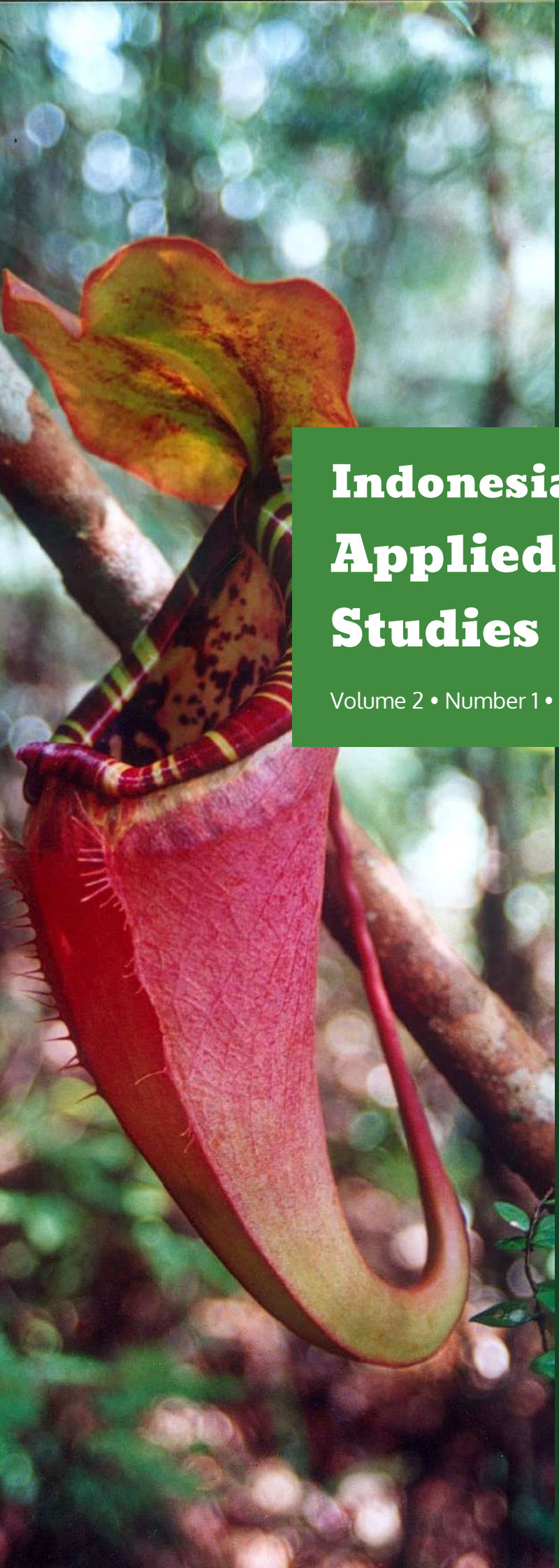

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Cover Photo : *Nepenthes sumatrana* is a tropical pitcher plant endemic to the Indonesian provinces of North Sumatra and West Sumatra. The picture taken in a hill between Padang Sidempuan and Sibolga in 2003 (©Dolly Priatna)

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GUEST EDITORIAL

Legislation study methods to save the environment

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ABSTRACT

This paper provides an overview of the different methods available to critical analyse existing environmental laws and their potential for achieving genuine environmental change. It highlights how misinterpretation of the substance of laws and regulations, malfunction of legislation, disagreement among stakeholders in the application of available legal instruments and the absence of monitoring, control, and surveillance can result in inappropriate application of laws, contributing to misuse of natural resources and the environment decline. It outlines four methods of legal analysis to review the efficacies of existing laws to identify areas potential for legal reform these are; analysis of legal content, legal functions, legal instruments, and legal monitoring, control and surveillance.

ABSTRAK

Makalah ini memberikan gambaran umum tentang berbagai metode yang tersedia untuk menganalisis secara kritis undang-undang lingkungan yang ada dan potensinya untuk mencapai perubahan lingkungan asli. Tulisan ini menyoroti bagaimana salah tafsir substansi undang-undang dan peraturan, ketidak berfungsinya undang-undang, ketidak sepakatan di antara para pemangku kepentingan dalam penerapan instrumen hukum yang tersedia dan tidak adanya pemantauan, kontrol, serta pengawasan, yang dapat mengakibatkan penerapan undang-undang yang tidak tepat, berkontribusi pada penyalah gunaan sumber daya alam, dan penurunan kualitas lingkungan. Ini menguraikan empat metode analisis hukum untuk meninjau efektivitas hukum yang ada untuk mengidentifikasi bidang yang berpotensi untuk reformasi hukum; analisis muatan hukum, fungsi hukum, perangkat hukum, serta pemantauan hukum, kontrol dan *surveillance*.

Keywords: *Environmental law, study methods, legal instruments*

BACKGROUND

Legislation for the purposes of this paper consists of all written regulations, regulatory policies, and policies, including the ratified international conventions, that regulate natural resources and the environment. To analyses if a legislation can save the environment, the question must be posed 'how can legislation save the environment?'. To answer this four analytical methods were applied to identify which aspects of laws and regulations were being implemented, why legislation was being employed improperly, and how this can contribute to, rather than reduce environmental problems.

Firstly, incomplete interpretation of the content of the law results in incorrect application of the law, and so failing to meet its legal objectives. In this context, a legal content analysis used normative and empirical approaches to understand the legal interpretation, reasoning and argumentation of relevant legislations. Almost all of these aspects are not explicitly described in the existing legislation, so that requiring a further analysis of. By understanding the legal and institutional aspects and the content of each legislation correctly, key stakeholders (e.g. government institutions, environmental managers, legal consultants, and law enforcers) will be able to apply the legislation appropriately as the legal basis for protecting the environment.

Secondly, the legislation is unable to function properly. This is because the content of legislation and its enactment does not reflect the current situation and conditions, such as political stability, existence of policies on economic efficiency, social prosperity, cultural value establishment, defense endurance, security pacification, and environmental sustainability, as well as legal public order, in an effort to save the environment. Understanding these factors can be used to develop recommendation to propose amendments to laws so they can be employed properly. Allowing for correct and/or improved application of the law to provide increased environmental protection.

Thirdly, different stakeholders will seek to apply environmental legislation with varying outcomes in accordance with their respective interests. The different missions of each stakeholders to comply with these

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legislations can also contribute to environmental problems. Therefore, alignment of stakeholder perceptions of this legislation is very important to form a common understanding in protecting the environment in accordance with their respective interests. Stakeholders must sit together, negotiate and agree a common understanding to harmonize their perceptions of the purpose of these legislations. In addition, this approach should be used to reach agreement on how to apply the legal instruments regulated under each legislation, and how best they can be applied to protect and preserve the environment.

Fourthly, lack of appropriate application as well as absence of monitoring, control, and surveillance (MCS) overseeing the implementation of various forms of laws and regulations can contribute to the increase of environmental problems. In particular, legislation and regulations for exploration, exploitation, management and conservation of natural resources and the environment. Environmental problems exacerbated by this absence include water depletion, forest fires, floods, acid rain, landslide, greenhouse effect and ozone depletion. Appropriate MCS, for example should provide assurance that any exploitation of natural resources is done so legally in accordance with the relevant regulations. With appropriate oversight in the application of relevant laws and regulations, environmental problems can be minimized or even prevented from happening.

LEGAL CONTENT ANALYSIS

Every law regarding natural resources and the environment has its purpose stated in its articles. The objectives will be achieved through a legal mandate for government agencies to apply the law through facilities and infrastructure provided by collaboration, coordination, and integration with other government agencies as well as with international, private, and non-government institutions. All of the articles in the legislation, should be carried out in accordance with legal mandate of each institution and are designed to support the meeting of the stated objectives. The process of achieving these objectives can be identified through understanding the legal interpretation, reasoning, and argumentation in each law. The legal and institutional aspects contained in a legislation consist of stated objectives, legal mandate, institutions, facilities and infrastructure, and collaborative institutional networks. Thus, each of these aspects must be addressed in advance when an institutional collaboration is expected.

To be affective the legal and institutional aspects of legislation must empowered stakeholders to carry out integrated management of natural resources and the environment. In this instance, the definition and meaning of 'natural resource management' has yet to be harmonized among stakeholders. Natural resource management can be defined as the conscious decision-making process applied to determine the allocation of natural resources over a given space and time for the purpose of achieving stated goals sustainably. The decision-making process to determine a 'sustainable' allocation of these resources, must take into account recommendations from science and technology, law and institutions, and public and business administration. Normally, this decision-making takes place during the planning, organizing, directing and controlling (POAC) activities of natural resource management. POAC activities include, database development, resource assessment, resource exploration, calculation of potential carrying capacity and absorptive capacity, resource allocation, resource exploitation, resource conservation, production processes, product marketing, and monitoring and evaluation. Therefore these management activities including resource-based management, community-based management, and market-based management must be reflected in the law governing natural resource use.

Therefore understanding the quality of existing legal instruments and how they can be harmonized will be key to improving the legal basis for environmental protection efforts. Area of the legal framework where this could be applied include the implementation of the 3R strategy (reduce, reuse, recycle), use of natural resources, strategies to adjust climate change, strategies to preserve diversity biodiversity, strategies to reduce emissions from deforestation and forest degradation (REDD), strategies to save energy, strategies to save water, strategies to save electricity, strategies to reduce plastics, strategies to reduce fossil fuels, and strategies to increase green open space in every city. As such if analysis of legislation legal content is applied properly to harmonize the legal and institutional aspects of the law, alongside the components of management activities, it will be able to inform environmental efforts to a create new and improved understanding of ecological jurisprudence and ecological engineering.

LEGAL FUNCTION ANALYSIS

Legislation will function properly only if it is implemented to meet the objectives of private and public stakeholders. Private interests include, inter alia, legal protection of the interests of private entities such as individuals, private and state companies, cooperative entities, foundations, and non-governmental organizations, both as consumers, producers or mediators. The public interests are formed through the following processes, a) compromise between private entities, b) respect for personal interests sacrificed for public interests by private entities, and c) the equal distribution of benefits to related private entities for the formation of public interests. An imbalance between private and public interests can create difficulties for

stakeholders to develop institutional collaboration, coordination, and integration in implementing laws towards saving the environment.

Applying a legal function analysis will identify whether or not the legal substance of the legislation and its implementation is functioning properly. Conditions of a functioning legislation are as follows: a) From political point of view, the legislation must balance private and public interests equitably; b) From economic point of view, legislation must produce efficiencies in defending private and public interests; c) From social point of view, the legislation must regulate opportunities for private and public interests to generate prosperity; d) From cultural point of view, legislation must strengthen the ethical values of personal and public interests; e) From defense standpoint, the legislation must be encourage private and public interests to strengthen various aspects of social life; f) From security standpoint, the legislation must be able to promote security between private and public interests; g) From environmental perspective, legislation must be able to provide legal guarantees for the development of sustainable private and public interests; h) From legal point of view, the legislation must be able to improve public order in establishing and carrying out private and public interests. If the legislation can meet all the parameters of the legal function, it will be used as a legal basis that meets the requirements for protecting and preserving the environment.

LEGAL INSTRUMENT ANALYSIS

Effective legislation requires legal instruments to function properly, with facilities and infrastructure that is implicitly and/or explicitly regulated within the law. Legal instruments can be identified and derived from the legal substance of the legislation, therefore, the chosen legal instrument must be standardized through negotiations among stakeholders to be used as an agreed legal instrument in environmental protection.

The first and most important legal instrument is the acceptance of the legislation by stakeholders. To realize this acceptance, the results of legal interpretation, reasoning, argumentation, and harmonization must be clear and prevent misperceptions and/or multiple perceptions of the rule of law by stakeholders. Efforts to promote harmonious perception must consider that each stakeholder will have a differing interpretation of the legislation because of their varying interests. The government will always employ laws as social engineering tools that define the parameters for effective and efficient exploration, exploitation, management and conservation of natural resources and the environment. Private entities are encouraged to obey the law as long as they are able to generate profit. Community stakeholders will accept the law as long as it sits in accordance with their social values. Legal practitioners will give their best efforts to find and build an effective and efficient legal basis for the benefit of their clients. Academics will try to develop legal basis that satisfies all stakeholders by employing legal interpretation, reasoning, argumentation, and harmonization. If the methods employed by legal academics are applied by all stakeholders, it will accelerate the efforts of stakeholders in developing harmonious perceptions as legal instruments to protect the environment.

The second most important legal instrument is the agreement of stakeholders regarding the application of the appropriate legal instruments to protect and preserve the environment. These legal instruments include environmental inventory, ecoregions, strategic environmental assessment, spatial planning, environmental impact assessment, environmental audit, and integrated natural resource and environmental management. In fact, this regulated legal instrument has been promulgated by the government and all stakeholders must comply.

If both of these important legal instruments are applied correctly, it can provide legal certainty to stakeholders to achieve the stated objectives with the articles of the law. If so, then the law will be functioning properly and efforts to protect the environment will be on the right track.

LEGAL MONITORING, CONTROL, AND SURVEILLANCE ANALYSIS

Implementation of the law must be accompanied by the ability to employ ongoing oversight if it is expected to be able to save the environment. Supervision and oversight can be employed using the monitoring, control, and surveillance (MCS) systems approach.

Monitoring focuses on measuring the physical relationship between humans and the environment. The objective of which is to determine the changes in the intensity natural resources and the environment are exploited and whether or not it this usage has reached a level that the environment can recover, it's 'carrying capacity'. If the intensity of exploitation has approaches that capacity, it inform the resource manager that usages must be stopped immediately or drastically reduced to aid natural recovery i.e. by closing the fisheries season early.

Control pays attention to the administrative relationship between humans and the environment. It aims to establish and check the legality of exploitation activities by, for example, observing their compliance with laws and regulations, and, in needed adjusting activities to fall within the legally permit conditions and conditions set for exploitation. Violations falling outside of legally permitted activities will be followed by warning letters and other forms of administrative sanctions.

Surveillance concentrates on the geographical relationship between humans and the environment. The objects of surveillance includes all activities and maneuvers, including the movement of environmental impacts on land and open water, at sea, and in the air. It is carried out by undertaking land, sea or sea and air patrols. Through surveillance, the time and location of violations of the law can be identified and mapped.

This brief explanation of integrated MCS implementation invites and enables the ability to make plans for the successful implementing of effective environmental legislation. Importantly, MCS can be a determining factor for the successful management of natural resources and the environment. It can to provide the evidence with certainty that efforts to save the environment are being carried out in accordance with the legislation. To be successful MCS activities and results must be periodically evaluated, to drive continual revision and improvements as it responds to changing environmental conditions. Because MCS oversight emphasizes the physical, administrative, and geographical relationships between people and the environment, it aligns to the permitting and environmental management system and can be considered as a useful tool for integrating management activities. As such MCS can also be applied to strengthen efforts to promote the harmonization of environmental law.

CONCLUSION

It is recommended that legislation studies to protect the environment should be carried out by applying the analysis of legal content, functions, instruments, and legal MCS. Analysis of legal content identified how and where the legal and institutional aspects and components of management activities can and should be harmonized. Analysis of the legal function contribute to the understanding the legal parameters by which identify whether or not the functions of the law are properly aligned or not. Analysis of legal instruments arises with the acceptance and agreement of stakeholders on applying selected legal instruments, the most important of which is if legal instruments are functioning and are harmonized properly. The legal MCS analysis provides the ability to oversee harmonious legislative functions and ensuring environmental protection efforts are accordance with the legislation. By making the best use of the results of these legislation studies and this approach, stakeholders will be able to develop integrated natural resource and environmental management for the purpose of protecting and conserving the environment.

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NEWS, NOTES & EVENTS

The results of applied research for solutions to environmental problems, expected!

Dolly Priatna and **Kathryn A. Monk** (Eds.)

With this issue, the Indonesia Journal of Applied Environmental Studies (InJAST) enters its second year, having been first published in April 2020 just as the Covid-19 pandemic was spreading globally. In the first two issues, InJAST published 13 articles, which were the results of research and ideas from academia, researchers from the Indonesian Institute of Sciences (LIPI) and members of conservation NGOs. Within its first year, the InJAST website has been visited by around 1,500 visitors from 50+ countries. Although the majority were from Indonesia, 30% were from across Europe, Asia, the Americas, and Africa, and included the USA, UK, Australia, and India.

One of InJAST's missions is to provide a vehicle for academia (students and lecturers), members of environmental NGOs, and young researchers, particularly from Indonesia, who are just starting to publish their ideas, literature reviews and research findings or articles in scientific journals. InJAST was also developed to accommodate scientific papers related to broader environmental topics, but as yet, most articles have focused on plant/wildlife ecology, nature conservation, and forest restoration (61%). Others were the result of the studies on environmental education (8%) and on the UN Sustainable Development Goals (SDGs) and other environmental issues (31%).

As we start the third decade of the 21st century, the environmental challenges we face are ever more complex and demanding. The UN's global action plan for the next 10 years set out in the "UN's 2030 Agenda for Sustainable Development", puts forward special measures to achieve a world that is fairer, more prosperous, and more respectful of the environment. The main global environmental challenges that, according to the UN, must be resolved in this decade, are climate change mitigation and adaptation, pollution problems and their effects on health, protecting oceans, the energy transitions and renewables, a sustainable food model, protecting biodiversity, sustainable urban development and mobility, hydric stress and water scarcity, extreme meteorological phenomena, and overpopulation and waste management. As academics, environmental researchers, and members of environmental NGOs, we can and should support the UN agenda by seeking the solutions to these major global environmental problems that affect all of us. We do this by carrying out relevant research and, just as importantly, publishing them in scientific journals so that we can disseminate our findings as widely as possible and suggested interventions can be trialed and then implemented on the ground.

This new issue of InJAST contains several papers focusing on plant ecology, endangered species conservation, and forest restoration, all of which are closely related to one of the main global problems identified by the UN, namely protecting biodiversity. Another paper analyses determinants and typology of hydrometeorological disasters that may relate to the problem of extreme meteorological phenomena. Strong pro-environmental legislation and government regulations are very important in implementing existing environmental policies, and environmental awareness and responsibility are also important to assess whether people are willing to participate in addressing global environmental problems at the local level. This is explored in two other papers in this issue of InJAST.

We reflect further that we are in a hugely different place from where we were at the start of 2020. The Covid pandemic, obviously a global tragedy, has changed many people's behavioral patterns and our subsequent impact of nature and the environment. It seems to have in many ways heightened people's awareness of nature and environmental issues, and the relationships between unsustainable production and consumption and the nature and climate change crises. A plethora of new research is emerging on these interdisciplinary questions and we look forward to submissions tackling these questions in future editions of InJAST.

Finally, as Editors-in-Chief, we have been working hard to improve and expand our peer review community, as well as the processes of online submission, reviewing and publishing. We are delighted to be presenting Volume 2 No 1 of InJAST and we encourage our colleagues from all sectors to submit their papers for the next issue.

InJAST's website and online submission portal is:
https://journal.unpak.ac.id/index.php/InJAST/index

Submissions can also be directed to the Chief Editors at: **injast@unpak.ac.id**

Comments on InJAST's website, reporting portal issues and other issues, should be addressed to the Editorial Manager at: **editor_injast@unpak.ac.id**

NOTES

Lithium-ion batteries towards circular economy: A literature review of opportunities and issues of recycling treatments

Nowadays, Lithium-ion batteries are widely used in advanced technological devices and Electric and Hybrid Vehicles, due to their high energy density for weight, reduced memory effect and significant number of supported charging/discharging cycles. As a consequence, the production and the use of Lithium-ion batteries will continuously increase in the near future, focusing the global attention on their End-of-Life management. Unfortunately, wasted Lithium-ion batteries treatments are still under development, far from the optimization of recycling processes and technologies, and currently recycling represents the only alternative for the social, economic and environmental sustainability of this market, able to minimize toxicity of End-of-Life products, to create a monetary gain and to lead to the independence from foreign resources or critical materials. This paper analyses the current alternatives for the recycling of Lithium-ion batteries, specifically focusing on available procedures for batteries securing and discharging, mechanical pre-treatments and materials recovery processes (i.e. pyro- and hydrometallurgical), and it highlights the pros and cons of treatments in terms of energy consumption, recovery efficiency and safety issues. Target metals (e.g. Cobalt, Nickel and Lithium) are listed and prioritized, and the economic advantage deriving by the material recovery is outlined. An in-depth literature review was conducted, analysing the existing industrial processes, to show the on-going technological solutions proposed by research projects and industrial developments, comparing best results and open issues and criticalities.

Mossali et al. (2020). Lithium-ion batteries towards circular economy: A literature review of opportunities and issues of recycling treatments. *Journal of Environmental Management* **264**:110500.

Challenges and practices on waste management and disposal during COVID-19 pandemic

The COVID-19 pandemic has imposed a global emergency and also has raised issues with waste management practices. This study emphasized the challenges of increased waste disposal during the COVID-19 crisis and its response practices. Data obtained from the scientific research papers, publications from the governments and multilateral organizations, and media reports were used to quantify the effect of the pandemic towards waste generation. A huge increase in the amount of used personal protective equipment (facemasks, gloves, and other protective stuffs) and wide distribution of infectious wastes from hospitals, health care facilities, and quarantined households was found. The amount of food and plastic waste also increased during the pandemic. These factors caused waste treatment facilities to be overwhelmed, forcing emergency treatment and disposals (e.g., co-disposal in a municipal solid waste incinerator, cement kilns, industrial furnaces, and deep burial) to ramp up processing capacity. This paper discussed the ways the operation of those facilities must be improved to cope with the challenge of handling medical waste, as well as working around the restrictions imposed due to COVID-19. The study also highlights the need for short, mid, and longer-term responses towards waste management during the pandemic. Furthermore, the practices discussed in this paper may provide an option for alternative approaches and development of sustainable strategies for mitigating similar pandemics in the future.

Hantoko et al. (2021) Challenges and practices on waste management and disposal during COVID-19 pandemic. *Journal of Environmental Management* **286**:112140.

A study of consumer behaviour towards food-waste in Ireland: Attitudes, quantities and global warming potentials

This study aimed to investigate consumer behaviour towards food waste in Ireland by analysing their attitudes and quantities of food waste generated. Global warming potential of the food waste generated weekly is then assessed. A total of 2115 participants from all over the Republic of Ireland contributed to the survey (of which 2062 were included in this research). Using factor and cluster analysis, two clusters of consumers were formed based on their attitudes towards food waste, and it was found that 62.56% of the sample were 'uncaring' consumers and 37.44%

were 'caring' consumers. The uncaring consumers consisted of more young males and were relatively unphased by food waste and take minimal precautions to reduce food waste at all stages of consumption. In contrast, caring consumers consisted of older and female consumers and were deeply disturbed by food waste, taking all precautions to reduce food waste at every stage of consumption. Regarding food waste quantities, uncaring consumers produced on average, 0.74 kg of food waste weekly, accounting for 2.74 kg of CO_2 equivalent in global warming potential, whereas caring consumers produced only half this amount. Our results thus suggest that consumers attitudes towards food waste directly impact the food waste quantities they generate and consequently the global warming effects. However, in Ireland all consumer groups can benefit from more information about food waste and our study contributes by providing information that can inform strategic communication campaigns at policy or organisational level, to educates consumers about food waste and how they are contributing to global warming.

Flanagan & Priyadarshini (2021). A study of consumer behaviour towards food-waste in Ireland: Attitudes, quantities and global warming potentials. *Journal of Environmental Management* **284**:112046.

Recent developments in Life Cycle Assessment

Life Cycle Assessment is a tool to assess the environmental impacts and resources used throughout a product's life cycle, i.e., from raw material acquisition, via production and use phases, to waste management. The methodological development in LCA has been strong, and LCA is broadly applied in practice. The aim of this paper is to provide a review of recent developments of LCA methods. The focus is on some areas where there has been an intense methodological development during the last years. We also highlight some of the emerging issues. In relation to the Goal and Scope definition we especially discuss the distinction between attributional and consequential LCA. For the Inventory Analysis, this distinction is relevant when discussing system boundaries, data collection, and allocation. Also highlighted are developments concerning databases and Input–Output and hybrid LCA. In the sections on Life Cycle Impact Assessment we discuss the characteristics of the modelling as well as some recent developments for specific impact categories and weighting. In relation to the Interpretation the focus is on uncertainty analysis. Finally, we discuss recent developments in relation to some of the strengths and weaknesses of LCA.

Finnveden et al. (2009). Recent developments in Life Cycle Assessment. *Journal of Environmental Management* **91**:1-21.

Environmental sustainability of anaerobic digestion of household food waste

Consumers are the leading producers of food waste (FW) in developed countries and the majority of household FW is still embedded in general waste where it is incinerated or landfilled. There is increasing awareness in the value of collecting FW as a separate waste stream for production of compost or recovery of energy through anaerobic digestion (AD). This study focuses on AD to evaluate the life cycle environmental sustainability of recovering energy and fertilisers from household FW in the UK. The analysis is carried out for two different functional units: i) treatment of 1 tonne of FW, which is compared to incineration and landfilling; and ii) generation of 1 MWh of electricity, which is compared to other electricity generation options. The former results in net negative greenhouse gas (GHG) emissions (−39 kg CO_2-eq./t) and primary energy demand (−2 GJ/t) due to the displacement of grid electricity and mineral fertilisers. AD has lower impacts than both incineration and landfilling across 15 of the 19 impacts. However, the application of digestate to land and the release of ammonia and nitrates lead to higher marine eutrophication (ME), terrestrial acidification (TA) and particulate matter formation (PMF). For the second functional unit, AD electricity emits 203 kg CO_2-eq./MWh, compared to 357 kg CO_2-eq./MWh for the UK grid mix. Compared to renewables, such as wind and solar, AD electricity has lower energy demand, toxicity potentials and metal depletion. However, it has higher global warming potential, ME, TA and PMF. At the UK level, treating 4.9 Mt of kerbside FW collected annually could provide 0.37% of the national electricity demand and save 190,000 t CO_2-eq./yr compared to the grid electricity. The digestate produced could displace 1% of industrial nitrogen fertilisers. Although small fractions of the national demands, they represent a valuable return from a largely unutilised waste stream and help towards implementation of a circular economy.

Slorach et al. (2019). Environmental sustainability of anaerobic digestion of household food waste. *Journal of Environmental Management* **236**:798-814.

Sustainable construction—The role of environmental assessment tools

Construction has been accused of causing environmental problems ranging from excessive consumption of global resources both in terms of construction and building operation to the pollution of the surrounding environment, and research on green building design and using building materials to minimise environmental impact is already underway. However, relying on the design of a project to achieve the goal of sustainable development, or to minimise

impacts through appropriate management on site, is not sufficient to handle the current problem. The aim for sustainability assessment goes even further than at the design stage of a project to consider its importance at an early stage, before any detailed design or even before a commitment is made to go ahead with a development. However, little or no concern has been given to the importance of selecting more environmentally friendly designs during the project appraisal stage; the stage when environmental matters are best incorporated. The main objectives of this paper are to examine the development, role and limitations of current environmental building assessment methods in ascertaining building sustainability used in different countries which leads to discuss the concept of developing a. sustainability model for project appraisal based on a multi-dimensional approach, that will allow alternatives to be ranked is discussed in detail in the paper.

Ding (2008). Sustainable construction—The role of environmental assessment tools. *Journal of Environmental Management* **86** (**3**):451-464.

The impact of COVID 19 on air pollution levels and other environmental indicators - A case study of Egypt

The outbreak of coronavirus disease (COVID-19) not only affected health and economics, but also its effect extended to include other aspects, such as the environment. Using Egypt as a case study, this paper presents the impact of COVID-19 pandemic on air pollution levels by studying nitrogen dioxide (NO_2), ozone (O_3), particulate matter represented in absorbing aerosol index (AAI), carbon monoxide (CO), and greenhouse gas (GHG) emissions. The paper also highlights the impact of COVID-19 pandemic on other environmental indicators including environmental noise, medical and municipal solid wastes. The paper presents the Egyptian COVID-19 story from its different angles including the development of confirmed COVID-19 cases, containment measures from the government, the impact on the country's economy and the national energy consumption so as to effectively evaluate the effect on both the air pollution levels and the other studied environmental indicators. For the other environmental indicators, a strong link was observed between COVID-19 lockdown and the reduction in environmental noise, beaches, surface and groundwater pollution. For environmental noise, this has been confirmed by officially governmental announcements which reported that the level of environmental noise in Egypt was reduced by about 75% during the lockdown period. On the other hand, there are some negative effects, including an increase in medical solid waste (from 70 to 300 ton/day), municipal solid waste, as well as a less efficient solid waste recycling process. For air pollution levels, the data were obtained from National Aeronautics and Space Administration (NASA) and European Space Agency satellite data sets. The data for the lockdown period in 2020 have been extracted and compared to the corresponding months in the selected baseline period (2015–2019) to identify the effect that the lockdown period had on the air pollution levels in Egypt with focus on Cairo and Alexandria governorates. It was found that the AAI decreased by about 30%, the NO2 decreased by 15 and 33% over Cairo and Alexandria governorates, respectively, and that the CO decreased by about 5% over both governorates. In addition, the GHG emissions in Egypt were reduced by at least 4% during the pandemic. In contrast, ozone levels increased by about 2% over Cairo and Alexandria governorates. It can be concluded that the implemented containment measures during COVID-19 pandemic had resulted in both positive and negative environmental impacts. The positive environmental impacts are not sustainable and deterioration on them is expected to occur after the lockdown as it was before the pandemic. Therefore, stricter laws must be enacted to protect the environment in Egypt.

Mostafa et al. (2021). The impact of COVID 19 on air pollution levels and other environmental indicators - A case study of Egypt. *Journal of Environmental Management* **277**:111496.

Enhancing domestic water conservation behaviour: A review of empirical studies on influencing tactics

The world faces imminent drought-related challenges that, from a tap-water supply perspective, require increasingly expensive infrastructure enhancement and energy expansion to maintain sufficient service levels. This paper argues that enhancing domestic water conservation provides a promising alternative or necessary addition to reduce costs and to stimulate pro-environmental behaviour. Although the number of field experiments on how people's behaviour can be changed with respect to their daily water consumption is growing, to date, most studies in this field have focussed either on explanatory socio-economic factors (e.g. water pricing, income, or family composition) or behavioural intentions and personal characteristics related to behavioural change. Accordingly, there is limited empirically validated knowledge about the use and effectiveness of different influencing tactics to change behaviour. This paper provides a review of the empirically oriented literature in this field and aims to provide an up-to-date assessment that identifies eight different Behavioural

Influencing Tactics (BITs) that target long-term water conservation behaviour within households. Our analysis is structured around three information processing routes: the reflective route, the semi-reflective route, and the automatic route. We conclude that the current body of literature is promising and provides a useful body of evidence on the range and effectiveness of individual water conservation mechanisms, but that needs further development to deepen our understanding of how to effectively prolong and reinforce newly formed water conservation routines.

Koop et al. (2019). Enhancing domestic water conservation behaviour: A review of empirical studies on influencing tactics. *Journal of Environmental Management* **247**:867-876.

Biological approaches to tackle heavy metal pollution: A survey of literature (Review)

Pollution by heavy metals has been identified as a global threat since the inception of industrial revolution. Heavy metal contamination induces serious health and environmental hazards due to its toxic nature. Remediation of heavy metals by conventional methods is uneconomical and generates a large quantity of secondary wastes. On the other hand, biological agents such as plants, microorganisms etc. offer easy and eco-friendly ways for metal removal; hence, considered as efficient and alternative tools for metal removal. Bioremediation involves adsorption, reduction or removal of contaminants from the environment through biological resources (both microorganisms and plants). The heavy metal remediation properties of microorganisms stem from their self defense mechanisms such as enzyme secretion, cellular morphological changes etc. These defence mechanisms comprise the active involvement of microbial enzymes such as oxidoreductases, oxygenases etc, which influence the rates of bioremediation. Further, immobilization techniques are improving the practice at industrial scales. This article summarizes the various strategies inherent in the biological sorption and remediation of heavy metals.

Jacob et al. (2018). Biological approaches to tackle heavy metal pollution: A survey of literature (Review). *Journal of Environmental Management* **217**:56-70.

Microalgae harvesting techniques: A review (Review)

Microalgae with wide range of commercial applications have attracted a lot of attention of the researchers in the last few decades. However, microalgae utilization is not economically sustainable due to high cost of harvesting. A wide range of solid - liquid separation techniques are available for microalgae harvesting. The techniques include coagulation and flocculation, flotation, centrifugation and filtration or a combination of various techniques. Despite the importance of harvesting to the economics and energy balance, there is no universal harvesting technique for microalgae. Therefore, this review focuses on assessing technical, economical and application potential of various harvesting techniques so as to allow selection of an appropriate technology for cost effectively harvesting of microalgae from their culture medium. Various harvesting and concentrating techniques of microalgae were reviewed to suggest order of suitability of the techniques for four main microalgae applications i.e biofuel, human and animal food, high valued products, and water quality restoration. For deciding the order of suitability, a comparative analysis of various harvesting techniques based on the six common criterions (i.e biomass quality, cost, biomass quantity, processing time, species specific and toxicity) has been done. Based on the order of various techniques vis-a-vis various criteria and preferred order of criteria for various applications, order of suitability of harvesting techniques for various applications has been decided. Among various harvesting techniques, coagulation and flocculation, centrifugation and filtration were found to be most suitable for considered applications. These techniques may be used alone or in combination for increasing the harvesting efficiency.

Sing & Patidar (2018). Microalgae harvesting techniques: A review (Review). *Journal of Environmental Management* **217**:499-508.

EVENTS

Towards a New Era of Natural Resources and Environmental Management. The 2nd International Seminar on Natural Resources and Environmental Management (ISeNREM) 2021 (4-5 August 2021, Online)

Natural Resources and Environmental Management Science (NREMS) Study Program, Graduate School of IPB University will hold an international scientific seminar in environmental science, namely "The 2nd International Seminar on Natural Resources and Environmental Management 2021" or ISeNREM 2021. The NREMS successfully conducted the 1st ISeNREM in 2019. This activity is a seminar which is expected to be a "kick off" event for the exchange of scientific information from various scientific disciplines between experts from many countries in the field of environment in a broad sense, as well as creating networks and collaborations in further research in efforts to find solutions to environmental problems. In addition, as an event to increase the possibility for

young researchers to conduct independent research in their home countries in the future.
https://isenrem.ipb.ac.id/

The 6th INAFOR 2021 - Greener Future: Environment, Disaster Resilience, and Climate Change (7-8 September 2021)

INAFOR – International Conference of Indonesia Forestry Researchers is the global network for Forests and also environment scientist. It unities more than 2,500 scientists in almost 50 organizations on over 20 countries. Scientists cooperate in INAFOR on a voluntary basis. This is a promising space for sharing research, building awareness also generating network throughout the world, crossing oceans and mountains, beyond those boundaries. The 6th INAFOR 2021 will stream on forest and environment management while supporting Sustainable Development Goals-SDGs, thereby, the general theme may has "Greener Future: Environment, Disaster Resilience, and Climate Change". It is also an opportunity to promote the Indonesian's and other countries' work on improving environment on the ground, and to showcase success at the implementation, put sciences is in place. Pandemic COVID-19 is now become a global challenge to generate efforts for survive. The critical given that forests and environments, also broader landscapes are important to stakeholders giving efforts to achieve their SDGs targets.
http://inafor.forda-mof.org/

The UK will host the 26th UN Climate Change Conference of the Parties (COP26) in Glasgow on 1 – 12 November 2021.

The COP26 UN climate change conference set to take place in Glasgow in November 2020 has been postponed due to COVID-19. This decision has been taken by the COP Bureau of the UNFCCC (United Nations Framework Convention on Climate Change), with the UK and its Italian partners. Dates for a rescheduled conference in 2021, hosted in Glasgow by the UK in partnership with Italy, have been set to 1-12 November 2021. In light of the ongoing, worldwide effects of COVID-19, holding an ambitious, inclusive COP26 in November 2020 was no longer possible. Rescheduling will ensure all parties can focus on the issues to be discussed at this vital conference and allow more time for the necessary preparations to take place. We will continue to work with all involved to increase climate ambition, build resilience and lower emissions.
https://unfccc.int/process-and-meetings/conferences/glasgow-climate-change-conference

IUCN World Conservation Congress 2021: One Nature, One Future. Marseille, France, 3-11 September 2021.

Protected and conserved areas – a critical conservation tool. When managed effectively, protected and conserved areas are a critical tool for biodiversity conservation and for safeguarding ecosystem services. There are also many socioeconomic benefits that are reaped by local communities in and around these areas. The messages and reflections below from IUCN Members address various types of protected and conserved areas, share success stories, and emphasise initiatives such as the goal to protect 30% of land and oceans by 2030, which IUCN Members endorsed during an online vote at the end of last year. Managing landscapes for nature and people will be a major theme of the IUCN World Conservation Congress, with over 100 sessions focusing on protected and conserved areas. For further information and registration please visit https://civicrm.iucn.org/civicrm/mailing/view?reset=1&id=3053

16th International Peatland Congress 2021(03 - 06 May 2021, Online from Tallinn)

The format of the Congress will remain as planned. Alongside the scientific programme, the IPC2021 will include the Industry Summit, PEAT-talks, excursions and mid-congress fieldtrips, a student programme, exhibition and several social and networking events. The photo contest is up and running and you all have the opportunity to submit your work via the Congress website until the end of March 2021. The abstracts submitted for the 2020 Congress that have been accepted by the Scientific Committee will retain their status for the 2021 Congress. The authors will receive detailed instructions from the Congress Secretariat at the beginning of June in case the authors need to update their short or extended abstracts. The Scientific Committee of IPC2021 has also decided to open additional abstract submission in October 2020. This serves to give new authors the opportunity to present their work at the Congress. Exact guidelines will be published on the Congress website.
https://www.cifor.org/event/16th-international-peatland-congress-2021/

Nature-Based Solutions: How Restoration can Support a Healthy Climate, Economy and Planet (29 April 2021, online)

Over 40 percent of the world's population is affected by land degradation. Land degradation threatens food security, fuels violent conflict, drives biodiversity loss and contributes to the climate crisis through carbon and nitrous oxide emissions. It costs the global economy around USD 6–10 trillion per year, or roughly 10 percent of gross world product. One of the most promising solutions to land degradation is forest

and landscape restoration (FLR), which aims to regain ecological functionality and enhance human well-being in deforested or degraded landscapes. More than 2 billion hectares of such landscapes stand to be restored globally. However, FLR implementation still remains far below the level needed to address land degradation on a global scale. On 29 April 2021, the Global Landscapes Forum will organize a digital forum on FLR hosted jointly by the Collaborative Partnership on Forests (CPF) and the Global Partnership on Forest and Landscape Restoration (GPFLR). This event will help increase understanding in three key areas where FLR can make significant contributions: climate mitigation and adaptation, job creation, and reducing threats to biodiversity. It will also provide an opportunity to showcase the role of partnerships and collaboration in successful FLR.

https://www.cifor.org/event/nature-based-solutions-how-restoration-can-support-a-healthy-climate-economy-and-planet/

Composition and structure of a lowland forest in the Core Zone of the Bukit Duabelas National Park, Jambi, Indonesia

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ABSTRACT

The objective of the study was to obtain data on composition and structure of the forest in the midsection of the Bukit Duabelas National Park core zone, designed to complement the existing data and provide new information potentials for the management of the park core zone. The study was carried out in October-November 2012. Observations were made on plots of one hectare (100 m x 100 m), which was divided into 100 subplot, measuring 10 m x 10 m each. Enumeration of tree species with diameters ≥ 10 cm revealed that as many as 540 individuals were recorded, consisting of 89 species and 36 families, with a total basal area of 30.837 m^2 and only three species of *Dipterocarpaceae* were registered. The forest had a low diversity as indicated by low species richness, much lower than in the undisturbed lowland primary forests in the Batang Gadis National Park in North Sumatra, where similarity was very low (5.9 %). The forest in the plot was designated as the *Dacryodes rostrata- Shorea leprosula* Association, named after two species with highest importance values, thus the dominant. The structure and species composition pointed to the regenerating forest after heavy disturbances. The forest has been undergoing slow natural succession, leading to the formation of the forest similar to the original climax forest. Natural recovery through succession could be enhanced and assisted by means of ecological restoration, through planting of tree species characteristics of forests in Jambi, including species of *Dipterocapaceae*, useful species having values to maintain the livelihood of the indigenous native tribe Suku Anak Dalam and rare, endemic other species having high conservation values.

ABSTRAK

Tujuan studi ini adalah untuk memperoleh data tentang komposisi dan struktur hutan di bagian tengah zona inti Taman Nasional Bukit Duabelas. Studi dirancang untuk melengkapi data yang telah ada dan untuk menyajikan informasi baru yang berpotensi untuk digunakan dalam pengelolaan zona inti taman nasional. Penelitian dilaksanakan pada bulan Oktober-November 2012 dalam petak seluas satu hektare (100 m x 100 m), yang dibagi menjadi 100 anak-petak dengan ukuran masing-masing 10 m x 10 m. Pencacahan pohon dengan diameter ≥ 10 cm menghasilkan 540 batang, yang terdiri atas 89 jenis dan 36 suku, dengan luas bidang dasar total 30.837 m^2 dan hanya tercatat tiga jenis *Dipterocarpaceae*. Keanekaragaman jenis hutan rendah, seperti ditunjukan oleh rendahnya kekayaan jenis, jauh lebih rendah dibandingkan dengan hutan primer yang tidak terganggu di Taman Nasional Batang Gadis di Sumatra Utara, yang mempunyai kesamaan hanya 5,9 % dengan Taman Nasional Bukit Duabelas. Berdasarkan dua jenis dominan dengan nilai kepentingan tinggi, komunitas pohon dalam petak dinamakan Asosiasi *Dacryodes rostrata- Shorea leprosula*. Struktur dan komposisi jenis menunjukan status hutan sebagai hutan yang sedang beregenerasi setelah mengalami gangguan. Hutan sedang mengalami suksesi alami yang lambat menuju ke pembentukan hutan yang serupa dengan hutan klimaks aslinya. Pemulihan alami melalui suksesi dapat dipercepat dan dibantu dengan restorasi ekologi melalui penanaman jenis-jenis khas hutan alami Jambi, termasuk *Dipterocapaceae*, jenis-jenis bermanfaat dan mempunyai nilai untuk keberlanjutan kehidupan dan kesejahteraan masyarakat asli Suku Anak Dalam dan jenis-jenis langka, endemik dan jenis lain yang mempunyai nilai konservasi tinggi.

Keywords: *Association, disturbances, regenerating forest, ecological restoration, species richness, structure and composition*

INTRODUCTION

The lowland rain forests of Sumatra constitute an important center of plant species diversity and the hub of the geography of plant families and genera within the Malesian region (Steenis 1950; Whitmore, 1986; Kartawinata, 2013). The Bukit Duabelas National Park (BDNP) contains a fraction of these lowland rain forests (Sylviani, 2008; Setiawan, 2010) and constitutes an important biodiversity center in the middle section of Sumatra [BAPPENAS (Badan Perencanaan Pembangunan Nasional), 2003]. Much of the lowland rain forests of Sumatra, dominated by dipterocarp species, have experienced destructive and extensive commercial logging, leaving only undisturbed remnants of forets as scattered mosaics in the

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lowlands. The Bukit Dua Belas National Partk is also a catchment area for the Batanghari River, one of the largest rivers in Jambi (Wiriadinata & Setyowati, 2000; Setiawan, 2010. It is a uniqe protected area in view of the fact that it is the last home of the ethnic Suku Anak Dalam (SAD) or known also as *orang rimba* (Wiriadinata & Setyowati 2000; Setyowati, 2003; Sriyanto et al. 2003).

Conservation and management of forests within protected areas, including BDNP, require a good and correct planning. In this respect optimal and sustainable management of forest resousrces can be implemented well if accurate, complete and up-to-date data and information on vegetation were available. They should provide a representation of current condition of plant communities. which constitute the habitats to support the survival of numerous other organisms living in the BDNP areas.

A better knowledge on detailed description of strructure, composition and ecology of lowand rain forests of Sumatra, required for better sustainable development and conservation, are relatively limited. Data and information on the vegetation and physiography of Sumatra have been summarised by Laumonier (1997). Scattered studies on vegetation, primarily forests, have been conducted in various parts of Sumatra, mainly in the national parks and other protected areas. They include those in the Batang Gadis National Park (Kartawinata et al., 2004), Berbak National Park (Silvius et al.,1984), Gunung Leuser National Park (Abdulhadi, 1991; Samsoedin and Heriyanto, 2010), Harapan Tropical Rain Forest (Mansur et al. 2010), Hutan Adat Imbo Mengakadai (Elviqar, 2013; Hermawan, 2013), Hutan Danau Bangko (Polosakan, 2011), Kerinci Seblat National Park (Gillisosn et al., 1996), Rimbo Panti Nature Reserve (Yusuf et al., 2005), Tesso Nilo National Park (Gillison, 2001). Studies on the structure and species composition in the eastern and western sections of the BDNP core zone, respectively were undertaken by Rahmah et al. (2016) and Sehati (2013).

The present phytosociological study in the midsection of the BDNP core zone was designed to complement the existing data and provide new information on the species composition, structure and the potentials of the forest in the BDNP core zone. They can be used as a scientific basis and reference for better execution of conservation and management of the park.

METHODS

The BDNP was established by the Decree of the Ministry of Forestry and Plantation (No. 258/Kpts-II/2000 dated 23 August 2000). It had a total area of 60.500 hectare, consisting of primary and secondary forests, which were converted from the permanent production forests, limited production forests and forest designated for other uses (Sriyanto et al., 2003). The entire park was located within the lowland dipterocarp forest region of Sumatra (Lamounier, 1997; Whitmore, 1986).

Many important useful plants could be found in BDNP, including fruit trees such as durian (*Durio* spp.), important hard wood producing *bulian* (*Eusideroxylon zwageri*), latex producing tree species (*Dyera costulata*) and rattan producing palms such as *rotan manau* (*Calamus manan*) and *jernang* (*Daemonorops draco*). To date 41 species of orchids.107 species of flowering plant and 27 species of fungi have been recorded to have medicinal values (Kementerian Kehutanan dan Balai TNBD, 2011). The Bukit Duabelas National Park (BDNP) contained also rare plant species, including *Eusideroxylon zwager*i, *Fagraea fragrans*, *Calamus manan*, *Daemonorops draco* and *Dyera costulata* (Kementerian Kehutanan dan Balai TNBD, 2011; Rahmah et al., 2016)

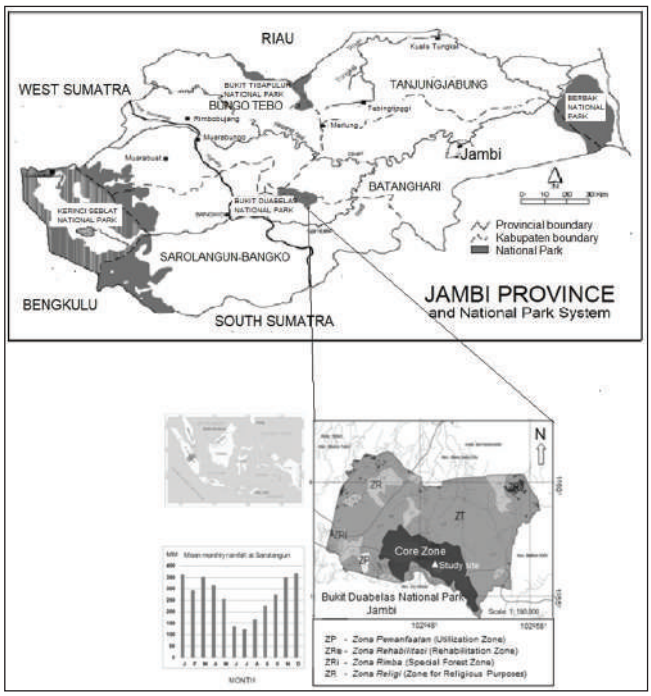

Figure 1. The map showing the geographic location and the mean monthly rainfall of the study site in the midsection of the core zone of the Bukit Duabelas National Park within the National Park System of the Jambi Province (After Rahmah et al., 2016 & Kementerian Kehutanan dan Balai TNBD, 2011; with modification)

The map of BDNP (Figure 1) shows the park geographic location at the $102^{0}31'37"$ - $102^{0}48'27"$ East and $01^{0}44'35"$-$02^{0}03'15"$ South. The topography ranged from undulating to hilly, with the altitude of 260-400 masl (meter above sea level). The Red Yellow Podsolic soil was dominant in the area (Kementerian Kehutanan dan Balai TNBD, 2011). The 38-year record of the mean annual rainfall (Berlage, 1949) was 3224 mm. The highest mean monthly rainfall of 392.9 mm was recorded in November and the lowest of 27.1 mm in August and 52.7 mm in September [BPS

(Badan Pusat Statistik) Kabupaten Sarolangun, 2015]. The temperature range in the area was 23 – 30 ^{0}C and the humidity range was 80 - 94% (Kementerian Kehutanan dan Balai TNBD, 2011).

Specifically the sampling was undertaken in the forest at the midsection of the core zone of the park using the plot method (Cox 1967; Mueller-Dombois & Ellenberg1972, 2016), with the plot size of one-hectare. Habitat conditions, including plot position, mean elevation, topography, gaps and tree crown coverage, soils, presence of litters, pH and air humidity were recorded. The mean elevation of the plot was measured by the method of Harms et al. (2001).

The one hectare plot (100 m x 100 m) was divided into 100 subplots of 10 m x10 m each (Kartawinata et al., 2004; Samsoedin & Heriyanto, 2010; Rahmah et al, 2016). All tree species with DBH [Diameter at Breast Height at the height of 1.30 m (Kartawinata et al., 2004; Purwaningsih & Yusuf, 2005; Heriyanto et al., 2019)] ≥ 10 cm were recorded. The records included name of species, number of trees, stem diameter (diameters of trees with buttresses were measured 20 cm above the buttresses), tree height, bole height to the first branch (Mueller-Dombois & Ellenberg, 1974, 2016) and tree position using the GPS (Global Positioning System). The subplots and the plot were made permanent, in which every tree with a DBH ≥ 10 m was numbered and labelled using an alluminum plate nailed to the stem 10 cm above the line of the diameter measurement.

Preliminary identification of species was undertaken in the field using available published keys, including guide to identifiction of dipterocarp trees of Sumatra (Newman et al.,1999). Voucher specimens of trees within the plot were collected and further identified and confirmed at the Herbarium Bogoriense, Center for Biological Research, LIPI at Cibinong, Bogor.

All collected data were tabulated and analysed to determine Density (D), Relative Density (RD), Frequency (F), Relative Frequency (RF), Dominance (Do), Relative Dominance (RDo), and Importance Value (IV) [Cox, 1967; Mueller-Dombois & Ellenberg, 1974, 2016]. The standard method (Mueller-Dombois & Ellenberg. 1974, 2016; Rahmah et al., 2016; Purwaningsih et al., 2017) was applied to calculate density frequency and dominance. Density was defined as the number of individuals per unit area. In the present study we were dealing with trees, hence the density per species was calculated by the number of trees of each species in the plot of one hectare. The density in the plot was the sum of the trees of all species and was presented as the number of trees per hectare. The Relative Density (RD) for each species was then computed as follows:

$$RD = \frac{number\ of\ trees\ of\ a\ species}{total\ number\ of\ trees}\ x100\ \%$$

Frequency was expressed as the number of occurrences of a species in subplots within the plot and was computed as the percentage of the total number of subplots. Relative Frequency (RF) was expresed as follows:

$$RF = \frac{frequency\ of\ a\ species}{sum\ of frequency\ of\ all\ species}\ x100\ \%$$

The dominance (Do) was determined by the stem cover, which was expressed as basal area (BA). BA was calculated with the formula of BA = (½d)2 π, where d stands for diameter. The dominance of a species was obtained by totalling the BA values for all trees in the species . The Relative Dominance (RDo) was then computed with following formula:

$$RDo = \frac{dominance\ of\ a\ species}{dominance\ of\ all\ species}\ x100\ \%$$

The Importance Value (IV) of a species was calculated by summing up RD, RF and RDo in the plot, thus:

$$IV = RD + RF + RDo$$

The Family Important Value (FIV) was computed by totaling the Importance Values of all species in a family (Kartawinata et al., 2004).

RESULTS

Composition

Appendix 1 shows that in 100 subplots making up the one-hectare plot, we recorded 540 individual trees, comprising 89 species and 36 families with the total basal area (BA) of 30.837 m^2/ha. The authors of the scientific names in the present study are attached to all species listed in Appendix 1. The characteristics of the composition and structure of the forest is summarised in Table 1, which shows that *Dipterocarpaceae* was not dominant, consisting only of *Shorea leprosula*, *Parashorea lucida* and *Parashorea* sp. (Appendix 1).

Appendix 1 indicates that most of species had low values of density (D), dominance expressed as basal area (BA), frequency (F) and importance value (IV). It shows that 10 species had high IV, where two of them had the highest IV, that were *Dacryodes rostrata* (IV= 15.80) and *Shorea leprosula* (IV=15.58). They constituted the dominant and co-dominant species and on the basis of this dominance (Mueller Dombois & Ellenberg, 1974, 2016) the tree community in the forest of the midsection of BDNP core zone could be designated as the *Dacryodes rostrata- Shorea leprosula* Association. Other eight prevalent species with IV > 10 (Appendix 1), that characterized the association were *Hydnocarpus* sp. (IV=14.91), *Antidesma neurocarpum* (IV=14.30); *Dialium platysepalum* (IV=12.67), *Artocarpus odoratissimus* (IV=10.83), *Dacryodes rugosa* (IV=10.17), *Parashorea*

lucida (IV=10.11), *Mussaenda frondosa* (IV=9.33) and *Symplocos* sp. (IV=9.03).

Dacryodes rostrata had the highest density (32 trees/ha), followed by *Hydnocarpus* sp. and *Antidesma neurocarpum* (Figure 2a), while the lowest tree density occured in 30 species with *Dacryodes rostrata* density of one tree peer hectare (Appendix 1). The highest frequency was recorded in *Dacryodes rostrata* followed by *Antidesma neurocarpum* and *Hydnocarpus* sp. (Figure 2b). In terms of basal area Appendix 1 shows that three species had the highest values, they were *Shorea leprosula* (2.83 m^2), *Dialium platysepalum* (2.58 m^2) and *Artocarpus odoratissimus* (1.84 m^2).

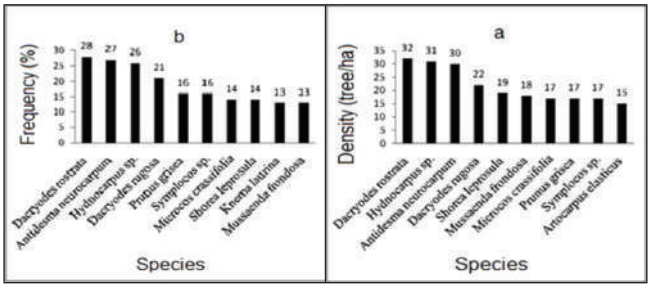

Figure 2. (a) Ten tree species with highest density (trees/ha) and (b) ten tree species with highest frequency in the forest of the mid section of the BDNP core zone.

Among the 89 tree species present in the plot, 10 species having IV > 10 jointly dominated the forest, where as mentioned above *Dacryodes rostrata* was the primary species with highest IV of 15.80 (Appendix 1). The highest IV was atributed to high density and high frequency, implying that its mean tree diameter was small (20.02 cm). It was smaller compared to diameters of *Dialium platysepalum* (45.17 cm), *Shorea leprosula* (38.20 cm), *Parashorea lucida* (37.08 cm) and *Artocarpus odoratissimus* (36.74 cm). To the contrary *Diallium platysepalum*, *Shorea leprosula*, *Parashorea lucida* and *Artocarpus odoratissimus*. which were included in the 10 dominant species were observed to have a relatively lower density and frequency compared to that of *Dacryodes rostrata*.

Table 1. Characteristics of the composition and structure of the forest in a one hectare plot at the midsection of the BNDP core zone, Jambi.

Forest characteristics	Dipterocarpaceae	Non Dipterocarpaceae	Total
Number of species	3 (3.37%)	85 (96.63%)	88
Density (Trees/ha)	36 (6.67%)	504 (93.33%)	540
Basal Area (m^2)	5.01 (16.25%)	25.827 (83.75%)	30.837
Importance Value	28.89 (9.63%)	271.11 (90.37%)	300

Figure 3 demonstrates the species-area curve expressing the pattern of tree species richness in subplots. It shows that the number of species increased as the area extended and there was no indication of the curve to flatten, implying that the one-hectare area did not represent the minimal area. This is comparable to the phenomenon in the primary lowland forests of Sumatra and Kalimantan (Kartawinata et al., 2004; Kartawinata et al., 2008).

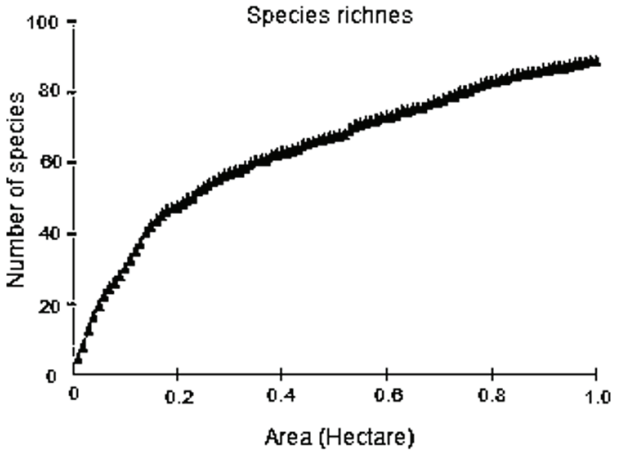

Figure 3. Species-area curve of tree species with DBH ≥ 10 cm in 100 subplots of the 100 m x 100 m plot in the forest of the midsection of BDNP core zone.

In this study we recorded 36 families and 20 of them had highest IV (Table 2). They were families commonly found in the lowland forests of Sumatra, including *Burseraceae*. *Dipterocarpaceae*, *Rubiaceae*, *Lauraceae* and *Euphorbiaceae* (Anwar et al., 1984). *Lauraceae* contained the highest number of species. It is the family characterizing the lowland forests of Southeast Asia (Yamada, 1976), including Kalimantan (Kartawinata et al., 2008). The other families with high species number were *Euphorbiaceae* and *Malvaceae*.

Euphorbiaceae and *Phyllanthaceae* commonly occurred in both primary and secondary lowland forests (Kartawinata et al., 2004). The species of these families have an adaptive capability to grow in the open areas, including gaps in primary forests (Whitmore, 1986). In the mean time 14 families (39%) contained one species each. *Dipterocarpaceae* (Table 1) was represented by only three species (*Parashorea lucida*, *Parashorea* sp. and *Shorea leprosula*) with the total basal area of 5.01 m2 or 16.25% of the total (Table 1).

Table 1 shows that the total BA in the plot was 30.837 m^2 representing 540 trees with the mean BA of 0.057 m^2. Table 3 indicates that the soil surface of the one-hectare plot in the mid-section of the core zone of BDNP was mostly covered by 10 species having highest BA totalling 15.515 m^2 or 50.31% of the total BA. The pecies of *Dipterocarpaceae* having the highest BA was represented by *Shorea leprosula* with BA of 2.829 m^2 and *Parashorea lucida* with BA of 1.795 m^2 or 14.99 % of the total BA, comparable to the values elsewhere in Sumatra (Kartawinata et al., 2004) and Kalimantan (Kartawinata et al, 2008). Another dipoterocarp species, *Parashorea* sp. had only an insignificant BA (0.38 m^2).

Table 2. Ten families with highest number of tree species with DBH ≥ 10 cm and highest IV in the one-hectare lowland forest plot at the mid-section of the BDNP core zone, Jambi.

Family	Species		Family	IV	
	Number	%		Number	%
Lauraceae	6	6.74	Burseraceae	31.60	10.53
Euphorbiaceae	5	5.62	Dipterocarpaceae	28.89	9.63
Malvaceae	5	5.62	Phyllanthaceae	23.38	7.79
Clusiaceae	4	4.49	Moraceae	22.37	7.46
Moraceae	4	4.49	Flacourtiaceae	20.21	6.74
Myristicaceae	4	4.49	Fabaceae	16.32	5.44
Olacaceae	4	4.49	Lauraceae	13.89	4.63
Phyllanthaceae	4	4.49	Rubiaceae	12.85	4.28
Rubiaceae	4	4.49	Euphorbiaceae	11.94	3.98
Sapotaceae	4	4.49	Malvaceae	10.06	3.35
Total	44	49.44	Total	191.51	63.84
Other 26	45	50.56	Other 26	108.49	36.16

Table 3. Desending Basal Area (BA) of ten tree species with DBH ≥ 10 cm in the one-hectare lowland forest plot at the mid-section of the BDNP core zone, Jambi.

No	Species	Family	BA (m^2)
1	*Shorea leprosula*	*Dipterocarpaceae*	2.829
2	*Dialium platysepalum*	*Fabaceae*	2.580
3	*Artocarpus odoratissimus*	*Moraceae*	1.840
4	*Parashorea lucida*	*Dipterocarpaceae*	1.795
5	*Dacryodes rostrata*	*Burseraceae*	1.261
6	*Hydnocarpus* sp.	*Flacourtiaceae*	1.235
7	*Baccaurea macrophylla*	*Phyllanthaceae*	1.031
8	*Mussaenda frondosa*	*Rubiaceae*	1.021
9	*Antidesma neurocarpum*	*Phyllanthaceae*	0.978
10	*Artocarpus elasticus*	*Moraceae*	0.945
Total			15.515 m^2 (50.31%)
79 other species			15.322 m^2 (49.69%)
Total			30.837 m^2 (100%)

STRUCTURE

The stucture of a forest is reflected by the horizontal and vertical ditribution. Horizontal distribution is generally expressed in terms of diameter class distribution (Purwaningsih & Yusuf, 2005) and vertical distribution by height stratification of tree crowns ((Richards,1996; Mirmanto, 2009).

It is always the case and is a feature of a primary tropical forest that a diameter class distribution curve forms an inverted J shape, where the tree diameters < 20 cm are dominant in the population, reflecting general characteristics of dynamic tropical rain forest (Richards, 1996). In the present plot the trees with DBH < 20 cm amounted to 292 trees or 54.07 % (Figure 4) .

Table 4 shows the diameter class distribution of the 10 tree species with highest IV. *Dacryodes rostrata* was dominant at the 10-19.9 cm diameter class. It should be noted also that the ten species were well represented in the 10.9 – 19.9 cm and 30 – 30.9 cm diameter classes. The number of species decreased as the diameter increased. At the upper end of diameter class of 90-90.9 cm we recorded only two species, that were Dialium platysepalum and Parashorea lucida, while Shorea leprosula was present at 80 – 89.9 cm.

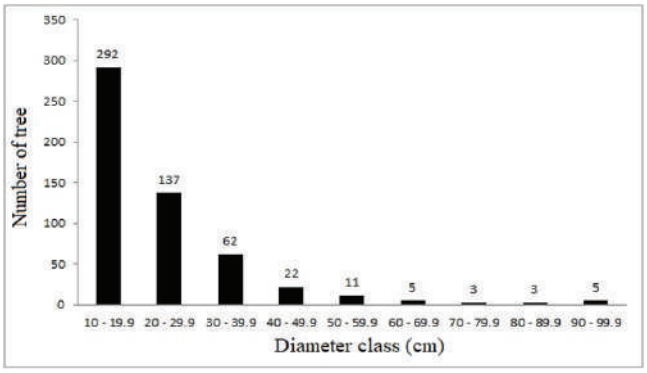

Figure 3. Species-area curve of tree species with DBH ≥ 10 cm in 100 subplots of the 100 m x 100 m plot in the forest of the midsection of BDNP core zone.

Four height classes of trees in the plot could be identifed (Figure 5), comprising the A stratum (> 30 m), B stratum (20.1- 30 m), C stratum (4.1-20 m) and D stratum (1.1-4 m) The highest number of trees (452) occurred in the 4-20 m class (Figure 5). The A stratum which was the emergent stratum was dominated by *Dipterocarpaceae*, the B stratum by *Moraceae*, *Burseraceae* and *Flacourtiaceae*, the C stratum by *Burseraceae*, and the D stratum by the four families, each of which was represented by one tree.

Figure 6 is a simulated profile diagram of the forest on the plot constructed using the method of Kartawinata et al., (2004) by plotting each tree sequentially during the recording and measuring the

Table 4. Number of trees of 10 species with highest importance values (IV) along the diameter class gradient in a one-hectare plot in the forest of the midsection of the BNDP core zone, Jambi.

No	Species	Diameter class (cm)								
		10 - 19.9	20 - 20.9	30 - 30.9	40 - 40.9	50 - 50.9	60 - 60.9	70 - 70.9	80 - 80.9	90 - 90.9
1	*Dacryodes rostrata*	22	4	4	2					
2	*Shorea leprosula*	6	2	2	3	3		2	1	
3	*Hydnocarpus sp.*	14	11	4	1	2				
4	*Antidesma neurocarpum*	18	7	5						
5	*Dialium platysepalum*	4	0	2	2				1	2
6	*Artocarpus odoratissimus*	2	5	2	3	1			1	
7	*Dacryodes rugosa*	15	6	1						
8	*Parashorea lucida*	4	3	1		2	1			1
9	*Mussaenda frondosa*	6	8	3			1			
10	*Symplocos sp.*	6	7	3	1					

trees. It revealed the heights of the individual trees from 1.9 m to 45 m, forming the A, B, C and D strata. The heights of the strata in BDNP were shorter than in the undisturbed primary forest at the Batang Gadis National Park, where the A stratum was 50-60 m and the B stratum, which was the main forest canopy, was 30-50 m. The tallest tree with the height of 45 m and DBH of 86 cm was A*rtocarpus odoratissimus*. The shortest trees with the height of 1-4 m were *Bombax anceps, Memecylon excelsum, Pertusadina eurhyncha* and *Madhuca* sp. with mean DBH of 12.02 cm.

The emergent top A stratum (> 30 m) consisted of only of 16 trees of the 10 prevalent spesies, which were dominated by species of *Dipterocarpaceae* consisted of five trees or 31,3% of the total. Dominance of *Dipterocarpaceae* in the upper canopy is a general characteristics the forests in Sumatra (Anwar et al., 1984; Kartawinata et al., 2004). The B stratum was dominated by big trees, including *Artocarpus odoratissimus* (mean DBH of 36.74 cm), *Dacryodes rostrata* (mean DBH of 20.02 cm), *Diallium platysepalum* (mean DBH of 45.17 cm) and *Shorea leprosula* (mean DBH of 38.20 cm). In C & D strata (1-20 m) the trees were dominated by species of *Burseraceae* (12,1%), *Phyllanthaceae* (7,0%), *Flacourtiaceae* (6,8%), *Lauraceae*

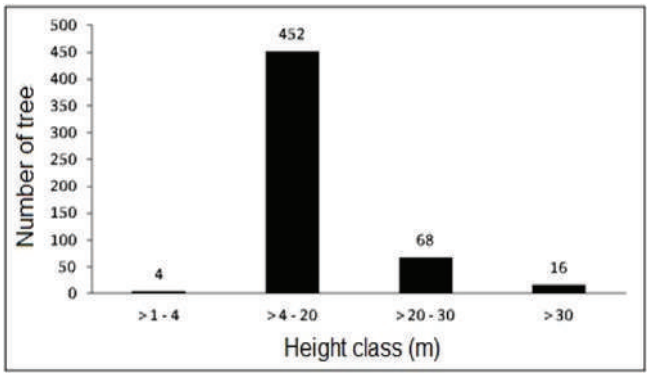

Figure 5. histogram of height class distribbution of trees with DBH ≥ 10 m in a one-hectare plot in the forest of the midsection of the BNDP core zone, Jambi.

(6,6%) and *Dipterocarpaceae* (5,3%). The B stratum (20.1-30 m) was dominated by species of the families *Moraceae* (13,2%), *Burseraceae* (11,8%), *Dipterocarpaceae* (10,3%) and *Flacourtiaceae* (10,3%).

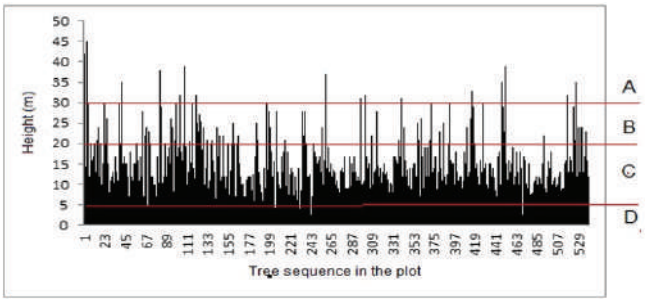

Figure 6. Simulated profile diagram of the forest on the plot constructed by plotting the height of each tree and sequential tree position from tree no. 1 in the 1st subplot up to the tree no 529 in the 100th subplot in the mid-section of the BDNP core zone.

Abiotic Factor

The topography of the one-hectare study plot is indicatred in Figure 7. The forest in the study site was the lowland primary forest with topography ranging from undulating to hilly. The altitude ranges from 265 m to 327 m asl, with slopes vary from 2 to 45 %.
The soil had pH of 5.6-7.36, mean daily temperature was 26.630 C, and the relative humidity ranged from 60.3% to 88.5%.

We recorded that the highest number of trees was recorded at the altitude of 290 - 299 m asl (193 trees) and the lowest number at 330 -339 m asl (3 trees). The highest nunber of trees (371) occurred at the slopes of 0 - 8 % and the lowest number (46) at the slope of 16-45 %. It was comparable to the situatioin in Mt. Galunggung (Pratiwi, 1989) and in the Mt. Gede-Pangranago National Park (Siagian, 2000).

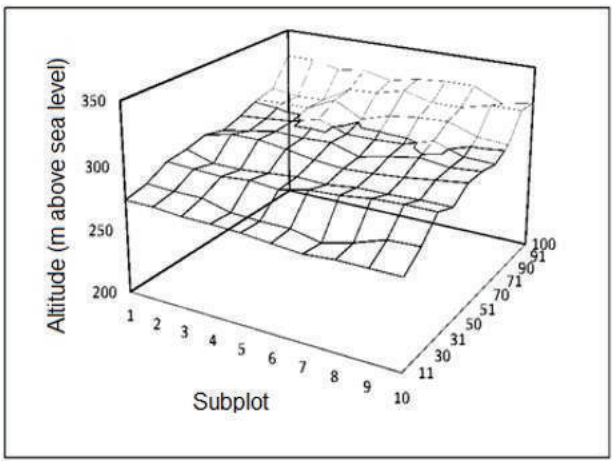

Figure 7. Topographic configuration of the (10 mx 10 m) subplots in relation to the one-hectare (100 m x 100 m) study plot at the mid-section of the BDNP core zone, Jambi.

DISCUSSION

Figure 8 shows the comparison of the species richness and the tree density in one-hectare plot in the present study to the findings in one-hectare plots of other studies in lowland forests of Sumatra and Kalimantan. The species richness refers to "the number of species in a sampling unit" (McCune & Grace, 2002), which indicates species diversity at the first level or alpha diversity (Whittaker, 1972). In the present study the species richness was the lowest amounted to only 89 species per hectare, comparable to those at the research plots in Sarolangun, Jambi (Elviqar, 2013; Hermawan, 2013; Sehati, 2013 and Rahmah et al., 2016). It was much smaller than the species richness in the typical undisturbed primary lowland forests at the Batang Gadis National Park in North Sumatra (Kartawinata et al., 2004) and at Malinau in East Kalimantan (Sheil et al., 2010) with the nunber of 205 species, respectively.

The implication of this phenomenon points to the conditions of the forests in the present study as well as in the other studies in Sarolangun, Jambi (Elviqar, 2013; Hermawan, 2013; Sehati, 2013 and Rahmah et al., 2016). They must have been, in one way or another, diturbed by human activities, including highly destructive selective logging by commercial forest concessionairs and less destructive harvesting by the indigenous Suku Anak Dalam (SAD). As indicated by Sriyanto et al., (2003) the forests at BDNP had a total consisted of primary and secondary forests, which were converted from the permanent production forests, limited production forests and forest designated for other uses. It should be noted that the forests constituting the national park were set aside for the protection of the livelihood of of the SAD inhabiting the natural ecosystems of the area.

The floristic similarity between the present study plot and that in the eastern core zone of BDNP (Rahmah et al., 2016) was 40.8 % and with those at Hutan Adat Imbo Mengkadai (HAIM) 1 and HAIM 2 was 8.3 %, respectively, while with the Batang Gadis NP was 5.9 %, thus showing a totally different composition. It implies that differences were due to disturbances, leading to diverse compositional development of the disturbed forests resulting from the close assotiation of the regrowth of original forest tree species and the late successional secondary forest species (Connel, 1978; Slik et al., 2008; Sheil & Burslem, 2003;).

The two dominant species in the plot, *Dacryodes rostrata* and *Shorea leprosula* (Appendix 1) signified the secondary nature of the forest. Yusuf (2005) noted that in West Sumatra *Dacryoisdes rostrata* occurred only in 20-30 years old secondary forests and was not found in 10 years old secondary forest. Secondary forest species recorded in the present study plot included *Cratoxylum cochinchinense, Macaranga hypoleuca, Macaranga tanarius, Mallotus mollissimus, Mussaenda frondosa, Neonauclea calycina* and *Shorea leprosula*. *Shorea leprosula* is a primary lowland rain forest species but often behaves like secondary forest species or even like a pioneer species invading canopy gaps and forest edges (Whitmore, 1986).

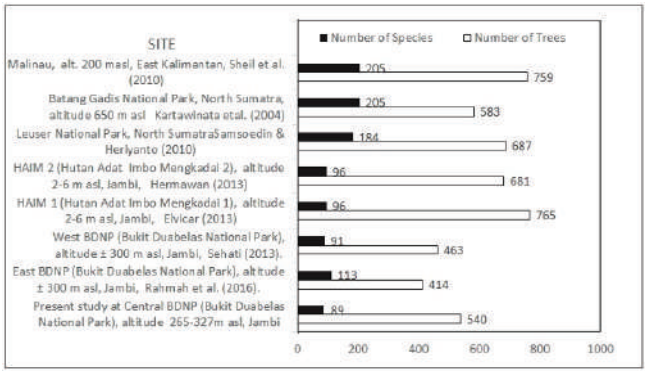

Figure 8. Comparison of the number of species and number of of trees in one-hectare plots in forests of Sumatra and Kalimantan reported in various studies and the present investigation.

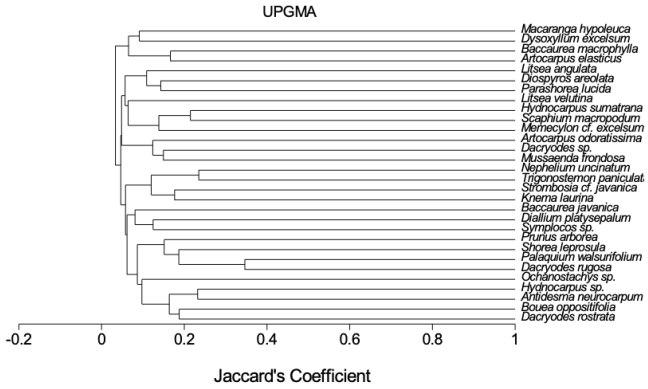

Figure 9. Association dendrogram of species having frequency > 5 %.

Table 5. The status of tree species occurring in the mid-section of the core zone of the BDNP as listed in the IUCN Red List Spesies.

No	Scientific name	Family	IUCN Status	D	F	Do	IV
1	*Parashorea lucida*	Dipterocarpaceae	CE	12	10	1.79	10.11
2	*Shorea leprosula*	Dipterocarpaceae	E	19	14	2.83	15.58
3	*Dacryodes rostrata*	Burseraceae	LR/LC	32	28	1.26	15.80
4	*Prunus grisea*	Rosaceae	LR/LC	17	16	0.70	8.72
5	*Scaphium macropodum*	Malvaceae	LR/LC	10	9	0.63	5.75
6	*Diospyros areolata*	Ebenaceae	LR/LC	7	6	0.18	3.12
7	*Aglaia odoratissima*	Meliaceae	LR/LC	6	5	0.19	2.75
8	*Knema latifolia*	Myristicaceae	LR/LC	4	4	0.13	1.98
9	*Alangium javanicum*	Cornaceae	LR/LC	1	1	0.01	0.43

Legend: CE = Critically Endangered; E = Endangered; LR/LC = Lower Risk/Least Concern

The presence of only three species of *Dipterocarpaceae* with D (density) of 36 trees/ha and BA (basal area) of 5.01 m^2 was unusual in view of the fact that in undisturbed lowland forests of Sumatra, the species of *Dipterocarpaceae* are generally dominant. It was exemplified by the lowland forest at the Batang Gadis National Park, which contained 16 dipterocarp species with D of 122 trees/ha and BA of 18.99 m^2 (Kartawinata et al., 2004). We assumed that this phenomenon was due to intensive selective logging of dipterocarp species which mostly have high commercial values. The heights of the strata in BDNP (Figure 6) were shorter than in the undisturbed primary forest at the Batang Gadis National Park, where the A stratum was 50-60 m and the the B stratum, which was the main forest canopy was 30-50 m. Structurally it points to the disturbed condition of the forest at the midsection of the core zone of BDNP.

The widespread distribution of *Dacryides rostrata* as shown by high frequency value of 28 % was apparently related to its fruits, which were palatable to birds and primates (Balgooy, 1998), thus functioned as dispersers. Fruits of *Dacryodes rostrata* were reported to have high nutritive values, where 100 g of fruits contained 241 kcal energy, 35 mg protein, 399 mg K, 83 mg Ca and 83 mg Mg (Hoe & Siong, 1999).

Distribution of a species is generally not dependent on the distribution of other species, implying the absence of association among species. It was revealed by the association of species having frequencies > 5 % , indicating the Jaccard Coefficient of < 0.4 (Figure 9). It was further confirmed by X^2 test (df = 1 and α = 0.05) for 5 species with highest frequency, which showed negative association ($X^2 < X^2$ Table).

In the plot, we recorded only two species that were listed in the IUCN Red List of having high IUCN conservation status. They were *Parashorea lucida* and *Shorea leprosula*. *Parashorea lucida* had only12 trees and was listed in the category of *Critically Endangered*, while *Shorea leprosula* had only 19 trees and listed in the category of *Endangered* (Table 5). The entire area of BDNP, however, contained also rare plant species, including *Eusideroxylon zwageri, Fagraea fragrans, Calamus manan, Daemonorops draco* and *Dyera costulata* (Kementerian Kehutanan dan Balai TNBD, 2011; Rahmah et al., 2016).

The concept of Hubbell & Foster (1986) states that if on the average, a species had one or fewer individuals per hectare, it can be considered as a rare species on the local scale. Applying this concept, 59 species of 32 families occurring in the plot can be considered as rare in view of the fact that they had the percentage of number of trees of 1-5 %. Of 32 families, 15 of them were represented by one individual each (Table 5). This phenomenon should not be in any way perceived on the global scale as defined by IUCN criteria of rareness.

CONCLUSION

The one-hectare study plot contained 540 trees, comprising 89 species and 36 families. On the basis of two dominant species we designated the tree community in the forest as the ***Dacryodes rostrata-Shorea leprosula Association***. Folristically it was a poor community with low species richness and non-dipterocarp species were prevalent. The one hectare plot should not in any way considered as the minimal area representing the surrounding forests, but it sufficiently provided an illustration of the forest locally. The plot was established as a permanent plot so that it can be used for monitoring dynamic processes

and future studies in various aspects valuable to support sustainable management of the BDNP and the livelihood of SAD.

Structurally and floristically the forest represented a developing and regenerating disturbed forest, with heterogenous species composition as reflected by very low frequency and density in the majority of the species. The core zone of the BDNP has undergone changes from dipterocarp dominated forest to that dominated by non-dipterocarps, due to human activities.

A natural succession has been taking place in the forest of the core zone, leading to the formation of forest similar to the original one prior to disturbance. This rate of natural succession is, however, extremly slow. It can be enhanced and assisted by means of ecological restoration through planting of tree species characteristics of forests in Jambi. They include species of *Dipterorocapaceae* , useful species having values to maintain the livelihood of the SAD, rare and endemic species and others with high conservation values. Species that were persistent and would maintain themselves in the forest in the future are currently represented in almost all diameter classes, although with low density.

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Appendix 1. Density (D = trees/ha), frequency (F in %) and BA (Basal Area in m sq.) of tree species in a one-hectare plot of a lowland forest at the midsection of the core zone of the Bukit Duabelas National Park, Jambi.

NO	Scientific name	Family	Local name	D (trees/ha)	F (%)	BA (m2)	IV (%)
1	*Dacryodes rostrata* (Blume) H.J.Lam	Burseraceae	Jagul besak	32	32	1.261	15.80
2	*Shorea leprosula* Miq.	Dipterocarpaceae	Meranti bungo	19	19	2.829	15.58
3	*Hydnocarpus* sp.	Flacourtiaceae	Kelat merah	31	31	1.235	14.91
4	*Antidesma neurocarpum Miq.*	Phyllanthaceae	Kelat putih	30	3	0.978	14.30
5	*Dialium platysepalum* Baker	Fabaceae	Keranji umbut	11	11	2.580	12.67
6	*Artocarpus odoratissimus* Blanco	Moraceae	Terap kangkung	14	14	1.840	10.83
7	*Dacryodes rugosa* (Blume) H.J.Lam	Burseraceae	Kedundung tunjuk	22	22	0.542	10.17
8	*Parashorea lucida* Kurz	Dipterocarpaceae	Tengkawang bukit	12	12	1.795	10.11
9	*Mussaenda frondosa* L.	Rubiaceae	Berumbung	18	18	1.021	9.33
10	*Symplocos* sp.	Symplocaceae	Kayu garam	17	17	0.795	9.03
11	*Prunus grisea (Blume ex Müll.Berol.) Kalkman*	Rosaceae	Mesuai	17	17	0.698	8.72
12	*Palaquium walsurifolium* Pierre ex Dubard	Sapotaceae	Balam merah	17	17	0.611	8.02
13	*Artocarpus elasticus* Reinw. ex Blume	Moraceae	Terap nasi	15	15	0.945	7.49
14	*Ochanostachys* sp.	Olacaceae	Petaling putih	11	11	0.775	6.62
15	*Knema laurina* Warb.	Myristicaceae	Menerah	14	14	0.311	6.29
16	*Memecylon excelsum* Blume	Melastomataceae	Kelat jambu	14	14	0.364	6.25
17	*Baccaurea macrophylla* (Müll.Arg.) Müll.Arg.	Phyllanthaceae	Medang labu	7	7	1.031	5.88
18	*Scaphium macropodum* (Miq.) Beumée ex K.Heyne	Malvaceae	Muaro kepayang	10	1	0.629	5.75
19	*Trigonostemon* sp.	Euphorbiaceae	Banit putih	13	13	0.200	5.74
20	*Dacryodes* sp.	Burseraceae	Kedundung kedal	11	11	0.471	5.63
21	*Hydnocarpus sumatrana Koord.*	Flacourtiaceae	Medang seluang	9	9	0.611	5.30
22	*Bouea oppositifolia* (Roxb.) Adelb.	Anacardiaceae	Temeras	10	1	0.194	4.55
23	*Nephelium uncinatum* Radlk.	Sapindaceae	Idan tunjuk	8	8	0.193	3.76
24	*Litsea angulata* Blume	Lauraceae	Medang pawas	7	7	0.284	3.66
25	*Litsea velutina* (Blume) Hook. f.	Lauraceae	Medang cempako	7	7	0.237	3.51
26	*Strombosia javanica* Thwaites	Olacaceae	kayu tulang	7	7	0.223	3.47
27	*Gluta* sp.	Anacardiaceae	Terentang	2	2	0.768	3.27
28	*Parashorea* sp.	Dipterocarpaceae	Anai baik	5	5	0.381	3.20
29	*Ficus elastica* Roxb. ex Hornem.	Moraceae	Kayu aro	2	2	0.729	3.15
30	*Diospyros areolata* King & Gamble	Ebenaceae	Banit hitam	7	7	0.180	3.12
31	*Dysoxylum excelsum* Blume	Meliaceae	Jagul tunjuk	7	7	0.156	3.04
32	*Macaranga hypoleuca* (Rchb.f. & Zoll.) Müll.Arg.	Euphorbiaceae	Mang	6	6	0.192	2.97
33	*Pternandra azurea* (DC.) Burkill	Melastomataceae	Kayu ubi	7	7	0.177	2.90
34	*Polyalthia sumatrana* (Miq.) Kurz	Annonaceae	Balam putih	3	3	0.521	2.86
35	*Archidendron bubalinum* (Jack) I.C.Nielsen	Fabaceae	Kabau	5	5	0.250	2.77
36	*Baccaurea javanica* (Blume) Müll.Arg.	Phyllanthaceae	Tungau	6	6	0.129	2.77
37	*Aglaia odoratissima* Blume	Meliaceae	Idan cuko	6	6	0.186	2.75
38	*Madhuca* sp.	Sapotaceae	Putat talang	6	6	0.181	2.73
39	*Neonauclea calycina* (Bartl. ex DC.) Merr.	Rubiaceae	Medang kuning	5	5	0.273	2.64
40	*Lithocarpus sundaicus* (Blume) Rehder	Fagaceae	Barangan benar	4	4	0.390	2.63
41	*Litsea* sp.	Lauraceae	Medang kalo	5	5	0.181	2.55
42	*Durio oxleyanus* Griff.	Bombacaceae	Barangan babi	5	5	0.177	2.53
43	*Neolitsea cassiifolia* Merr.	Lauraceae	Medang so	3	3	0.342	2.28
44	*Gonocaryum gracile* Miq.	Cardiopteridacea e	Meribung	4	4	0.171	2.12
45	*Sterculia cordata* Blume	Malvaceae	Kelumpang batu	4	4	0.142	2.03
46	*Claoxylon longifolium* (Blume) Endl. ex Hassk.	Euphorbiaceae	Medang pangkat	2	2	0.371	1.99
47	*Knema latifolia* Warb.	Myristicaceae	Cemunik	4	4	0.129	1.98
48	*Gordonia excelsa* (Blume) Blume	Theaceae	Kayu bulan	2	2	0.298	1.75
49	*Diospyros curranii* Merr.	Ebenaceae	Kayu cingkuk	3	3	0.136	1.62
50	*Cryptocarya crassinervia* Miq.	Lauraceae	Medang batu	3	3	0.087	1.46
51	*Palaquium ridleyi* King & Gamble	Sapotaceae	Pinang baik	3	3	0.080	1.43
52	*Callophylum tetrapterum*	Clusiaceae	Selancar	3	3	0.074	1.42
53	*Sterculia rubiginosa* Zoll. ex Miq.	Malvaceae	Semasam	3	3	0.072	1.41
54	*Durio zibethinus* L.	Bombacaceae	Durian mas	2	2	0.189	1.19
55	*Neouvaria* sp.	Annonaceae	kalintang tanggo	2	2	0.103	1.12
56	*Madhuca sericea* (Miq.) S.Moore	Sapotaceae	Putat tasik	1	1	0.219	1.10
57	*Lithocarpus encleisocarpus* (Korth.) A.Camus	Fagaceae	Cemening babi	2	2	0.042	0.92
58	*Artocarpus anisophyllus* Miq.	Moraceae	Berkil	2	2	0.036	0.90
59	*Elaeocarpus glaber* Blume	Elaeocarpaceae	Keniti	2	2	0.030	0.88

60	*Dialium indum* L.	Fabaceae	Keranji batu	2	2	0.028	0.87
61	*Macaranga tanarius* (L.) Müll.Arg.	Euphorbiaceae	Sengkubung	1	1	0.096	0.70
62	*Knema globularia* (Lam.) Warb.	Myristicaceae	Anggung	1	1	0.064	0.60
63	*Scorodocarpus borneensis* (Baill.) Becc.	Olacaceae	Kulim	1	1	0.052	0.56
64	*Nephelium mutabile* Blume	Sapindaceae	Samak ketan	1	1	0.051	0.56
65	*Gynotroches axillaris* Blume	Rhizophoraceae	Kayu buluh	1	1	0.045	0.54
66	*Mallotus mollissimus* (Geiseler) Airy Shaw	Euphorbiaceae	Setarak	1	1	0.044	0.53
67	*Oncosperma horridum* (Griff.) Scheff.	Arecaceaae	Bayas	1	1	0.039	0.52
68	*Diospyros hermaphroditica* (Zoll.) Bakh. ex Steenis	Ebenaceae	Nilau nasi	1	1	0.029	0.49
69	*Garcinia parvifolia* (Miq.) Miq.	Clusiaceae	Kandih burung	1	1	0.023	0.48
70	*Dysoxylum* sp.	Meliaceae	Tampoi kuro-kuro	1	1	0.023	0.47
71	*Syzygium cymosum* (Lam.) DC.	Myrtaceae	Kelat samak	1	1	0.022	0.46
72	*Eurycoma longifolia* Jack	Simaroubaceae	Semedu tanah	1	1	0.021	0.46
73	*Knema mandaharan* Warb.	Myristicaceae	Benal	1	1	0.020	0.46
74	*Timonius timon* (Spreng.) Merr.	Rubiaceae	Itam telutuk	1	1	0.020	0.46
75	*Pittosporum moluccanum* Miq.	Pittosporaceae	Kalumpang Beras	1	1	0.019	0.45
76	*Paranephelium nitidum* King	Sapindaceae	Kemangar	1	1	0.017	0.45
77	*Garcinia* sp.	Clusiaceae	Inggi daro	1	1	0.015	0.44
78	*Microcos opaca* Burret	Malvaceae	Sesumpit	1	1	0.015	0.44
79	*Garcinia atroviridis* Griff. ex T.Anderson	Clusiaceae	Asam gelugur	1	1	0.013	0.43
80	*Cratoxylum cochinchinense* (Lour.) Blume	Hypericaceae	Semampat	1	1	0.013	0.43
81	*Bombax anceps* Pierre	Malvaceae	Kakabu	1	1	0.013	0.43
82	*Memecylon edule* Roxb.	Melastomataceae	Belimbing hutan	1	1	0.013	0.43
83	*Ochanostachys amentacea* Mast.	Olacaceae	Petaling merah	1	1	0.013	0.43
84	*Gironniera hirta* Ridl.	Cannabaceae	Medang sailok	1	1	0.011	0.43
85	*Pertusadina eurhyncha* (Miq.) Ridsdale	Rubiaceae	Kayu pisang	1	1	0.011	0.43
86	*Neolitsea* sp.	Lauraceae	Medang pergam	1	1	0.011	0.43
87	*Alangium javanicum* (Blume) Wangerin	Cornaceae	Nilau ruso	1	1	0.010	0.43
88	*Baccaurea dulcis* (Jack) Müll.Arg.	Phyllanthaceae	Tampoi kerawak	1	1	0.010	0.43
89	Unidentified		Akar jangat	1	1	0.032	0.49
Total				540	540	30.837	300

Prediction of genetic gain in progeny test of Samama [*Anthocephalus macrophyllus* (Roxb.) Havil.] in West Seram District, Maluku Province, Indonesia

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ABSTRACT

The research objective is to find out genetic variation, estimated heritability value and the expected genetic gain of Samama [*Anthocephalus macrophyllus* (Roxb.) Havil.] on variation in stem diameter and plant height as superior seed producers. The research was conducted in Uraur Village, West Seram Regency, Maluku Province. The trials consisted of 80 families. All of the trials were laid out in randomized complete block designs (RCBD), 4-trees plots with 4 replications (blocks) at spacing of 5m×2m. Data collection was carried out for 2 months (February to March 2020) and was focused on observing growth variations and genetic parameters in the progeny trial block at 4 years of age including plant height and diameter at breast height. The results of this study indicate that there are variations in growth, where the Anova test results show very significant differences in the plant height parameters namely Family (F = 3.417 p <0.01), Block (F = 437.465 p <0.01) and Family and Block Interactions (F = 3.351 p <0.01). The stem diameter parameters also showed very significant differences, namely Family (F = 2.785 p <0.01), Block (F = 353.095 p <0.01) and Family and Block Interaction (F = 2.611 p <0.01). The value of family heritability and individual heritability on plant height characters belonged to a high category with a family heritability value of 0.7213 and individual heritability value of 0.8811, while the stem diameter character for individual heritability was high with a value of 0.4406 but family heritability was moderate with value of 0.5204. The value of genetic correlation was high and positive and generally shows a greater value than the phenotypic correlation. Genetic correlation values ranged from 0.967 while phenotypic correlation values ranged from 0.8944. The highest selection priority was found in the height of the stem with a weight constant of 0.239. Predicted expected genetic gain was 3.0% for diameter parameter and 3.2% for height parameter.

ABSTRAK

Objektif dari penelitian ini adalah menemukan variasi genetik, taksiran nilai heritabilitas serta peluang perolehan *expected genetic gain* tanaman Samama [*Anthocephalus macrophyllus* (Roxb.) Havil.] pada variasi diameter dan tinggi pohon sebagai penghasil benih unggul. Penelitian dilakukan di Desa Uraur Kabupaten Seram Bagian Barat Provinsi Maluku. Percobaan ini menggunakan 80 famili. Penelitian ini dibangun dengan desain randomized completely block design (RCBD), jarak tanam 5 x 2 m, 4 ulangan (blok) dan 4 treesplot. Pengumpulan data dilakukan selama 2 bulan (Februari sampai dengan bulan Maret 2020) memfokuskan pada pengamatan variasi pertumbuhan dan parameter genetik yang berada di blok uji keturunan pada umur 4 tahun meliputi tinggi dan diameter setinggi dada. Hasil Penelitian ini menunjukkan bahwa terdapat variasi pertumbuhan, dimana dari hasil uji Anova menunjukkan perbedaan sangat nyata pada parameter tinggi yaitu Famili (F=3,417 p<0,01), Blok (F=437,465 p<0,01) dan Interaksi Famili dan Blok (F=3,351 p<0,01). Pada parameter diameter juga menunjukkan perbedaan sangat nyata yaitu Famili (F=2,785 p<0,01), Blok (F=353,095 p<0,01) dan Interaksi Famili dan Blok (F=2,611 p<0,01). Nilai heritabilitas famili dan heritabilitas individu pada karakter tinggi tanaman memiliki kategori tinggi dengan nilai heritabilitas famili 0,7213 dan nilai heritabilitas individu 0,8811, sedangkan pada karakter diameter tanaman untuk heritabilitas individu tergolong tinggi dengan nilai sebesar 0,4406 namun heritabilitas famili tergolong sedang dengan nilai 0,5204. Nilai korelasi genetik bernilai tinggi dan positif serta secara umum menunjukkan nilai yang lebih besar dibandingkan dengan korelasi fenotipik. Nilai korelasi genetik berkisar 0,967 sedangkan nilai korelasi fenotipiknya berkisar 0,8944. Prioritas seleksi tertinggi ditemukan pada tinggi batang dengan nilai konstanta bobot sebesar 0,239. Prediksi *expected genetic gain* diperoleh 3,0 % untuk parameter diameter dan 3,2 % untuk parameter tinggi.

Keywords: *Samama, heritability, phenotypic, expected genetic gain, tree diameter, tree height*

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INTRODUCTION

Samama [*Anthocephalus macrophyllus* (Roxb.) Havil.] is one of the superior plants of Maluku Province which has fast growth, can grow in broad climate distribution and has high economic value. Samama also has a smooth wood texture and straight wood fiber direction. The red wood color is also quite unique and has a strong and durable wood. Taking into account the nature of Samama plants the fast-growing, have high end product value and can be processed extensively such as for sawn timber, plywood, plywood or veneer as well as being a type of native plant of Indonesia, the development of this plant must be carried out continuously to be able to meet the ecological and economic needs community (Mulyana, 2010).

Samama species development still faces many obstacles related to seed quality where the seeds used in planting activities often do not pay attention to genetic, physical and physiological qualities.

In the framework of providing superior seeds of Samama plants to increase productivity of Samama plants, the Maluku and Papua Forest Plant Seedling Centers have established a Samama Seedling Seed Orchad in the Uraur Village, West Seram Regency, Maluku Province. The concept of establishing Seedling Seed Orchad conducted combines the concept of tree breeding with conservation of genetic resources where the construction of Progeny test blocks and Seedling Seed Orchad blocks are built separately but are still in the same area. The concept of developing Seedling Seed Orchad was born as a solution with the increasingly minimal presence of Samama plant genetic material in its natural habitat. This research was conducted to determine the best growth variation, genetic parameters, family (Mother Plant) and predicting the expected genetic gain in the 4-year-old Samama progeny test block which will later be used as the basis for selecting the Seedling Seed Orchad block.

METHODS

The study was conducted on the Samama Progeny test block located on the land belonging to the Maluku Protestant Church Synod located in Uraur Village, Kairatu District, West Seram District, Maluku Province with an area of 1.28 Ha of the total area of the Seedling Seed Orchad of 5 Ha with a height of ± 15 meters above sea level (m asl). Based on the seed zone, this location belongs to the lowland rain seed zone, the red yellow podsolic soil type with red sandy clay texture. This land is quite fertile, characterized by the presence of forests with teak plants around the study site.

The research material used was 4-year-old Samama plant in progeny test blocks, experimental design maps, and plant measurement sheets (tally sheet). The equipment used is measuring poles, diameter tape, brushes, and computers.

The experimental design used in the construction of the Samama Progeny test block is consisted of 80 families. All of the trials were laid out in randomized complete block designs (RCBD), 4-trees plots with 4 replications (blocks) at spacing of 5m×2m.

The number of plants observed was 1,280 plants. Plant heights were measured using poles from the base of the tree to the highest growing point. The stem diameters were measured using a diameter tape (diameter tape) at breast height (± 1.30 m). Data were analyzed follows the equation:

$$Yijkl = \mu + Bi + Fj + BFij + Eijkl$$

Where:

Yijkl = individual k-tree observations of the j-th family in the i-th block

μ = general average

Bi = i-th block effect

Fj = j-th Family effect

BFij = interaction effects of the i-th block and j-family

εijkl = random error on observation to ijkl

Estimated value of individual heritability (h^2i) and family heritability (h^2f) are calculated using the following formula (Hardiyanto, 2007):

$$h^2i = \frac{4\,\sigma^2 f}{(\sigma^2 f + \sigma^2 bf + \sigma^2 e)} \qquad h^2 f = \frac{\sigma^2 f}{(\sigma^2 f + \sigma^2 bf/b + \sigma^2 e/nb)}$$

Where:

$\sigma^2 f$ = Components of family variance (Mother Plant)

$\sigma^2 bf$ = components of the variance of block and family interactions (Mother Plant)

$\sigma^2 e$ = component error variance

n = the harmonic mean of the number of trees per plot

b = the average harmonic number of blocks

f = average harmonic number of families (Mother Plant)

According to Cotterill and Dean (1990) *in* Indrioko et al. (2016) Heritability values are explained as follows:

Low: $h^2f \leq 0.40$ and $h^2i \leq 0.1$
Moderate: $0.40 \leq h^2f \leq 0.60$ & $0.10 \leq h^2i \leq 0.30$
Height: $h^2f > 0.60$ and $h^2i > 0.30$

Genetic correlation between two traits (rxy) is calculated using the following formula(Williams et al., 2002):

$$rxy = \frac{\sigma^2_{xy}}{\sqrt{\sigma^2_x \sigma^2_y}}$$

Where:

rxy = covariance of two properties (x and y) at the family level (Mother Plant)

σ^{2x} = variant component for x properties at the family level (Mother Plant)

σ^{2y} = component variance for y properties at the family level (Mother Plant)

Selection of the best Family (Mother Plant) based on the selection index value (I):

$$I = [bh * H + bd * D]$$
$$b = P_f\text{-}1 * G_f * a \text{... (Yamada, 1977)}$$

Where:

I = Index value

bh = high weight value

bd = weight value of diameter properties

H = high

D = diameter

b = a matrix of the weight values of each trait

P_f^{-1} = inverse matrix phenotypic family variance and covariance

G_f = matrix family of variance and covariance components

a = each relative economic coefficient vector is calculated as the inverse of the standard deviation phenotypic family

To estimate the expected genetic gain, used a formula according to Zobel and Talbert (1984):

$$G = H^2 \text{ x } S \text{ or } G = H^2 \text{ x } I \text{ x } s_p$$

Where:

G = estimated genetic gain (*Expected genetic gain*)

H = heritability

S = Differential Selection

s_p = Standard Deviation of the Phenotype

To find out the success of Samama plant life in the Samama progeny test block, the percentage of plant life is calculated using the formula:

$$Pi = (ni/n) \text{ x } 100\%$$

Where:

Pi = percentage of plant life

ni = The number of plants living in the census field

n = The number of plants that should be present

RESULTS AND DISCUSSION

Adaptation and Growth

The adaptability shown by percentage Samama plant life in the progeny test block in Uraur Village, West Seram District, Maluku Province up to 4 years is relatively good. In general, the plant growth rate is quite good where there are 51 families that have a life percentage above 75% and 29 families have percentage life 50% - 74%.

Based on data on the number of individuals in the plot (4 trees per plot), on average percentage plant life in the plot is 75% or the average number of plants that live in each plot is 3 plants. Growth data of height and diameter of Samama plants in the progeny test block also showed a good growth rate. Percentage Samama plant life is quite high in the progeny test block probably caused by the nature of Samama plants that are able to grow and adapt to various conditions of the place to grow, relatively free from pests and serious diseases and relatively easy silvicultural treatment (Krisnawati et al., 2011). Surip et al. (2017) reported that Jabon Merah plant growth was still quite high in the first generation progeny test plot which was built in Wonogiri where land conditions were marginal land with a low average annual rainfall (1,645 mm / year). Percentage plant life is an important factor in plant breeding actions to maintain the validity of data analysis (Chambers and Borralho, 1997 *in* Sumardi et al., 2018).

The results of this study indicate the average growth of Samama plants for height parameters is 5.735 m with a range between 5.39 - 6.20 m, while the average diameter parameter growth is 6.33 cm with a range between 5.70 - 6.70 cm. The height and diameter growth value of Samama or better known as Jabon Merah [*Anthocephalus macrophyllus* (Roxb.) Havil.] is better than the growth of height and diameter of Jabon Putih [*Anthocephalus cadamba*.], this can be proven in the results of Junaedi's research (2018) on the growth of 4-year-old Jabon Putih [*Anthocephalus cadamba*.] in Riau, the average height growth is 4.17 m and the average diameter is 5.15 cm. The difference is thought to be caused by differences in plant genetic material, site

conditions and silvicultural treatment. Differences in growth of white A. cadamba between locations were also reported by Krisnawati et al. (2011) and Seo et al. (2015).

In general, the growth rate of plant diameter (StDev = 3.779 mean = 7.056) is faster than the growth rate of plant height (StDev = 3.058 mean = 6.423). The phenotypic variation in diameter (s^2 = 20.592) looks greater when compared to the phenotypic variation in plant height (s^2 = 15.52). However, in general the phenotypic variation of plants showed that the Samama plants in the progeny test block still had normal plant growth (Figure 1).

Genetic Variation in Growth

Analysis of variance in the 4 year old Samama progeny test block is presented in App. 1, that the Samama plant in the progeny test block in Uraur Village, West Seram Regency, Maluku Province,showed very significant differences in the height parameters namely Family (F = 3,417 p <0.01), Block (F = 437,465 p <0.01) and Family and Block Interaction (F = 3.351 p <0.01). The diameter parameters also showed very significant differences, namely Family (F = 2.785 p <0.01), Block (F = 353.095 p <0.01) and Family and Block Interaction (F = 2.611 p <0.01). The influence of family factors (mother plant) and blocks on height and diameter are also shown in the results of the study of Mashudi and Baskorowati (2015) on the *Alstonia scholaris* island aged 2 years, Kinho et al. (2015) on ebony (*Diospyros rumphii*) one year old, Santos et al. (2015) in *Eucalyptus badjensis*, Haryjanto et al. (2014) at the life (*Ficus variegata*) at 8 months, Yudohartono (2013) at the white jabon (*Anthocephalus cadamba*) aged 5 and 8 months, *Araucaria cunninghamii* aged 18 and 5 years (Setiadi, 2010; Setiadi and Susanto, 2012). Hadiyan (2010) in sengon (*Falcataria moluccana*) at 4 months, and in Mahfudz et al. (2010) in merbau (*Intsia bijuga*) aged 18 months.

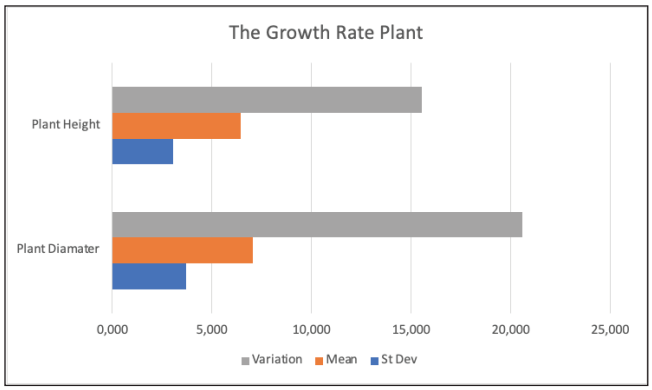

Figure 1. The growth rate of plants.

The difference is very evident in the source of block variation, giving the sense that there are variations in the place of growth in one planting location gives a real influence on the growth and height of Samama plants. Thus the making of blocks in the Progeny test Samama of the plant native from Maluku Province becomes very effective in anticipating the effect of different places of growth on plant growth. In accordance with the purpose of making plant blocks as stated Na'iem (2007) that the building of the block aims to minimize the variation of the existing or presumed environment of the families tested in each block, so that in each block of the plant environmental conditions must be as homogeneous as possible.

Estimated Heritability Value

All traits observed, the proportion of the variance component to the largest total variation is shown at the source of variation in the plot (74.50% - 86.20%), and then the variance component interaction of the family x block (10.60% - 21%) and the smallest at component of family variance (3.20% - 4.50%). The diameter of the stem has a greater proportion of the variance component in the plot (86.20%) compared to the plant height (74.50%), but instead the high nature has a greater proportion of the variance component interaction of the family x block (21%) than the diameter (10.60%) (App. 2).

Based on the division of values according to heritability Cotterill and Dean (1990) *in* Indrioko et al. (2016) Family heritability and individual heritability at high characters have a high category with family heritability> 0.60 (h^2f = 0.7213) and individual heritability> 0.30 (h^2i = 0.8811) while those with diameter are categorized as high. For individual heritability with an individual heritability value > 0.30 (h^2i = 0.4406) for moderate family heritability is 0.40 ≤ h^2f ≤ 0.60 (h^2f = 0.5204).

The results also showed that the family heritability value was not always greater than the individual heritability value as seen in the high parameter (h^2f = 0.7123 <h^2i = 0.8811) even though the Diameter parameter showed different results (h^2f =0.5204> h^2i = 0.4406). The high value of individual heritability compared to family heritability is usually obtained after selection, as in the results of Sutrisno's research (2007) on *Acacia mangium* which reported that individual heritability was higher than family heritability after thinning. Likewise with the results of studies on other types of conifers (*Pinus sylvertris*) aged 10 years.

In general these results identify that the variation in the growth of high traits is quite strongly influenced by genetic factors. Based on the value of family heritability on the high character that has a high value in the progeny test block indicates that family selection in the Seedling Seed Orchad block based on plant height properties has the potential to provide greater genetic gain.

Estimated Genetic Correlation Value

Genetic correlations are high and positive and generally show greater values compared to phenotypic correlations (Table 1). Genetic correlation values ranged from 0.967 while phenotypic correlation values ranged from 0.8944. Hardiyanto (2008) suggested that phenotypic correlations are correlations between values measured from two traits in a population, whereas genetic correlations are correlations between breeding values for different traits and are mainly caused by genes that affect more than one trait (*pleiotrophy*). Phenotypic correlation is basically a complex function of genetics and environment that has little use as a reference to genetic conditions (White et al., 2007).

Table 1. Genetic and phenotypic correlations between diameter and plant height traits of Samama.

Parameters	Plant Height	Stem Diameter
Plant height	-	0.967
Diameter	0.8944	-

Note: genetic correlation (above diagonal), phenotic correlation (below diagonal)

Table 1 also shows that the growth of height and diameter growth have a fairly close and positive close relationship. In relation to the efficiency of the selection work to be carried out in the seedling nursery block, one parameter can be used, namely selection based on height or diameter. This is because genetic improvement of height parameters will be followed by genetic improvement of plant diameter parameters. Genetic correlations between height and diameter are high in forestry plants, including *Intsia bijuga* (Mahfudz, 2013), *Falcataria moluccana* (Ismail and Hadiyan, 2008; Hadiyan, 2010), *Aracauria cunninghamii* (Setiadi, 2010), and *Shorea parvifolia* (Prasetyawati, 2009).

Determination of the Best Family

In general, progeny test is carried out for spacing selection in a tree plot that will be converted into a seedling seed orchad. Progeny test of Samama plants conducted in Uraur Village, West Seram Regency, Maluku Province is an progeny test to obtain selected family information that will be used for family selection in the Seedling Seed Orchad block (KBS), where the Progeny test and KBS tests are built in two separate populations. Family ranking (Mother Plant) in breeding programs is a very important factor because family ranking (Mother Plant) is a measure of the performance of the family (Mother Plant) tested in an Progeny test which can later be used as a basis for selection and development of more breeding programs continued (Halawane, 2013).

Table 2. The stem diameter and plant height of Samama.

No.	Parameters	b
1	High	0.239
2	DBH	0.027

This study produces a positive value at the value of "b" or the weight constant for each of the measured quantitative genetic parameter traits, where the value of the high parameter weight constant is 0.239 and the diameter parameter weight constant is 0.027 (Table 2). This shows that the selection of the traits of the quantitative genetic parameters for tree selection is the height or criteria for determining the tree or family to be chosen.

The best family / ranking family (Table 3) for family selection in the progeny test in this study was determined from the index value. The index value is a combined value of two parameters of height and diameter. Table 3 shows that family number 50 has the largest index value of 1.67 with an average value of height is 6.205 m and diameter of 6.802 cm, the acquisition of this index value also indicates that family number 50 is the best family (rank I) .Purwanta (2012), states that family ranking in a breeding program will be easier if it is based on one trait, however if based on many traits of breeders it will be faced with the fact that the ranking of the best family in one trait is not always the best in another. The results of this study indicate that the index value will facilitate the ranking when there is a family that gives the best value in one of the parameter properties but not in the other parameters as described in families number 73 with 3, and 27 with 23 (Table 4).

Table 3. The top ten families of Samama.

Fam	Index	Rank	Height (m)	DBH (cm)
50	1.67	1	6.205	6.802
31	1.61	2	5.957	6.760
13	1.60	3	5.951	6.733
11	1.60	4	5.961	6.635
75	1.60	5	5.939	6.780
65	1.60	6	5.952	6.594
73	1.60	7	5.946	6.646
3	1.60	8	5.924	6.709
27	1.59	9	5.914	6.539
23	1.59	10	5.918	6.498

Table 4. Predicted value of expected genetic gain.

No.	Trait	Mean	S.D	*Expected Genetic Gain*
1	Diameter	5.735	1.1193	0.17 (3.0%)
2	Height	6.333	1.332	0.22 (3.2%)

Expected Genetic Gain Prediction

Genetic gains is a response to selection, whereas selection is based on the principle that the average genetic value of the selected individual will be better than the average value of all individuals in the population. When the genetic gain is calculated on the population before selection, it is called the expected genetic gain, while the genetic gain calculated based on existing controls or unimproved seeds is called the realized genetic gain.

Table 4 shows that Expected Genetic Gain on diameter and height parameters at the age of 4 years showed results that did not differ too far. This can illustrate the magnitude of the intensity of the selection that will be applied to the seedling nursery block in order to increase genetic gain (read: increased production and quality). These results are related to the results of the family heritability value at the high parameter 0.72 and the heritability value at the diameter parameter 0.52. It appears that with a large heritability value, the chances of genetic enhancement that can be obtained will be even greater. While the value of heritability will increase with increasing plant age, this is in accordance with the opinion of Kien et al. (2009), which states that an increase in heritability as a result of increasing plant age may also occur due to a competitive effect on older stand age, which can lead to an estimate of heritability that is greater than it should be. Genetic enhancement also becomes higher with higher levels of selection intensity.

CONCLUSION

Based on Data analysis and discussion above, then in this study several conclusions can be drawn as follows:

Samama plant growth 4 years old in the progeny test block in Uraur Village, West Seram Regency, Maluku Province has growth variation, which is from the Annova test results showed very significant differences in the height parameters namely Family ($F = 3.417$ $p < 0.01$), Block ($F = 437.465$ $p < 0.01$) and Family and Block Interaction ($F = 3.351$ $p < 0.01$). The diameter parameters also showed very significant differences, namely Family ($F = 2.785$ $p < 0.01$), Block ($F = 353.095$ $p < 0.01$) and Family and Block Interaction ($F = 2.611$ $p < 0.01$).

Quantitative genetic characteristics of Samama plants in the progeny test block indicate that the family heritability and individual heritability values in plant height characters have a high category with a family heritability value of 0.7213 and an individual heritability value of 0.8811, whereas in plant diameter characters for individual heritability are high with value of 0.4406 but family heritability is moderate with a value of 0.5204. Another quantitative genetic characteristic is the value of high and positive genetic correlations and generally shows greater values compared to phenotypic correlations. Genetic correlation values ranged from 0.967 while phenotypic correlation values ranged from 0.8944. Expected expected genetic gain is obtained 3.0% for diameter parameters and 3.2% for height parameters.

The top ten families that can be used as producers of superior seeds based on the calculation of successive index values are families number 50, 31, 13, 11, 75, 65, 73, 3, 27, and 23.

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Appendix 1. Analysis of diversity for plant height and diameter characters.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Parameter Height (m)					
Corrected Model	14140.252a	319	44.327	7.450	. 000
Intercept	20424.038	1	20424.038	3432.726	. 000
Family	1605.997	79	20.329	3.417	. 000
Block	7808.492	3	2602.831	437.465	. 000
Family * Block	4725.763	237	19.940	3.351	. 000
Error	5711.810	960	5.950		
Total	40276.100	1280			
Corrected Total	19852.062	1279			
Diameter Parameters (cm)					
Corrected Model	17491.205a	319	54.831	5.950	. 000
Intercept	24647.220	1	24647.220	2674.686	. 000
Family	2027.759	79	25.668	2.785	. 000
Block	9761.297	3	3253.766	353.095	. 000
Family * Block	5702.148	237	24.060	2.611	. 000
Error	8846.395	960	9.215		
Total	50984.820	1280			
Corrected Total	26337.600	1279			

R Squared (height) =.712 (Adjusted R Squared =. 617), R Squared (Diameter) =.664 (Adjusted R Squared =.553)

Appendix 2. Variance components of family and individual heritability (plant height and diameter) of Samama trees.

Character	Variance Component			h^2i	h^2f
	Family	Family in blok	Family in plot		
High	0.20 (4.50%)	0.92 (21%)	3.26 (74.50%)	0.8811	0.7123
Diameter	0.25 (3.20%)	0.83 (10.60%)	6.73 (86.20%)	0.4406	0.5204

Note: Figures in parentheses are the proportion (%) of the variance component to the total phenotypic variance

Sequential explanatory analysis of environmental awareness towards responsible environmental behavior (REB) of high school students in Depok City, West Java, Indonesia

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ABSTRACT

Objective of this study is to obtain information about the interrelationship between environmental awareness and the responsible environmental behavior of high school students. Research conducted toward students of the Masjid Terminal High School (SMA) at Depok City in December 2019 to July 2020 with samples of 111 respondents by proportional random sampling technique. A mix-method was employed in this study, which is a combination of quantitative and qualitative methods as sequential explanatory. Collection of quantitative data was conducted using a questionnaire with rating scale for X and Y variables. The validity test used Pearson's product moment and the reliability test used alpha Cronbach. The analysis of quantitative data with a prerequisite test in the form of a normality test employed the Kolmogorov-Smirnov test and a homogeneity test using a Levine statistic. Testing the data hypothesis was using the correlation test with Pearson product moment using SPSS 26. Qualitative research data was obtained from the interviews, and the data was analyzed by reducing data, presenting data and drawing conclusions. The results showed that there was a positive correlation between environmental awareness and responsible environmental behavior with the regression equation $\hat{Y} = 99.939 + 0.161x$ with a correlation coefficient of $r = 0.195$ and r^2 of 3.80%. The contribution of r^2 means that 3.80% of responsible environmental behavior is influenced by environmental awareness, while 96.20% is influenced by other factors. Based on above results, can be conclude that there are positive correlation between environmental awareness and responsible environmental behavior which influenced by the factors of family background, habits, information, as well as social environment.

ABSTRAK

Tujuan penelitian ini adalah untuk memperoleh informasi tentang hubungan antara kesadaran lingkungan dengan perilaku tanggung jawab lingkungan pada siswa SMA. Penelitian dilakukan terhadap siswa sekolah (SMA/*High School*) Masjid Terminal, Kota Depok, Jawa Barat, pada bulan Desember 2019 hingga Juli 2020 dengan jumlah sampel 111 responden dengan teknik proporsional random sampling. *Mix-method* digunakan dalam penelitian ini, yang merupakan kombinasi antara metode kuantitatif dan kualitatif sebagai *sequential explanatory*. Pengumpulan data kuantitatif dilakukan dengan menggunakan kuesioner dengan skala sikap (*rating scale*) untuk variabel X dan Y. Uji validitas menggunakan *Pearson's product moment* dan uji reliabilitas menggunakan *alpha Cronbach*. Analisis data kuantitatif dengan uji prasyarat berupa uji normalitas menggunakan uji *Kolmogorov-Smirnov* dan uji homogenitas menggunakan statistik *Levine*. Pengujian hipotesis data menggunakan uji korelasi dengan *Pearson's product moment* menggunakan SPSS 26. Data penelitian kualitatif diperoleh dari wawancara, dan data dianalisis dengan mereduksi data, menyajikan data dan menarik kesimpulan. Hasil penelitian menunjukkan bahwa terdapat hubungan positif antara kesadaran lingkungan dengan perilaku tanggung jawab lingkungan dengan persamaan regresi $\hat{Y} = 99{,}939 + 0{,}161x$ dengan koefisien korelasi $r = 0{,}195$ dan r^2 sebesar 3,80%. Kontribusi r^2 berarti 3,80% perilaku tanggung jawab lingkungan dipengaruhi oleh kesadaran lingkungan, sedangkan 96,20% dipengaruhi oleh faktor-faktor lain. Berdasarkan hasil di atas, dapat disimpulkan bahwa terdapat hubungan positif antara kesadaran lingkungan dengan perilaku tanggung jawab lingkungan yang dipengaruhi oleh faktor latar belakang keluarga, kebiasaan, informasi, serta lingkungan sosial.

Keywords: *Responsible environmental behavior (REB), environmental awareness, high school students.*

INTRODUCTION

The environment is a place where there is a living thing together with living and nonliving things. The environment is not only a place to live, but also it has a very important role in fulfilling human life. It is because in the environment there are interactions, and one of which is humans.

The interaction between humans and the environment occurs normally. Humans are living things that are very dependent on the environment. All human needs are also found in the environment by utilizing existing natural resources, therefore humans and the environment cannot be separated. The environment greatly affects human life, if there is environmental damage then human life will also be

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disturbed. The emergence of environmental problems is caused by human carelessness. Human behavior that causes environmental problems occurs due to a lack of responsibility for the environment and low environmental awareness.

A person's behavior towards the environment can be seen from the surrounding environment and the habits that are reflected in him. The low level of responsible environmental behavior in a person can cause environmental problems as well as damage to the environment. Responsible environmental behavior is also influenced by several factors. According to Krajhanzl (2010), responsible environmental behavior is influenced by three factors, namely: 1) condition factors/external factors, 2) personality factors and 3) relationship factors with nature.

The level of one's environmental awareness is not always high, this is influenced by several factors such as environmental knowledge, environmental values and one's environmental behavior. Environmental awareness also means helping social groups and individuals to gain awareness and sensitivity to the same problems they face with their environment (Kang & Grewak, 2015). Environmental awareness is needed to solve environmental problems and awareness needs to be brought through environmental education to individuals (Cruz & Tantengco, 2017). This is because one of the results of environmental education is creating environmental awareness. For this reason, environmental awareness will become a global phenomenon in the near future (Badoni, 2017).

Education plays an important role in preserving the environment. Student behavior towards a sense of responsibility in protecting the environment is minimal due to a lack of environmental awareness. This problem can be solved by the younger generation, through informal education. Formal education is an important external factor in the development of environmental love (Slavoljub et al., 2015). Responsible environmental behavior can be taught from an early age both in the school environment and in the home environment. Responsible behavior in protecting the environment will also have a positive impact on life. One's environmental awareness needs to be possessed to solve environmental problems that are increasing Kabadayi & Altinsoy (2019).

This is in line with the opinion of Akpofure (2018), which explains that one of the most fundamental characteristics of environmental awareness is action that produces better environmental outcomes, not just the accumulation of knowledge or skills. The lack of students' sense of responsibility towards the environment can have a negative impact.

Lack of environmental awareness of a person causes individuals to not respect the surrounding environment and even damage the beauty of the environment by destroying, destroying and scribbling. This happens a lot to adolescents, which is even vandalism that by scribbling on public facilities such as school toilets, bridges, chairs, tables, and even destroying or slashing plant stems. Lack of responsible environmental behavior (REB) in teenagers currently, causes them to seem like they don't care about the environment around them. Vandalism is considered a type of social problem that is different from other social problems such as crime in terms of the type and age of the perpetrator, the target of the action, and the motive for the action (Mushtaha & Hamid, 2016).

Based on the description above, further study is needed through research on responsible environmental behavior in terms of the factors that are thought to have a relationship.

Objective of this study is to obtain information about the relationship between environmental awareness and responsible environmental behavior of students and other factors that influencing an responsible environmental behavior (REB) of students at the High School Masjid Terminal in Depok.

METHODS

This research was conducted in Depok. This research was conducted in the even semester of the 2019/2020 school year. The method used in this research is a combination of sequential explanations quantitative and qualitative.

There are two variables in this study. The first variable is the dependent variable (Y), responsible environmental behavior (REB). Independent variable (X), environmental awareness. The research design is shown in Figure 1.

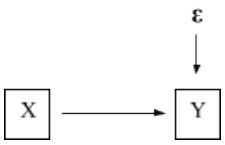

Figure 1. Research Design

Notes:
X: Environmental Awareness Y: Responsible Behavior
ε: Other factors that influence variable Y

The population used in this study are all 154 students of SMA Masjid Terminal in Depok, school year of 2019/2020. The sample was determined using the technique Proportional Random Sampling, based on the calculation, the number of samples in the study was 111 students. Determination of the number of samples using formula from Slovin as shown below:

$$n = \frac{N}{1+N.e^2} = n = \frac{154}{1+154.0{,}05^2} = n = \frac{154}{1{,}385} = 111{,}19$$

Notes:
n = Sample Size
N = Population Size
e = Error tolerance 5% (0.05)

Determination of the research data source was taken by using purposive sampling and snowball sampling. Purposive sampling is a technique in determining the source of data based on certain considerations. The data obtained in this study are the results of interviews through informants and field observations. Data collection techniques are the most important step in research, because the main purpose of research is to get data. The data collection technique was carried out by observation and interviews using purposive sampling technique. Qualitative data analysis was conducted by having data reduction, data presentation, on-site analysis, inter-site analysis and drawing conclusions.

Data analysis was carried out by combining the two similar data so that quantitative data can be expanded and deepened with qualitative data. The first step is analysis using quantitative methods using correlation technique Pearson Product Moment. Prior to data analysis, the prerequisite test of all data was carried out. To determine the hypothesis testing technique, first a descriptive statistical calculation is carried out in the form of calculating the average, mean, mode, and standard deviation of all the data obtained. Then performed quantitative data analysis with SPSS 26, prerequisite test in the form of normality test using the Kolmogorov-Smirnov test to prove the population is normally distributed and homogeneity test using Levine statistic to prove the data is homogeneous. Pearson product moment was used to test the data hypothesis using the correlation test to determine the magnitude of the relationship between responsible environmental behavior and environmental awareness.

Whereas qualitative data consists of data reduction, on-site analysis, inter-site analysis and drawing conclusions. This qualitative data collection is taken when it already has quantitative result data. After obtaining quantitative data, an interview was held to obtain qualitative data.

RESULTS

Based on the SPSS output table above, the constant value (a) is 99.939 and the constant value (b) is 0.161 so the regression equation $\hat{Y} = 99.939 + 0.161X$. Based on the SPSS output table, it was shown that the probability value (sig.) is 0.04 which is less than α 0.05 so that the results can be concluded that the regression equation $\hat{Y} = 99.939 + 0.161X$ is significant. Thus, the regression equation $\hat{Y} = 99.939 + 0.161X$ can be used to predict responsible environmental behavior based on environmental awareness.

Linear regression

Based on the SPSS output table that the value of deviation from linearity shows a significance of 0.351 greater than 0.05, which means that the deviation from the linear state is insignificant, so it can be concluded that the two variables with the regression equation $\hat{Y} = 99.939 + 0.161X$ is linear.

The next stage of the regression equation can be interpreted that before students have environmental awareness, they have environmentally responsible behavior with a constant of 99.939. Every increase of one unit of environmental awareness will cause an increase in the environmentally responsible behavior of students by 0.161.

Determining correlation coefficients and its significance

Based on the SPSS output table shows that the correlation coefficient between environmental awareness and responsible environmental behavior (ry) is $0.195 > 0$, which means that there is a positive relationship between environmental awareness and responsible environmental behavior and the significance value is 0.040 less than 0.05, so it can be concluded that the correlation is significant.

Coefficient of determination (r^2) = 0.195 = 0.0380, which means that 3.80% of environmental awareness contributes to responsible environmental behavior. The remaining 96.20% is a contribution from factors other than environmental awareness.

Qualitative

Results from qualitative study are the results of analysis of qualitative data obtained from interviews. Data analysis includes data reduction activities, data presentation and drawing conclusions. Each data that has been obtained is then given an informant code to make it easier to organize the data. Based on the results of quantitative research, the correlation coefficient value between environmental awareness (X) and responsible environmental behavior (Y) is 0.195.

The coefficient value shows that there is a low positive relationship, because the correlation coefficient obtained ranges from 0.00 to 0.199, so the sub-focus in this study will strengthen the reasons for lower relationship between environmental awareness and responsible environmental behavior (REB) and other factors that are thought to have a relationship with REB.

According to the results of interviews with informants, it was found that the low relationship between environmental awareness and REB of students at SMA Masjid Terminal Depok was due to the lack of environmental awareness that students had to be responsible at least with the surrounding environment.

Where students do not understand about natural conditions such as knowing the condition of the environment around both animals and plants, knowing the impact that will be caused if the environment is damaged, is not sensitive to natural conditions, and does not care about the environment.

Environmental awareness can be increased by implementing activities related to the environment in everyday life, because environmental awareness can be learned by a person, so that person understands the state of nature.

In addition, information about environmental knowledge through additional subjects or activities at school is needed to increase environmental awareness in students. This can be reflected in the habits and behavior to be responsible for the environment. As well as there are factors that influence responsible environmental behavior in addition to environmental awareness of the students of SMA Masjid Terminal Depok, such as family, habits, environment (circle of friends, school environment or neighborhood) as well as information.

DISCUSSION

Based on the results of the study, it was found that the degree of positive relationship was shown by statistical analysis of the SPSS output table resulting in a correlation coefficient (r) of 0.195 at the significance level α (0.05). This shows a low positive relationship between environmental awareness and responsible environmental behavior of students at SMA Masjid Terminal Depok.

This can be seen in the results of the regression equation which shows a linear relationship between responsible environmental behavior and environmental awareness. Where responsible environmental behavior occurs when a person has a high environmental awareness. Environmental awareness is one of the factors shaping a person's responsible environmental behavior, but not a variable that directly influences this behavior. The low relationship between environmental awareness and responsible environmental behavior is caused by other factors.

According to Ajzen (2005) theory of planned behavior, there are several factors that shape a person's behavior, namely Attitude towards the behavior (attitude), Subjective norm and perceived behavioral control. The value of the correlation coefficient of 0.195 is included in the low category, because the correlation coefficient value obtained ranges from 0.00 - 0.199. The coefficient of determination (r^2) is 3.80%, which means that the increase or decrease in the environmentally responsible behavior of students can be determined by environmental awareness of 3.80% while the remaining 96.20% is another factor that plays a role in increasing students' responsible environmental behavior.

Environmental awareness in a person can be increased by getting close to nature and learning to love the environment from an early age. A person who has environmental awareness will show his concern for nature so that person can know what to do with nature because he understands the impact if he takes bad actions towards nature. This is in accordance with research conducted by Rahman (2016), regarding internal knowledge and environmental factors on environmental care behavior, showing that 44% of the variance in behavior is predicted by social influence factors, information resources, environmental management facilities, knowledge, trust, attitude and personal responsibility, whereas 56% of the variant was attributed to other factors not investigated in the study. In addition, Nikerson & Raymond (2003) state that environmental awareness is the beginning of the formation of a person's concern in protecting the environment from various environmental damage. Environmental awareness also has an important role in creating balance, environmental sustainability and the formation of pro-environmental behavior with high environmental awareness, so it will be easier for someone to protect the environment from the threat of damage.

A person who has environmental awareness will have knowledgeable information about the environment which forms the belief that he must have good responsible environmental behavior. This can be a character that can be seen from the habits and behavior to be responsible for the environment. Ardianti et al. (2017), stating that the character will be formed through behavior that is done repeatedly. According to Darmawan (2010), environmental awareness is a form of one's concern for environmental quality.

Based on the results of quantitative research conducted in the field, it shows that there is a low relationship between environmental awareness and responsible environmental behavior of students at SMA Masjid Terminal Depok which is marked by a correlation coefficient (r) of 0.195. This is due to the lack of knowledge about the environment that students get and the low environmental awareness of students and there is no desire in themselves to care about the environment. There are still many students who do not really care about how important lessons about the environment are. These findings indicate that the lack of information that students get has not been able to apply properly about the environment they have in the form of behavior, environmental awareness should be reflected in a balanced manner in one's knowledge, skills, attitudes and behavior in activities.

The low relationship between environmental awareness and responsible environmental behavior is due to other factors that can influence the responsible environmental behavior, where environmental awareness is not the only determinant of a person's

responsible environmental behavior. According to research by Sengupta et al. (2010), students' environmental awareness is not only visible from their knowledge, but also from their attitudes, behaviors and skills in solving environmental problems.

Based on the results of qualitative research conducted at SMA Masjid Terminal Depok with 9 informants consisting of 4 teachers and 5 students, it can be concluded in the first sub-focus that there is a low relationship between environmental awareness and responsible environmental behavior because someone is said to have a responsible behavior. Environmental responsibility can not only be seen from environmental awareness but many other influencing factors. For example, someone who is aware of environmental cleanliness does not necessarily mean that someone has high responsible environmental behavior. This is because there are other factors that can influence a person to behave in an environmentally responsible manner. So, environmental awareness is not the only factor that can influence responsible environmental behavior. This is in accordance with Hungerford & Volk (1990), which states that there are several factors that influence environmentally responsible behavior, namely the desire to act, the previous knowledge factor about environmental problems and the desire to act, leading to actual actions on a person. A person's desire to act is influenced by a number of personality factors such as locus of control, attitudes towards the environment and taking action as well as situational factors such as age, gender and level of education.

Efforts can be made to improve students' responsible environmental behavior so that they have responsible environmental behavior and can apply it to everyday life, such as getting used to cleaning the classroom before the learning process takes place. Habit is a process of forming attitudes and behaviors that are indirect through repetitive activities. Therefore, getting used to positive things to students is expected to be able to increase the responsible environmental behavior.

Based on the results of qualitative research on the second sub-focus, the factors that are thought to have a strong relationship with responsible environmental behavior, the first is family, that the habits and parenting practices of parents will become an example for their children and from one's family can form a character of behavior certain as had been taught by the parents.

A person tends to spend more time in the family environment than other environments such as schools and playgrounds, so the behavior that is ingrained in a person is largely a factor of the family itself. According to Tria (2016), family parenting patterns are important in the formation of child behavior. Parental guidance is very important because parents are foundation builders and children's character (Surya et al., 2017). In line with previous opinions, Andi & Dewi (2018) stated that parents play a role in teaching and disciplining children to form positive attitudes in children. According to Qurrotu (2017), the form of parenting patterns affects the formation of the child's personality as an adult because it has been ingrained since childhood. A person who is educated to be responsible for the environment from an early age, will be someone who has good responsible environmental behavior. Habits that are done continuously will be a natural thing to do, therefore it is very appropriate to educate children with positive things.

This is in line with Sugiyanto (2015)'s statement, which stated that parents play a role in nurturing, guiding, supervising and setting a good example to the child, so that it will have an impact on the formation of children's behavior. Positive behavior to the environment taught by the family is more meaningful, because the behavior has been instilled in a person since childhood so that if the family has a high environmentally responsible behavior, thus the responsible behavior of one's environment outside the family environment will also be high.

Therefore, family is a powerful enough factor to influence a person's REB. The second factor is the habit that a person has. Habits appear in a person because of doing something continuously so that it becomes a habit and becomes something that is natural for that person. Habits can affect a person's responsible environmental behavior because if a person is used to doing good things to the environment then it will be continuously done and become a habit. Moreover, the habit that has emerged since childhood, where the habit has been applied from a young age so that it becomes an experience. This is in accordance with the opinions expressed by Hines, Hungerford and Tomera in Pretty (2016), regarding responsible environmental behavior depending on various factors such as attitude, locus of control, ability to act, knowledge of strategies for action, knowledge of environmental issues, personality factors and situational factors that include new environmental paradigms, environmental sensitivity, economic factors or gender factors. Gifford & Nilsson (2014), states that awareness of need represents a feeling of one's obligation to act and knowing that others expect certain behaviors.

The third factor is environmental factors that include the scope of friendship or association and the school environment. Friendship or social factors have an influence on responsible environmental behavior because a person tends to spend time with friends. Thus, a person's behavior will tend to follow the habits of friends around him. The scope of a good friendship will be a reflection of someone and vice versa. This is in line with Surya et al. (2017) which states that friendship or association affects one's behavior. In the current era of friendship becoming a factor that can affect one's behavior, then this factor can influence the responsible

behavior of one's environment. This is in accordance with the stated by Septiyuni et al. (2015), that peer groups as a social environment for teenagers (students) have an important role for their personal development. In addition, peers have tremendous power to determine the direction of life of students, if students are in a social environment full of negative energy, then all forms of attitudes, behaviors, and goals of life of students become negative as well (Megita, 2017).

The next factor is the environmental factor of the school where the school can be said to be a second home for students. The school environment can also influence a person's responsible behavior. If the school environment is clean, beautiful and comfortable, then indirectly the students in the school have good environmental behavior. The behavior of teachers in schools can also be a reflection for their students because students will imitate what their teachers do. This is in line with the opinion of Blazar & Kraft (2017), that teachers can help students to develop student attitudes and behaviors. According to Pavelka et al. (2016), the close relationship between teachers and students has benefits such as developing positive behaviors in students. Teachers can also guide students to be environmentally responsible for making students environmentally responsible. Additional activities in schools or extracurricular activities such as youth scientific groups, nature lovers and scouts influence student behavior. These activities can train students to be environmentally responsible. Extracurricular activities such as nature lovers, direct students to conduct activities in the natural environment that can stimulate the formation of environmental care attitudes (Rifki & Listyaningsih, 2017). A person will be accustomed to doing things that are environmentally responsible if they are always involved in doing such activities in their neighborhood. This is in accordance with the statement of Pauw & Petegem (2013) which states that children involved in environmental programs, the value of the environment will increase. Learning experience obtained by students directly from the environment can improve the behavior of students' environmental responsibilities and have a positive effect (Ardianti et al., 2017).

The fourth factor is information. Information can be obtained from any source such as through lessons in school such as Biology lessons, or from family, friends and through social media even obtained from the surrounding environment. Teachers can teach students through school lessons so that students have knowledge of the environment and how important it is to have an responsible environmental behavior. This is in line with the opinion of Ardianti et al. (2017) which states that a teacher should be able to instill good behavior that will be the character of the student. According to Prihatini et al. (2018) education will affect the ability to digest the information received and consider the information as the basis for further behavior. In the opinion of Robert Gifford & Nilsson (2014), a high knowledge of environmental issues influences one's useful decision making.

CONCLUSION

Based on the results of the study, it can be concluded that there is a low positive relationship between environmental awareness and responsible environmental behavior of high school students of SMA Masjid Terminal Depok. The positive relationship can be described by the regression equation $\hat{Y} = 99.939 + 0.161x$ with r of 0.195 and the coefficient of determination (r^2) of 0.0380 (3.80%) which means that the contribution of environmental awareness to responsible environmental behavior by 3.80% indicates a low interpretation value and there are other factors of 96.20%. Based on the results of qualitative research obtained several other factors that affect responsible environmental behavior, namely family, habits, environment (friendship environment, school environment or surrounding environment) and information.

Based on the findings of qualitative data, there is a low relationship between environmental awareness and responsible environmental behavior. This can be due to other factors that affect a person's responsible environmental behavior; some of these factors are family, habits and environment (friendship environment, school environment or surrounding environment) and information. Therefore, there are several things that need to be considered in order to shape the responsible environmental behavior of students, including: a) Further research is needed on the relationship of these factors to responsible environmental behavior. b) The family is expected to habituate the child to instill responsible environmental behavior and guide the child to get used to doing things that are responsible for the environment, ranging from simple things, such as dumping garbage in its place, tidying the room, caring for plants, saving energy, and others. c) Schools are expected to hold science or biology subjects as well as other school programs on the environment so as to improve students' responsible environmental behavior such as hygiene or environmental sustainability. In addition, the school always provides trash cans in every classroom. d) Teachers should give students an understanding of the environment through learning and motivate students on the importance of behaving environmentally responsibly, such as getting used to cleaning the classroom before the learning process takes place, and e) For students are expected to get used to behaving environmentally responsible early, so that periodically such behavior can improve.

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Analysis of the determinants and typology of hydrometeorological disaster in Sukajaya Subdistrict, Bogor Regency, West Java, Indonesia

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ABSTRACT

The objective of this research is to determine the factors as a typology of hydrometeorological disasters. The research method employed is post-disaster survey activities through hypothetical descriptions from October to December 2020. The analysis technique uses factor analysis on five variables, namely runoff, infiltration, slope, land cover, and infrastructure. The data retrieval obtained nine areas of landslide disaster points along 20 kilometers from Kiarapandak Village to Cisangku Village, Sukajaya Subdistrict, Bogor Regency, one of which were the areas affected by landslides in January 2020. From the factorial analysis results, it was found that the five variables above were suitable as a factor for determining disaster based on correlation values (r), that includes Factor 1 which is the variable of land slope (0.855) and the infrastructure variable (0.872). Factor 2 is water infiltration (0.928), water runoff (0.269), and land cover (0.717). In conclusion, the typology of hydrometeorological disasters is distinguished based on two determinants, firstly the physical construction of land, slopes, as well as infrastructure of road and river. Secondly, factors of water flow, water infiltration, runoff, and land cover.

ABSTRAK

Tujuan penelitian adalah membuat determinasi faktor-faktor sebagai tipologi kebencanaan hidrometeorologi. Metode penelitian melalui kegiatan survey pasca bencana melalui deskripsi hipotetik pada bulan Oktober-Desember 2020. Teknik analisis menggunakan analisis faktor pada 5 (lima) variabel yaitu limpasan, resapan, kemiringan, tutupan lahan, dan infrastruktur. Pengambilan data mendapatkan 9 (sembilan) daerah titik bencana longsor sepanjang 20 kilometer dari Desa Kiarapandak sampai Desa Cisangku, Kecamatan Sukajaya Kabupaten Bogor, yang merupakan wilayah terkena bencana longsor pada bulan Januari 2020. Dari hasil analisis faktorial diperoleh bahwa 5 (lima) variabel di atas layak dijadikan faktor determinasi kebencanaan berdasarkan nilai korelasi (r), meliputi Faktor 1 adalah variabel kemiringan lahan (0,855) dan variabel infratruktur (0,872). Faktor 2 adalah resapan air (0,928), limpasan air (0,269), dan tutupan lahan (0,717). Kesimpulan, tipologi bencana hidrometeorologi dibedakan berdasarkan dua faktor determinasi yaitu pertama faktor konstruksi fisik lahan, kemiringan dan infratruktur jalan dan sungai, dan faktor aliran air, resapan air, limpasan, dan tutupan lahan.

Keywords: *hydrometeorology, rainfall, landslide disaster, Bogor Regency*

INTRODUCTION

Current climate change is also suspected of causing an increase in hydrometeorological disasters such as floods, landslides and tornadoes. Currently, flooding is a problem that is also a major concern throughout regions in many countries. This problem is exacerbated by global climate change. Several climate projection models predict that the greenhouse effect will influence the hydrological cycle. High rainfall will directly affect the expansion of flood inundation areas in the lowlands (Rosyida et al., 2019).

Hydro-climatological disaster categories consist of (1) flood runoff, and (2) landslides. Flood runoff comes from runoff that flows through rivers or becomes a puddle. Whereas runoff is the flow of water flowing on the ground surface caused by rainfall after the water experiences infiltration and evaporation, then flows into rivers (Hadisusanto, 2011). Furthermore, it is stated that the form of flood hydrograph in a catchment area is determined by two things, such as: 1) characteristics of heavy rain, namely the distribution of rain intensity in time and space., and 2) characteristics of the catchment area e.g., area, shape, channel system and land slope, type and distribution of soil layers as well as geological and geomorphological structures.

Whereas in the category of landslides, soil movements are directly related to various natural physical properties such as geological structure, parent material, soil, drainage patterns, slopes/landforms, rain and dynamic non-natural properties such as land use and infrastructure (Barus, 1999). According to Suripin (2002) landslides are a form of erosion where the transportation or movement of the soil mass occurs at a time in a relatively large volume. Wang et al. (2017) stated that the occurrence of landslides is related to

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various factors such as precipitation, geology, distance from the fault, vegetation, and topography.

Bogor Regency has a considerably large potential for natural disasters in West Java Province, especially natural disasters such as hydrometeorological floods and landslides, this is because of rain with very high intensity and with high topography has the potential to cause runoff and land shifts that result in landslides. According to BPBD Bogor Regency, there are 15 subdistricts with high potential for natural disasters including Sukaraja, Tamansari, Megamendung, Cisarua, Suka Makmur, Cariu, Cigudeg, Leuwiliang, Tamansari, and the western region of Bogor Regency which geographically consists of hills.

In the formulation of disaster handling and management, research on typology based on general dimensions is needed that is not only across different sources of disasters, but also between the same sources of disaster (Quarantelli, 1987). For this reason, this research is compiled to conduct a typology diagnosis of disasters with symptoms of a disaster by studying the impacts that occur both on the community, infrastructure, and public facilities as well as the supporting devices. From the description above, the problem formulation that can be taken is, "What is the typology of disasters that occurred in various regions based on the type of hydrometeorology?. Moreover, what are the determinants of disasters based on typology of hydrometeorological disasters?".

The core structure in a disaster typology study consists of three important layers. The first layer or the basic description *timeline* of the disaster event includes the core pre-event, event, and post-event. The second layer is about expansion of each core, and the third layer introduces the concept of "*strengthening resilience*".

Each layer consists of studies on the pre-event, event, and post-event phases. The pre-event is the status of the community about hazards and risks, the event stage is about damage and its consequences, disturbances, changes in function, response, rescue, and assistance, while the post-event stage is about recovery and reconstruction, and renewal (Wong et al., 2017).

Qodriatun (2013) stated that hydrometeorological disaster is a term of disaster caused by meteorological parameters (rainfall, humidity, temperature, and wind). These types of disasters include drought, flood, storm, forest fire, El Nino, La Nina, landslide, tornado, whirlwind, typhoon, cold wave, heat wave, fohn wind (gending wind, brubu wind, bohorok wind, and kumbang wind).

Parameters of disaster factors can be distinguished as (1) Land Slope; based on the analysis of land slope calculations, the landslide susceptibility is divided into four classes, namely 0-15%, 15-25%, 25-45%, 45-65%,> 65%. Weight/scoring of each slope classification shows that the steeper the relief, the greater the weight, so that it will result in a greater vulnerability value. (2) Land Cover; based on the results of land cover analysis, there are four classes of land cover in the Bogor Regency, namely high, rather high, medium, rather low and low. This land cover class shows that the lower the land cover class (category), the better the land cover, so that it is more effective in controlling landslides compared to high land cover classes (categories). (3) Runoff; flood comes from runoff that flows through a river or becomes a puddle. Whereas runoff is the flow of water flowing on the ground surface caused by rainfall after the water experiences infiltration and evaporation, then flows into rivers (Hadisusanto, 2011).

According to (Suripin, 2004), flooding is a condition in which water cannot be accommodated in the drainage channel (riverbed) or water is blocked in the drain, which cause it to overflows the surrounding area (flood plain). (4) Soil Infiltration; infiltration is the process of infiltrating water or the process of infiltrating water from the soil surface through soil pores. From the hydrological cycle, some rainwater that falls on the ground will seep into the ground, in which some will fill the surface basin and the remaining will become an overland flow. The speed of rainwater entering the soil surface is influenced by the type and texture of the soil.

Based on the description above, the parameters that can be used in assessing the typology of landslide disasters including soil infiltration, water runoff, land cover or canopy, slope, and the medium for composing the physical structure of the land (soil type, geological rock).

METHODS

The type of the research is a descriptive survey through hypothetical analysis techniques and factorial analysis (Sugiyono, 2010). The research location is in the administrative area of Bogor Regency, West Java Province (Figure 1). Geographically, Bogor Regency has a varied geographical type of area, from relatively low plains in the northern area to highlands in the southern part, which is around 29.28% at elevation of 15-100 meter above sea level (m asl), 42.62% at elevation of 100-500 m asl, 19.53% are at an elevation of 500-1,000 m asl, 8.43% at 1,000-2,000 m asl, and the rest of 0.22% at elevation of 2,000-2,500 m asl. Bogor Regency is located at the position between 6° 19' and 6° 47' South Latitude, as well as between 106° 01' and 107° 103' East Longitude.

According to the Administrative Map of Bogor Regency and data from BPS Bogor Regency in 2019, the area of Bogor Regency is 2,663.81 km^2, with an administrative area consisting of 40 Subdistricts. In terms of area, Jasinga Subdistrict is the largest (208.06 km^2), followed by Cigudeg Subdistrict (158.89 km^2).

The subdistrict with the smallest area is Ciomas Subdistrict (16.30 km^2). This research was conducted from October to December 2020.

Figure 1. Location of landslide research in Sukajaya Subdistrict, Bogor Regency.

RESULTS AND DISCUSSION

General description of the physical typology of landslides in Sukajaya Subistrict, Bogor Regency was obtained through surveys and hypothetical depiction of a catastrophic event that has occurred 6-12 months after the event. Based on the length of the observation area, which include along 20 km area between the villages of Kiara Sari to Cerewed and towards 16 landslide points, it was obtained that nine locations of landslide profiles were identified to be in the observable category. After the landslide disaster, access to transportation and mobility has been repaired both permanently and on a limited basis.

In general, the description of landslides is an event of movement of the land surface caused by high rainfall and triggered by road and river structure media (Dewi & Istiadi, 2016). The physical characteristics of land with a slope of more than 60^o have a vulnerability and a threat to the magnitude of landslides that occur. The

Table 3. Scores of landslide disaster parameters for each variable at each point of disaster location.

No.	Location	Scoring				
		Infiltration (P1)	Runoff (P2)	Canopy (P3)	Slope (P4)	Infrastructure (P5)
1	1.7	4	2	3	5	3
2	2.1	2	2	2	5	3
3	5.6	1	2	1	5	4
4	7.1	3	4	4	3	1
5	8.1	2	2	2	5	4
6	10.3	2	3	3	3	3
7	11.2	2	3	4	4	2
8	11.5	3	2	3	4	3
9	12.1	2	2	2	2	2

condition of the soil structure that becomes a catalyst in this landslide disaster is related to the soil substrate, the amount of vegetation cover, land use, water infiltration, and water runoff when it rains.

Land use patterns tend to have the potential to weaken the strength of the soil structure, especially the designation of settlements, secondary crops on non-cultivated land, unmanaged shrublands, in the absence of runoff flows in the soil structure, especially in infrastructure media such as roads and bridges.

The area of Sukajaya Subistrict is a hilly area between Cidurian River and tributaries of Cikatomas River, and various other tributaries. The road access between Kiara Sari and Cisangku is the main access road which has a busy traffic frequency level for the mobility of people and goods in more than 12 densely populated villages. Nevertheless, the road condition is not equipped by adequate drainage facilities, so that causing water runoff which gives vulnerability to the strength of the road structure.

The recording of landslide physical typology includes land slope, landslide length and width, land use, ownership, infiltration, canopy cover, and runoff. Based on the results of the observations, it can be explained that the nine landslide locations are as follows (Table 1).

Data analysis through SPSS 16.5 shows that the KMO MSA value is 0.614 which means this value > 0.50 and the result of Bartlett's test of sphericity (sig.) value is 0.049 <0.05. Therefore the factor analysis in this study can be continued because it fulfills the first requirement. The table "*Anti-image Matrices*" to

determine the appropriate variable, it is known that the value of the MSA (Measure of Sampling Adequacy) is: (1) Infiltration of 0.575; (2) Runoff of 0.618; (3) Canopy of 0.634; (4) Slope of 0.617; (5) Infrastructure of 0.717.

In this research we use five variables which means five components are analyzed. There are two types of analysis to explain a variant, namely Initial Eigenvalues and Extraction Sums of Squared Loadings. The Initial Eigenvalues variant shows the formed factors. If all the factors are added up, it shows the variable (3.021 + 1.132 + 0.577 + 0.152 + 0.118 = 5 variables). Meanwhile, the Extraction Sums of Squared Loadings section shows the number of variations or the number of factors that can be formed. In the output results above, there are 2 (two) factor variables, those are 3.021 and 1.132.

Based on the table total output of *Variance Explained* in the "Initial Eigenvalues" section, there are 2 (two) factors that can be formed, where the requirements to be a factor states that the Eigenvalues value must be > 1. The Eigenvalue Component 1 is 3.021 or > 1 then it becomes a factor of 1 and is able to explain 60,426% variation. While the value of Eigenvalue Component 2 is 1.132 or > 1, it becomes a factor of 2 and is able to explain 83.071% of the variation (Figure 2). The total component value 3,4,5 is not calculated because their Eigenvalues is <1.

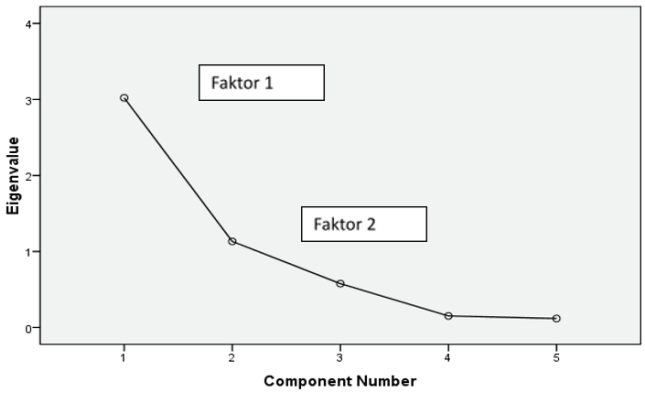

Figure 2. Scree plot to show the number of factors formed.

Table 2. The Rotated Component Matrix table shows the amount of variable correlation based on the components of the formed factors, namely Factor 1 and Factor 2.

	Component	
	1	2
Infiltration	.005	**.938**
Runoff	-.821	**.269**
Canopy	-.611	**.717**
Slope	**.855**	.159
Infrastructure	**. 872**	-.350

For ensuring of which factor is included in a group of factors, it can be determined by looking at the value of the largest correlation between the variable and the formed factor (component). How to read the results of the rotation model factor analysis is explain as follows (Table 2).

1. Infiltration variable. The correlation value of this variable with Factor 1 = 0.005 and with Factor 2 = 0.938, because the correlation value of Factor 2 > Factor 1, so that the Infiltration variable is included into the group of Factor 2
2. Runoff variable. The correlation value of this variable with Factor 1 = -0.821 and with Factor 2 = 0.269, because the correlation value of Factor 2 > Factor 1, so that the Runoff variable is included into the group of Factor 2
3. Canopy variable. The correlation value of this variable with Factor 1 = -0.611 and with Factor 2 = 0.717, because the correlation value Factor 2 > Factor 1, so that the Canopy variable is included into the group of Factor 2
4. Slope variable. The correlation value of this variable with Factor 1 = 0.855 and with Factor 2 = 0.159, because the correlation value of Factor 1 > Factor 2, so that the Slope variable is included into the group of Factor 1
5. Infrastructure variable. The correlation value of this variable with Factor 1 = 0.872 and with Factor 2 = -0.350, because the correlation value of Factor 1> Factor 2, so that the Runoff variable is included into the group of Factor 1

Based on the factorial analysis results above, it is shown that two determinant factors are obtained, those are Factor 1 and Factor 2. Factor 1 is categorized as a factor of construction media characteristic, while Factor 2 as factor of natural characteristic. Natural characteristic variables include soil absorption power or soil infiltration variable, runoff variable which is the amount of water wasted on the soil surface, and canopy or land cover variable as the power to hold rainwater so that it doesn't fall directly to ground surface. The infiltration variable has a correlation of 0.958, which means that it shows a close relationship or has the potential to influence the occurrence of landslides. The runoff variable has a correlation of 0.269 which is very closely related to landslides, although it is not considered as a cause. The variable of land cover or canopy has a correlation of 0.717, which means that it has a tendency to influence the occurrence of landslides.

In the category of construction media characteristic factors, the slope variable has a correlation of 0.855 which indicates a very large potential for landslide effects. The infrastructure variable has a correlation of 0.872 which also shows a great potential as an influence

for landslides.

In previous study that has been done on the determination of landslide vulnerability through the method *Landslide Susceptibility Analysis* (LSA) and by means of the calculation of the bivariate relationship, it shows the effect of different variables on the formation of landslide events. At a high level of vulnerability it can affect 63%, at a moderate level of vulnerability it can affect 26%, and at a low level of vulnerability it can affect 11% for the occurrence of landslides on various variables, especially land slopes, land cover, and the presence of river structure media (Avci & Esen, 2019). Therefore, in the typology pattern of landslide vulnerability, it is necessary to study the category of vulnerability level. According to the research, there are four categories which is based on landslide typology, those are (1) "no warning" category, (2) "alert" category, (3) "attention" category, and (4) the "warning" category (Susandi et al., 2018). This category is adjusted to the level of correlation between the variables which become the typology of the landslide disaster.

In the aspect of variable of artificial structure media, transportation assets such as vehicles and road infrastructure are the basic components in handling landslide disaster risks. This is revealed by Argyroudis et al. (2019) which is the results of their research explains that landslide vulnerability is a basic component of risk and an important understanding to characterize the reliability of assets and transportation infrastructure systems to mitigate risks. This provides an explanation of the existence of infrastructure media, especially roads and transportation flows, which are included in the category of Factor 1 that triggers landslides caused by large amounts of rain precipitation with a correlation level of 87%.

Landslide disaster can also be distinguished based on their cause, such as based on geological earthquakes or caused by high intensity of rainfall. These two causes can occur simultaneously between geological earthquakes and high intensity of rainfall. During the occurrence of rain, rain water will enter into the rock bed in the soil then it can change the structure of the slope and soil surface which will increase the pressure of rainwater in the soil. The occurrence of land and rock landslides could change the formation of land slopes which will have an impact on the loss of roads or other natural formations such as rivers (Yang, 2018).

The previous elaboration shows that the catastrophe caused by high intensity of rainfall will also be accompanied by a geological earthquake which is characterized by land movement, and is stimulated by the characteristics of land slope, water infiltration into the ground, as well as characteristics of river infrastructure and transportation access in an area.

CONCLUSION

1. The typology of hydro-climatological disasters can be distinguished based on regional characteristic with the variable of levels of water infiltration by soil, land cover by vegetation canopy, water runoff in high intensity of rainfall, slope level, and infrastructure that consisting of soil texture and rock geology, as well as physical road construction or the existence of water from river stream.
2. Determinant factors of hydro-climatological disasters can be divided into two factors, namely land characteristics factor and ecological maintenance of rainfall factor. THESE two factors can be used as a combination of policies in mitigating of areas prone to hydro-climatological disasters.

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The occurrence of Sumatran Tiger (*Panthera tigris sumatrae*) in an industrial plantation forest area, North Sumatra, Indonesia

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ABSTRACT

Sumatran tiger lives in the remaining forests on the Sumatra island, both in conservation and production areas. There are not many tiger monitoring activities conducted in production forest. Using camera traps this occupancy survey of Sumatran tiger (*Panthera tigris sumatrae*) carried out in a plantation forest area of PT. Toba Pulp Lestari (PT. TPL) to obtain information and monitor tiger presence in the area. However, there were no Sumatran tigers captured by the camera traps during the occupancy activities. The existence of Sumatran tiger was proven by the finding of footprints and scrapes. Other species were photographed by the camera traps, such as marbled cat (*Pardofelis marmorata*), pig-tailed monkey (*Macaca nemestrina*), treeshrew (*Tupaia* sp.), Asian palm civet (*Paradoxurus hermaphroditus*), lizards (*Eutropis* sp.), Hoogerwerf's pheasant (*Lophura hoogerwerfi*), wood mouse (*Apodemus sylvaticus*) as well as birds. It is assumed that the Sumatran tiger didn't cross the location of research during the camera installation period. However, there are several other reasons why Sumatran tigers weren't captured by camera traps, such as the camera traps observation time was too short and didn't cover a larger area, so it lessens the opportunity of encounter with Sumatran tiger.

ABSTRAK

Harimau Sumatera hidup di hutan yang masih tersisa di pulau Sumatera, baik di kawasan hutan konservasi maupun hutan produksi. Kegiatan pemantauan harimau di hutan produksi belum banyak dilakukan. Dengan menggunakan camera trap, survei okupansi harimau sumatera (*Panthera tigris sumatrae*) ini dilakukan di areal konsesi hutan tanaman industri PT. Toba Pulp Lestari (PT. TPL) untuk mendapatkan informasi dan memantau keberadaan harimau di kawasan tersebut. Namun, tidak ada harimau sumatera yang terfoto oleh kamera trap selama kegiatan survei okupansi. Keberadaan harimau sumatera dibuktikan dengan ditemukannya jejak tapak dan cakaran. Selain itu, terdapat ppesies lain yang terfoto oleh kamera trap, seperti kucing batu (*Pardofelis marmorata*), beruk (*Macaca nemestrina*), tupai tanah (*Tupaia* sp.), musang pandan (*Paradoxurus hermaphroditus*), kadal (*Eutropis* sp.), sempidan aceh (*Lophura hoogerwerfi*), tikus hutan (*Apodemus sylvaticus*) serta burung. Diasumsikan bahwa harimau sumatera tidak melintasi lokasi penelitian selama masa pemasangan kamera. Namun, terdapat beberapa alasan lain mengapa harimau sumatera tidak terfoto kamera trap, seperti waktu pengamatan kamera trap yang terlalu singkat dan tidak mencakup area yang lebih luas, sehingga memperkecil peluang perjumpaan dengan harimau sumatera.

Keywords: *Sumatran tiger, camera traps, plantation forest, North Sumatra*

INTRODUCTION

Sumatran tiger (*Panthera tigris sumatrae* Pocock, 1929) is one of three tiger subspecies in Indonesia. Sumatran tigers are protected species based on the Ministry of Environment and Forestry Regulation No. P.92 of 2018 and included in the Appendix I category of CITES (*Convention on International Trade in Endangered Species of Wild Flora and Fauna*). Currently, the number of Sumatran tiger population is rapidly decreasing and getting harder to find in the natural habitat from time to time (Sumitran & Oktorini, 2014).

Declining the number of Sumatran tiger population is caused by various factors, such as the forest area is narrowed down due to land conversion for agricultural purposes, local inhabitant settlements, and industrial land which contribute to the decreasing number of Sumatran tiger population. The declining rate of the Sumatran tiger population was triggered by the so-called "*The Evil Quartet*", or the term for habitat degradation and fragmentation, conflict with humans, overexploitation of natural resources, and exponential extinction (Sriyanto, 2003).

Tiger habitat is usually in lowland to mountainous rainforests at the altitude of 0 - 3,000 m above sea level (asl). Sumatran tigers require three basic needs, which are availability of prey, water sources, and dense vegetation to catch its prey (Ganesa & Aunorrohim, 2012). Their most active time period is between 2pm in the afternoon and 10pm in the evening (Priatna et al., 2012). However, forests on the island of Sumatra, which are the natural habitat of Sumatran tigers, have been converted into plantations, agriculture and settlements area. Within their natural habitat in

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Sumatra, wild tigers utilize vegetation cover of plantation/regrowth (bush/young secondary forest with very high intensity (Priatna et al., 2012). Nowadays, Sumatran tigers could be found in plantation, agricultural and residential areas due to the limited space for movement and the difficulty of finding prey and eventually end up having conflicts with humans. Direct hunting of tigers and their prey also contribute greatly to the decline in the Sumatran tiger population in the wild (Sinaga, 2004).

Sumatran forests, which are natural habitats for Sumatran tigers, are having its forest cover area decreased significantly from time to time. Forest cover on the island of Sumatra was still 80% of the total land area in 1950. In 1985, the forest cover was reduced to 49%. The forest area decreased into 35% of total land area based on 1997 survey. The change or forest cover in Sumatra from 1985-1997 was around 6.7 million Ha (FWI / GFW, 2001).

The main objective of this study is to obtain information of tiger presence in industrial plantation forest concession area, which is dominated by monoculture of Eucalyptus trees, as a basis for routine tiger monitoring activities.

METHODS

The study was carried out from March to November 2020 in an industrial plantation forest concession area that is dominated by monoculture of Eucalyptus trees at the Aek Nauli Sector, PT. Toba Pulp Lestari (PT. TPL). It is located in Sosor Ladang Village, Porsea Sub District, Toba Samosir Regency, North Sumatra. The area of the concession in the Aek Nauli Sector is 20,428 ha or around 10.9% from the total of concession area (Figure 1).

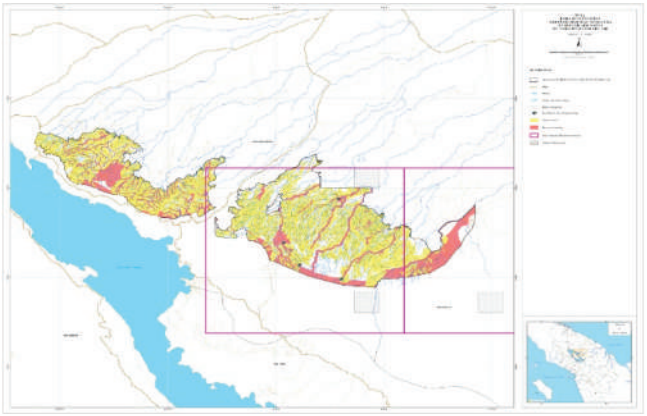

Figure 1. Map of the study area within protected area (red) of Aek Nauli Sector in the concession of PT. TPL, North Sumatra.

For the data collection, camera traps were employed as a main tool of observation. Global Positioning System (GPS), compass, memory card, and digital camera were also used as supporting research equipment. All data gathered from the field were analysed using software of Microsoft Excel as well as ArcGIS 10.5.

Camera traps were placed on the trail where tiger signs were found during tiger sign-based occupancy survey was conducted previously in this area (Figure 2). All camera traps were set up at a height of 30-40 cm from the ground level and at a distance of 2-3 meters from the target trail. The spacing between camera trap station was between 1.5 - 3 km, and at every station placed two cameras that set up in pair for allowing us to identify the stripes at the right and left sides of a tiger. Camera traps collected data in the field continuously for three months and were visited every one or two weeks for maintenance and data retrieval.

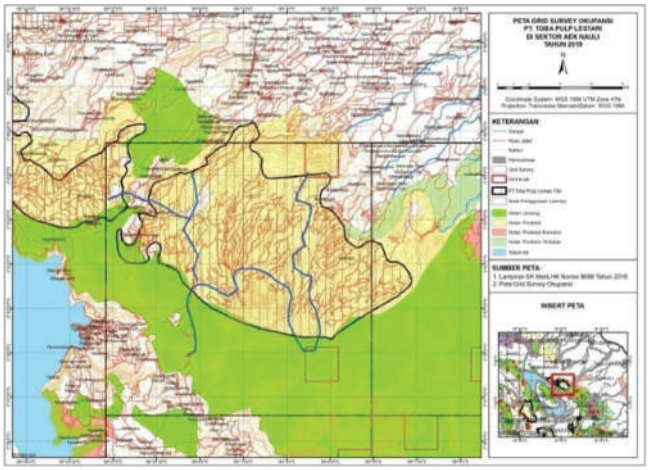

Figure 2. Sumatran Tiger Occupancy Grid in Aek Nauli Sector

Cameras were installed in the buffer zone area, KPPN (germ plasm preservation area) of Talun Sungkit, the border of Hapasuk River as well as along the Green Belt. The selection of camera installation location was not only based on the findings of tiger signs at that location, but also based on the other consideration such as altitude class, slope class and the distance from the river. The altitude class in Aek Nauli Sector area can be seen in Figure (3).

All the data recorded and obtained including the GPS coordinates of camera traps location, altitude, slope and distance from the river data which were processed using ArcGis 10.5 to produce a map of individual Sumatran tiger distribution in the Aek Nauli Sector of PT. TPL.

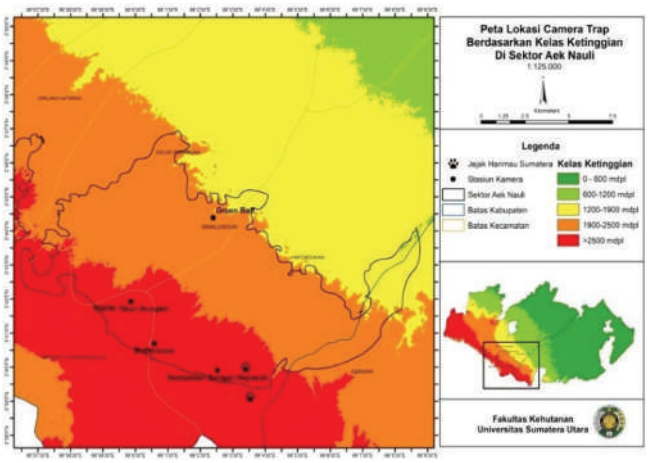

Figure 3. Location of camera traps placement based on altitude class in the Aek Nauli Sector area.

RESULTS AND DISCUSSION

The habitat of the Sumatran tiger is in lowland areas and the altitude of 0-600 m asl (lowland) is the best altitude to set up the camera traps. Although the Aek Nauli sector is located at >1000 m asl which is a highland area, footprints of Sumatran tigers were still found based on previous occupancy surveys. Santiapilai & Romano (1993) stated that lowland forests are the main habitat for Sumatran tigers with a density of 1-3 tigers/ 100 km^2, while mountain areas is 1 tiger/100 km2. However, the high rate of destruction of lowland forest in Sumatra (65-80%) has triggers the Sumatran tigers to migrate towards hill and mountain forests. The slope class is the next parameters that is considered in deciding location to install the camera traps. Data on the slope of the Aek Nauli Sector can be seen in Table 1 and Figure 4.

Table 1. Slope class of Aek Nauli Sector area.

Sector	Slope	Area (Ha)
AEN	0-8%	42,377.71
	8-15%	19,713.77
	15-25%	9,112.75
	25-40%	5,229.19
	> 40%	3,936.19
Area sector AEN		80,369.62

Figure 4 shows that the camera trap location was placed at areas with slope classes of 0-8% (flat) and 8-15% (ramps). The slope class is chosen based on the habits of Sumatran tigers which are active in flat areas. According to O'Brien et. al. (2003), tigers spent all their time (100%) in lowland areas and flat areas with a slope of 0-8%. Other than the altitude and slope class, the distance to the river is another important parameter to consider for camera trap placement. A map based on the distance to the river in the Aek Nauli Sector can be seen in Figure 5.

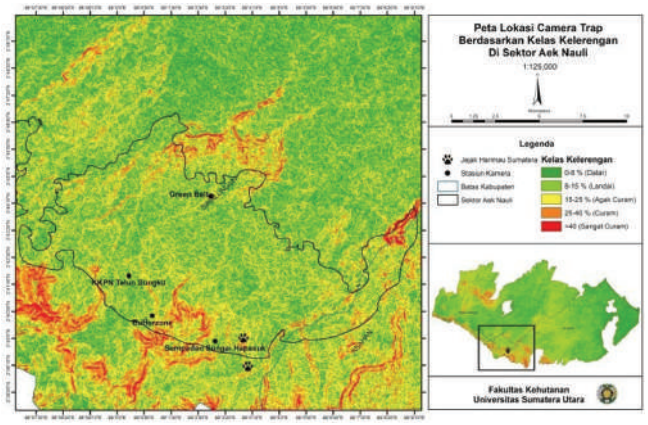

Figure 4. Location of camera traps placement based on slope class in the Aek Nauli Sector area.

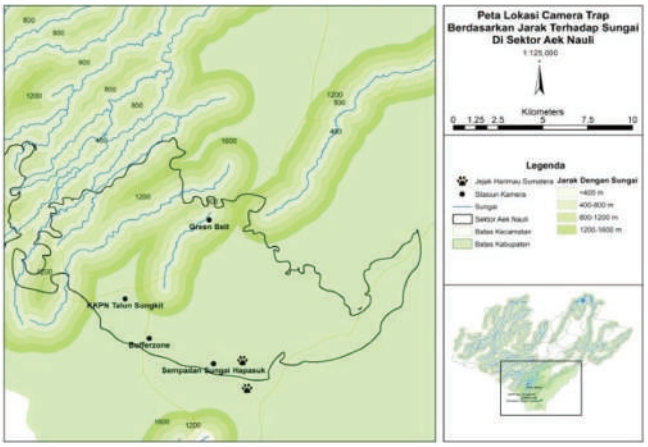

Figure 5. Location of camera traps placement based on distance to river in the Aek Nauli Sector area.

Figure 5 shows that the location of camera trap placement is close to the river. The location that is adjacent to the river is Green Belt area which has a <400 m distance based on the criteria. This location is selected because it is frequently visited by the Sumatran Tigers and it is also place where the prey animals do their activity. Karanth (2001) also states that tigers are animals that love water and able to swim. River is also a gathering place for animals, and it may lead to predation when tigers are on that area. The cameras that have been installed are then removed based on the determined schedule, which is 7 days of installation in buffer zone area, the KPPN of Talun Sungkit, Hapasuk River border and 13 days in Green Belt area, which is the farthest installation station.

During the study conducted, no photograph of tiger and their main prey were found. However, our camera traps recorded other wildlife that classified as tiger potential prey such as pig-tailed macaque (*Macaca nemestrina*). The other wildlife species that were captured by the camera trap which are marbled cat (Pardofelis marmorata), treeshrew (*Tupaia* sp.), Asian palm civet (*Paradoxurus hermaphroditus*), lizards (*Eutropis* sp.), Hoogerwerf's pheasant (*Lophura hoogerwerfi*), and wood mouse (*Apodemus* sp), and birds (Figure 6). Dinata

& Sugarjito (2008) argue, the existence of the main prey animals is directly correlated with the existence of the tiger in an area which tiger prefer to prey wild boar, muntjac, sambar deer, mouse deer, and serow, which are their main prey, while macaque and tapir as their optional prey. Rudiansyah (2007) stated that tigers always follow the movements of their prey and are always close to their preys.

There is a direct correlation between the existence of Sumatran tiger and its prey which is also affected by the altitudinal factor. Griffith & Schaik (1994) stated that prey species found in forest at 100 – 600 m asl altitude have higher density and diversity compared to forests at the altitude of 600-1,700 m asl. Aek Nauli is located at the altitude of > 1000 m asl, which means that the diversity and density of prey species is limited so that it also affects the existence of the Sumatran tigers.

Figure 6. Wildlife species encountered by camera traps during field study in Aek Nauli Sector: (a) marbled cat (b) pig-tailed macaque (c) treeshrew (d) Hoogerwerf's pheasant (e) Hoogerwerf's pheasant (f) Asian palm civet.

CONCLUSSION

Based on the result we conclude were the presence of tiger main prey in this study area is very low and it is affected to tiger existences in this area. Camera trap operation in each location very short and cover area survey quite small could be other factors where this study could not record tiger photograph. Furthermore, regular tiger monitoring activities need to be carried out followed by conducted protection activities with

stakeholders collaboration to conserve and maintain tiger existence in plantation forest area of PT. TPL.

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Dynamics of vegetation structure and composition within early regeneration forest in the Danau Bangko Protected Area, Jambi, Indonesia

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ABSTRACT

An analysis of the growth dynamics of a 1-ha (100 m x 100 m) permanent plot was carried out in the Danau Bangko Protected Area (DBPA) in March 2020. DBPA is part of the industrial plantation forest concession of PT Rimba Hutani Mas (PT RHM) in Jambi Province. The study aims to determine the dynamics of vegetation structure and composition between 2018 and 2020 in early regeneration forest. All trees tagged in 2018 were remeasured in 2020. Trees that had not been tagged previously but were ≥10 cm in diameter at breast height (DBH) were identified as a new recruit and tagged with a new number. Observations and data analysis were carried out on three stages of growth phases, namely in the tree phase (≥ 10 cm DBH), sapling phase (<10 cm DBH), and seedling phase (height <1.5 m). The results showed that the number of species, genera, and families within the tree and sapling phases were high, but were low in the seedling phase. The dominant species in the tree phase in 2018, *Alseodaphne bancana*, had been replaced by *Archidendron bubalinum* in 2020, whereas the dominant species in the sapling phase (*Rothmania* sp.) and seedling phase (*Aporusa microsphaera*) remained the same from 2018 to 2020 . Mortality rates in all growth phases (tree, sapling and seedling) together is 4.67%. Recruitment into the tree phase from 2018 to 2020 was 2.67%, consisting of eight species, eight genera, and seven families. Within one hectare permanent plot, all members of each tree species were distributed randomly. The vertical structure of the forest area is dominated by stratum C (4-20 m height). The results of hypothesis testing for each phase (tree, sapling, seedling) were different, however overall the results showed that the plot structure and composition had changed.

ABSTRAK

Studi dinamika hutan dilakukan di Kawasan Lindung Danau Bangko (KLDB) pada Maret 2020 dengan menggunakan pendekatan plot permanen seluas satu hektar (100 m x 100 m). KLDB merupakan bagian dari konsesi hutan tanaman industri PT Rimba Hutani Mas (PT RHM) di Provinsi Jambi. Penelitian ini bertujuan untuk mengetahui dinamika struktur dan komposisi vegetasi antara pengukuran tahun 2018 dan 2020, khususnya pada areal dengan tutupan Belukar Tua (BT). Diameter semua pohon yang telah diberi tanda nomor pada tahun 2018 diukur kembali. Pohon yang belum diberi tanda sebelumnya tetapi diameternya ≥10 cm setinggi dada (DBH) ditetapkan sebagai rekrutmen baru dan diberi tanda dengan nomor baru. Pengamatan dan analisis data dilakukan terhadap tiga tahap tahap pertumbuhan, yaitu tingkat pohon (≥10 cm DBH), tingkat pancang (<10 cm DBH), dan tingkat semai (tinggi <1,5 m). Hasil penelitian menunjukkan bahwa jumlah spesies, jumlah marga, dan jumlah famili pada tingkat pohon dan pancang tinggi, sedangkan pada tingkat semai rendah. Jenis dominan pada tingkat pohon pada tahun 2018 adalah *Alseodaphne bancana* telah digantikan oleh *Archidendron bubalinum* pada tahun 2020, sedangkan pada tingkat pancang (*Rothmania* sp) dan tingkat semai (*Aporusa microsphaera*) merupakan jenis yang dominan baik pada tahun 2018 maupun pada tahun 2020. Angka kematian pada semua tahapan pertumbuhan bervariasi dengan rata-rata 4,67%. Rekrutmen di tingkat pohon 2,67% yang terdiri dari 8 spesies, 8 marga, dan 7 famili. Secara keseluruhan, semua spesies tersebar secara acak. Tinggi tajuk pohon didominasi oleh stratum C (tinggi 4 m - 20 m). Hasil pengujian hipotesis pada setiap tingkatan (pohon, pancang, semai) berbeda, namun hasil penggabungan semua data menunjukkan bahwa telah terjadi dinamika.

Keywords: *Forest dynamics, early regeneration forest, structure and composition, Danau Bangko, Batanghari, Jambi, Indonesia*

INTRODUCTION

Forests consist of biotic (like trees, animals, plants, and other living things) and abiotic (such as soil, water, air, and landforms) components. All of these components together make up a forest ecosystem.

Management designed to produce rational and optimal use of forest resources is based on long-term sustainability, not oriented towards or influenced by current short-term use. Sustainable forest management depends on a variety of data and information on the condition of the vegetation, including data on the dynamics of the stands from each

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period. Absolute data and information must be available as the basis for determining long-term management policy strategies, so as to maximize the benefits obtained based on the principle of sustainability.

Continuous deforestation has wide-ranging impacts, especially by reducing biodiversity, thereby weakening or removing links in the food chain in forest areas, and ultimately weakening the entire forest ecosystem. In 2004, when the company granted a permit to manage a production forest for industrial plantation forest, some blocks of remaining natural forest were set aside as protected areas within the industrial plantation forest (HTI) of PT. Rimba Hutani Mas (PT. RHM), Batanghari District, Jambi Province, which is one of them called as DBPA that aiming to preserve the complete range of forest habitats within the locality.

Based on the report of Samsoedin et al. (2018), the DBPA is divided into three land cover types, namely Early Regeneration Forest or Young Regeneration forest (YRF), Scrub (S), and Open Land (OL), as are used in the classification of the High Carbon Stock (HCS) area (Adriani et al., 2017).

The DBPA is a relatively intact forest area located within the plantation forest concession of PT. RHM, the latter dominated by eucalyptus (*Eucalyptus pellita*) and acacia (*Acacia mangium*). In addition to protecting an intact forest are, the DBPA provides and enhances a range of ecosystem services affecting the surrounding areas, particularly as a source of germplasm for several climax forest tree species that are still found in the DBPA (Samsoedin et al., 2018).

Monitoring forest areas continuously (*time series*) is a tool that can answer many hypotheses when studying forest growth dynamics. The permanent plot in the DBPA, which was established in 2018, is a natural laboratory for studying the dynamics of vegetation (succession), including stem diameter growth rates, mortality, natality, population growth, dominance, and recruitment. (Kusumo et al., 2016).

Vegetation studies using permanent plots in forest areas are still relatively rare, so relevant information is still limited, and little is known about the DBPA itself (Samsoedin, 2009). The challenge for this research was that there was no existing comprehensive information on the dynamics of the specific forest locality. The objective of the study was therefore to understand the dynamics of the vegetation structure and composition in the DBPA that occurred in the short term, over the two years following the setting up of the permanent plot.

METHODS

A one hectare of permanent plot (100 m x 100 m) was set up in 2018 in DBPA when the first set of data collected. Remeasurement of similar parameters carried out in March 2020, in the same permanent plot. The DBPA lies inside the industrial plantation forest concession of PT Rimba Hutani Mas (PT. RHM), which has set aside DBPA as the required protected area. Administratively, it is located in Lubuk Ruso Village, Subdistrict Pemayungan, Batanghari District, Jambi Province (Figure 1).

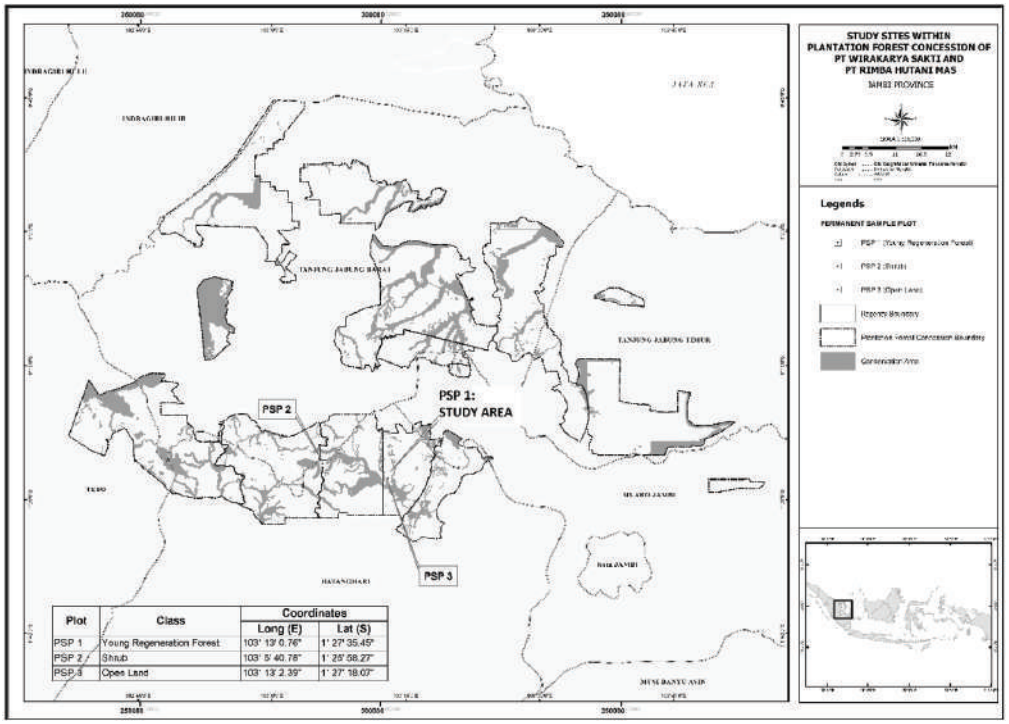

Figure 1. Location of the study area in the DBPA within PT. RHM concession, Jambi.

Three phases of research activities were undertaken. Pre-field studies included preparation of tools and materials. The field research included re-measuring all trees that were tagged in 2018 as well as identifying newly recruited trees, and preparing herbarium samples. Post-field studies included data input and analysis, drying of herbarium samples, and taxonomic identification of the samples which carried out at the Botany Laboratory, Herbarium Bogoriense, Indonesian Institute of Sciences (LIPI), Cibinong, Bogor.

General conditions of the study site

The permanent plot is located within a lowland wet tropical forest area of the DBPA. It is geographically located at 1°27'33.5" South and 103°13'00.2" East with an elevation of ±40 m above sea level (asl). Topographically, the area is a mix of flat and hilly areas with slopes ranging from 8% to15%. Soil types include alluvial associations consisting of acid tuff, sandstone, and sand deposits. There is a thick layer of red to yellow solum, with low nutrient content, which is easily eroded (Samsoedin et al., 2018). The microclimate within study area is considered to be type "A" based on Schmidt and Ferguson's climate classification (Schmidt & Ferguson, 1951). Rainfall total was 958.7–1,613.5 mm over 57-73 days, the wet season being from February to June. Above ground biomass content varied between 167.6 tonnes/ha and 307.6 tonnes/ha (Samsoedin et al., 2018). Average air temperature was 28.78 °C (27.2-30.4 °C), soil temperature 28.50 °C (27-30.2 °C), humidity level 82.40% (66% - 89%), soil moisture 83.64% (69% - 90%), and average soil pH 5.35 (4 - 6).

Data analysis

All field data collected in 2020 from the permanent plot were processed and analysed following Mueller-Dombois & Ellenberg (1974) as well as Soerianegara & Indrawan (2014), using Excel software.

RESULTS

The analysis used data collected from the permanent plot collected in 2018 when the plot was first established and data from 2020. The data were categorized according to three growth phases, namely the tree, sapling and seedling phases, and in 2020 comprised a total of 101 species, 77 genera, and 38 families. The families represented by five or more species were Euphorbiaceae (11 species), Rubiaceae (eight species), Lauraceae (six species), Annonaceae (six species), Dipterocarpaceae (five species), and Myristicaceae (five species) (Heriyanto et al., 2020; Kartawinata et al., 2004; Samsoedin et al., 2018; Wardani & Heriyanto, 2015).

Composition and structure in the tree phase (≥10 cm DBH)

This phase contained 83 species, 65 genera and 35 families, at a density of 485 trees/ha. The change in numbers from 2018 to 2020 was not statistically significant. The diversity index (H'), number of species, number of genera, number of family, and basal area all increased from 2018 to 2020, but tree density decreased (Table 1). Thirteen tree species had been recruited (2.67%) in the permanent plot between 2018 and 2020 (Table 2). These comprised eight species, eight genera, and seven families.

Sixteen trees died between 2018 and 2020 (mortality rate 2.88%), consisting of 14 species, 13 genera, and 12 families (Table 3). Seven dominant species had an Important Value Index (IVI) >10% (Table 4). The most dominant species is *Archidendron bubalinum* (IVI= 24.92%), with *Alseodaphne bancana* (INP = 19.52%) as a subdominant. The distribution pattern of all species is random. The value of hypothesis test result is -1.28 which means that there has been dynamic within two years period (between the period of 2018 and 2020). The result of the analyses with Graphic of Trend (GT) also shows that there has been significantly dynamics, and it is predicted that there will continue to be development or dynamics.

Table 1. Characteristics of the tree phase in the 1-ha permanent plot.

Parameter	2018 *	2020
Species diversity index (H')	3.64	3.80
Richness index (C)	0.05	0.05
Similarity index (E)	0.05	0.32
Mortality (%)	0	2.88
Number of species	75	83
Number of genera	64	65
Number of families	34	35
Density (trees/ha?)	486	485
Basal area Units?	19.74	20.09
Frequency/distribution (Number of individual trees?)	344	335

Note: *Samsoedin et al. (2018)

Table 2. Species recruitment in the tree phase in 1-ha permanent plot.

No.	Species	DBH (cm)	Height (m)	Tagging No.	Subplot location
1	*Ixora javanica**	10.83	9.4	487	A
2	*Endiandra rubescens**	10.83	9.3	488	A
3	*Sandoricum koetjape*	11.94	12.6	489	C
4	*Neouvaria acuminatissima**	10.51	12.2	490	G
5	*Aglaia* sp.*	10.51	14.4	491	L
6	*Dyera costulata*	16.82	10.5	492	T
7	*Knema* sp.*	11.46	15.3	493	R
8	*Alseodaphne bancana*	10.51	7.8	494	R
9	*Diospyros frutescens**	10.73	16.4	495	P
10	*Baccaurea* sp.*	10.83	11.2	496	O
11	*Canarium* sp.	10.38	15.4	497	Y
12	*Antidesma cuspidatum**	10.70	13.7	498	Y
13	*Dacryodes rostrate*	11.11	16.3	499	V

Note: *New record in the plot

Table 3. Individual trees in 1-ha permanent plot found dead in 2020.

No.	Species	DBH (cm)	Height (m)	Tagging No.
1	*Agelaea trinervis*	17.70	1.,8	248
2	*Alseodphane bancana*	24.00	18.3	353
3	*Alseodphane bancana*	11.20	89	209
4	*Antidesma tomentosa*	11.10	13.0	115
5	*Archidendron bubalinum*	13.50	9.2	352
6	*Archidendron bubalinum*	13.50	22.4	60
7	*Baccaurea motleyana*	12.00	8.8	157
8	*Gaertnera* sp.	19.00	17.1	350
9	*Kokoona reflexa*	25.00	20.9	198
10	*Monocarpia* sp.	21.90	21.1	411
11	*Palaquium ridleyi*	41.60	21.3	370
12	*Rothmania* sp.	20.00	13.2	147
13	*Sandoricum koetjape*	30.00	19.9	246
14	*Santiria laevigata*	10.00	8.2	227
15	*Shorea acuminate*	17.00	18.1	412
16	*Syzygium* sp.	17.30	16.8	300

Table 4. Species in tree phase with Important Value Index (IVI)= >10% in 1-ha permanent plot (DR= Relative Dominance; KR= Relative Density; FR= Relative Frequency).

Species	DR (%)	KR (%)	FR (%)	IVI (%)
Archidendron bubalinum	7.23	11.42	6.27	24.92
Alseodphane bancana	7.83	6.61	5.07	19.52
Agelaea trinervis	6.94	7.21	4.18	18.33
Ochanostachys amentacea	6.66	5.81	4.18	16.65
Strombosia ceylanica	7.27	2.81	2.39	12.47
Monocarpia sp.	5.50	3.21	2.69	11.39
Sandoricum koetjape	4.95	2.81	2.99	10.74

Growth in the sapling phase (<10 cm DBH)

The sapling level in 2020 consisted of 47 species, 43 genera, and 27 families with a sapling density of 218 trees/ 625 m^2 (or 3,488 trees/ha). The results from 2018 and 2020 do not vary significantly. The 2020 *Shannon Wiener* (H') Index, density and basal area were higher than in 2018, but other parameters remain the same (Table 5).

Table 5. Characteristics of the sapling phase at the 1-ha permanent plot.

Parameter	2018*	2020
Species diversity index (H')	3.40	3.42
Richness index €	0.35	0.35
Similarity index €	0.88	0.88
Mortality (%)	0	3.54
Number of species	47	47
Number of genera	43	43
Number of family	27	27
Density	226 (3,616/ha)	218 (3,488/ha)
Basal area	0.18 (2.88 m^2/ha)	0.21 (3.36 m^2/ha)

The mortality rate of saplings over the two years was 3.54% (eight saplings) (Table 6). There are ten dominant species in 2020 with IVI > 10% (Table 7), the most dominant being *Rothmania* sp. (IVI= 23.17%), followed by *Aporusa microsphaera* (IVI= 19.68%). The most dominant species at sapling phase in 2018 was also *Rothmania* sp. (IVI= 28.45%), , (with an increased IVI The dominance and IVI of other species had shifted from 2018 to 2020, with some species' IVI increasing to >10 in 2020, e.g., *Gonocaryum littorale* (IVI= 12.94%) and *Ixora siamensis* (IVI= 10,67%).

The distribution pattern of species within this phase is also random. The hypothesis test results is -1.03 indicating significant change in the plot structure within this phase. The analyses of GT shows that there is a change but that is not as significant as in the tree phase (R^2= 0.81).

Table 6. Individual saplings in 1-ha permanent plot found dead in 2020

Species	DBH (cm)	Height (m)
Alseodphane bancana	6.0	11.4
Archidendron bubalinum	3.0	4.8
Diospyros bantamensis	1.0	3.1
Diospyros bantamensis	1.0	2.6
Paraserianthes falcataria	7.5	6.8
Pimelodendron griffithiianum	7.6	5.2
Prunus arborea	2.5	5.8
Syzygium clavimyrtus	0.5	2.1

Table 7. Species in the sapling phase with Important Value Index (IVI)= >10% in 1-ha permanent plot (DR= Relative Dominance; KR= Relative Density; FR= Relative Frequency).

Species	KR (%)	FR (%)	DR (%)	IVI (%)
Rothmania sp.	7.60	8.26	7.32	23.17
Aporusa micosphaera	7.77	6.42	5.49	19.68
Archidendron bubalinum	7.82	5.50	4.88	18.20
Monocarpia sp.	5.47	5.96	5.49	16.92
Hydnocarpus woodii	4.58	5.96	5.49	16.03
Dacryodes rostrata	4.92	5.50	5.49	15.91
Sterculia oblongata	4.10	6.42	4.88	15.40
Ochanostachys amentacea	4.28	5.96	4.88	15.12
Gonocaryum litorale	3.01	5.05	4.88	12.94
Ixora simalurensis	3.34	3.67	3.66	10.67

Growth in the seedling phase (height <1.5 m)

Within the seedling phase, most of the parameters (diversity, richness and similarity indexes, and number of species and family) decreased from 2018 to 2020. In 2020, there were 28 species, 27 genera, and 21 families (Table 8). The mortality rate was 8.44%, with the loss of 12 trees and saplings species. There are six dominant species (five families) within the sapling phase with an IVI= >10% (Table 9).

Aporosa micosphaera (IVI= 30.32%) was the most dominant species in 2018 and in 2020, although there was a change in the IVI values for other species, including *Monocarpia* sp. which was replaced in 2020 by *Archidendron bubalinum*.

Table 8. Characteristics of the seedling phase at 1-ha permanent plot.

Parameter	2018*	2020
Species diversity index (H')	2.78	2.70
Richness index (C)	0.54	0.42
Similarity index (E)	0.82	0.81
Mortality (%)	0	8.44
Number of species	30	28
Number of genera	29	27
Number of family	22	21
Density	154 (15,400/ha)	142 (14,200/ha)

Note: *Samsoedin et al. (2018)

There was no additional species recruitment into the seedling phase by 2020, but two species decreased, namely *Gluta velutina* and *Hydnocarpus woodii*. Thirteen seedlings (from seven species and five families) died (mortality rate 8.44%) (Table 10). The species distribution pattern at this phase was again random, and the hypothesis test shows that low levels of dynamics.

Species	KR (%)	FR (%)	IVI (%)
Aporusa micosphaera	16.90	13.41	30.32
Archidendron bubalinum	14.08	976	23.84
Monocarpia sp.	14.08	8.54	22.62
Rothmania sp.	13.38	6.10	19.48
Strombosia ceylanica	4.93	8.54	13.47
Ixora simalurensis	4.93	6.10	11.03

Table 10. Species in seedling phase in 1-ha permanent plot found dead in 2020

No.	Species	Family	N
1	*Rothmania sp.*	Rubiaceae	4
2	*Ixora simalurensis*	Rubiaceae	2
3	*Ixora* sp.	Rubiaceae	1
4	*Strombosia ceylanica*	Olacaceae	1
5	*Gluta velutina*	Guttiferae	1
6	*Hydnocarpus woodii*	Flacourtiaceae	1
7	*Monocarpia sp.*	Annonaceae	3
Total			**13**

Forest regeneration

Regeneration in the tree phase is relatively good (Figure 2). The area is dominated by trees with a DBH of 10-19.9 cm (299 trees / 61.65%). Trees with a DBH of >50 cm are least frequent (6 trees / 1.24%). The sapling phase is dominated by those with a DBH of 1-2.9 cm (116 trees / 53.21%), and the least common are those with a DBH of 6 - 9.9 cm (24 trees / 11.01%). The 2020 survey showed that 15 species (11 families) have been recruited across all growth phases (tree, sapling, seedling) since 2018 (Table 11).

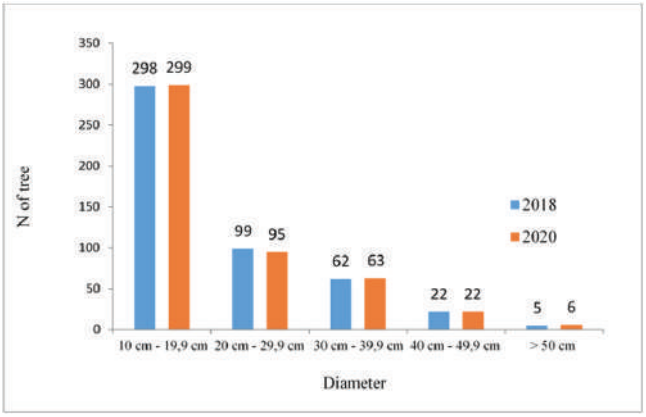

Figure 2. Distribution of all tree diameter classes (>10cm DBH) within a 1-ha permanent plot in 2018-2020.

In the tree and sapling phases, six species showed a DBH increase >0.1 cm, the highest growth occurring in *Archidendron bubalinum* (average 1.04 cm) and the lowest in *Strombosia ceylanica* (average = 0.23 cm). The average growth of all other species is <0.1 cm (Table 12).

Table 11. Species occurring in all growth phases in 1-ha permanent plot.

Species	IVI (%)		
	Tree	Sapling	Seedling
Agelaea trinervis	18.33(3)*	2.43	1.92
Alseodphane bancana	19.52(2)*	9.74	1.92
Aporusa micosphaera	0.56	19.68(2)*	30.32(1)*
Aporusa sphaeridophora	0.61	5.93	3.85
Archidendron bubalinum	24.92(1)*	18.20(3)*	23.84(2)*
Baccaurea motleyana	4.14	5.98	9.62
Dacryodes rostrata	4.76	15.91(6)*	1.92
Diospyros bantamensis	4.49	5.04	4.55
Gompia serrata	1.16	1,22	7.69
Ixora simalurensis	3.22	10.67(10)*	11.03(6)*
Litsea tomentosa	4.98	1.14	1.92
Monocarpia sp.	11.80(6)*	16.92(4)*	22.62(3)*
Ochanostachys amentacea	19.86	15.12(8)*	6.48
Rothmania sp.	9.34	23.17(1)*	19.48(4)*
Xanthophyllum excelsum	2.24	5.93	1.92

Note: *IVI= >10%

Table 12. Species with highest increase in DBH during the period 2018-2020 in 1-ha permanent plot.

Species	Family	Mean DBH growth (cm)
Archidendron bubalinum	Leguminosae	1.04
Bouea oppositifolia	Anacardiaceae	0.49
Koompassia malaccensis	Caesalpinaceae	0.72
Nephelium mutabile	Sapindaceae	0.13
Sandoricum koetjape	Meliaceae	0.17
Strombosia ceylanica	Olacaceae	0.23

Forest stratification

Tree stand structures in various diameter classes are horizontally spread across subplots A-Y within the 1 haa permanent plot (Figure 3). The tallest tree is 32 m in height and the smallest is 7 m, with an average of 15.17 m. The tallest in the sapling phase is 11.4 m and the smallest 1.2 m, with an average of 3.77 m. Overall, canopy cover averages 40%, or classified as medium category according to Indriyanto (2008).

The tree canopy within study area is divided into three strata. Trees in stratum C (4-20 m height) are most dominant, followed by those in stratum B (20-30 m height), and stratum A with trees>30 m. The highest percentage of species at stratum C (which greater than 5%) are *Alseodphane bancana* (75 trees / 18.75%), *Ochanostachys amentacea* (32 trees / 8.00%), and *Agelaea trinervis* (25 trees / 6.25%). While the family in stratum C which greater than 10% are Leguminosae (47 trees / 11.75%). The highest percentage of species at stratum

B (which greater than 5%) are including *Diospyros bantamensis* (7 trees / 8.33%), *Bouea oppositifolia* (6 trees / 7.14%), *Dehaasia* sp. (6 trees / 7.14%), *Barringtonia racemosa* (5 trees / 5.95%), and *Baccaurea motleyana* (5 trees / 5.95%). Stratum A only contains one species (0.21%), namely *Horsfieldia glabra*.

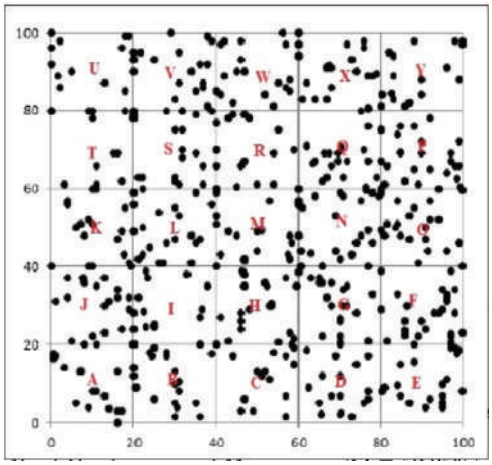

Figure 3. Distribution of trees (≥10 cm DBH) in subplots within the permanent plot in 2020.

Similarity index

The Similarity index (SI) is used to determine the similarity of a species which has IVI= >10% within 25 subplots. The results of the analyses showed that most of species are different, and only three species have a SI index >50%. The highest correlation occurs between Alseodaphne bancana and Mococaria sp. (SI = 52.25%) with Ochanostachys amentacea (SI = 50.03%). The correlation among other species is <50%, some even tends to uncorrelated such as Strombosia ceylanica (SI = 31.44%). The occurrence of different correlation between these species means that the symbiosis between species is considered as low mutualism (Figure 4). There are eight subplots that have SI > 50% while another 17 subplots have SI < 50%, this means that each subplot has a relatively different condition.

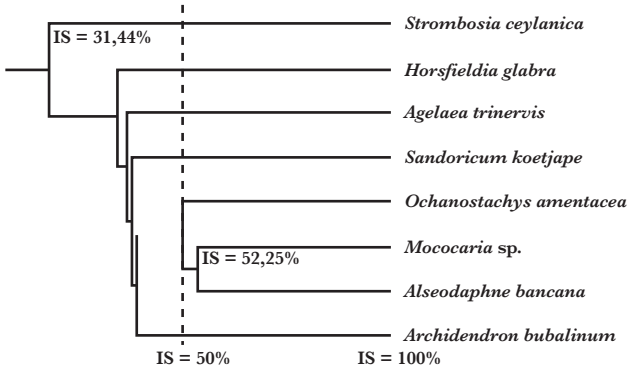

Figure 4. Percentage of tree species correlation IVI=> 10% within one hectare permanent plot.

DISCUSSION

Indonesia's forests are among the most diverse and the most threatened in the world, especially lowland rainforest (occurring below 500 metres asl). The country's largest remaining tract of lowland rainforest is located on Sumatra, and this includedthe forest area within DBPA (Suwardi et al., 2013 in Sadili et al., 2019).

Permanent plots can contribute significantly to our understanding of the dynamics of lowland rainforest and its resilience in the face of different disturbances, but few such plots exist in Indonesia. The 1-ha plot examined here was only set up two years ago and the various analyses presented here indicate change but nothing statistically significant(Table 1, 5, 8). According to Kuswandi (2017), a 1-ha permanent plot that is observed periodically for more than fiveyears is sufficiently representative of the area to illustrate the dynamics of growth. The permanent plot within DBPA is therefore still included in the category of YRF, with DBH measurements being predominantly relatively small (Figure 2).

Altitude affects the diversity of natural forest in one hectare of lowland forest there are usually more than 150 tree species (Whitmore, 1994). Mansur et al. (2010) found 123 and 126 tree species/ha in two plots in a lowland area of Harapan Rainforest, Jambi, Central Sumatra. . The tree species diversity in DBPA is lower than in Harapan. This is because the vegetation conditions in the two forest areas are different, where the vegetation conditions in Harapan Rainforest is better, while in DBPA used to be heavily logged before 2004. Tree species richness in DBPA is also lower than the eastern core zone of Bukit Duabelas National Park, Jambi, which is consisting of 113 species and 38 families (Rahmah et al., 2016). Moreover, the tree species diversity in both areas is lower than in the lowland rainforest of Sekundur, Gunung Leuser National Park in Northern Sumatra, which has 133 species (39 families) (Priatna et al., 2006). The tree species richness and tree density in DBPA is also lower than in a permanent plot located ini Bodogol, Gunung Gede Pangrango National Park, West Java, which has 119 species (44 families) (Sadili, 2014; 2018).

The mean mortality rate of species measured in DBPA over the two years was 4.67% (trees, saplings, seedlings). This mortality rate indicates that the successional process is still a long way from reaching a climax forest, because the natural climax tropical forests usually have a mortality rate of 1%-2%/year. In addition, the DBPA permanent plot is characterized by many species of shrubs and pioneer trees (fast growing species), but already some slow-growing families are also present, such as Lauraceae, Annonaceae, Dipterocarpaceae, Myristicaceae, Fagaceae, and Burseraceae.

Euphorbiaceae (11 species) and Rubiaceae (eight species) are two of the largest families in Malaysiana flora, but they usually occupy the lower or middle forest strata. Euphorbiaceae's success in dominating many forest types is evidence that this family is highly adaptableto environmental conditions and opportunistic (Proctor at al, 1983; Priatna et al., 2006; Sadili, 2014).

Occurrence of gaps in the forest canopy can stimulate dormant seeds of pioneer tree species are growing up, and provide opportunities for of several species of shrubs to develop, so that plant species show a mixture of pioneer trees and shrub species. Based on visual observation, several small gaps also formed both in and around the permanent plot due to naturally broken tree branches. Indriyanto (2008) classify forest canopy covers into three different phases namely high (> 70%), moderate (40 -70%), and low (<40%).

The similarity index (SI) determines the level of similarity or degree of grouping among several objects under the study using several variables (positive or negative collaboration). In this study we employed SI to measuring whether the composition of the plant community in each sub-plot is similar. According to Kramer & Kozlowski (1979) in Pamoengkas & Prayogi (2011), growth is the end result of the interaction of various physiological processes that are influenced by environmental conditions. The picture of the species correlation of IVI >10% is mostly low (SI= <50%), which means that there is no high mutualism symbiosis. Then the results of the analysis for 25 different subplots (SI= <50%), shows that the research area within permanent plot is representative (heterogeneous subplots).

The distribution of all tree diameter classes (≥10cm DBH) within a 1-ha permanent plot in 2018-2020 can be seen in (Figure 2). This shows common condition of a natural tropical forests including in permanent plot, and is called the "inverted J" type. This pattern is a characteristic of dynamic natural forests (Proctor et al., 1983; Samsoedin & Heriyanto, 2010).

Knowing the species distribution pattern is very important for basic forest management. Many factors influence these distribution patterns, particularly climatic conditions and nutrient availability (Sofiah et al., 2013). According to Wahyuni et al. (2017), random distribution patterns of plant species occur when the dispersal of their seeds is mostly by wind or animals, and when the species displays significant environmentally tolerance. This study shows that the overall distribution pattern of the tree species is random, which is indicating that they are mainly plant species that dispersed by wind or animals.

High IVI values such as *Archidendron bubalinum* (tree), *Rotmania* sp. (sapling), and *Aporusa microsphaera* (seedling) are species that have a big opportunity of maintaining their growth and sustainability because the dominant species is the species that can utilize the environment where they grow in more efficiently than other species in the same area. The results of this study indicate that those three species, *Archidendron bubalinum*, *Rotmania* sp., and *Aporusa microsphaera*, are the most dominant species in each growth phases (tree, sapling and seedling) in the plant communities within the DBPA forest.

The Dipterocarpaceae are one of the main constituent families of Indonesia's lowland forests, particularly in Sumatra (Purwaningsih, 2004) and five Dipterocarp species were recorded in the permanent plot area, namely *Shorea acuminata*, *S. hemsleyana*, *S. leprosula*, *Dipterocarpus hasseltii*, and *Vatica rassak*. Not all species were recorded in all growthphases. *Shorea leprosula* was only found in the seedling phase, while *Shorea acuminata* occurred in both seedling and sapling phases. Other species are only recorded in the tree phase, so at this point, *Shorea acuminata* is the most dominat of the Dipterocarp species.

The emergent layer was categorized as very poor because only one single species and single tree was recorded in that emergent layer (>30 meters height). Natural, undisturbed forests of Sumatra and Kalimantan are usually dominated by members of Dipterocarpaceae, Burseraceae, and Leguminosae in the emergent layer. Again, this is an indication the permanent plot has had previously been disturbed and heavily logged, because based on its history, prior to 2004 this DBPA area was a logging concession area which was accompanied by illegal logging activities.

CONCLUSION

1. In a 1-ha permanent plot in Central Sumatra, we found a total of 101 species, 77 genera, and 38 families occurring in the tree, sapling, and seedling phases. All species are randomly dispersed.
2. *Archidendron bubalinum*, *Rothmania* sp., and *Aporusa microsphaera* are the most dominant species in the growth phases of tree, sapling and seedling, respectively.
3. Regeneration as manifested in the tree and sapling phases is quite good, but not in the seedling phase. Basal area, or stand density of trees and saplings, had increased over the two years by 3.64%.
4. Eight species, eight genera, and seven families had been recruited into the permanent plot from 2018 to 2020.
5. Mortality rates in all growth phases (tree, sapling and seedling) is 4.67% across 2018-2020, or 2.34% / year.
6. Tree densities are 485/ha in the tree phase, 3,488/ha in the sapling phase, and 14,200/ha in the seedling phase.

7. Overall, the analyses indicatethat permanent plot has experience some growth dynamics in tree and sapling phases but not in the seedling phase.

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Species names: The first time a species is mentioned, its scientific name should follow in parenthesis and in italics: e.g., Asian elephant (*Elephas maximus*). English names should be in lower case throughout except where they incorporate a proper name (e.g., Asian elephant, Cookson's wildebeest, long-billed vulture).

Abbreviations: Full expansion should be given at first mention in the text.

Units of measurement: Use metric units only for measurements of area, mass, height, etc.

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