambing hutan sumatera, konservasi kambing gunung/kambing hutan sumatera*) with the Indonesian search terms being far more productive. All reported seizures and prosecutions were scrutinized to avoid duplication. We extracted information from each record on date of seizure, commodity seized (live animals, horns, skull, skin, medicinal derivatives, etc), quantities of each commodity, purpose of hunting/trade (i.e., for consumption, use in traditional medicines), location of seizures and trafficking routes, suspects arrested and prosecution outcomes. Using the seizure data, we mapped points where trade exists. We have estimated a minimum number of serow recorded in trade from commodities seized, by either counting whole or near-whole specimens seized (e.g., live animals, skins), or by tallying quantities of body parts seized (e.g., horns, skull) that form one whole individual per seizure record. Due to inherent biases in the way seizure data are reported (given varying levels of law enforcement, reporting and recording practices, language biases, etc.), this dataset is interpreted with caution. Reported seizures are likely to represent only a fraction of the illegal trade and therefore the dataset presented here is not to be assumed as representing absolute trafficking trends or volumes.

Exchange rates used were USD 1 = ~ IDR 14,384.

RESULTS

From 2014 to 2021, a total of 13 seizures were obtained, involving an estimated minimum of 32 serows. On average there were one to two seizures each year except for four seizures in 2020. There were no reported seizures in 2015 and 2018. The greatest number of seizures occurred in West Sumatra (n=4) followed by Aceh (n=2) (**Figure 1**). The provinces of West Sumatra and South Sumatra were where the highest estimated number of animals were seized based on commodities confiscated. Only two seizures occurred outside the species' range i.e., in Java.

Figure 1. The range of the Sumatran serow (*C. s. sumatraensis*) in Indonesia and location of seizures that occurred between 2014 and 2021 including estimated number of animals involved in each incident.

All seizure incidents obtained, barring one, comprised the seizure of multiple species, their parts and derivatives (**Table 2**). This most frequently involved tigers (*Panthera*

[1]Balai Konservasi Sumber Daya Alam – Indonesian Nature Conservation Agency

tigris) (n=7 incidents) and deer species (n=7 incidents) followed by sun bears (*Helarctos malayanus*) (n=5 incidents). At least three seizures were the result of investigations into illegal wildlife trade syndicates, three the result of raids on wildlife markets and a restaurant, three the result of information provided by members of the public, two the result of police checks at roadblocks and one the result of an investigation into the advertising of wildlife products on Facebook. Apart from one incident, all seizures were successfully prosecuted (**Table 2**). However, the highest penalty imposed was 2.6-year (approximately 31 months) imprisonment and IDR50mil fine (~USD3,475) on two suspects in possession of body parts from serow, tigers, deer and birds poached from the Gunung Leuser National Park. The one incident where no one was arrested involved the killing and consumption of a serow by people living around a protected forest in Pematang, North Sumatra.

Table 1. The different commodities of the Sumatran serow seized from 2014 to 2021

Year	Commodity (Quantity)					
	Carcass	Head	Horn	Skeleton	Skin (pieces)	Skull
2014		2				
2016			3			1
2017		7	2	1	2	
2019		5			11	
2020		5	9			
2021	1		4			

Table 2. Seizure incidents involving Sumatran serow from 2014 to 2021 in Indonesia and prosecution outcomes

No.	Date	Seizure location	Commodity	Quantity	Suspects arrested	Prosecution outcome	Other wildlife seized
1	03/01/2014	Aceh	heads	2	2	1 year jail and IDR10mil (~USD695) fine or additional 4 months jail	tiger, clouded leopard, golden cat, leopard cat, sun bear, hornbill
2	15/01/2016	Jakarta Barat	skull horn	1 3	1	1 year jail and IDR50mil (~USD3,475) fine or additional 1 month jail	tiger, sun bear, deer, clouded leopard, golden cat, Bali starling leopards, birds of paradise, parrots, eagle, pythons
3	06/03/2017	Lampung	skeleton horn skin (pieces)	1 1 2	1	8 months jail and IDR5mil (~USD348) fine or additional 1 month jail	tiger, sun bear, rhino, Malayan tapir, deer, elephant, crocodile
4	27/04/2017	South Sumatra	head	7	1	7 months jail and IDR10mil (~USD695) fine or additional 1 month jail	leopard cat, golden cat, sun bear, muntjac, tiger, hornbill
5	19/02/2017	West Sumatra	horn	1	1	2 years jail and IDR30mil (~USD2,083) fine or additional 3 months jail	hornbill, deer
6	13/01/2019	West Sumatra	head	1	1	1.6 years in jail and IDR5mil (~USD348) or additional 2 months jail	part of a wildlife trade syndicate
7	04/04/2019	West Sumatra	heads skin (pieces)	4 11	2	6 months jail and IDR200k (~USD14) fine or additional 10 days jail	rhino heads, false gharial head and Sambar deer antlers

8	24/04/2020	Jambi	horns	5	1	2 years jail and IDR10mil (~USD695) fine or additional 2 months jail	tiger, pig-tailed macaque, deer, dugong, eagle
9	17/09/2020	Bengkulu	horns	2	1	5 months jail and IDR5mil (~USD348) fine or additional 2 months jail	Sambar deer
10	20/07/2020	West Java	heads	5	1	8 months jail and IDR5mil (~USD348) fine or additional 2 months jail	tiger, anoa, hawksbill turtle, saltwater crocodile, triton, nautilus, muntjac, deer, leopard cat, snake, sun bear, green peafowl
11	10/09/2020	West Sumatra	horns	2	2	7 months jail and IDR20mil (~USD1,390) or additional 2 months ail; 1.2 years jail and IDR40mil (~USD2780) or additional 3 months jail	pangolin, slow loris
12	01/03/2021	Aceh	horns	4	2	2 .6 years jail and IDR50mil (~USD3475) fine or additional 2 months jail	deer, tiger, great argus
13	28/03/2021	North Sumatra	dead	1	-	-	-

DISCUSSION

The analysis of seizure data presented here shows that serows are being poached and illegally traded in Indonesia in violation of national legislation. Illegal exploitation of protected species is a common and widespread occurrence in Indonesia (Chng & Eaton, 2016; Gomez & Shepherd, 2021; Pires et al, 2021). Protected species, including their parts and derivatives, are sold openly in markets and shops across the country and, increasingly, via online platforms (Gunawan et al, 2017; Gomez et al, 2019; Thomas et al, 2021). Trade of serow parts, especially horns, have been observed occurring openly in souvenir shops in North Sumatra, especially in the mountain town of Brastagi (Shepherd & Magnus, 2004; Shepherd pers. obs., 1996, 2008). There were too few seizures involving serows in Indonesia to determine whether the species is targeted or caught incidentally by poachers. But a study on tiger poaching in the Kerinci Seblat National Park in Sumatra seemed to imply that snare traps found along mountain ridge trails were intended for serow (Linkie et al, 2003). Further, the fact that serow were found in trade on Java indicates demand and use beyond the species range in Indonesia.

Based on commodities seized (i.e., mostly heads and horns), the trade in serow parts appears to be mostly for traditional medicine and perhaps trophies. This corresponds with findings elsewhere in Southeast Asia observed with an active trade in serows, their parts and derivatives (Leupen et al, 2017; Nijman & Shepherd, 2017; Phan et al, 2020). A recent study on the use of wildlife for traditional medicine in Indonesia found that serow is often used to treat skin and infectious diseases (Mardiastuti et al, 2021). In Lao PDR and Myanmar, the head, skeleton or parts of the serow are generally boiled or rendered down to obtain oil/fat which is then used to treat various ailments including arthritis and muscle and joint pain (Nijman & Shepherd, 2017; Davis & Glikman, 2020). In China, serow horn and blood are used for rheumatism relief (Mainka & Mills, 1995). In India, serow horns are used to treat abscesses (Velho & Laurance, 2013). Serow horns are also coveted for decorative purposes and its likely the same occurs in Indonesia. At least one seizure incident, occurring in a village in Pematang, North Sumatra, revealed that serow are also hunted for local consumption. Local authorities here (i.e., BKSDA) claimed this was largely due to a lack of awareness on wildlife conservation issues and regulations. Note however that as meat is likely consumed shortly after the animal is killed, it is less likely to detect serow meat in trade and therefore less likely for meat to be seized by the authorities.

All seizures analysed in this study, barring one, involved a number of other species and in some cases involved wildlife smuggling syndicates. This indicates

that serow were not specifically targeted by enforcement agencies. It may also explain the low number of serow seizures obtained for this study. For example, seven of the incidents included in this analysis involved tigers, which are a high profile and priority species for enforcement agencies. One incident was the result of an undercover investigation into five tiger poaching rings operating in North Sumatra (Parker 2014). The confiscation of serow parts was a by-product of these efforts. Investigations into the illegal trade of high-profile species clearly benefits lower priority species like serow. That said, neglecting to regulate the trade in lower profile species may mean that a large volume of illegal exploitation occurs undetected. The Sumatran serow is particularly vulnerable to the illegal wildlife trade considering its restricted range and threatened status.

The majority of cases in our dataset were prosecuted, yet the maximum penalty provided by the law (five years and fine of up to IDR100 million (~USD6,952)) was never imposed. Considering the numerous protected species seized in each incident, the low penalty outcomes show the little importance given to wildlife crimes as well as a lack of understanding or awareness on the impacts of the illegal wildlife trade. The illegal wildlife trade is among the greatest threats to biodiversity and is estimated to be worth billions of dollars (TRAFFIC, 2008; World Animal Protection, 2020). While it is debatable whether harsher penalties would deter potential offenders or reoffending criminals (Wilson & Boratto, 2021), the high value associated with species exploitation is more attractive if there is minimal risk associated with breaking the law (Ciavaglia et al, 2015). Given that serow parts have been openly observed in shops in Sumatra indicates that retailers are either unaware of the illegality of such trade or perceive the risk of being caught and sanctioned as low. Greater research on deterrence in wildlife crime is needed as we know little about what acts as an effective deterrent. The broader criminological literature suggests that the perceived certainty of being caught and sanctioned has a greater deterrent effect than perceived severity of punishment (see Wilson & Boratto, 2021). Looking at ways to improve the perceived likelihood of detection and prosecution could therefore prove beneficial and should be considered the subject of ongoing research.

CONCLUSION AND RECOMMENDATIONS

Serow populations are in decline across the entire range in Southeast Asia due to a large extent to the illegal wildlife trade (Phan et al, 2020). Given there is no recent estimate of the serow population in Sumatra, it is not possible to gauge the impact of the removal of 32 adult serow from the wild. However, as suitable habitat for serow in Sumatra continues to be destroyed and fragmented, and as encroachment into protected areas continues, it is likely that ongoing illegal offtake will have a negative impact on the population overall. In the interest of conservation, more effort should be made to tackle the poaching and illegal trade of the Sumatran serow.

Indonesia currently has the legislation in place to protect the Sumatran serow. What is now needed is for government and non-government agencies and organisations monitoring wildlife trade in Indonesia to pay attention to the illegal exploitation of serow. Information gathered can be used to establish a baseline of availability from which to measure trade dynamics and threats and evaluate conservation measures and enforcement action. The information can also be used to support enforcement efforts to deter the poaching and illicit trade in serow parts and derivatives. Successful prosecutions relating to poaching serow, trading, possessing or using serow parts and derivatives should be highlighted in the media and other forums to raise awareness of the conservation needs of this species, the laws protecting it and the threat of prosecution for violating these laws. In this respect, local community engagement is warranted to address their role in the illicit sourcing and use of wildlife for meat and medicine. Strategies to reduce demand for serow parts and derivatives for traditional medicine should be developed, trialed and implemented in Indonesia. These measures are urgently needed considering the huge risk wildlife trade can pose through the possible transmission of zoonotic diseases.

Efforts to raise awareness of serow and their conservation needs among the general public would also be useful in enhancing overall efforts to protect this species, and this might be done through inclusion of serow in conservation education messaging and wildlife conservation campaigns.

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Threat of landslides hazard at the core zone of Cultural Conservation Strategic Area of Gunung Padang megalithic site, in Cianjur District

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ABSTRACT

The megalithic site of Gunung Padang is an area prone to landslides. Based on the Regulation of Cianjur District No. 17 of 2012, this site area is designated as a Cultural Conservation Strategic Area. This study aims to analyze the potential for landslide hazards in the Gunung Padang Megalithic Site area. The research method is quantitative. Primary data was collected through observation and interview experts; secondary data was collected through literature studies and agency surveys. The analytical method used is quantitative through analysis of Geographic Information Systems (GIS), with overlay and weighting techniques. The results showed three landslide susceptibility classifications: very high, medium, and very low. A very high level of landslide hazard is found in the area around the site, which is currently exposed, amounting to 9.03% of the core zone of the Cultural Conservation Strategic Area.

ABSTRAK

Situs megalitikum Gunung Padang merupakan kawasan rawan longsor. Berdasarkan Peraturan Bupati Cianjur No. 17 Tahun 2012, kawasan situs ini ditetapkan sebagai Kawasan Strategis Cagar Budaya. Penelitian ini bertujuan untuk menganalisis potensi bahaya longsor di kawasan Situs Megalitikum Gunung Padang. Metode penelitian adalah kuantitatif. Data primer dikumpulkan melalui observasi dan wawancara ahli, data sekunder dikumpulkan melalui studi literatur dan survei keagenan. Metode analisis yang digunakan adalah kuantitatif melalui analisis Sistem Informasi Geografis (SIG), dengan teknik overlay dan pembobotan. Hasil penelitian menunjukkan tiga klasifikasi kerawanan longsor yaitu sangat tinggi, sedang dan sangat sangat rendah. Tingkat kerawanan longsor yang sangat tinggi terdapat di wilayah sekitar tapak yang saat ini terpapar, yaitu sebesar 9,03% dari zona inti kawasan strategis cagar budaya.

Keywords: *Cultural conservation, landslides, strategic area*

INTRODUCTION

Gunung Padang megalithic site is a cultural conservation site with a national rating by the Minister of Education and Culture No. 023 / M / 2014. The site is in the form of the largest terraced punden in Southeast Asia(Ramadina,2013). The site is a megalithic relic estimated to be between 500 and 200 years BC based on carbon dating and is estimated to have been built between the IV-XVI centuries (Rusata, 2019).

Based on the Cianjur District Regulation no. 17 of 2012 About The Cianjur District Spatial Plan 2011-2031, the Gunung Padang megalithic site is strategic cultural conservation. According to the Spatial Planning Law of the Republic of Indonesia no 26 of 2007, the Strategic Cultural Conservation Area is an area whose spatial planning is prioritized because it has a significant social and cultural influence. Based on the Cultural Conservation Area Law of the Republic of Indonesia no 11 of 2010, cultural conservation areas need to be conserved because they have essential values for history, science, education, religion, and culture. As a Strategic Cultural Conservation Area, the site's conservation is essential because, until now, archaeological research in this Strategic Cultural Conservation Area is still ongoing. Many factors can cause site damage; apart from human behavior, there are also natural factors, one of which is landslides. Landslides are a form of erosion where the transportation or movement of the soil mass occurs at a time in a relatively large volume (Suripin, 2002; Istiadi & Priatna, 2021). Wong et al. (2017) and Yang (2018) stated that the occurrence of landslides is related to various factors such as precipitation, geology, distance from the fault, vegetation, and topography.

The Gunung Padang megalithic site is located at an altitude of about 800-1200 above sea level (Bronto & Billy, 2016). In addition, the site is located at the intersection of the Cimandiri and the Gede-Cikondang fault (Bronto & Billy, 2013). Based on Cianjur District Regulation 17 of 2012 about Cianjur District Spatial Plan 2011-2031, the Gunung Padang megalithic site is an area of land movement and landslides. Landslides are a type of soil or rock mass movement, or a combination of the two, that descends or exits a slope due to

disturbance of the stability of the soil or rock making up the slope. (Dewi & Abdi, 2017). The danger of landslides in the Gunung Padang megalithic site is a threat to the existence of the site. Therefore, in the context of mitigation, it is necessary to analyze the level of landslides hazard as a basis for mapping landslides hazard in the Gunung Padang megalithic site area. Landslides hazard mapping is a form of non-structural mitigation. In reducing disaster risk, non-structural mitigation is more sustainable because it provides security in the long term (Dewi & Istiadi, 2016).

Based on this, the research aims to analyze and map the level of landslide hazard at the core zone of the Cultural Conservation Strategic Area of the Gunung Padang megalithic site. As for the benefits, it is hoped that the local and central governments will be able to mitigate these dangers so that the Gunung Padang megalithic cultural conservation area can be protected from severe damage caused by debris, flows, and falls.

METHODS

Based on the Cianjur District Spatial Plan 2011-2031, the Gunung Padang Strategic Cultural Conservation Area is divided into three zones; the Core, Buffer, and Development Zones. However, based on expert research, the Gunung Padang site is estimated to be very wide and exceeds what is seen now. Based on this, the Gunung Padang Strategic Cultural Conservation area is set in 2 villages, namely Karya Mukti and Cimenteng Villages.

This research was conducted at the core zone of the Strategic Cultural Conservation Area of Gunung Padang Megalithic Site in Karyamukti and Cimenteng Villages, Campaka subdistrict, Cianjur district. Located at 6°59,664'S 107°3,375'E, the site has a total area of 28.79 km^2. For more details regarding the scope of the region can be seen in Figures 1 and 2.

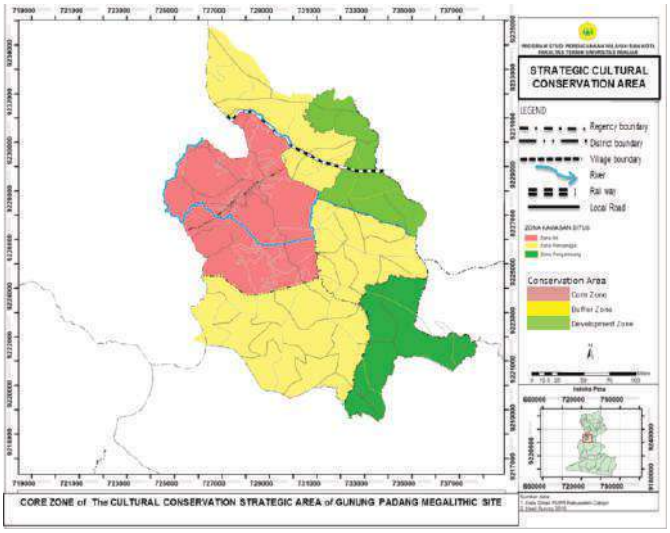

Figure 1. Strategic Cultural Conservation Area of Gunung Padang megalithic site.

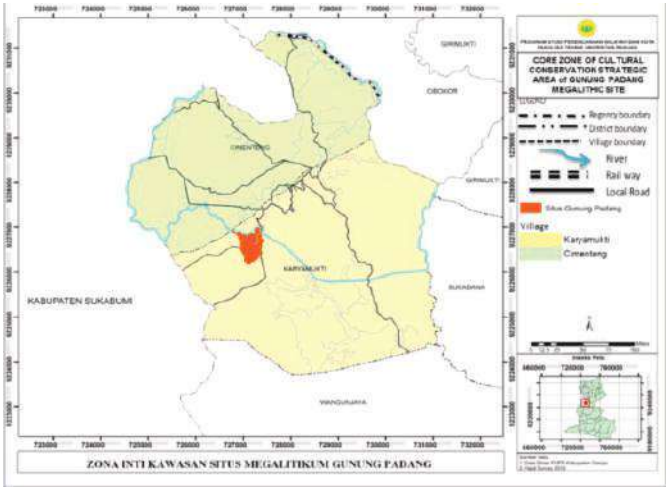

Figure 2. Core zone of Strategic Cultural Conservation Area of Gunung Padang site.

Primary data was taken in July 2019. Field observations were to assess the physical condition of the core zone. Expert interviews were conducted with three sources: the Head of BPBD Cianjur District, Historians and Archaeologists, and Environmental Geomorphologists. The interview is intended to measure the weight of the landslide hazard and hazard variables.

Law No. 11 of 2010 concerning Cultural Conservation, Law No. 24 of 2007 concerning Disaster Management, Minister of Public Works Regulation No. 22 of 2007 about Spatial Planning in Landslides Disaster Areas, and Cianjur District Regulation No. 17 of 2012 about Regional Spatial Planning Cianjur District 2011-2031 are document used for secondary data. Another secondary data include map of Cianjur Regency 1: 125,000; Rainfall 1:125,000; Soil Type 1:125,000, Land Use 1:125,000, Slope 1:125,000, River flow 1:125,000, and the National Model Elevation Digital Map (Demnas) of 2018 with a resolution of 12.5 m.

Data analysis used Geographic Information System (GIS) with ArcGIS 10.3. Analysis of the landslides hazard level is carried out in 2 stages. The first stage analyzes landslide hazards through 5 variables: slope, land use, soil type, river density, and rainfall (**Table 1**).

In the second stage, the vulnerability analysis results are refined by adding two variables: the frequency of landslide events and secondary disasters due to landslides. The consideration is that the more frequent landslides occur, the higher the threat of landslides in that location. Secondary disasters are also considered because the intensity of landslide hazards is getting immense with the emergence of secondary disasters due to landslides. Furthermore, each variable is classified into five classes: very low, low, medium, high, and very high, with a value of 1 to 5. The weights are obtained from the results of expert interviews. The score is the multiplication of the value with the weight. (**Table 2**).

Table 1. Landslides susceptibility variables.

Variable	Classification	Range	Value	Weight (%)	Score
Rain Fall (mm/Y)	Very Low	<2000 mm/Y	1	24	0.048
	Low	2000-2500 mm/Y	2		0.096
	Medium	2501-3000 mm/Y	3		0.114
	High	3001-3500 mm/Y	4		0.192
	Very High	>3500 mm/Y	5		0.24
Land use	Very Low	Forest	1	17	0.034
	Low	Farm	2		0.068
	Medium	Fields, Moor, Shrublands	3		0.102
	High	Rice Fields, Mining	4		0.136
	Very High	Settlement	5		0.17
Slope	Very Low	0-8%	1	42	0.084
	Low	8-15%	2		0.168
	Medium	15-25%	3		0.252
	High	25-40%	4		0.336
	Very High	>40%	5		0.42
Soil Type	Very Low	Aluvial	1	11	0.022
	Low	Latosol	2		0.044
	Medium	Litosol	3		0.066
	High	Podsolik	4		0.088
	Very High	Grumosol	5		0.11
River Density	Very Low	0,25-5 km/km^2	1	6	0.012
	Low	5-10 km/km^2	2		0.024
	Medium	10-15 km/km^2	3		0.036
	High	15-25 km/km^2	4		0.048
	Very High	>25 km/km^2	5		0.06

Source: Analysis 2020

Table 2. Landslides hazard variables.

Variable	Classification	Range	Value	Weight (%)	Score
Suceptibility	Very Low	0,012-0,093	1	48	0.096
	Low	0,094-0,175	2		0.192
	Medium	0,176-0,257	3		0.288
	High	0,258-0,339	4		0.384
	Very High	0,340-0,420	5		0.48
Frequency	Very Low	0	1	26	0.052
	Low	1x	2		0.104
	Medium	2x	3		0.156
	High	3x	4		0.208
	Very High	>4x	5		0.26
Secondary Disaster	Very Low	non	1	26	0.052
	Low	once	2		0.104
	Medium	rarely	3		0.156
	High	often	4		0.208
	Very High	very often	5		0.26

Source: Analysis 2020

The level of landslide hazard is classified into five classes. Class division can use the formula: i = (VHS-VLS)/n. Where i is the interval, VHS = the highest score, VLS = the lowest score, and n = 5 is the number of classes; the GIS analysis (Table 3).

Table 3. The level of landslides hazard.

No	Level of Landslides Hazard	Score
1	Very Low	0.052-0.137
2	Low	0.138-0.223
3	Medium	0.224-0.309
4	High	0.310-0.395
5	Very High	0.396-0.480

Source: Analysis 2020

RESULT AND DISCUSSION

The results of the analysis of the landslide susceptibility level show that there are three levels of landslide susceptibility at the core zone of the Strategic Cultural Conservation Area of the Gunung Padang megalithic site: very low (24.49%), low (52.69%), and moderate (17.82%). This result occurs because, from the five susceptibility variables, only rainfall strongly influences landslide susceptibility. The average annual rainfall is 3000-3500 mm. The use of residential land, rice fields, and mining which can trigger landslides are low (31.37% of the core zone area). Areas with slopes above 25%, which can trigger landslides, are low (19.14% of the core zone area). The soil type at the core zone area is latosol. Latosol has very low erodibility (Taslim et al., 2019). The Gunung Padang site area has a very high river density(27.05 km/km^2), and areas that have high river density are very low (0.40% of the core zone area) (**Figure 3**).

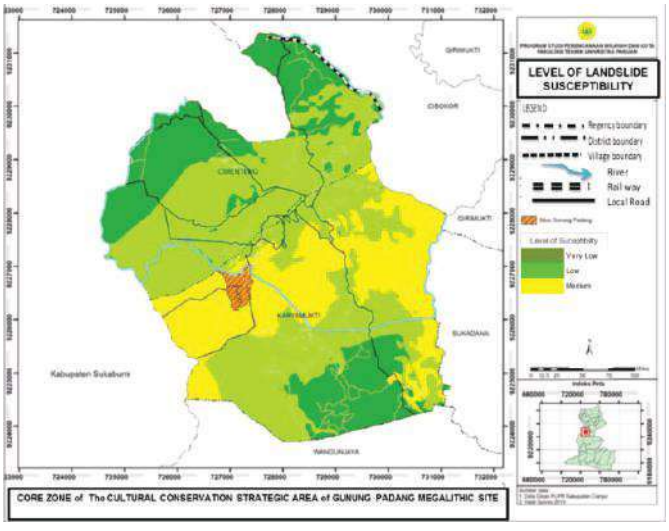

Figure 3. Landslides susceptibility level at the core zone of the Strategic Cultural Conservation Area of Gunung Padang megalithic site.

Based on data from the Cianjur Regency Tourism Office, the site's land area that can be seen is more or less 0.30 Km^2, located in Karyamukti Village, with an altitude between 800-975 m above sea level. The structure of the Gunung Padang megalithic site is made up of a set of polygonal rock columns. These columns were formed when lava cooled into igneous andesite or basalt rock (Ramadina, 2013). The Gunung Padang megalithic site is a terraced building commonly referred to as 'punden terraces,' consisting of five terraces or levels. The higher the level or terrace, the narrower the terrace area (Ramadina, 2013).

The hazard analysis results show that the exposed site is in moderate susceptibility. The occurrence of landslides at the core zone of Strategic Cultural Conservation Area of the Gunung Padang megalithic site from 2017-2019 is shown in Figure 4.

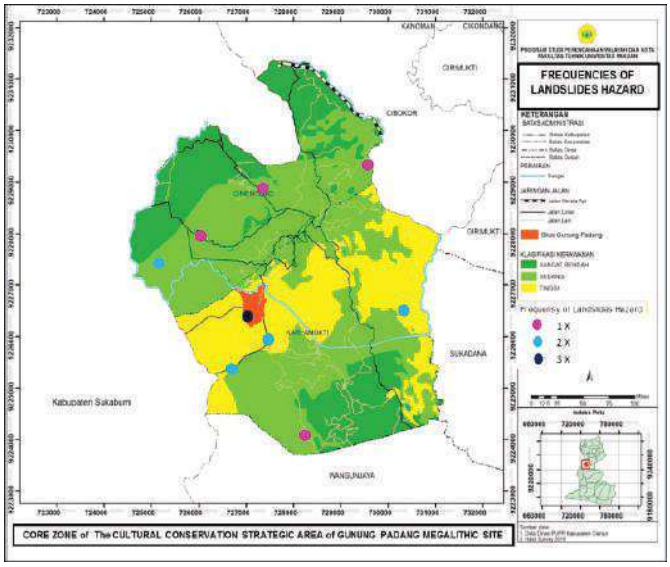

Figure 4. Landslides disaster locations 2017-2019 at the core zone of the Strategic Cultural Conservation Area of Gunung Padang megalithic site.

In 2019, landslides occurred on the second terrace at a site location that has been exposed. The cliff fell on the second terrace, buried the gardens and the Cikuta river at the bottom. The landslide incident caused a secondary hazard between flash floods and the Cikuta river embankment bursting so that the mud-covered two compartments of rice fields.

The landslide hazard level analysis at the core zone of the Cultural Conservation Strategic Area of the Gunung Padang megalithic site (**Figure 5**) shows that the landslide hazard level varies from very low to very high. The very low, moderate, and very high levels are 38.83%, 52.14%, and 9.03%, respectively, of the cultural conservation area core zones.

The level of landslide hazard is very high in the Gunung Padang megalithic site, which has been exposed on terraces 5, 4, 3, and part of terraces 2 (**Figure 6**).

This landslide hazard level varies because the terraces are between 800-975 m above sea level and have a steep slope of 25% and 40%. This finding is in line with research carried out by several researchers at the megalithic site of Gunung Padang. According to

Sampurno (2002), cited in Yondri (2020), there are three forms of natural disasters that threaten the punden rock structure of Gunung Padang, such as debris, falls, and flows. The construction of the terrace wall made of andesite stone blocks arranged vertically at the top of the hill is very prone to collapse. The construction of the terrace wall, which is on a hillside slope, is very prone to fall hazards, and the construction arrangement, which is in an area with a gentle slope, is also very prone to flow hazards (Yondri, 2020). Furthermore, Yondri's research stated that on the terraces of the megalithic site of Gunung Padang, traces and remnants of the avalanche

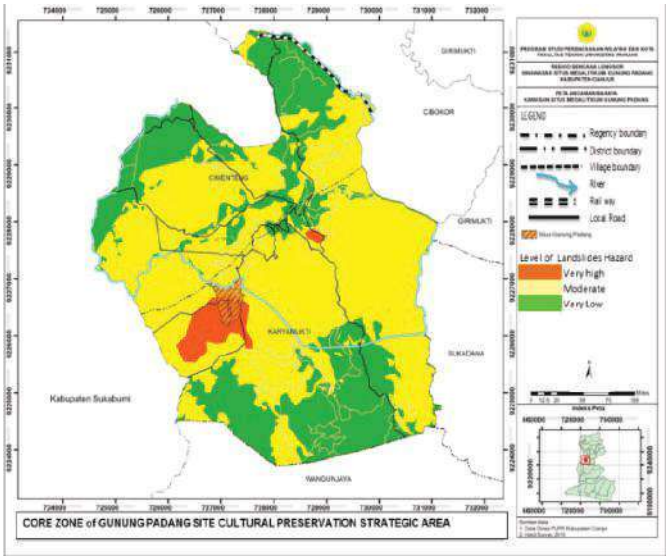

Figure 5. Landslides hazard level at the core zone of the Strategic Cultural Conservation Area of Gunung Padang megalithic site.

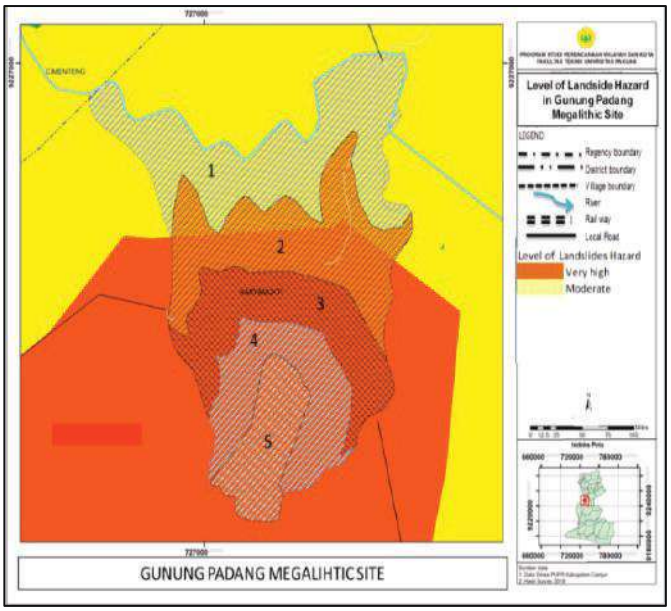

Figure 6. Level of landslides hazard in the Gunung Padang megalithic site.

were found (Yondri, 2020). Furthermore, on the eastern, western, northern, and northeastern slopes of Gunung Padang, stone columns with long axis tilted in the direction of the sloping plane are evidence of repeated landslides (Bronto & Billy, 2016).

CONCLUSIONS

The level of landslide hazard at the core zone of the Strategic Cultural Conservation Area of the Gunung Padang Megalithic site consists of Very Low, Medium, and Very High. The threat level of landslides hazard is very high around the Gunung Padang megalithic site, which has been exposed on terraces 5, 4, 3, and part of terraces 2, which can threaten the sustainability of the site.

Based on the study's results on the level of landslide hazard, structural and non-structural mitigation efforts are needed to maintain the site's sustainability. To maintain the Gunung Padang site's safety, structural and non-structural measures are required. The structural measures include reinforcing the steep terrace wall, and the non-structural measures include restricting tourist access to high-risk landslides. In addition, it is necessary to increase the capacity of local government officials and the community through socialization about site security and its rules, as well as increase public awareness of the need to participate in the preservation of the site.

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The Role of the parties in mangrove ecosystem recovery in Juntinyuat Coast, West Java, Indonesia

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ABSTRACT

Coastal abrasion is a problem that needs to be addressed thoroughly. If not properly managed, coastal abrasion can lead to other environmental issues, such as damage to mangroves and coastal ecosystems. The local government is actively carrying out mangrove ecosystem restoration program to conserve the coastal ecology by involving related agencies, industries, and the community surrounding the Juntinyuat coastal area. The focus of this research is to find out the planning, implementation, and monitoring carried out in relation to the restoration of the mangrove ecosystem based on the involvement of the parties in overcoming coastal abrasion on the coast of Juntinyuat, Indramayu Regency, West Java. Data were collected by conducting observations, interviews, and documentation to the community and the parties involved in restoring the mangrove ecosystem on the Juntinyuat coast. The results showed that mangrove ecosystem damage in the coastal area of Juntinyuat generates a high level of abrasion. The damage caused by abrasion threatens settlements, ponds, and agricultural land, as well as threatens the gas and oil pipelines of Pertamina Gas in the West Java operation area (Pertagas OWJA). There is a relationship between the critical condition of the mangrove ecosystem in the Juntinyuat coastal area and the initiation of efforts to restore the mangrove ecosystem. The initiation of mangrove ecosystem restoration arose from the critical condition of mangroves, which necessitates careful planning to restore damaged mangrove conditions. Related parties concerned with the preservation of the mangrove ecosystem subsequently coordinate to plan the mangrove ecosystem restoration program on the Juntinyuat coast. The mangrove ecosystem restoration was conducted after an initial survey in mid-2014. The role of the parties in planning, implementing, and monitoring the restoration of the mangrove ecosystem is running well and maximally with a clear division of duties and responsibilities. Currently, the results of the restoration of the mangrove ecosystem on the Juntinyuat coast can be felt together with the denser mangrove cover, reducing the abrasion impact, and making it a mangrove ecotourism area. In the future, it is necessary to form a coordinating team for the strategy of mangrove ecosystem management at the regency and sub-district levels to synergize policies and programs for managing mangrove ecosystems. Empowerment activities need to be carried out intensively to encourage a change in the role of mangrove management.

ABSTRAK

Abrasi pantai merupakan masalah yang perlu ditanggulangi secara tuntas. Jika tidak dikelola dengan baik, abrasi pantai dapat menimbulkan masalah lingkungan lainnya, seperti kerusakan mangrove dan ekosistem pesisir. Pemerintah setempat secara aktif melakukan program restorasi ekosistem mangrove untuk melestarikan ekologi pesisir dengan melibatkan instansi terkait, industri, dan masyarakat sekitar kawasan pesisir Juntinyuat. Fokus penelitian ini adalah untuk mengetahui perencanaan, pelaksanaan, dan pemantauan, yang dilakukan terkait restorasi ekosistem mangrove berdasarkan pelibatan para pihak dalam penanggulangan abrasi pantai di pesisir Juntinyuat, Kabupaten Indramayu, Jawa Barat. Pengumpulan data dilakukan dengan melakukan observasi, wawancara, dan dokumentasi kepada masyarakat serta pihak-pihak yang terlibat dalam pemulihan ekosistem mangrove di pesisir Juntinyuat. Hasil penelitian menunjukkan bahwa kerusakan ekosistem mangrove di kawasan pesisir Juntinyuat menghasilkan tingkat abrasi yang tinggi. Kerusakan akibat abrasi mengancam pemukiman, tambak, dan lahan pertanian, serta mengancam jaringan pipa gas dan minyak milik Pertamina Gas di Wilayah Operasi Jawa Barat (Pertagas OWJA). Terdapat hubungan antara kondisi kritis ekosistem mangrove di kawasan pesisir Juntinyuat dengan inisiasi upaya restorasi ekosistem mangrove. Inisiasi restorasi ekosistem mangrove berawal dari kondisi mangrove yang kritis, sehingga diperlukan perencanaan yang matang untuk memulihkan kondisi mangrove yang rusak. Pihak terkait yang terkait dengan pelestarian ekosistem mangrove selanjutnya berkoordinasi untuk merencanakan program restorasi ekosistem mangrove di pesisir Juntinyuat. Restorasi ekosistem mangrove dilakukan setelah survei awal pada pertengahan tahun 2014. Peran para pihak dalam perencanaan, pelaksanaan, dan pemantauan pemulihan ekosistem mangrove berjalan dengan baik dan maksimal dengan pembagian tugas dan tanggung jawab yang jelas. Saat ini, hasil restorasi ekosistem mangrove di pantai Juntinyuat dapat dirasakan seiring dengan semakin rapatnya tutupan mangrove, mengurangi dampak abrasi, dan menjadikannya sebagai kawasan ekowisata mangrove. Di masa depan, perlu dibentuk tim koordinasi strategi pengelolaan ekosistem mangrove di tingkat kabupaten dan kecamatan, untuk mensinergikan kebijakan dan program pengelolaan ekosistem mangrove. Kegiatan pemberdayaan perlu dilakukan secara intensif untuk mendorong perubahan peran pengelolaan mangrove.

Keywords: *abrasion, Juntinyuat, mangrove ecosystem, recovery, role of the parties*

INTRODUCTION

Mangrove forest ecosystems have crucial ecological functions as spawning, nursery, and rearing areas, or foraging for certain fish and animals, as well as functioning as areas of protection against abrasion and seawater intrusion (Supriharyono, 2009). Economically, mangrove forests provide several environmental services to humans directly and indirectly. Mangrove forest will function properly if the use of mangrove forests is managed sustainably.

According to data from the KLHK (2017), Indonesia has the world's largest mangrove ecosystem, housing the highest biodiversity. With a coastline of 95,181 km, Indonesia has a mangrove area of 3,489,140.68 hectares (ha). This amount is equivalent to 23% of the world's mangrove ecosystems. From the area of mangroves in Indonesia, 1,671,140.75 ha is in good condition, while the remaining area of 1,817,999.93 ha is in damaged condition. On the island of Java, the decline in mangrove forests is caused by land conversion for fish farming activities (ponds), human settlements, and other uses as a result of the surrounding community's limited understanding and awareness of the ecological importance of mangroves, and the uncertainty of land status (Kustanti et al., 2014; Oni et al., 2019). West Java has approximately 15,276 ha (38.06%) of degraded mangroves, with Karawang Regency suffering the most damage (32.85%), followed by Bekasi 10,481 ha, Indramayu 8,720 ha, Subang 7,346 ha, Cirebon 190 ha, Ciamis 170 ha, Garut 32 ha, and Sukabumi 9 ha (Dishut Jabar, 2018a). Mangrove loss in Indramayu Regency has caused severe erosion in the villages of Ujung Gebang, Limbangan, and Juntinyuat (Dishut Jabar, 2018b).

One of the issues that should be addressed thoroughly is coastal abrasion in the Indramayu coastal area. If not managed properly, coastal abrasion may cause other environmental issues, such as damage to mangroves and coastal ecosystems. The Juntinyuat Coast in Indramayu Regency has experienced abrasion as a result of the degradation of the mangrove forest area. Collaboration with all stakeholders to restore coastal ecosystems and mangrove forests in targeted areas of damage and abrasion is an alternative solution to the problem. Currently, ecosystem restoration has become a global concern (Rochmayanto, 2021). The local government is actively carrying out the mangrove recovery program as part of a larger plan to preserve coastal ecosystems by involving relevant agencies, companies, and the community surrounding the Juntinyuat coastal area. As a development actor, companies have an operational impact from natural resource exploration activities that have significant environmental impacts. PT. Pertamina Gas Western Java Area (WJA) is one of the companies that has a working area along the Juntinyuat coast. This existence makes the company have a responsibility to participate in restoring the mangrove ecosystem on the Juntinyuat coast. This responsibility is stated in the company's policies and programs regarding environmental sustainability, one of which is the mangrove restoration program. Efforts to restore the mangrove ecosystem is done by companies in collaboration with local governments, related agencies, and local communities. It is being undertaken to preserve coastal ecosystems and the biodiversity that exists within them.

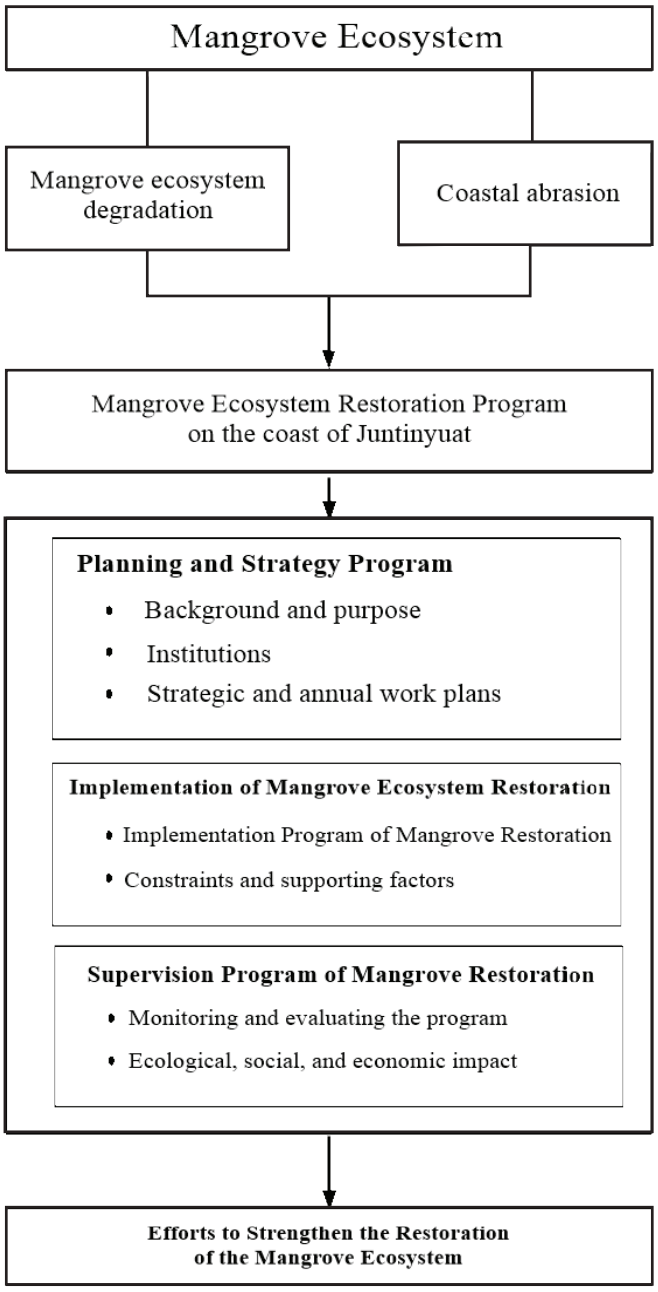

Figure 1. The research framework.

Based on the description above, the research question is: how effective is stakeholder-based mangrove recovery in preventing coastal abrasion on the coast of Juntinyuat, Indramayu Regency, West Java? This study has several sub-focuses based on the research focus mentioned above, including:

1. How is the planning of the stakeholder-based mangrove recovery program on the Juntinyuat coast in coastal abrasion prevention?
2. What is the management strategy of the stakeholder-based mangrove recovery program on the Juntinyuat coast in dealing with coastal abrasion?
3. How is the process of implementing a stakeholder-based mangrove recovery program on the Juntinyuat coast dealing with coastal abrasion?
4. How is the monitoring of a stakeholder-based mangrove recovery program on the Juntinyuat coast in coastal abrasion prevention?

The objectives of the research are to understand the planning, the management strategy, the process of implementing, as well as the supervision of the stakeholder-based mangrove recovery program on the coast of Juntinyuat to cope with coastal abrasion.

Most of the mangrove ecosystem conditions along the north coast of West Java Province have been degraded or damaged, ranging from moderate to severe levels. The condition of the damaged mangrove ecosystem needs to be restored to reestablish its ecosystem function. Ecosystem degradation that is not appropriately handled causes abrasion in coastal areas. One of the coastal areas that is experiencing degradation and abrasion is the Juntinyuat coast of Indramayu Regency. Efforts to restore the mangrove ecosystem on the coast of Juntinyuat have been carried out by PT. Pertamina Gas WJA through the planting of mangrove seedlings along the coast. The effort involves various parties, including local government, related agencies and the participation of the community around the area. The outline of the research framework is shown in Figure 1.

METHODS

Study Site

This research was conducted in the coastal area of Juntinyuat, Indramayu Regency, West Java Province (**Figure 2**). The location of the research is along a stretch of coast where a mangrove ecosystem exists. All research activities were carried out from June to December 2021.

Research Methods

The research was conducted with a qualitative approach. Prastowo (2016) define qualitative methodology as a research technique that generates qualitative descriptive data in the form of written or spoken words from people and observed behavior. Furthermore, according to Lincoln in Ahmadi (2016), the word qualitative expresses an emphasis on processes and meanings that are not tested or measured precisely in quantity, amount, intensity, or frequency.

Qualitative research is carried out under natural conditions and is inventive. In qualitative research, the researcher is the key instrument. Therefore, researchers must hold broad theory and insight to ask questions, analyze and construct objects under study to be more precise. This research emphasizes more on meaning and is value bound.

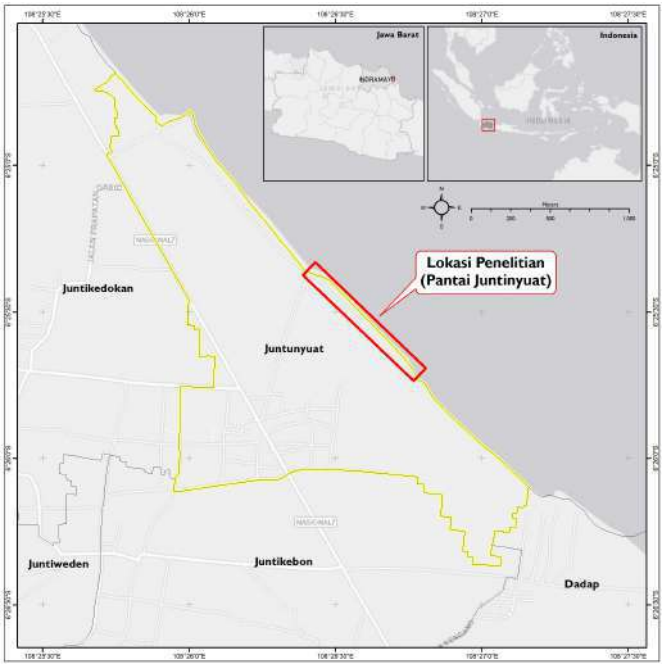

Figure 2. Location of research in the coastal area of Juntinyuat Sub-district, Indramayu, West Java.

Data Collection

Data collection techniques are the most strategic step in research because the primary purpose of a study is to obtain data. According to Sugiyono (2016), qualitative research employs at least four data collection methods: observation, interviews, documentation, and a combination of the first three.

The data collection in this study was carried out by observation, interview and documentation. Observation consisted of observing the processes that occurred during the research process to obtain more comprehensive results. Interview is a technique used to obtain the whole picture and valid results about program implementation. Interviews in this research were conducted with relevant parties involved in the program, both internally and externally. Documentation involves the documents and written information regarding the implementation of the mangrove restoration program.

Data Analysis

Data analysis was carried out after all data were collected from observations, interviews, and field documentation. Data analysis is a step taken after getting the data to organize and sort it into patterns or categories so it can be appropriately structured. Sugiyono (2016)

explains that the analysis starts by formulating and explaining the problem before going into the field and continuing until the research writing is finished. The data analysis technique used in this research is the Flow Model (Miles & Huberman, 2012), which is divided into three stages: data reduction, data presentation, and conclusion.

RESULTS

General Conditions of the Research

Juntinyuat Village has an area of 281.10 ha, which is divided into 35 neighborhood units (RT) and 5 (five) community units (RW) with a land elevation of 1 meter above sea level (m asl). Comparable to Indonesia, Juntinyuat Village has a tropical climate with an average temperature of 27° Celsius and average annual precipitation of approximately 18,517 millimeters. Land use patterns in Juntinyuat Village are characterized by rural communities that cultivate rice fields. The economic condition of the community is satisfactory. According to the profile of Juntinyuat Village, the community's occupations ranged from laborers, fishermen, and educators to private employees. The majority of the population is engaged in agriculture and entrepreneurship.

Critical Condition of the Mangrove Ecosystem

The critical condition of the mangrove ecosystem on the Juntinyuat coast can be seen from several characteristics based on the community's narrative around the area and field conditions. The critical condition characteristics of the mangrove ecosystem include the denudation of the Juntinyuat coastal land (K1), conversion of land into agricultural land (K2), a large pile of garbage on the mangrove trees (K3), and the disruption of young mangrove trees by bruising waves and human activities (K4).

The village chief of Juntinyuat explained that the mangrove ecosystem on the coast of Juntinyuat has been in poor condition since the 2000s, several areas have been damaged which may affect the occurrence of abrasion on the Juntinyuat coast. The severe damage to the mangrove ecosystem is caused by several factors such as encroachment and conversion of mangrove forests into non-forest areas such as ponds, agricultural areas, and cultivation.

Uncontrolled use is one of the factors contributing to the destruction of the mangrove ecosystem in the Juntinyuat coastal region, as the local population is highly dependent on the area. Consequently, the conversion of mangrove forests for various purposes (plantations, ponds, agricultural land, tourism, etc.) without considering the sustainability and function of the surrounding environment.

Damage to the mangrove ecosystem along the coast of Juntinyuat has led to a relatively high level of abrasion in the Juntinyuat region. This happened due to natural factors and a lack of maintenance by the communities. In the past ten years, abrasion in the Juntinyuat coastal region has obliterated nearly half of the village.

Initiation of Mangrove Ecosystem Recovery

The damage to the mangrove ecosystem and the situation of coastal abrasion, which is increasingly eroding the coastal area of Juntinyuat, encourages parties to pay more attention to the preservation of the mangrove ecosystem. The parties' involvement in preserving the mangrove ecosystem offers hope for the sustainability of the ecology around the mangrove ecosystem and improving environmental conditions.

The restoration initiatives of the mangrove ecosystem in the coastal area of Juntinyuat is one of the response from the parties in an effort to improve the environment. From the results of in-depth interviews with stakeholders and document studies, there are initiatives to restore the condition of the mangrove ecosystem on the Juntinyuat coast. The initiation began with determining an environmental policy (P1), followed by the issuance of a Decree on the Determination of Mangrove Conservation Areas (P2), and the formation of a team charged with the restoration of mangrove ecosystems along the coast of Juntinyuat (P3).

The subsequent initiation was to conduct an initial survey of the current condition of the mangrove ecosystem on the Juntinyuat coast (P4). P4 was then followed by a stakeholder meeting (P5) involving various related parties to discuss the results of the survey that had been carried out. Finally, formulate a strategic plan and work plan (P6) to restore the mangrove ecosystem on the Juntinyuat coast. As an outcome of these initiations, several parties have agreed to collaborate to restore the mangrove ecosystem (P7), in this case, PT. Pertamina Gas WJA and the Department of Forestry and Plantations (Dishutbun) of Indramayu Regency.

The Implementation of Mangrove Ecosystem Restoration

The restoration of the mangrove ecosystem in the Juntinyuat coastal area was implemented after an inventory of information, and an initial survey of the site was undertaken in mid-2014 to determine the activities to be conducted to rehabilitate the coastal border conservation area along the Juntinyuat coast. The following activities were conducted to restore the mangrove ecosystem:

a. Training community on the cultivation and utilization of mangrove fruit
b. Technical plans preparation for planting

c. Planting ceremony
d. Rehabilitation/planting of mangrove and coastal forest plant species
e. Maintaining/embroidering of mangrove and coastal forest
f. Creating bulletin/prohibition boards
g. Monitoring and evaluating the activities

The implementation of the mangrove ecosystem restoration program from 2014 to 2021 has experienced quite a lot of dynamics in the process of restoring the mangrove ecosystem (**Figure 3**). Such as a small percentage of mangrove plant growth due to many dead mangrove seedlings and uncertain natural conditions up to management changes in the company.

Figure 3. Implementation of planting with Dishutbun (Forestry and Plantation Agency) in 2014.

Monitoring and Recovery Impact

Periodic monitoring and evaluation in the Juntinyuat mangrove area is needed to determine the development or the increase in value of biodiversity contained in the area. The monitoring and evaluation activities involve creating an inventory of biodiversity including the diversity of flora, fauna and aquatic biota. In addition, the absorption value of biomass from the mangrove area was also estimated.

The purpose of the monitoring program (C1) for the restoration of the mangrove ecosystem is to determine the recovery area's condition and any issues or obstacles that could impede the restoration's implementation along the coast of Juntinyuat. One of the monitoring programs is plant maintenance activities (clearing weeds and replacing dead plants), both mangrove plants and coastal ecosystem plant species (C2). Maintenance is carried out periodically, foremost by observing the plant's growth. Plants may grow well, poorly, or even perish. Several factors cause plants to fail or even die, including poor seed origin, damaged seeds during transportation, improper planting techniques, human or animal disturbances, garbage disturbances, tidal waves, and many others (C3).

Based on the statement mentioned above, the follow-up plan as a sustainable solution step (C4) must account for the planting season, which is September to October, due to the tidal influence of seawater. Furthermore, another follow-up plan is to look for references to planting methods (C4) involving wave arresters and mangrove groups, village parties, and related institutions in the implementation program. One other possible sustainable solution related to seedlings (C4) is planting seedlings in polybags filled with soil.

The direct and indirect effects of the mangrove ecosystem restoration on the coast of Juntinyuat Indramayu can be observed from the economic, environmental, and socio-cultural aspects of the community around the area (C5). In this study, the impact is measured based on the actual effect that the community can perceive. According to Kusmana & Sukristijono (2016), local communities derive direct and indirect benefits from mangrove wood products and mangrove ecosystems by utilizing mangrove ecosystem resources. Additionally, the mangrove ecosystem has potential benefits such as coastal conservation areas and disaster mitigation.

DISCUSSION

Initiation and Planning for Ecosystem Recovery

Mangrove ecosystems are essential habitats for wildlife, most of which are waterbirds and several species of land birds. The presence of waterbirds can be seen as an indicator of biodiversity in mangrove forest areas. One of the coastal areas where the mangrove ecosystem is in poor condition is the north coast of Java Island, especially the Indramayu area, West Java. The conditions of the mangrove ecosystem in the Juntinyuat Coastal area, Indramayu, and its surroundings are critical, if no efforts are to be made to improve the mangrove ecosystem.

The research result demonstrates that implementing a program to restore the mangrove ecosystem along the coast of Juntinyuat, Indramayu, involves multiple stages

of processes and activities. The stages of processes and activities start from planning, implementing strategies, and implementing programs, until monitoring and evaluating the mangrove ecosystem restoration program on the Juntinyuat coast.

At each phase of the activity process, codes are used to summarize the implementation stages of the mangrove ecosystem recovery program (**Table 1**), as well as for its planning, organizing, and implementation activities (**Table 2**). Based on the collected data, the frequency of program implementation varies at each stage of the implementation process, ranging from once to multiple times. The frequency of implementation at this stage shows how much influence it has on the success of mangrove ecosystem restoration involving various related parties, including companies, local governments, related agencies, village governments, and community groups.

Table 1. Code of conditions/activities in the recovery of mangrove ecosystem.

Conditions /activities	Code	Information
Critical Condition	K1	Deforestation on the coast
	K2	The conversion of mangrove land into agriculture
	K3	Piles of garbage around the mangrove
	K4	Disruption of young mangroves
Planning	P1	Environmental policy
	P2	Area Determination Decree
	P3	KEHATI Team Decree
	P4	Initial survey
	P5	Stakeholder meeting
	P6	Strategic Plan & Work Plan
	P7	Cooperation of the stakeholders
Organizing	O1	Duties of HR/stakeholders
	O2	Counseling
	O3	Training
	O4	Seed management

The denudation of coastal land and the conversion of mangrove ecosystem areas into agricultural land on the Juntinyuat coast created a sense of empathy and care from various parties to improve these conditions. Additionally, the large pile of garbage in the mangrove area and the leaning of young mangroves are factors that support the efforts to restore mangrove ecosystems. The initiation was carried out by determining environmental policies, establishing mangrove ecosystem conservation areas to maintain existing mangroves, and immediately forming a team that directly handled the restoration. The critical condition of the mangrove ecosystem on the Juntinyuat coast triggered initiatives to restore the mangrove ecosystem. This context will form the relationship between K1, K2, K3, and K4 with P1, P2, and P3.

In order to understand more about the current damage to the mangrove ecosystem on the Juntinyuat coast, an initial survey was carried out at the location of the mangrove ecosystem, and then the results were discussed with the responsible parties. The follow-up of the meeting was to formulate a strategic plan by involving the parties to establish cooperation in efforts to restore the mangrove ecosystem. This concept will connect the critical conditions of mangroves (K1, K2, K3, K4) and P4, P5, P6, and P7 to the initiation and planning of mangrove ecosystem restoration.

The initiation and planning of mangrove ecosystem restoration will run better and more effectively if it is prepared with a strategy for carrying out the plans that have been made. Some of the strategic steps taken were to determine the main functions and tasks of each party involved in the restoration of the mangrove ecosystem, then provide counseling and training related to the importance of maintaining the mangrove ecosystem and how to manage seedlings properly and correctly. This concept shows a relationship between planning (P5, P6, P7) and recovery strategies (O1, O2, O3, O4).

Figure 4 below describes the connection between the critical condition of the mangrove ecosystem in the coastal area of Juntinyuat and the efforts to restore the mangrove ecosystem. Initiating mangrove ecosystem restoration from critical conditions also requires careful planning. Figure 4 also shows a link between mangrove ecosystem restoration planning and strategies carried out in the mangrove ecosystem restoration plan on the Juntinyuat coast.

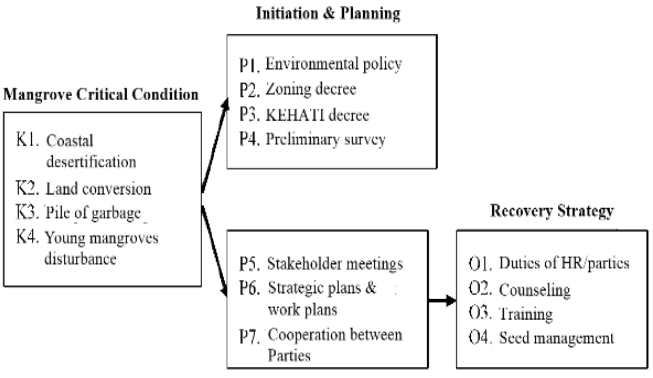

Figure 4. The connection between critical mangrove conditions, the initiation and the strategy of recovering mangrove ecosystems.

Linkage of Planning to Implementation and Successful Mangrove Recovery

Careful planning in the mangrove ecosystem restoration program is needed so that during

implementation, it can be carried out maximally to provide significant results. This program planning is complemented with a strategy to implement the mangrove ecosystem restoration program, especially on the Juntinyuat coast.

The planning stage of the mangrove ecosystem recovery program is the longest activity in the process, where many meetings were held between relevant stakeholders; this shows how vital the shared vision and mission are in the planning process toward mangrove ecosystem restoration. The involvement of various stakeholders proves that the restoration of the mangrove ecosystem cannot only be done or held responsible by one party - it is a shared responsibility among the stakeholders in protecting the environment. In addition, preliminary survey activities are an essential stage in defining the planning of mangrove ecosystem restoration programs by field conditions. The initial survey was carried out twice to ensure that the plans followed the field conditions and needs, namely on the coast of Juntinyuat.

Stakeholder involvement can be done to speed up the recovery process. The mutual management approach is based on norms, regulations, and sanctions from communities around natural resources such as mangrove ecosystems. This type of management is considered more efficient since regulations, prohibitions, and sanctions are made based on the habits and knowledge of the people around the natural resources (Kustanti, 2011; Kustanti et al., 2014). Regulations, prohibitions, and sanctions in controlling the number of beneficiaries and the number of resources allowed to be taken are considered more in favor of the physical condition of the existing natural resources and the socio-economic conditions of the people who use the natural resources. The connection between planning and implementation and the success of the mangrove ecosystem restoration can be seen on Figure 5.

"Indeed, this mangrove planting activity does not stop here, but will continue to be carried out because along this coast there is Pertagas, which is a gas pipeline asset that must be protected from the impact of shoreline erosion or abrasion in a natural way." (SL, 35 y.o)

The implementation of efforts to restore the mangrove ecosystem by planting and replanting mangrove trees in the Juntinyuat coastal area is carried out by involving the local community. In addition, the company and related agencies conduct training on mangrove cultivation and raise awareness among the public on the importance of maintaining the mangrove ecosystem. The purpose of doing this is to involve community participation to discover how to cultivate mangroves that will impact the community economically.

"Saving the fate of the coast based on planting mangrove trees is the most effective and natural way. Apart from protecting the coast, mangrove trees can also provide economic benefits for the community in the future." (ND, 37 y.o)

Table 2. Code of planning, organizing, and implementation activities.

Conditions /activities	Code	Information
Planning	P5	*Stakeholder* meeting
	P6	MoU/ Dishutbun Cooperation
	P7	Strategic Plan & Work Plan
Organizing	O1	Duties of HR/parties
	O2	Counseling
	O3	Training
	O4	Seed management
Actuating	A1	Planting
	A2	Stitching
	A3	Water breaker repair
Controlling	C1	Program monitoring
	C2	Plant maintenance
	C3	Obstacles/obstacles
	C4	Sustainable solutions
	C5	Recovery impact

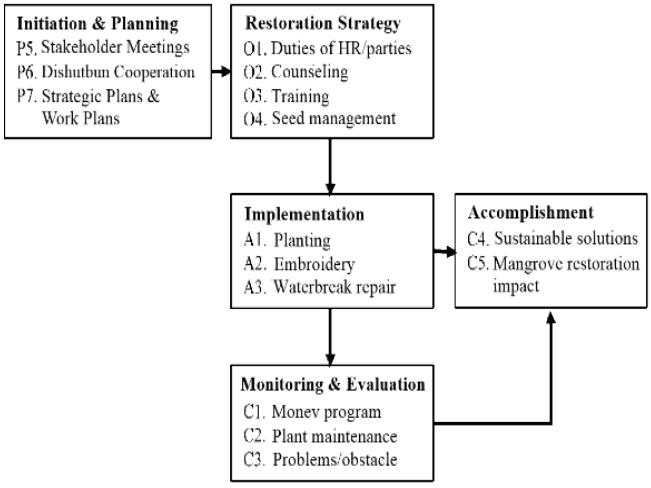

Figure 5. The connection between planning and implementation and the success of the mangrove ecosystem restoration

Ecosystem restoration efforts are required to restore damaged vegetation or ecosystem function in line with conservation area management goals. The process of ecosystem recovery, which includes natural succession, rehabilitation, and restoration, is in line with the level of damage that has been done. The success of mangrove rehabilitation activities is influenced by various factors, including the availability of healthy plant seedlings in sufficient quantities, at the right time. According to Kusmana et al. (2010), several stages of mangrove rehabilitation activities include making nurseries, planting mangroves, and monitoring and evaluating the

growth of mangrove plants. In addition, understanding autecology and hydrological patterns are also important in supporting the success of mangrove rehabilitation (Wibowo et al., 2021).

One of the impacts of the restoration of the mangrove ecosystem on the coast of Juntinyuat is the development of mangrove ecotourism. Based on the results of interviews with the Juntinyuat village government and ecotourism managers, mangrove ecotourism on the Juntinyuat coast is included in one of the Juntinyuat BUMDES (Village Owned Enterprises) in the tourism sector. Juntinyuat mangrove ecotourism is managed directly by the village and local communities. This exemplifies the strength of the direct collaboration between the government and the surrounding community in managing ecotourism. With such collaboration, the procurement of infrastructure was carried out quickly.

Mangrove ecotourism on the Juntinyuat coast is located in a strategic location, easily accessible from the main road, either by vehicle or on foot. PT. Pertamina Gas WJA also contributed to the development of mangrove ecotourism on the coast of Juntinyuat, because it has the oil pipeline that traverses the coast of Juntinyuat; consequently, a regular flow of funds from the company is used for the management of mangrove ecotourism.

Tourists have a good perception of the natural scenery around the Juntinyuat mangrove ecosystem. It is proven by the number of tourists who take pictures of the mangrove ecotourism. Because of having a good perception from tourists, ecotourism activities will not damage existing natural resources. The existence of ecotourism can increase the economy for ecotourism management and the surrounding community. Furthermore, the funds collected can be used to manage mangrove ecotourism on the Juntinyuat coast.

The development of mangrove ecotourism on the Juntinyuat coast requires support and collaborative partnership from stakeholders such as the management, village government, the private sector, and the Department of Culture and Tourism. Stakeholders have the primary task and function of achieving the goals of ecotourism development.

CONCLUSION

The planning of a stakeholder-based mangrove recovery program on the Juntinyuat coast is due to the damage level of the mangrove ecosystem, and the increasing coastal abrasion at the coastal area of Juntinyuat, which encourges involved parties to take part in the mangrove ecosystem preservation. The parties' involvement in preserving the mangrove ecosystem provides a glimpse of hope for the sustainability of the ecology around the mangrove ecosystem and improves environmental conditions.

The management strategy of a stakeholder-based mangrove recovery program on the Juntinyuat coast in combating coastal abrasion is carried out by engaging the parties to continue to be mutually responsible for the environment. Planning and strategy for mangrove ecosystem restoration must be accompanied by implementation in line with the plan and regular monitoring and evaluation.

A stakeholder-based mangrove recovery program on the Juntinyuat coast was implemented after an inventory of information, and an initial site survey was carried out in mid-2014 to determine the activities to rehabilitate the coastal border conservation area on the Juntinyuat coast. The activities to restore the mangrove ecosystem include (a) training on the cultivation and utilization of mangrove fruit, (b) preparation of technical plans for planting, (c) ceremonial planting, (d) rehabilitation /planting of mangrove species and coastal forest plant species, (e) maintaining/embroidering mangrove forest and coastal forest plants, (f) creating bulletin/prohibition boards, and (g) monitoring and evaluation programs.

The monitoring and evaluation of a stakeholder-based mangrove recovery program identified that the benefits of the existence of the mangrove ecosystem were to protect the coast from erosion and abrasion. The presence of mangroves on the coast is useful to keep the coastline stable and not eroded by waves. The success of the mangrove ecosystem restoration program on the Juntinyuat coast is inseparable from the involvement of many stakeholders. The participation of companies, local governments, and local communities is vital in establishing great collaboration among stakeholders and having their respective main tasks and functions as one of the best steps in successfully restoring the mangrove ecosystem. The mangrove ecosystem restoration in the coastal area of Juntinyuat needs to pay attention to leadership change conditions. The management of the company and the village government have all changed, but must be ensured that the mangrove areas status is not altered to for other purposes, as well as is still well-managed so that create benefits to the economy of local community, environment, and culture.

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Seawater quality and diversity of phytoplankton species in the waters of the North Coast of Jakarta

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ABSTRACT

The North Coast of Jakarta is a strategic area to support the economy of the DKI Jakarta Province and as a place to live for organisms, one of which is phytoplankton. Phytoplankton is a primary producer in aquatic ecosystems that have an essential role in maintaining aquatic ecosystems and as an indicator of water quality. This study aims to determine the quality of seawater (turbidity, TSS, BOD, Phosphate, and Nitrate) and the diversity of species (H') of phytoplankton in the waters of the North Coast of Jakarta around the reclamation islands C and D from 2006 to 2021. Types of data used in this study is secondary data from Environmental Impact Analysis (ANDAL) documents and reports on the implementation of the Environmental Management Plan and Environmental Monitoring Plan for Reclamation and Development on Islands C and D. Concentrations of turbidity, TSS, BOD, phosphate, and nitrate in coastal waters North of Jakarta around the reclamation islands C and D are fluctuation and several sampling times exceed the quality standard. The species diversity index (H') of phytoplankton in the coastal waters of North Jakarta around the reclamation islands C and D is dominantly included in the criteria for community stability in stable conditions (H > 3). Based on the partial correlation test, phosphate with the diversity of phytoplankton species in the waters of the North Coast of Jakarta around reclamation island C and D had a significant relationship (P < 0.05).

ABSTRAK

Pantai Utara Jakarta merupakan kawasan strategis untuk menunjang perekonomian Provinsi DKI Jakarta dan sebagai tempat hidup organisme salah satunya fitoplankton. Fitoplankton merupakan produsen primer di dalam ekosistem perairan yang memiliki peran penting untuk mempertahankan ekosistem perairan dan sebagai salah satu indikator kualitas perairan. Penelitian ini bertujuan untuk mengetahui kualitas air laut (kekeruhan, TSS, BOD, Fosfat dan Nitrat) dan keanekaragaman jenis (H') fitoplankton di perairan Pantai Utara Jakarta di sekitar pulau reklamasi C dan D dari tahun 2006 hingga tahun 2021. Jenis data yang digunakan dalam penelitian ini merupakan data sekunder yang bersumber dari dokumen Analisis Dampak Lingkungan (ANDAL) dan laporan pelaksanaan Rencana Pengelolaan Lingkungan Hidup dan Rencana Pemantauan Lingkungan Hidup Reklamasi dan Pembangunan di atas Pulau C dan D. Konsentrasi kekeruhan, TSS, BOD, fosfat dan nitrat di perairan Pantai Utara Jakarta sekitar pulau reklamasi C dan D yaitu fluktuatif dan terdapat beberapa waktu sampling yang melebihi baku mutu. Indeks keanekaragaman jenis (H') fitoplankton di perairan Pantaiu Utara Jakarta sekitar pulau reklamasi C dan D dominan masuk pada kriteria stabilitas komunitas dalam kondisi stabil (H > 3). Berdasarkan uji korelasi secara parsial, fosfat dengan keanekaragaman jenis fitoplankton di perairan Pantai Utara Jakarta sekitar pulau reklamasi C dan D memiliki hubungan yang signifikan (P < 0,05).

Keywords: *BOD, nitrate, North Coast of Jakarta, phosphate, phytoplankton, TSS, turbidity*

INTRODUCTION

The North Coast of Jakarta has a strategic role in the economy of the DKI Jakarta Province (Puspasari et al., 2017) and as a place to live organisms, one of which is phytoplankton. Phytoplankton is a primary producer in aquatic ecosystems that have an essential role in maintaining the health of the structure and function of aquatic ecosystems (Sulastri, 2018).

Nontji (2008) states that phytoplankton is also referred to as primary producers because they can produce organic materials from inorganic materials. The energy in phytoplankton can be channeled to various other ecosystem components through the food chain so that all ecosystem functions can occur.

Apart from being primary producers, phytoplankton is the beginning of the formation of the food chain in the waters. Phytoplankton is essential for the food chain in the ocean because it provides the most significant contribution to total primary production, determines fertility, and is an aquatic biological resource (Nugroho, 2006).

Phytoplankton is a biological parameter that can be used as an indicator to evaluate the quality and level of fertility of water. The critical role of phytoplankton as the initial binder of solar energy makes phytoplankton play an important role in aquatic life (Fachrul, 2005 in Sirait et al., 2018).

The use of phytoplankton as an indicator of the quality of the aquatic environment can be used by knowing the diversity of its species, also called species heterogeneity. A community is said to have high diversity if the abundance of each species is high, and species diversity is low if only a few species are abundant (Fachrul, 2012).

Species diversity is a parameter used in knowing a community. This parameter characterizes species richness and balance in a community. Ecosystems with low diversity are unstable and vulnerable to the influence of external pressures compared to ecosystems with high diversity (Boyd, 1999 in Pirzan et al., 2008). One of these pressures is water quality.

Water is a natural resource necessary for all living things' survival. One of the main problems related to water resources is declining water quality. Many activities cause a decrease in water quality, causing disturbance, damage, and danger to living things that depend on water resources (Effendi, 2003).

Several water quality parameters are used to see water quality following Indonesian Government Regulation Number 22 of 2021 About the Implementation of Environmental Protection and Management (Attachment VIII about Seawater Quality Standards; Marine Living Things), including turbidity, BOD, TSS, phosphate, and nitrate.

This study aims to determine seawater quality and the diversity of species (H') of phytoplankton in the waters of the North Coast of Jakarta around the reclamation islands C and D from 2006 to 2021.

METHOD

Research Time and Location

For the seawater quality and diversity of phytoplankton, this study employed secondary data from the Amdal document's laboratory tests and PT Kapuk Naga Indah's Report on implementing the Environmental Management Plan and Environmental Monitoring Plan for Island C and Island D Reclamation. The seawater quality data is from 2006 until 2021, namely before construction (pre-construction), during construction (construction), and after Island C and Island D (post-construction). Details of the secondary data used in this study can be seen in Table 1.

The research location for parameters of seawater quality and phytoplankton diversity is in the waters of the North Coast of Jakarta in the North of Penjaringan Subdistrict, North Jakarta Administration City (around the location of Island C and Island D). The seawater quality sampling points can be seen in Figures 1, Figure 2, and Figure 3.

Table 1. Sampling time for seawater quality and phytoplankton.

Pre-Construction	Construction	Post-Construction
June 2006, January 2011 and July 2011	February 2012, June 2012, June 2013, September 2013, March 2014, June 2014, December 2014, March 2015, May 2015, September 2015, November 2015, February 2016, June 2016, September 2016, December 2016, April 2017, July 2017, September 2017, December 2017, March 2018, June 2018, September 2018, January 2019, April 2019, July 2019, October 2019, January 2020, and April 2020	July 2020, October 2020, January 2021, April 2021 and June 2021

Notes: PT Kapuk Naga Indah (2007), PT Kapuk Naga Indah (2012), PT Kapuk Naga Indah (2017) and PT Kapuk Naga Indah (2020)

Data Collection Materials

The materials used in this study were water quality data, namely turbidity, TSS, Biological Oxygen Demand (BOD), phosphate, nitrate, and phytoplankton diversity collected from 2006 to 2021.

Procedure

Data on seawater quality and diversity of phytoplankton species were collected from laboratory test results in the Amdal document, and the implementation report of the Environmental Management Plan and Environmental Monitoring Plan for Island C and Island D Reclamation made by PT Kapuk Naga Indah then determined the midpoint of the island reclamation location C and D and the points of the compass directions. Furthermore, the data is grouped according to the cardinal directions, namely:

a. South side (135°-225°)
b. East side (45°-135°)
c. North Northeast side (0°-45°)
d. North Northwest side (315°-360°)
e. West side (225°-315°)

Data Analysis

a. Trend analysis by using graphs and then analyzing descriptively.
b. Comparing with the quality standards according to the Indonesian Government Regulation Number 22 of 2021 About the Implementation of Environmental Protection and Management (Attachment VIII about Seawater Quality Standards; Marine Living Things)
c. Criteria for diversity index (H')

The criteria for the Shannon-Weiner diversity index (Basmi, 1999 in Fachrul, 2012) are:

H'< 1 = Unstable biota community
1 < H' < 3 = Medium living things community stability

H'> 3 = Stability of the living things community in prime condition (stable)

d. Analysis of the correlation between seawater quality and the diversity of phytoplankton species

Analysis of the relationship between seawater quality and diversity of phytoplankton species using Multiple Linear Regression statistical analysis.

According to Uyanik and Gule (2013) in Padilah and Adam (2019), multiple linear regression is an algorithm used to explore the pattern of relationships between the dependent variable and two or more independent variables. As affirmed by Yuliara (2016), multiple linear regression is an equation that describes the relationship between two or more independent variables (X1, X2, X3 …Xn) and one dependent variable (Y). Multiple linear regression analysis aims to determine the direction of the relationship between the independent and dependent variables.

The multiple linear regression equation is mathematical as follows:

$$Y = a + b_1X_1 + b_2X_2 + \ldots + b_nX_n$$

Note:
Y= dependent variable
a = Constant
$b_1, b_2 \ldots b_n$ = Regression coefficient
$X_1, X_2 \ldots X_n$ = Independent variable

Determination of the relationship between the concentrations of seawater quality with the diversity of phytoplankton species will use the F test and t-test.

The data processing of this research begins with entering the data into excel and then analyzing using the Multiple Linear Regression method with the help of IBM SPSS Statistics 23 software.

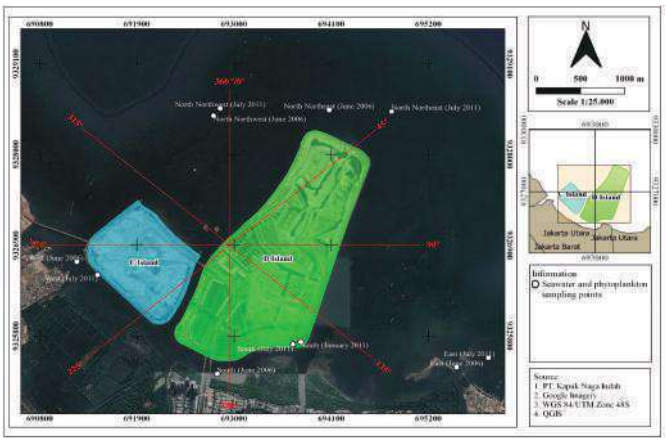

Figure 1. Seawater and phytoplankton sampling locations before construction (pre-construction) (Processed from ANDAL 2007, ANDAL 2012 and report on the implementation of RKL/RPL for reclamation island C and D, PT. Kapuk Naga Indah)

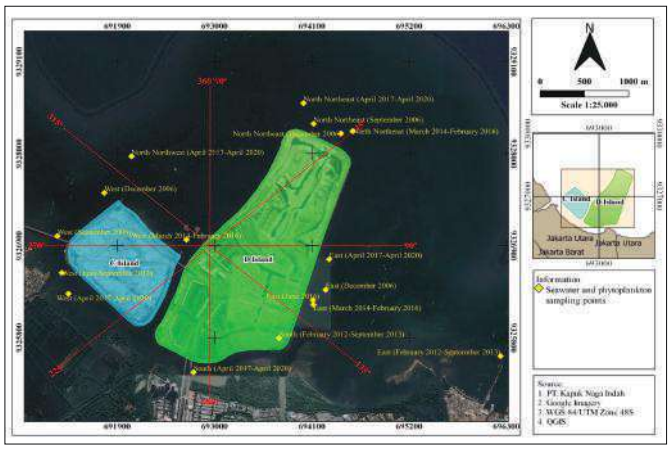

Figure 2. Location of Sampling of Seawater and Phytoplankton during Construction (Processed from Andal 2012 and Report on the Implementation of RKL RPL for Reclamation Island C and D, PT. Kapuk Naga Indah)

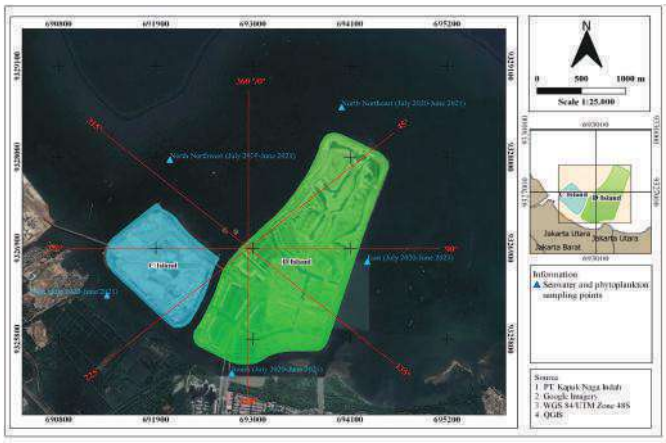

Figure 3. Seawater and Phytoplankton Sampling Locations After the Island Reclamation (Post Construction) (Processed from the Report on the Implementation of RKL RPL for Reclamation Island C and D, PT. Kapuk Naga Indah)

RESULTS AND DISCUSSION

Seawater Quality Parameters

Turbidity

The concentration of turbidity in the waters of the North Coast of Jakarta around Reclamation Islands C and D can be seen in Figure 4 and Figure 5.

Figure 4 shows that the turbidity concentration in the South, East, North Northeast, North Northwest, and West fluctuates and tends to decrease, and several samples are above the quality standard.

Based on Figure 5, the turbidity concentration in pre-construction was 1 mg/L to 30 mg/L. Most concentrations were at 2 mg/L to 9.5 mg/L and 27% above the quality standard. At the construction time, it was 0.5 mg/L to 52 mg/L; most concentrations were at 2 mg/L to 6 mg/L and 26% above the quality standard. In post-construction, the turbidity value was 0.76 mg/L (meets quality standards).

Turbidity describes the optical properties of air which are determined based on the amount of light emitted

and emitted by the materials contained in the air. Turbidity is caused by dissolved organic and inorganic materials (APHA, 1976; Davis and Cornwell, 1991 in Effendi, 2003).

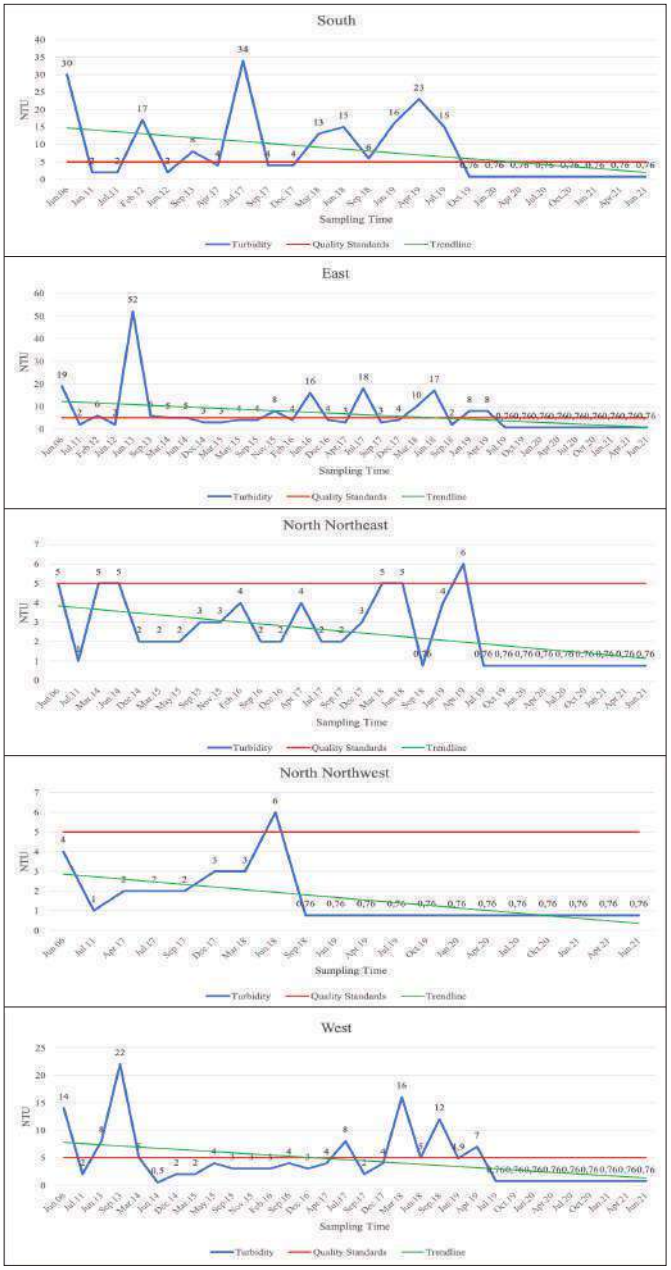

Figure 4. Concentration of Turbidity

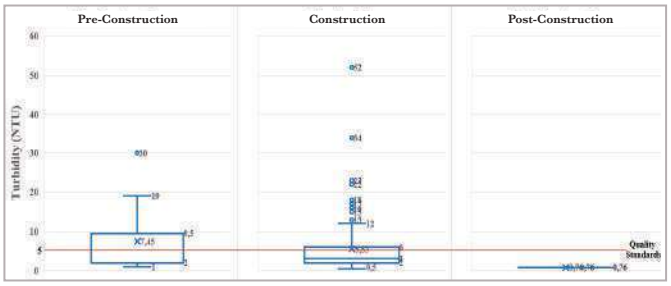

Figure 5. The concentration of Turbidity in Pre-Construction, Construction, and Post-Construction

Suspended materials can cause turbidity in the form of colloids, fine particles, and more extensive suspended materials. High turbidity can disrupt the osmoregulation system, such as respiration and the visibility of aquatic organisms, and can inhibit the penetration of light into the water (Effendi, 2003).

Total Suspended Solid (TSS)

The concentration of TSS in the waters of the North Coast of Jakarta around Reclamation Islands C and D can be seen in Figure 6 and Figure 7.

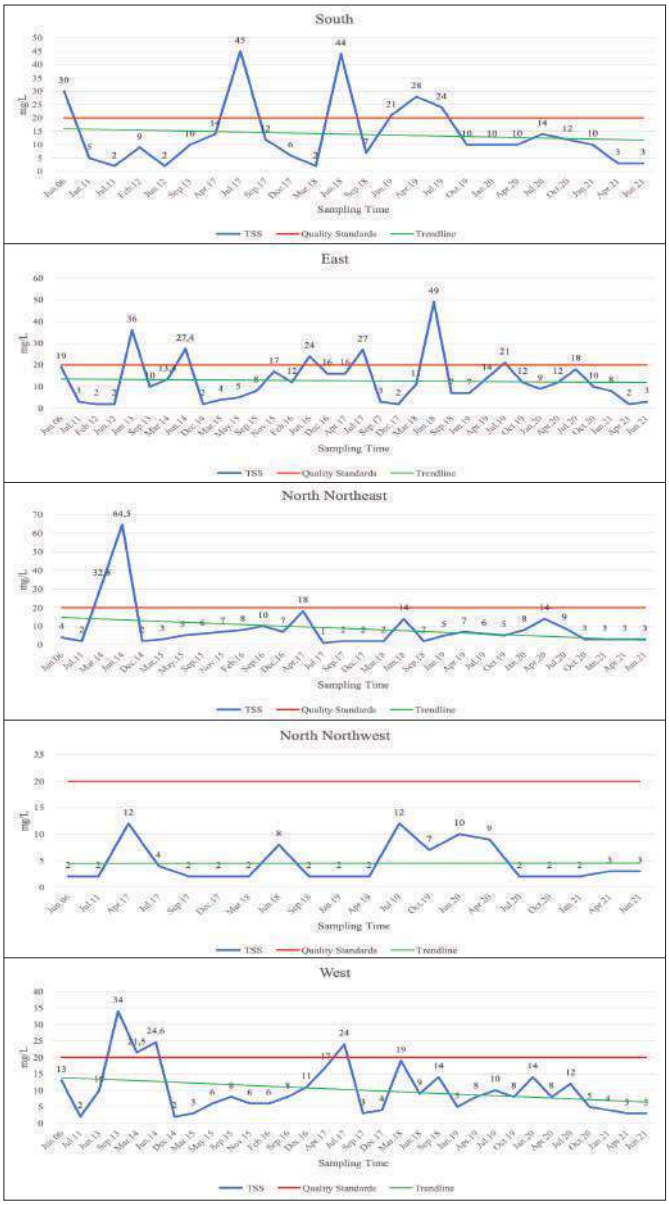

Figure 6. TSS Concentration

Figure 6 shows that the concentration of TSS in the South, East, North Northeast, and West fluctuates and tends to decrease, except for the North Northwest, which tends to be flat. Besides that, several samples are above the quality standard.

Based on Figure 7, the pre-construction TSS concentration is 2 mg/L to 30 mg/L; most TSS

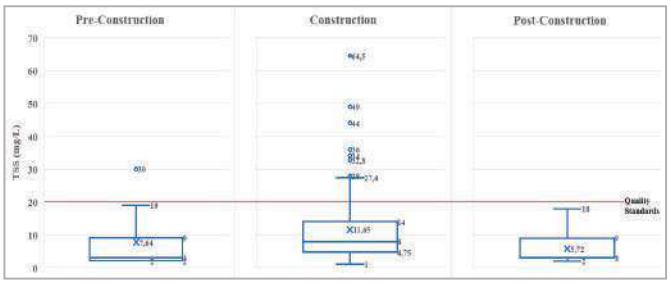

Figure 7. TSS Concentration in Pre-Construction, Construction, and Post-Construction

concentrations are at 2 mg/L to 9 mg/L and 9.1% above the quality standard. At construction time, it was 1 mg/L to 64.5 mg/L, and most TSS concentrations were at 4.75 mg/L to 14 mg/L and 16% above the quality standard. In post-construction, it is 2 mg/L to 18 mg/L (below the quality standard), and most TSS concentrations are at 3 mg/L to 9 mg/L.

The presence of suspended solids (TSS) is closely related to the brightness of the waters. The existence of TSS can block the penetration of light entering the waters (Gazali et al., 2013 in Purnamasari, 2017).

Suspended solids are positively correlated with turbidity; the higher the value of suspended solids, the higher the turbidity value. However, highly suspended solids are not always accompanied by high turbidity (Effendi, 2003).

Biochemical Oxygen Demand (BOD)

BOD levels in the waters of the North Coast of Jakarta around Reclamation Islands C and D can be seen in Figures 8 and Figure 9.

Figure 8 shows that BOD levels in the South, East, North Northeast, North Northwest, and West fluctuate and tend to decrease, and several samplings are above the quality standard.

Based on Figure 9, the pre-construction BOD levels were 1.3 mg/L to 11 mg/L, and most BOD levels were from 1.65 mg/L to 9 mg/L (below the quality standard). At the time of construction, 2 mg/L to 41.69 mg/L, most BOD levels were at 2 mg/L to 9 mg/L and 5.8% above the quality standard. In post-construction, BOD levels were at 2 mg/L (below the quality standard).

Biochemical Oxygen Demand (BOD) describes organic matter levels, namely the oxygen aerobic microbes need to oxidize organic matter into carbon dioxide and water (Davis and Cornwell, 1991 in Effendi, 2003). BOD describes organic matter that can be decomposed biologically (biodegradable) (Effendi, 2003). BOD is used as an indicator of the occurrence of pollution in waters. The high value of BOD in water indicates that the water is polluted (Agustira, 2013 Purnamasari, 2017).

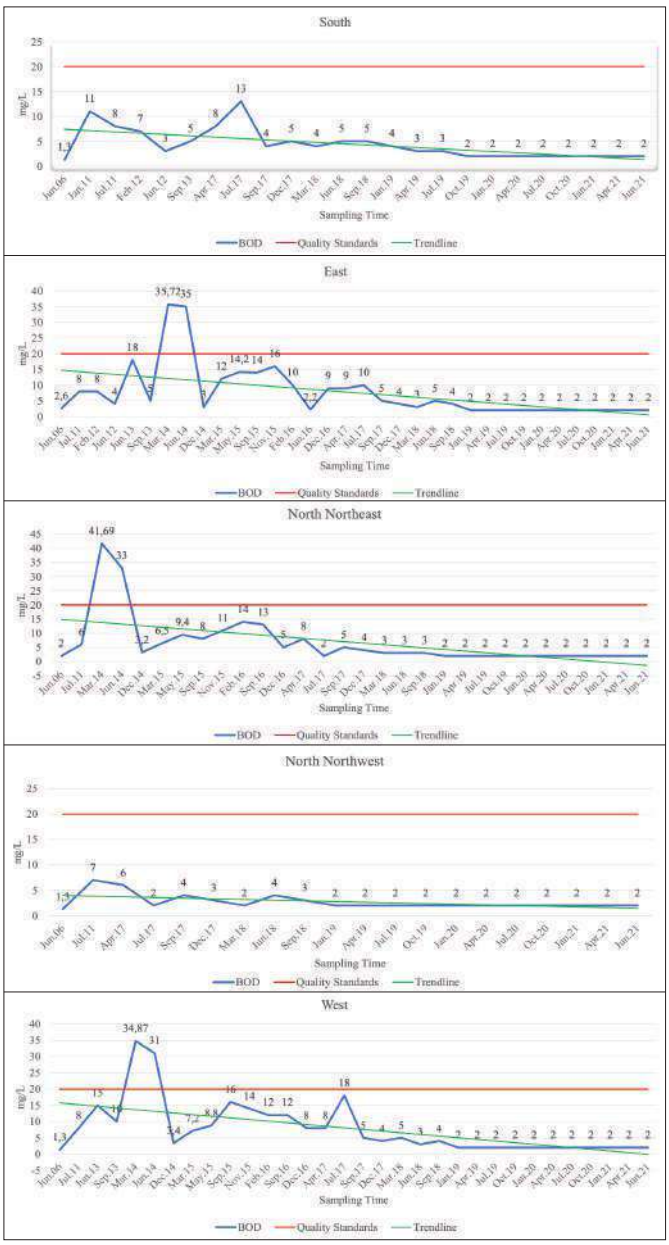

Figure 8. BOD Levels

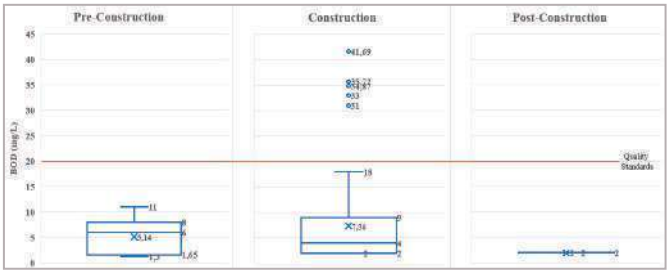

Figure 9. BOD levels in Pre-Construction, Construction, and Post-Construction

Phosphate

The concentration of phosphate in the waters of the North Coast of Jakarta around Reclamation Islands C and D can be seen in Figures 10 and Figure 11.

Figure 10 shows that the concentration of phosphate in the South, East, North East, North West, and West fluctuates and tends to decrease, and several samplings

are above the quality standard.

Figure 11 shows that the concentration of phosphate in the pre-construction is 0.01 mg/L to 0.11 mg/L; the majority of the phosphate concentration is at 0.01 mg/L and 9.1% above the quality standard. At the time of construction, namely 0.006 mg/L to 1.56 mg/L, most concentrations were at 0.011 mg/L to 0.047 mg/L and 48% above the quality standard. In post-construction, it was 0.009 mg/L to 0.011 mg/L (below the quality standard).

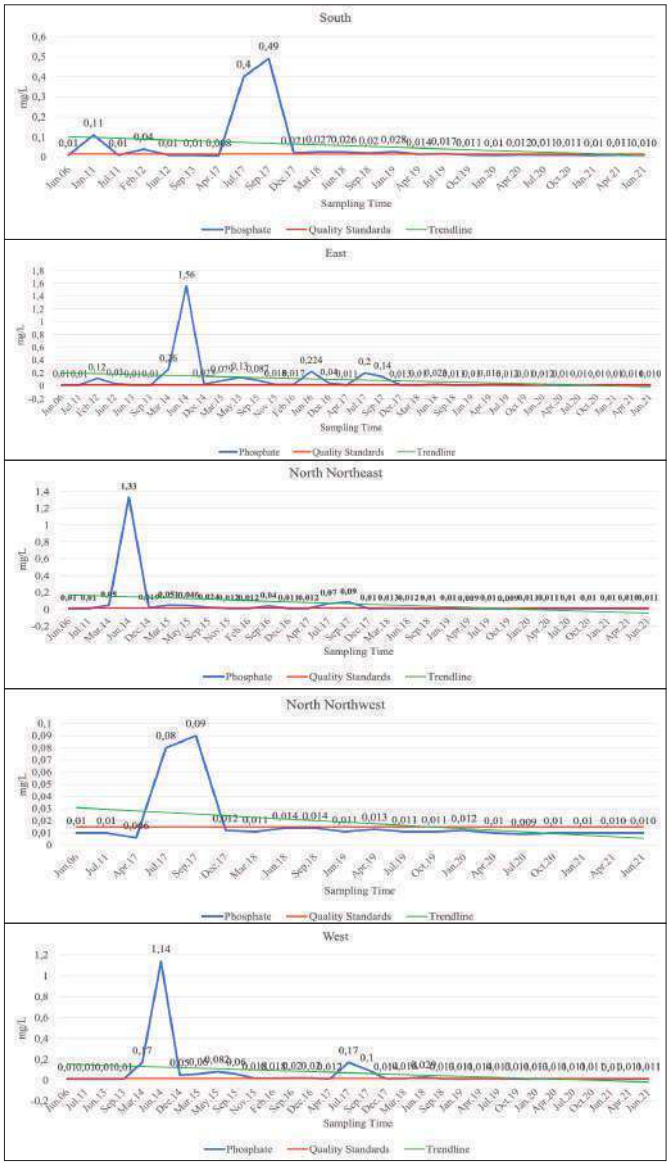

Figure 10. Phosphate concentration

The sea is an extensive body of water and can be the estuary of activities on land, such as phosphate. According to Odum (1998) in Faturohman et al. (2016), the primary source of phosphate in the sea comes from rivers, the decomposition of residual organisms, and the stirring of the seabed. A phosphate is a form of phosphorus that can be utilized by plants (Dugan, 1972 in Effendi, 2003).

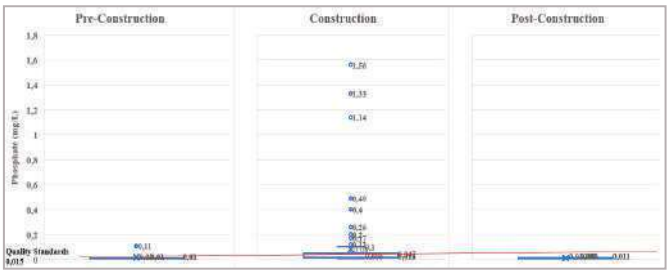

Figure 11. Phosphate Concentration in Pre-Construction, Construction, and Post-Construction

Phosphate is a nutrient needed for the process and development of phytoplankton life. These nutrients play an essential role in photosynthesis (Mustofa, 2015).

Nitrate

The concentration of nitrate in the waters of the North Coast of Jakarta around Reclamation Islands C and D can be seen in Figures 12 and Figure 13.

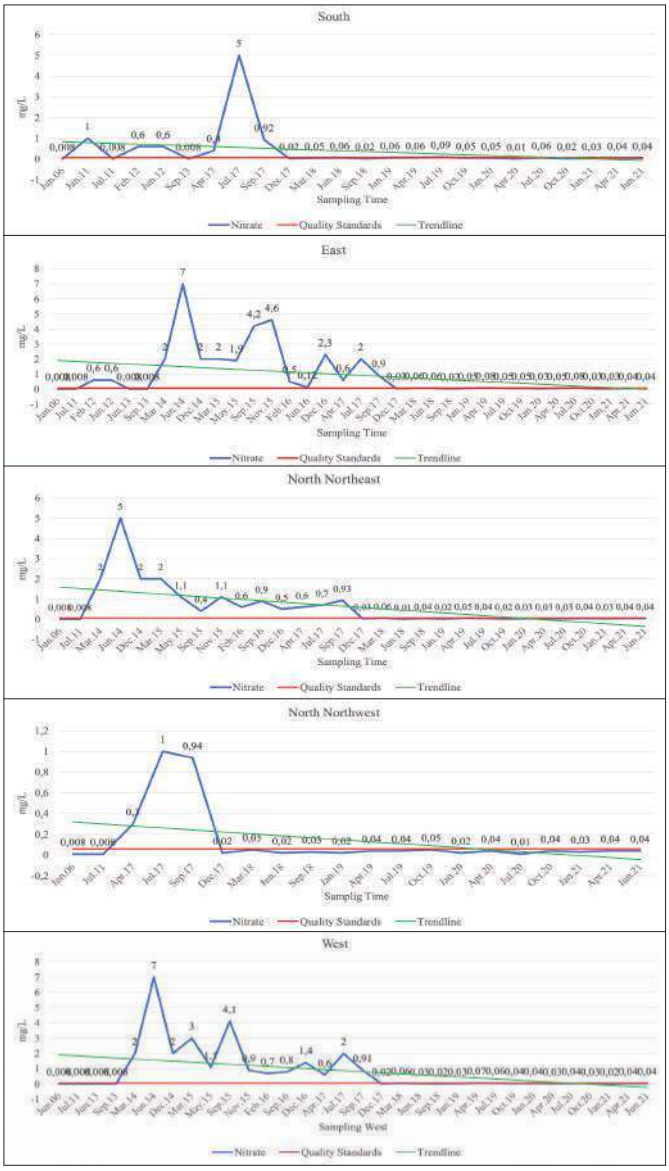

Figure 12. Nitrate concentration

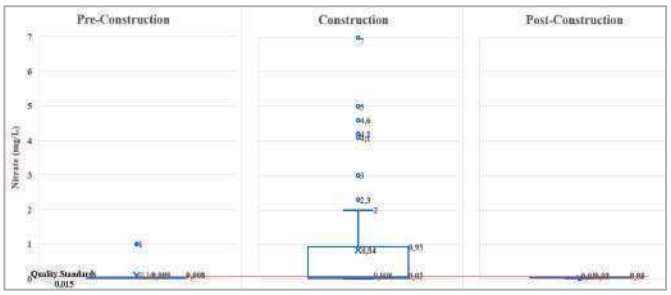

Figure 13. The concentration of nitrate in pre-construction, construction, and post-construction

Based on Figure 13, the nitrate concentration in pre-construction was 0.008 mg/L to 1 mg/L; most of the nitrate concentration was 0.008 mg/L and 9.1% above the quality standard. At the time of construction, namely 0.008 mg/L to 7 mg/L, most concentrations were at 0.03 mg/L to 0.94 mg/L and 50% above the quality standard. In post-construction, namely 0.01 mg/L to 0.08 mg/L, the majority of concentrations were at 0.03 mg/L to 0.04 mg/L and 4% above the quality standard.

Nitrate comes from ammonium that enters water bodies mainly through domestic waste (Mustofa, 2015). Nitrates are essential nutrients for plants. Excess nitrate will accelerate eutrophication and cause an increase in the growth of aquatic plants. It affects dissolved oxygen levels, temperature, and other parameters (Irwan et al., 2017; Patricia et al., 2018).

Sources of nitrate can be sourced from activities on land or sea coast which then flows into the sea (Odum, 1998) in Faturohman et al., 2016) stated that dissolved nitrate is a supply from the mainland through rivers.

Diversity of Phytoplankton Species

The results of phytoplankton research conducted from 2006 to 2021 around Reclamation Islands C and D recorded as many as 190 species. In comparison, the number of phytoplankton types based on the observation locations, namely South, East, North Northeast, North Northwest, and West in pre-construction, construction, and post-construction, can be seen in Figure 14.

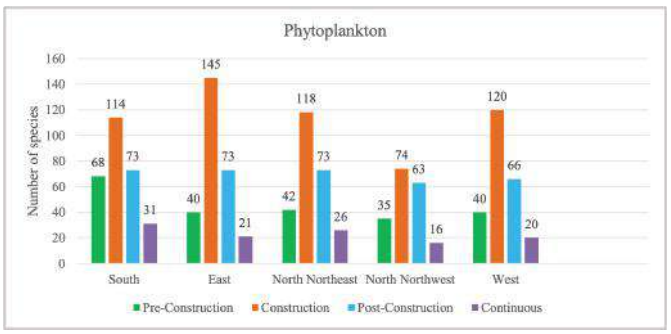

Figure 14. Number of phytoplankton species

Figure 14 shows that the number of phytoplankton species in the South in pre-construction, during construction, and post-construction recorded 68, 114, and 73 species, respectively, and continuous 31 species. In the East, pre-construction, during-construction, and post-construction recorded 40, 145, and 73 species, respectively, and a continuous 21 species. In the North Northeast at pre-construction, during construction, and post-construction recorded, 42, 118, and 73 species, respectively, and continuous 26 species. In the North Northwest at pre-construction, during construction, and post-construction recorded, 35, 74, 63 species, and 16 species of continuous. In the West, at the pre-, during- and post-construction recorded 40, 120, 66 species, and continuous 20 species.

Several species of continuous phytoplankton recorded from pre-construction, construction, and post-construction (after the reclamation of islands C and D) can be seen in Table 2.

As in Table 2, the number of continuous phytoplankton species based on the observation locations was 43. Moreover, the number of continuous species in all observation locations was six, namely *Chaetoceros affine*, *Coscinodiscus asteromphalus*, *Coscinodiscus sp6*, *Navicula sp1*, *Pleurosigma normanii*, and *Rhizosolenia calcar-avis*. The number of continuous species in all the observation locations is 3.2% of the total number of species.

Odum (1996) in Nento et al. (2013) stated that diversity is identical to an ecosystem; if an ecosystem's diversity is relatively high, the condition of the ecosystem tends to be stable. Diversity includes two main things: variations in the number of species and the number of individuals in an area. According to Sugianto (1994), a community has high species diversity if the community is composed of many species with the same or almost the same species abundance.

The species diversity index (H') of phytoplankton at pre-construction, during construction, and post-construction on the North Coast of Jakarta around the reclamation islands (Islands C and D) can be seen in Figure 15.

Figure 15 shows that the pre-construction phytoplankton diversity index is 0.31 to 4.17, and most of the diversity index is from 0.55 to 3.9. At the time of construction, 0.88 to 5.09, and the majority of the diversity index was at 3.55 to 4.59. Post-construction is 2.24 to 4.62, with the majority diversity index at 3.4 to 4.12.

The species diversity index (H') of phytoplankton in the five locations from 2006 to 2021 was dominantly included in the criteria for community stability in stable conditions ($H > 3$). The diversity index (H') included in the unstable biota community ($H' < 1$) is South, North Northeast, North Northwest, and West in June 2006 and at the East point in June 2006 and June 2016.

Table 2. Species of phytoplankton recorded from pre-cnstruction to post-construction

No	Species	South	East	North Northeast	North Northwest	West
1	*Amphiprora* sp.		√	√		
2	*Biddulphia mobiliensis*	√				
3	*Biddulphia sinensis*	√		√	√	√
4	*Chaetoceros affine*	√	√	√	√	√
5	*Chaetoceros curviselum*	√	√	√	√	
6	*Chaetoceros lorenzianum*		√	√		
7	*Chaetoceros pseudocurvisetum*		√	√		√
8	*Chaetoceros* sp1	√	√			√
9	*Chaetoceros* sp2	√	√	√		√
10	*Coscinodiscus asteromphalus*	√	√	√	√	√
11	*Coscinodiscus* sp6	√	√	√	√	√
12	*Euglena* sp*1*	√				
13	*Guinardia flaccida*	√	√		√	√
14	*Hemiaulus*			√		
15	*Lauderia borealis*	√		√		√
16	*Melosira* sp			√	√	√
17	*Navicula* sp1	√	√	√	√	√
18	*Navicula* sp5	√				
19	*Nitzschia longissima*	√		√	√	
20	*Nitzschia sigma*	√		√	√	√
21	*Oscillatoria* sp1	√	√	√		√
22	*Oscillatoria* sp2	√	√			
23	*Pediastrum duplex*	√				
24	*Pediastrum simplex*	√				
25	*Pediastrum* sp3	√	√			
26	*Phacus* sp		√			
27	*Pleurosigma compactum*	√				
28	*Pleurosigma elongatum*	√		√	√	√
29	*Pleurosigma normanii*	√	√	√	√	√
30	*Rhizosolenia acuminata*	√		√		√
31	*Rhizosolenia alata*		√	√	√	√
32	*Rhizosolenia calcar-avis*	√	√	√	√	√
33	*Rhizosolenia setigera*	√		√	√	
34	*Rhizosolenia* sp7			√		
35	*Rhizosolenia stolterfothii*		√	√	√	
36	*Rhizosolenia styliformis*					√
37	*Scenedesmus acuminatus*	√				
38	*Scenedesmus dimorphus*	√	√			
39	*Stephanopyxis* sp3			√		
40	*Streptotheca thamensis*	√				
41	*Thalassionema nitzschiodes*	√				
42	*Thalassiosira* sp		√			
43	*Thalassiothrix frauenfeldii*	√		√		√
	Number of Species	31	21	26	16	20

Meanwhile, the criteria for the stability of the moderate living things community (1 < H' < 3) are the South (March 2018 and January 2020), the East (June 2014, March 2018, January 2020, and June 2021), the North Northeast (July 2011, March 2018 and January 2020), North Northwest (March 2018, January 2020 and April 2021), and the West (July 2017, March 2018, January 2020, April 2021 and June 2021) (**Figure 16**).

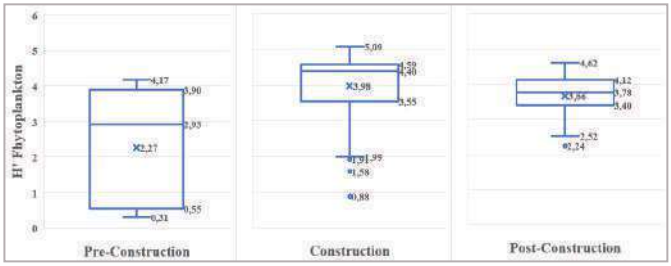

Figure 15. Phytoplankton species diversity index in pre-construction, construction and post-construction

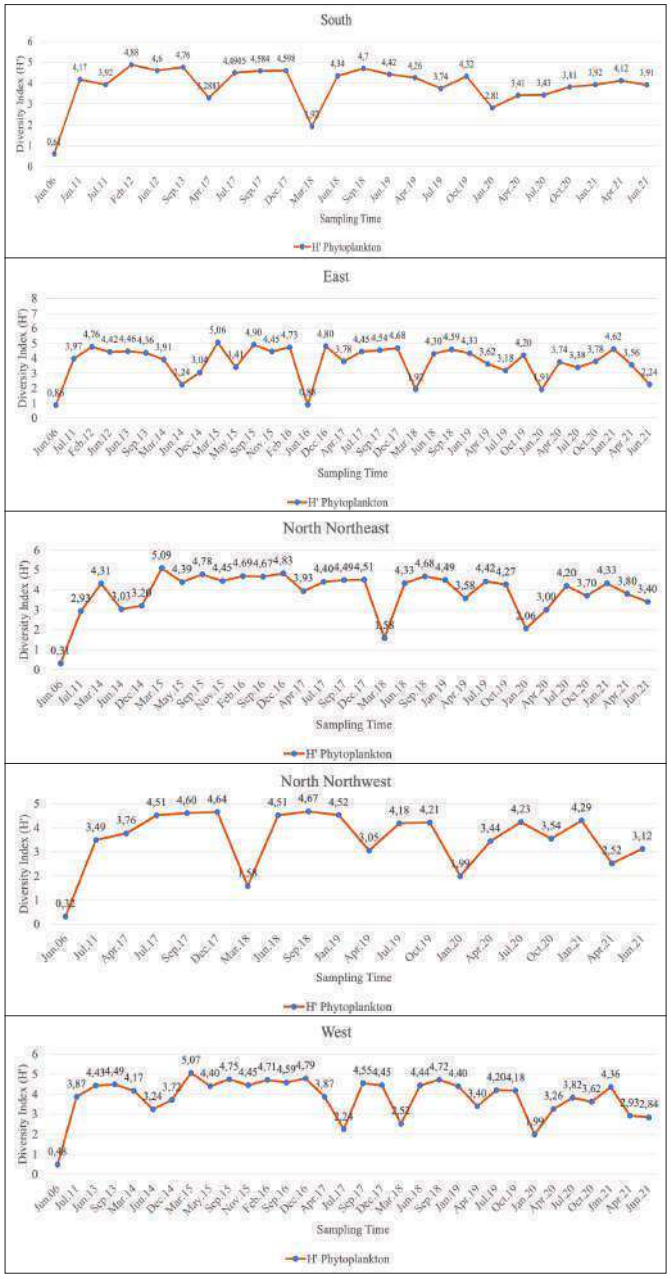

Figure 16. Phytoplankton species diversity index

Correlation between Seawater Quality Parameters and Phytoplankton Diversity

The correlation test results simultaneously showed the relationship between seawater quality and phytoplankton species diversity, as seen in Table 3.

Based on the results of the simultaneous correlation test (**Table 3**) show that there is a significant relationship between seawater quality and the diversity of phytoplankton species (F_{count} 3,586 > F_{table} 2.28 and a significant value of 0.004 < 0.05). However, the relationship is not strong (r value of 0.34). A partial relationship between seawater quality and phytoplankton species diversity can be seen in Table 4 and Figure 17.

Table 3. F test of seawater quality parameters and diversity of phytoplankton.

ANOVA[a]

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	18.258	5	3.652	3.586	.004[b]
Residual	136.451	134	1.018		
Total	154.709	139			

Notes:
a. Dependent Variable: H' Phytoplankton
b. Predictors: (Constant), Nitrate, Turbidity, TSS, BOD, Phosphate

Table 4. Seawater quality parameters t-test and diversity of phytoplankton.

Coefficients

Model	Unstandardized Coefficients		Standardize Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	3.682	.132		27.901	.000
Turbidity	-.018	.016	-.117	-1.081	.282
TSS	-.002	.013	-.023	-.188	.851
BOD	.034	.017	.236	1.943	.054
Phosphate	-2.265	.696	-.435	-3.253	.001
Nitrate	.231	.117	.277	1.969	.051

Notes:
a. Dependent Variable: H' Phytoplankton

The results of the partial correlation test (**Table 4** and **Figure 17**) show that phosphate with phytoplankton species diversity has a significant relationship (t_{count} > t_{table} 1.97783 and significant value <0.05). Phosphate with the diversity of phytoplankton species has a negative relationship, which means that the higher the phosphate, the lower the diversity of phytoplankton species.

Phosphate content will affect the growth of algae and aquatic plants. An increase in phosphorus content will increase the growth of algae and aquatic plants so that if the growth is too significant, it will create algae bloom and can result in the death of other aquatic organisms in

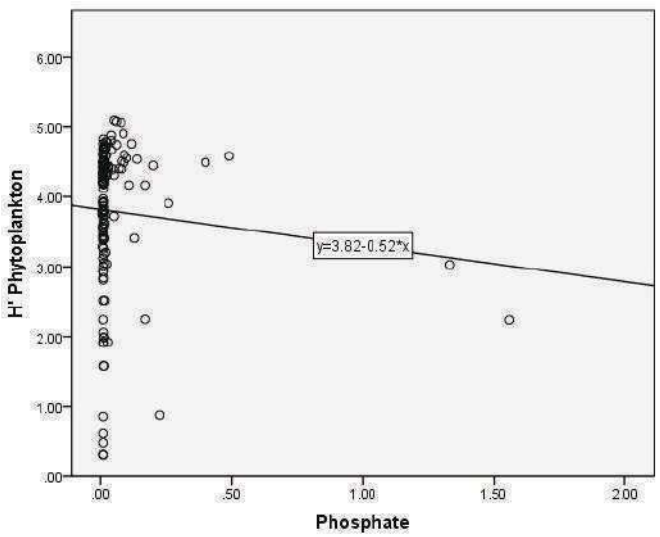

Figure 17. Correlation between phosphate and phytoplankton diversity

the environment (Erina, 2006 in Ikhsan et al., 2020). Therefore, certain species may be more dominant, harming the life of phytoplankton species.

METHOD

Concentrations of turbidity, TSS, BOD, phosphate, and nitrate in the waters of the North Coast of Jakarta around the reclamation islands C and D are fluctuating, and several sampling times exceed the quality standard.

The species diversity index (H') of phytoplankton in the waters of North Jakarta, around the reclamation islands C and D from 2006 to 2021, was dominantly included in the criteria for community stability in stable conditions (H' > 3).

There is a significant and negative relationship between phosphate and the diversity of phytoplankton species in the waters of the North Coast of Jakarta around Reclamation Islands C and D.

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The impact of conservation partnership on increasing community welfare at the Gunung Masigit Kareumbi Hunting Park (GMKHP)

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ABSTRACT

In conservation areas throughout Indonesia, there are at least 1.8 million hectares of open land in the form of damaged or degraded ecosystems following encroachment on conservation areas by local communities. Addressing this, the government of Indonesia has introduced a conservation partnership policy issued in 2018, namely the Director General of KSDAE Regulation No. P.6/KSDAE/SET/Kum.1/6/2018 concerning Technical Guidelines for Conservation Partnerships in Nature Reserves and Nature Conservation Areas. The objective of this study was to identify and analyze the impact of conservation partnerships on improving the welfare of the community in the Gunung Masigit Kareumbi Hunting Park (GMKHP). The research was conducted within the GMKHP area, with the samples taken from the community of Forest Farmer Groups (KTH) in the villages of Pelita Asih, Jaya Mekar, Sunda Mekar, Cikadu, Sukajaya, and Kaduwulung. The approach used in this study is qualitative. Data were collected by questionnaire survey, interviews, observations, and documentation in the field. Based on the results of the study, it is known that the production of pine resin tapping carried out by KTH members is as much as 29,033 kg/month or an average of 323 kg/person per month. This activity has an impact on increasing the income of KTH members by 170%, i.e. from their initial average income of Rp. 853,778 per month to become Rp. 2,307,278/month for each member. Additionally, there are also contributing funds to the neighborhood and social welfare coordinated by cooperatives, such as assistance for the poor and orphans, village treasury income, BUMDes (Village Enterprise) capital, wages for reading Qoran teachers, mosque maintenance, etc.

ABSTRAK

Di kawasan konservasi di seluruh Indonesia, setidaknya terdapat 1,8 juta hektar lahan terbuka berupa ekosistem yang rusak atau terdegradasi akibat perambahan kawasan konservasi oleh masyarakat setempat. Menyikapi hal tersebut, pemerintah Indonesia telah mengeluarkan kebijakan kemitraan konservasi yang dikeluarkan pada tahun 2018, yaitu Peraturan Dirjen KSDAE No. P.6/KSDAE/SET/Kum.1/6/2018 tentang Pedoman Teknis Kemitraan Konservasi di Cagar Alam dan Kawasan Konservasi Alam. Penelitian ini bertujuan untuk mengidentifikasi dan menganalisis dampak kemitraan konservasi terhadap peningkatan kesejahteraan masyarakat di kawasan Taman Buru Gunung Masigit Kareumbi (GMKHP). Penelitian dilakukan di dalam kawasan GMKHP, dengan sampel masyarakat Kelompok Tani Hutan (KTH) di Desa Pelita Asih, Jaya Mekar, Sunda Mekar, Cikadu, Sukajaya, dan Kaduwulung. Pendekatan yang digunakan dalam penelitian ini adalah kualitatif. Pengumpulan data dilakukan dengan survei kuesioner, wawancara, observasi, dan dokumentasi di lapangan. Berdasarkan hasil penelitian diketahui bahwa produksi penyadapan getah pinus yang dilakukan oleh anggota KTH sebanyak 29.033 kg/bulan atau rata-rata 323 kg/orang per bulan. Kegiatan ini berdampak pada peningkatan pendapatan anggota KTH sebesar 170%, yaitu dari pendapatan rata-rata awal mereka sebesar Rp. 853.778 per bulan menjadi Rp. 2.307.278/bulan untuk setiap anggota. Selain itu, juga ada kontribusi dana untuk kesejahteraan lingkungan sekitar dan sosial yang dikoordinasikan oleh koperasi, seperti bantuan untuk fakir miskin dan anak yatim, pendapatan kas desa, modal BUMDes (Badan Usaha Milik Desa), upah guru membaca Al-Qur'an, pemeliharaan masjid, dll.

Keywords: *conservation partnership, granting access, hunting park, income, pine tree resin*

INTRODUCTION

Historically, there has been a very high dependence of most Indonesians on the surrounding forests. Thus, the management of forest areas cannot be separated from their livelihoods (Pramesti et al., 2020). Economic development is crucial to improving the livelihood of the local communities around the park area (Panderi et al., 2022), so that the surrounding communities can support the preservation of conservation areas.

Gunung Masigit Kareumbi Hunting Park (GMKHP) was gazetted as a hunting park by the Decree of Ministry of Agriculture No. 29/Kpts/Um/5/1976 on May 15, 1976. Then, it was designated as a hunting park through the Decree of the Minister of Forestry No. 298/Kpts-II/98 on 27 February 1998 covering an area of 12,420.70 hectares. It is located in three regencies, namely Bandung Regency, Sumedang Regency, and

Garut Regency. Most of the area is in Sumedang and Garut. The area is a conservation forest that is designated for tourism forest, but it can also be used for hunting activities while still paying attention to the local community's welfare.

Government Regulation (PP) No. 108/2015 concerning Amendments to PP No. 28/2011 concerning Management of Nature Reserve Areas (KSA) and Nature Conservation Areas (KPA) mandates that the government, provincial governments, and district/city governments must empower communities around KSA and KPA to improve their welfare. The empowerment of the community is carried out, among others, through the provision of access to traditional uses in traditional KPA zones/blocks and capacity building. Furthermore, referring to the provisions of Ministry of Environment and Forestry Regulation No. P.43/Menlhk/Setjen/Kum.1/6/2017 concerning Community Empowerment Around KSA and KPA, it is explained that the granting of access to traditional uses includes collection of non-timber forest products (NTFPs), limited traditional cultivation, traditional hunting is limited to unprotected species, and limited use of aquatic resources to unprotected species.

Access to these traditional uses is given to communities/villages around the conservation area (buffer zone) whose historically their livelihoods are highly dependent on the traditional resource zones/blocks of conservation areas. More detailed arrangements regarding the management of conservation partnerships in KSA and KPA areas are regulated in the Regulation of the Director General of Natural Resources and Ecosystem Conservation (KSDAE) number: P.6/KSDAE/SET/Kum.1/6/2018. However, it is necessary to know the knowledge and understanding of the community about the conservation area before the partnership is implemented so that the relationship and communication between the conservation area manager and the community can be managed properly (Priatna et al. (2022). Regulation of the Director General of KSDAE Number: P.2/KSDAE/SET/Kum.1/2/2019 concerning Amendments to the Regulation of the Director General of KSDAE No. P.6/KSDAE/SET/Kum.1/6/2018 concerning Technical Guidelines for Conservation Partnerships in Nature Reserve Areas and Nature Conservation Areas. According to Rochaedi et al. (2021), the conservation partnership programme is a new policy from the Indonesia's Ministry of Environment and Forestry which aims to reduce conflicts due to forest land use in conservation areas in the country.

Since the introduction of granting access to traditional zones/blocks policy in 2015 to 2020, there have been ± 230,977.87 hectares of conservation areas that granted to the community. The granting access was done through a cooperation agreement scheme between management units at the site level and community groups. There are at least 10,857 the community involved in this scheme.

Since 2018 there have been 11 Forest Farmer Groups (KTH) from 8 villages domiciled around GMKHP. It spread over 2 (two) regencies and 5 (five) sub-districts, namely in Sumedang Regency (South Sumedang, Situraja, Cisitu, and Cibugel Sub-districts) and Garut (Selaawi Sub-district). The KTH have been given access to collect pine resin from within the GMKHP area, as a community empowerment programme carried out by the management of GMKHP (Zulvianita, 2019). Of course, the granting of access for pine tree sap collection above will have an impact on the welfare of the people involved.

The objective of this study to determine and analyze how far the impact of conservation partnerships is on increasing pine resin production in the GMKHP area. The study also assesses whether farmers who are members of KTH and have cooperation agreement on pine resin collection have experienced an increase in income.

METHODS

The research was carried out at the Gunung Masigit Kareumbi Hunting Park (GMKHP), East and West Kareumbi Resort Work Area, Bandung Region III Conservation Section, Regional II Soreang Conservation Division, Natural Resources Conservation Agency of West Java (BBKSDA Jawa Barat, 2013). The research assessed the Forest Farmer Groups (KTH) which already has a conservation partnership with the BBKSDA Jawa Barat (2017) covering Sunda Mekar Village (Cisitu Sub-district), Jaya Mekar Village (Cibugel Sub-district), Cikadu and Kaduwulung Villages (Situraja Sub-district) in Bandung Regency, as well as Sukajaya Village (South Sumedang Sub-district) in Sumedang Regency, and Pelita Asih Village (Selaawi Sub-district) in Garut Regency (**Figure 1**). The study was conducted from February to May 2021.

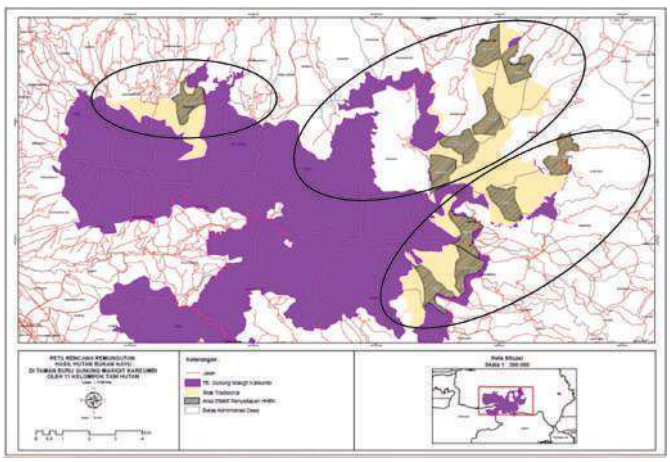

Figure 1. Distribution of research sites in the villages within GMKHP in Bandung, Sumedang, and Garut Regencies, West Java.

Data Collection

The sampling technique used was cluster sampling and purposive sampling. Cluster sampling is used when the elements of the population are geographically dispersed, making it difficult to construct a sampling frame (Kuncoro, 2013). The respondent's determination technique uses purposive sampling (purposed sample). This technique is a deliberate sampling in accordance with the required sample requirements, for example related to properties, characteristics, criteria, and so on. Respondents in the study were Forest Farmer Groups (KTH) members who already had agreement on harvesting pine resin NTFPs. The number of respondents for each cluster is thirty people so that the total number of respondents from KTH members is ninety people. To strengthen the results, interviews were conducted. An interview is a conversation with a specific purpose carried out by two parties, namely the interviewer who asks the question and the interviewee who provides the answer to the question (Moleong, 2010).

In this study, researchers used semi-structured interviews. This type of interview requires the interviewer to make a framework and outline the formulated points that do not need to be questioned sequentially (Moleong, 2010). Researchers used semi-structured interviews (in-depth interviews) using an interview guide that was principally then questions were developed along or while asking after the informant answered. This technique will give an interactive interview took place between the researcher and the informant. Interviews were conducted while being recorded so that the data obtained could be reconfirmed. In the interview technique, the researcher comes and deals directly with the respondent, or the subject being studied. Respondents interviewed in this study were directly involved in the implementation of conservation partnerships, including Section Heads, Resort Heads, Village Heads, Group Chairpersons of Cooperatives and KTH Members representing each research cluster.

Data Analysis

According to Sugiyono (2010), data analysis procedure techniques is a process of finding data, systematically compiling data obtained from interviews, field notes, and documentation, by organizing data into categories, breaking down into units, conducting synthesis, compiling into a pattern choosing which ones are important and which will be studied, and making conclusions so that they are easily understood by themselves and others. The data analysis used in this research is inductive data analysis. Inductive data analysis is drawing conclusions that depart from specific facts, to then draw general conclusions.

The steps of data analysis in this study are data collection such as searching, recording, and collecting everything objectively and as it is in accordance with the results of observations and interviews in the field, namely recording data and various forms of data that exist in the field and data reduction. Sugiyono (2010) explains that reducing data means summarizing, choosing the main data, focusing on the important data, looking for themes and patterns and removing unnecessary things. Data display according to Amailes & Huberman (in Sugiyono, 2010) is the most frequently used to present data in qualitative research is by text and narrative and conclusion and verification Sugiyono (2010).

Data Validity Check

A data is valid if it has four criteria as stated by Moleong (2010), namely credibility, transferability, dependability, and confirmability. In this qualitative research, the researchers use triangulation to check the validity of the data/test the credibility of the data. After the researchers got the data, whether it was interview data, documentation data, or observation data, they triangulated sources. Threangulate data is work by comparing data obtained through interviews with informants. We compare interview data between informants with one another and compare the interview data with the documentation that has been collected.

RESULTS AND DISCUSSION

The granting of access to NTFP collection for pine resin provided by the West Java's Natural Resources Conservation Agency (BBKSDA Jawa Barat) to the Forest Farmer Groups (KTH). The lisence is in the form of a conservation partnership cooperation. It is a formal legal access that provides legal certainty of the right to collect pine resin (NTFPs) for local communities within the traditional block of the GMKHP area. Especially, it will provide certainty of area they work on. The development of conservation partnerships between the Technical Implementation Units of the Ministry of Environment and Forestry and the community is carried out through a bottom-up, persuasive and collaborative approach (Rochaedi et al., 2021)

Impact on Pine Tree Sap Productions

The conservation partnership in the area has emerging pine sap production activities by the Forest Farmer Groups (KTH) members who collect pine resin. The members of the KTH under the legal umbrella of cooperation get certainty in cultivating the land that has been determined by each KTH chairman. The granting of access to KTH will certainly have an impact on pine resin production. Prior to the conservation partnership, pine resin tapping was never taken. Even if it was taken by the community, it was taken secretly from the hunting

park management because they realized that the activity of tapping pine resin was illegal.

In Figure 2, there are 8 percent of respondents from the KTH members carried out pine resin collection activities prior to the conservation partnership, while 92 percent of respondents from the KTH members stated that they had not tapped prior to the conservation partnership. Judging from the history of its management, the activities of collecting pine resin in GMKHP have gone through a long journey. The area previously managed by the West Java Forestry Service, Perum Perhutani and now by the West Java's BBKSDA Agency.

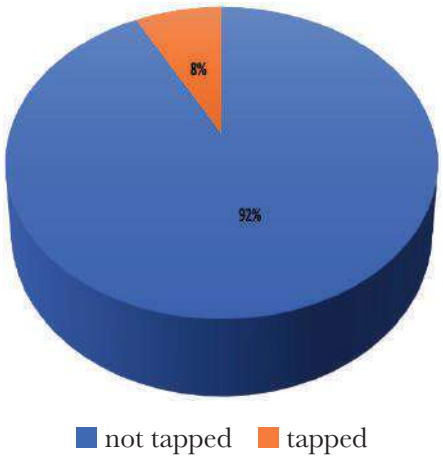

Figure 2. Percentage of community members who have tapped (orange) and have not tapped pine (blue) resin prior to the existence of the conservation partnership programme (Source: Primary data analyzed in 2021).

The collection of pine resin carried out by the KTH used the quarre method. Soetomo (in Huda, 2011) and Lempang (2018), stated that there are three tapping systems used in tapping pine resin: 1. The quarre system; 2. Drill system; 3. American system (ritser system). This quarre system originates from France and is the simplest method of tapping among other systems (Wibowo, 2006). According to Perangin-angin (2014), so far the quarre method or known as the *koakan* method is the most used for pine resin tapping (**Figure 3**). The advantages of this method are that it is easy and inexpensive to implement.

Tapping the sap begins with cleaning the bark of the tree trunk that will be tapped, followed by a "quarre" activity with a tool called a "koak/kadukul". The bark of the pine tree is scraped off gradually until the sap drips, the size of the scraps is quite diverse, the average size is ± 10 cm wide, 20-30 cm high and about 1-6 cm deep. The sap that comes out is channeled through the gutters. The installation of the gutters is attached to the bottom edge of the koakan and nailed on both sides. The gutter measures 10 cm x 5 cm with a curved shape made of zinc to help drain the sap into small coconut shells to accommodate the pine resin. Koakan renewal is done every 3 days once the length of the koakan is 3 cm. Pine sap collection under normal conditions is carried out twice a month. Coconut shells/shells containing pine resin are put in a plastic bucket container to be collected at the Gum Shelter in each KTH.

Pine sap production is influenced by several factors, including tree type, tree diameter, age of the stand, number of coaxes and place of growth. According to Hutabalian et al. (2015), the larger the diameter, the greater the production of latex produced. On the contrary, the smaller the diameter, the less production of latex is produced (Mampi et al., 2018). The altitude where the pine tree grows will affect the production of sap. The higher the place of growth, the sap will clot, and the flow of sap will be hampered (Prasetya, 2017) . It was due to low air temperature and the intensity of sunlight, so that sap production decreases (Rochidayat and Sukawi in Setyowiharto, 2008).

Figure 3. (a) quarre (*koakan*) method, (b) pine resin, and (c) shelter for resin collections.

Table 1. Total pine resin production collected by the each Forest Farmer Groups (KTH) (Source: Primary data analyzed in 2021).

No.	Name of KTH	N of Respondents	Size of Area (ha)	N of Trees	N of Days	Production (kg)
1	Nanggewer	10	20	9.200	28	3.480
2	Cibubut	10	15	3.880	28	3.161
3	Gordi	10	24	5.700	28	4.660
4	Datar Tepus	10	18	7.940	28	3.500
5	Simpay Wargi	10	14	7.450	28	3.170
6	Ciukir	10	13	3.510	28	2.000
7	Cikekes	10	15	4.650	28	3.170
8	Pojok	10	16	8.410	28	3.292
9	Sawargi	10	19	5.700	28	2.600
	Total	**90**	**154**	**56.440**		**29.033**

Sofyan (1999 in Listyandari, 2009), the production of pine sap is not only affected by the altitude, but also by the age of the tree. The older a pine tree, the higher the sap production. The old stands of *Pinus merkusii* tend to produce more sap than the young ones. Doan (2007) stated that the rainfall will affect the humidity around the tapping wound. High rainfall will cause the humidity around the tapping wound to be high and this can cause the sap to clot quickly. The results of the production of pine resin taps carried out by KTH members presented in Table 1.

In Table 1, it can be seen that, the total production of tapped pine resin by KTH member respondents was 29,033 Kg. On average, 323 Kg/person in one month (two harvests) with 56,440 pine trees or an average of 627 trees/person. People residing in an area of 154 hectares. Judging from the results above, there has been an increase in the production of tapped pine resin by members. Prior to the conservation partnership, they were only able to produce 1,230 kg of latex tapping per month.

Impact on Increase in Income

Conservation partnerships also mean providing additional employment and income opportunities for local communities who are members of the KTH (Sugianto et al., 2017; Susilo & Nairobi, 2019). Most of the people's main occupations before joining the conservation partnership programme were farmers/ cultivators, odd laborers, small tradesmen, and unemployed.

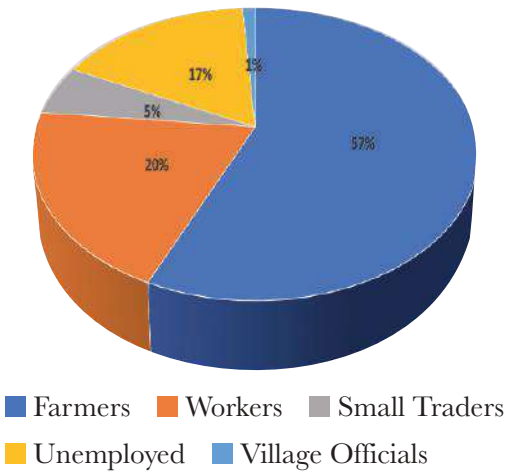

Figure 4. Percentage of Forest Farmer Groups (KTH) members main occupation: farmers (blue), workers (orange), small traders (grey), unemployed (yellow), and village officials (light blue) (Source: Primary data analyzed in 2021).

Figure 4 explains that most of main occupation of KTH members, apart from tapping pine sap, is as farmers/cultivators as much as 57 percent. There are farmers who work on their own land or land owned by others with a profit-sharing system. Apart from that, there are also KTH members who are working on the ex-Cultivation Right (HGU) area of PT. Ratu Gilang Kencana with a cultivated area of 1 to 2 hectares/person. Odd labors (workers) as much as 20 percent, unemployed 17 percent and village officials and traders occupy the least positions, namely 1 and 5 percent of the total respondents from KTH members who get conservation partnerships. Village officials who become KTH members are motivated by the desire to increase family income, apart from the distance from their residence to the pine resin tapping area, which is relatively close and can be reached by 2-wheeled vehicles, the same applies to KTH members who double as traders.

Based on Figure 5, the income earned by respondents from KTH members before the conservation partnership was very varied. The income of KTH members is mostly in the interval of Rp. 100,000-1 million/month, which is 70 percent, in this segment filled by the unemployed, casual laborers and farm workers. Then 25.6 percent are in the income interval of Rp. 1 million-1.5 million/month, which is the income of KTH members who work as farmers who have arable land. They usually harvest rice every four months with an income of Rp. 5-6 million or Rp.1.250.000-1.500.000,- per month. Meanwhile, the income between IDR 1,501-2 million per month is only 4.4 percent who are KTH members with professions as farmers as well as traders and some even become local village officials. On average, the income of KTH members before the conservation partnership was Rp. 853,778,- for one month or Rp. 10,245,333,- per year.

Based on data, per capita population expenditure in Sumedang Regency per month is Rp. 1,385,833, or Rp. 16,630,000,- per year (BPS Kabupaten Sumedang, 2020). Based on these data, if the average KTH member has 4 family members, then the average per capita expenditure per year is IDR 66,520,000. This means that most of the income of KTH members is not enough to meet household needs for one year.

The granting of access to the collection of pine resin will have an impact on the income received. However, this depends on each member of the KTH because the

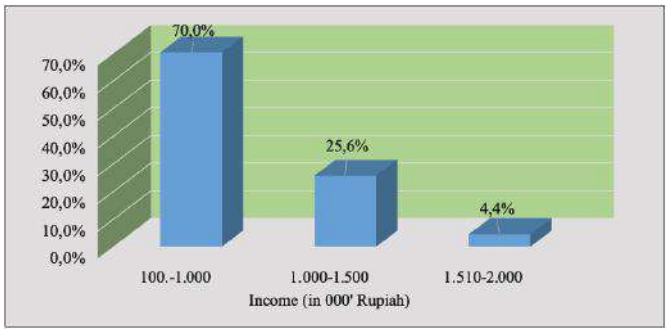

Figure 5. Interval of total monthly income of Forest Farmer Groups (KTH) members.

level of pine resin production depends on the area of the tapping area, tree density (number of trees per hectare), the number of koakans per tree as well as the work skills and willingness to tap from the KTH members themselves.

The production of pine sap produced by KTH members, harvested every two weeks, is collected in the TPG in each KTH (Pokja, 2018). After the pine resin of KTH members is collected, it is then sold to the Pinus Merkusii Cooperative at a price of Rp. 4,500.00,-. The average pine resin produced by KTH members from tapping pine trees in GMKHP is 323 kg/627 trees. while the price received by the tapper farmers from the collectors of the Pinus Merkusii Cooperative is 4,500/kg, so that the average revenue is Rp. 1,453,500,-/month (**Table 2**). The level of acceptance of KTH members is strongly influenced by the price and amount of pine resin produced.

The income of the community members of KTH after the conservation partnership consists of two main components, namely income outside of tapping pine resin (occupational laborers, sharecroppers, farmers, traders, village officials) and income from tapping pine resin. Judging from the amount, the average additional income of the community's income increased by 170 percent from the initial income of Rp. 853,778, - per month to Rp. 2,307,278, - an increase of Rp. 1,453,500,- as shown in Figure 6.

Table 2. Income of Forest Farmer Groups (KTH) Members per month from tapping pine resin (Sources: primary data analyzed in 2021).

No.	Explanation	Total
1	Production	323
2	Price (Rp.)	4.500
3	Income (Rp.)	1.453.500

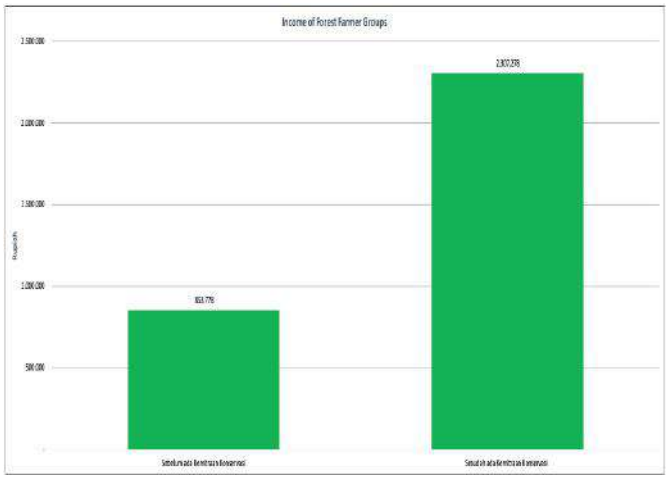

Figure 6. The average of income of Forest Farmer Groups (KTH) before and after joining conservation partnership programme (Source: primary data analized in 2021).

Table 3. Contribution of cooperatives to the neighborhood and social welfare (Source: Koperasi Pinus Merkusii, 2021).

No.	Nama Desa	November 2020			Desember 2020		
		Desa	Bumdes	Mui	Desa	Bumdes	Mui
1	Cikadu	598.600	598.600	1.496.500	415.900	415.900	1.039.750
2	Kaduwulung	572.100	572.100	1.430.250	135.900	135.900	339.750
3	Sundamekar	53.800	53.800	134.500	-	-	-
4	Bangbayang	457.800	457.800	1.144.500	131.300	131.300	328.250
5	Pelita Asih	993.300	993.300	2.483.250	1.070.500	1.070.500	2.676.250
6	Jaya Mekar	1.742.100	1.742.100	4.355.250	1.594.000	1.594.000	3.985.000
7	Tamansari	1.186.000	1.186.000	2.965.000	289.500	289.500	723.750
8	Sukajaya	419.100	419.100	1.047.750	151.600	151.600	379.000
9	Citengah	371.500	371.500	928.750	111.200	111.200	278.000
	TOTAL	**6.394.300**	**6.394.300**	**15.985.750**	**3.788.700**	**3.788.700**	**9.471.700**

The KTH pine resin production is still relatively low. Research on the production of pine sap using the quarre method has been conducted by Suswaji, et al. (2017. p. 131) in his research, the average production of pine resin in Tangkulowi Village, Kulawi District, Sigi Regency was 597.19 Kg/358 trees. The low yield of pine sap mentioned above is due to the existing mechanism in KTH not requiring its members to achieve certain production targets. The production of pine resin is left entirely to each member so that the production results will be different for each member.

The income received by KTH members from the sale of pine resin each month is net income which is not deducted by production costs. The production costs are taken from the mandatory and voluntary savings of the KTH members who are members of the Pinus Merkusii Cooperative which is also a collector of the members' pine resin tapping.

The Pinus Merkusii Cooperative was established in February 2018 as a forum for KTH members who utilize NTFPs in the Gunung Masigit Kareumbi Buru Park area. The purpose of establishing this cooperative is to

create uniformity, both in selling its products, treating the location of the leads, equipment, and other things. The existence of this cooperative whose members are all members of KTH, KTH members besides being able to sell pine resin to the cooperative can also benefit from Operating Income Savings (SHU), Ied holiday allowances (THR), health benefits, death insurance and the cooperative member savings. The contribution of cooperatives to neighborhood and social welfare is in the form of assistance for the poor and orphans, village treasury income, BUMDes (Village Enterprise) capital, wages for the teachers of reading Qoran, mosque maintenance as shown in Table 3. A study conducted by Rochaedi et al. (2021) in the villages surrounding Gunung Halimun Salak National Park shows that the conservation partnership programme has the potential to be used as a vehicle for the resolution of tenurial conflicts in conservation areas.

CONCLUSION

The conservation partnership for the collection of pine resin has provided welfare benefits to the community, including creating jobs, reducing unemployment, and increasing family income. Conservation partnerships also have a positive impact on neighborhood and social welfare. With such a partnership, some of the profits from the sale of pine resin set aside through the cooperative, are distributed to the neighborhood in the form of savings from business, Ied holiday allowances (THR), health benefits, death insurance, member savings in the cooperative, assistance for the poor and orphans, village treasury, as well as BUMDes capital. Additionally, the funds set aside are also used for wages of reading Qoran teachers, social assistance, and mosque maintenance.

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