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The Role of Environmental Law and Technology in Addressing Environmental Problems

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Preface

This proceeding has been published following a rigorous selection and editing process, requiring considerable time and effort. The 4th International Conference on Law and Society (ICLS) 2024, held at the end of last year, served as a platform for academics, practitioners, and researchers to discuss and share insights on crucial issues in law and society. With the high level of enthusiasm from the presenters, the manuscript selection process was carried out meticulously, ensuring that only the best works were included in this proceeding.

In 2024, ICLS adopted the theme "The Role of Environmental Law and Technology in Addressing Environmental Problems" in response to the increasingly complex global environmental challenges. The conference featured various panel discussions with a multidisciplinary approach, exploring the role of law and technology in developing sustainable solutions to environmental issues. From the many manuscripts submitted, the committee carefully selected twelve of the best papers, each offering innovative perspectives in the field of environmental law and technology.

We extend our deepest appreciation to the organizing committee and editorial team for their hard work and dedication in making this conference a success. We also sincerely thank all participants for their valuable contributions and insightful ideas, which enriched the discussions. We hope this proceeding will be beneficial to readers and serve as a valuable reference for the further development of environmental law and technology studies.

See you at ICLS 2025!

Prof. Dr. Bayu Dwi Anggono, S.H., M.H.
Dean, Faculty of Law, the University of Jember

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Earth Observation of Indonesia's Sumatran Rainforest: Monitoring Technology and World Heritage Governance

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ABSTRACT: Natural World Heritage sites are recognized for their Outstanding Universal Value (OUV) but remain subject to significant threats, including illegal activities, pollution and climate change. Effective monitoring is critical for protecting the integrity of World Heritage sites. This paper examines the use of satellite imagery as a monitoring tool to inform decision-making under the World Heritage Convention. Through a case study of the Tropical Rainforest Heritage of Sumatra (Indonesia) - now included on the 'In Danger List' - we explore how remote sensing may support governance in multi-scale settings. We conclude that remote sensing through earth observation has proven useful in monitoring threats to OUV. In the case of the Sumatran Rainforest, the application of this technology seems to have strengthened governance by empowering non-state actors to advocate for higher levels of compliance and accountability.

KEYWORDS: World Heritage, Earth Observation, Environmental Regulation

I. INTRODUCTION

World Heritage sites, celebrated for their Outstanding Universal Value (OUV), represent some of the most significant natural and cultural assets of humanity. Today, however, many World Heritage sites face escalating threats, including illegal logging, over-fishing, tourism, and climate change.[1] Much of this may be due to 'legacy issues' which were unidentified (or ignored) at the time of listing, including inadequate buffer zones and a lack of legislative safeguards and management planning.[2] Against this backdrop, safeguarding OUV and ensuring its transmission to future generations (as required by Article 4 of the Convention) requires robust monitoring practices.

To date, satellite imagery, or 'Earth Observation' as it is often referred to, has proven to be a versatile and valuable tool in monitoring land use change. It is beneficial for monitoring large-scale socio-ecological systems that are remote or challenging to access. Examples include the Indonesian, Malaysian and Brazilian rainforests. Over the last two decades, high-resolution satellite data have been used in a World Heritage context to track fishing activity,[3] monitor geohazards,[4] and map urban expansion.[5]

In this paper, we explore how it has also been used to monitor changes in forest cover in Indonesia's World Heritage-listed Tropical Rainforest Heritage of Sumatra ('the Sumatran Rainforest'). Though not without its challenges, we find that the ability of satellites to provide precise, real-time information supports national and international decision makers in responding to threats.

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1 Osipova, E., M. Emslie-Smith, M. Osti, M. Murai, U. Åberg, and P. Shadie. IUCN World Heritage Outlook 3: A conservation assessment of all natural World Heritage sites. Gland, Switzerland: IUCN, 2020.

2 Hamman, Evan, and Herdis Hølleland. Implementing the World Heritage Convention: Dimensions of Compliance. Edward Elgar Publishing, 2023.

3 Kroodsma, David, and Brian Sullivan. "World Heritage from space." (2016) In The Future of the World Heritage Convention for Marine Conservation, 35.

4 Pastonchi, L., Barra, A., Monserrat, O., Luzi, G., Solari, L., and Tofani, V., "Satellite data to improve the knowledge of geohazards in world heritage sites," (2018) 10:7 Remote Sensing 992.

5 Agapiou, A., "UNESCO World Heritage properties in changing and dynamic environments: change detection methods using optical and radar satellite data," (2021) 9:1 Heritage Science 1-14.

II. MONITORING COMPLIANCE USING TECHNOLOGY

A. Monitoring as a regulatory task

At its heart, regulation involves the establishment of rules and the monitoring and enforcement of those rules.[6] Typically, the development of rules is given the most attention by policymakers, with Parliaments, committees and other bodies engaging in lengthy debates about the wording and scope of legal provisions, often with little attention to how they will be enforced. In addition, the interrelationship between law and politics skews the focus as to what the rules are (or should be), rather than the impact on 'regulatees' or 'regulators'. The upshot has been that the important later stages of regulation (i.e., monitoring and enforcement) are often left under-resourced. This has prompted the development of theoretical regulatory models that support 'efficiency' such as risk-based regulation,[7] the enrolment of third parties,[8] and the notion of 'surrogate regulators'[9].

Although monitoring and enforcement are often considered the same thing, they are conceptually different. Monitoring refers to the 'various screening operations and actions for gathering information about whether the regulatees comply with environmental regulation.'[10] In short, it is the 'checking up on whether those covered by the law and regulations are doing (or not doing) what is required of (or forbidden to) them.'[11] 'Regulatory monitoring' can thus be distinguished

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6 Levi-Faur, D. (ed), Handbook on the Politics of Regulation, (2011) Edward Elgar, 6; Hutter, B., "The Role of non-state actors in Regulation," (2006) CARR Discussion Papers DP 37.

7 Black, J., and Baldwin, R., "Really responsive risk-based regulation," (2010) 32:2 Law & Policy 181-213

8 Black, J., "Mapping the contours of contemporary financial services regulation," (2002) 2:2 Journal of Corporate Law Studies 253-287.

9 Gunningham, N., Phillipson, M., and Grabosky, P., "Harnessing third parties as surrogate regulators: Achieving environmental outcomes by alternative means," (1999) 8:4 Business Strategy and the Environment 211-224; see also Black, J., "Enrolling actors in regulatory systems: Examples from UK financial services regulation," (2003) Public Law (Spring) 63-91. In a World Heritage context, see Hamman, E., "The role of NGOs in monitoring compliance under the World Heritage Convention: options for an improved tripartite regime," (2019) in Voight, C. (Ed.), International judicial practice on the environment: Questions of legitimacy (Studies on International Courts and Tribunals), Cambridge University Press, United Kingdom, pp. 417-442.

10 Tosun, J., "Environmental monitoring and enforcement in Europe: A review of empirical research," (2012) 22:6 Environmental Policy and Governance 437-448. Note that Tosun includes an additional clarification: 'that is, whether they modify their behaviour in accordance with the legal requirements' We consider this to be behaviour modification or enforcement, not monitoring.

11 Russell, C. S., "Monitoring and enforcement," (1990) in Public Policies for Environmental Protection, 1st ed., Routledge.

from 'environmental monitoring', on the basis that the former is more targeted towards gathering information in respect of compliance (or lack thereof). The latter is concerned with documenting physical change within an ecosystem.

Monitoring lies at the centre of all regulatory systems, including multi-scale systems such as World Heritage. Effective monitoring allows stakeholders know whether regulated entities are meeting or breaching their obligations. Regulatory monitoring can also provide broader insights into the collective impact of actors within a regulatory system and inform decisions about how best to direct (often) scarce regulatory resources. Monitoring is therefore a critical step in regulation, more narrowly, and in decision-making and governance more broadly.

B. Technology as a monitoring tool

Regulators today face many challenges in monitoring compliance with environmental rules. The scale and complexity of environmental problems, combined with inevitable resource constraints and the 'tyranny of distance' creates significant barriers to effective regulation.[12] Many regulators have started embracing new digital tools (or 'RegTech') to modernise how they monitor instances of pollution, respond to reports, and enforce regulations.[13]

The emergence of RegTech occurs against a backdrop of broader technological and environmental disruption. As regulators and researchers grapple with multiple, compounding environmental crises, digital technologies are becoming central to how state and non-state actors manage environmental risks.[14] While RegTech has received significant attention in domains such as financial regulation and policing, its application in the context of environmental regulation remains under-explored.[15]

Where environmental regulation scholarship has engaged on RegTech, it has tended to focus rather narrowly on specific technologies or one-off applications

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12 Gunningham, N., "Enforcement and Compliance Strategies," (2010) in Baldwin, R., Cave, M., and Lodge, M. (eds), *The Oxford Handbook of Regulation*, Oxford University Press, p. 120.

13 Holder, J., et al., "Regulatory Technology: Harnessing Technology to Support Environmental Regulation," (2022) 34 *Journal of Environmental Law* 45.

14 Glicksman, R. L., Markell, D. L., and Claire, "Technological Innovation, Data Analytics, and Environmental Enforcement," (2016) 44:1 *Ecology Law Quarterly*; Creutzig, F., et al., "Digitalization and the Anthropocene," (2022) 47 *Annual Review of Environment and Resources* 479.

15 Arner, D. W., Barberis, J., and Buckley, R. P., "FinTech, RegTech, and the Reconceptualization of Financial Regulation," (2017) 37:3 *Northwestern Journal of International Law and Business* 370, 373.

rather than considering broader systemic implications.[16] Such approaches risk overlooking important questions about how such technologies are transforming not just regulatory approaches, but decision-making in governance more generally.

III. MONITORING WORLD HERITAGE SITES

A. Overview of the World Heritage Convention

There are over 1200 properties currently inscribed on the World Heritage List. Most sites are inscribed for their cultural heritage values although natural and mixed sites dominate in terms of sheer geographical area. The emphasis on demonstrating Outstanding Universal Value (OUV) introduces unique challenges in the governance of World Heritage areas as they also hold important local and national values (which may or may not align with OUV).

At the time of listing, each site receives a Statement of Outstanding Universal Value which serves as the key reference point for its ongoing protection and management as far as the Convention is concerned.[17] State Parties are obliged to safeguard OUV and ensure the site's transmission to future generations. If a site's OUV comes under threat - due to factors such as conflict, natural disasters, or development - it may be included on the List of World Heritage in Danger. There are currently over fifty sites on the IDL (including the Sumatran Rainforest).

Unlike other Conventions, there is no Conference of the Parties (COP) for World Heritage. Rather, governance of the Convention is delegated to the World Heritage Committee, an intergovernmental body established under Article 8 of the treaty. The Committee is composed of 21 (rotating) member States. The Committee has various functions including making decisions on the inscription of sites to the World Heritage List (and the IDL), as well as overseeing the monitoring information on listed properties.

The Committee relies on technical guidance from its three advisory bodies: ICCROM (International Centre for the Study of the Preservation and Restoration of Cultural Property), ICOMOS (International Council on Monuments and Sites), and IUCN (International Union for Conservation of Nature). In practice, it may

[16] Anna Huggins et al, 'Siloes and Silences: A Review and Reflection on Environmental Law and Technology Scholarship' (2024) forthcoming

[17] This change was introduced in 2005. Sites that were inscribed before that time, must develop a 'Retrospective Statement of OUV'.

decide not to follow the Advisory Body's recommendations. The IUCN is the Advisory Body for all natural sites, which includes the Sumatran Rainforest.

B. Monitoring Compliance under the Convention

'Reactive Monitoring' is a key mechanism under the Convention for assessing and addressing threats to the conservation of World Heritage properties. Reactive Monitoring – involves the reporting to the Committee on the State of Conservation of properties. Where a property faces considerable threats, the IUCN and UNESCO may undertake a Reactive Monitoring Mission (i.e. a physical visit to the property to meet with stakeholders to understand the pressures). Reactive monitoring information is captured, analysed and decision-making (from the Committee) occurs on that basis. NGOs and other actors may raise concerns about conservation (for example, reports of damaging development) directly with the IUCN. IUCN will then typically raise those concerns with the Committee and the State Party concerned.

States Parties are also required to submit specific reports and impact studies whenever exceptional circumstances arise or activities are undertaken that could impact the OUV or state of conservation of a property.[18] Sites which are included on the IDL, or are threatened to be included on the IDL, are given greater monitoring scrutiny by the IUCN and UNESCO. This has been the case, as the next section shows, in the circumstances of the Sumatran Rainforest.

IV. THE TROPICAL RAINFOREST HERITAGE OF SUMATRA

A. Background to the World Heritage site

The Tropical Rainforest Heritage of Sumatra was inscribed on the World Heritage List in 2004. It was included on the basis of meeting three separate natural criteria: VII[19], IX[20] and X[21]. The site covers approximately two and a half

[18] UNESCO, *Operational Guidelines for the Implementation of the World Heritage Convention*, paragraph 172, available at https://whc.unesco.org/en/guidelines/.

[19] Contains superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance.

[20] Has outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals.

[21] Contains the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.

million hectares and consist of three national parks: Gunung Leuser National Park (GLNP), Kerinci Seblat National Park (KSNP), and Bukit Barisan Selatan National Park (BBSNP).[22] The parks span a wide altitudinal range, from sea level to the peak of Mount Kerinci - the highest volcano in Southeast Asia.[23]

The 'Leuser Ecosystem', which includes the GLNP, was reported at the time of listing to be the largest and most significant forest remnant remaining in Sumatra.[24] The current available satellite data (2024) shows that it remains the most intact area of tree cover in Sumatra.[25] Although the region has been protected by Presidential Decree since the 1990s,[26] the region remains under threat.

The Sumatran Rainforest is home to unique biodiversity, including the Sumatran tiger and the Orangutan.[27] It also features extraordinary landscapes such as forests, pristine rivers, volcanic formations, and alpine systems.[28] In IUCN's evaluation of the property at the time of nomination it concluded that the Sumatran Rainforest was of exceptional global importance due to its biodiversity, ecological processes, and natural beauty, recommending to the Committee that it be included on the List.[29] However, IUCN noted that the property faced several threats at the time, including loss of forest cover, noting it 'is a major problem in all three parks, and has [now] reached crisis proportions'.[30]

More broadly, the island of Sumatra has long been subject to loss of forest cover. Scientists monitoring deforestation on Sumatra (using satellite imagery) have summarised the losses as follows:

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22 The Leuser ecosystem is reported to represent the 'one of largest single continuous blocks of tropical rainforest left in the whole of south-east Asia.' BBC News, "The battle to save Sumatra's forests," (2018, February 17), available at https://www.bbc.com/news/in-pictures-43083872.

23 UNESCO World Heritage Centre, *Tropical Rainforest Heritage of Sumatra*, (n.d.), available at https://whc.unesco.org/en/list/1167.

24 World Heritage Committee, *Decisions adopted at the 28th session of the World Heritage Committee (Suzhou, 2004)*, WHC-04/28 COM/26, p. 16.

25 Global Forest Watch, available at https://www.globalforestwatch.org/map/.

26 For further background on the domestic legal protections for the Leuser system, see Eddy, T., "Embodying Ecological Policy in Defending the Leuser Ecosystem Area for Sustaining Collective Life," (2015) 5:10 Journal of Humanities and Social Science 252.

27 UNESCO World Heritage Centre, Tropical Rainforest Heritage of Sumatra, (n.d.), available at https://whc.unesco.org/en/list/1167.

28 UNESCO, ibid; IUCN, *World Heritage nomination: Tropical Rainforest Heritage of Sumatra (Indonesia) technical evaluation*, (2004), Gland, Switzerland: International Union for Conservation of Nature.

29 IUCN, ibid.

30 IUCN, ibid, p. 6.

> *Over the past 60 [years] Sumatra has experienced intensive industrial forestry and agricultural development that has significantly reduced the area of natural forest. In 1950, forest covered 71.2% of Sumatra … which was reduced to 49% by 1985 and to 35% by 1997 … Of the dominant drivers of forest cover loss, including agricultural expansion, wood extraction and infrastructure extension … the underlying causes of forest cover loss in Sumatra are related to the expanding global markets for pulp, timber and oil palm.*[31]

In addition to logging, the Sumatran Rainforest has been subjected to the threat of road development. In 2011, the World Heritage Committee made the decision to include the property on the IDL.[32] In its decision, the Committee 'expressed its utmost concern' that road development plans and agricultural encroachment 'pose a major threat to the property' and that 'these threats represent both a potential and ascertained danger [to OUV]'.[33]

In retrospect, inclusion on the IDL was not particularly unexpected as the property had been subjected to four Reactive Monitoring Missions between 2006 and 2018 (viz., 2006; 2007, 2013 and 2018). Even at the time of listing, there was discussion that it may, in the near future, be included on the IDL. This pressure has continued over the last two decades. In fact, between the years 2004 and 2011, the Committee was continually advised to place the property on the IDL 'as a result of continuing and aggravated threats to its values and integrity'.[34] It was reported by the IUCN and UNESCO that the Indonesia Government saw a potential listing on the IDL as a 'criticism' rather than an opportunity to strengthen international support.[35] At the time of writing, the Sumatran Rainforest remains on the IDL.[36]

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31 Citations omitted. See Margono, B. A., Turubanova, S., Zhuravleva, I., Potapov, P., Tyukavina, A., Baccini, A., Goetz, S., and Hansen, M. C., "Mapping and monitoring deforestation and forest degradation in Sumatra (Indonesia) using Landsat time series data sets from 1990 to 2010," (2012) 7:3 Environmental Research Letters 034010 at 12.

32 UNESCO World Heritage Committee, *Decision 35 COM 7B.16: Tropical Rainforest Heritage of Sumatra (Indonesia) (N 1167)*, (2011), in *Decisions adopted by the World Heritage Committee at its 35th session (Paris, UNESCO Headquarters, 2011)*, Paris, France: UNESCO.

33 Ibid.

34 Ibid.

35 IUCN, State of Conservation Report 2009: Tropical Rainforest Heritage of Sumatra, Indonesia.

36 As of 2024, efforts were being made by the Indonesian Government towards removing the property from the IDL including forest restoration, addressing encroachment and strengthening community engagement. See UNESCO World Heritage Committee, *Decision 46 COM 7A.56: Tropical Rainforest Heritage of Sumatra (Indonesia) (N 1167)*, (2024), in *Decisions*

B. Earth Observation of the World Heritage area

The threats facing the Sumatran Rainforest have been better understood and arguably better understood and responded to due to the application of earth observation techniques. In 2011, for instance, it was reported that satellite imagery was being used by the Indonesian Government, in collaboration with NGOs, for 'biological monitoring of the forest ecosystem', as well as to determine deforestation rates from illegal logging and agricultural encroachment.[37]

Satellite data was again drawn on by the IUCN, in addition to other evidence, to publicise to the Committee that agricultural encroachment was continuing around and within the World Heritage area, with more than 60% of the buffer zone for the KSNP park said to have been lost.[38] At the time (2010) the World Heritage Committee requested a report based on 'satellite imagery over the period 2006-2010' that demonstrated that concerns regarding encroachment, road construction and other activities were not threatening the OUV of the property.[39] In the same decision the Committee raised the possibility of inclusion of the property on the IDL unless 'substantial progress' could be made.

In the following year (2011), it was noted that satellite data had been successfully used by Indonesian Government in collaboration with UNESCO's regional office in Jakarta to determine the deforestation rate at the property as a result of illegal logging and encroachment. The rates across the three national parks which comprise the World Heritage area were provided as follows:

- BBSNP1200 ha/yr
- KSNP, 2000 ha/yr
- GLNP. 625 ha/yr[40]

adopted by the World Heritage Committee at its 46th session (New Delhi, 2024), Paris, France: UNESCO.

37 UNESCO World Heritage Centre, *State of conservation of World Heritage properties inscribed on the World Heritage List (WHC-11/35.COM/7B.Add)*, (2011), Paris, France: UNESCO, pp. 37-38.

38 IUCN, State of Conservation Report: Conservation issues presented to the World Heritage Committee in 2010; UNESCO World Heritage Centre, State of Conservation Report: Tropical Rainforest Heritage of Sumatra (Indonesia), available at https://whc.unesco.org/en/soc/485/.

39 UNESCO World Heritage Committee, Decision 34 COM 7B.14: Tropical Rainforest Heritage of Sumatra (Indonesia) (N 1167), (2010), in Decisions adopted by the Committee in 2010.

40 UNESCO World Heritage Centre, State of Conservation Report 2011: Conservation issues presented to the World Heritage Committee in 2011, Tropical Rainforest Heritage of Sumatra, available at https://whc.unesco.org/en/soc/322.

Although the Indonesian Government was criticised for not providing the 'time-series satellite imagery' for the period 2006-2010 (as requested by the Committee) there was evidence that it had been collaborating with NGOs over the use of satellite imagery, for example to monitor the impact of invasive species in the area.[41]

By 2015, IUCN and UNESCO were requesting that Indonesia provide 'time series of satellite images' from 2011-2015 as evidence for Indonesia's claim that there had been no further loss of primary forest cover and no further net loss of secondary forest cover during that period.[42] The State of Conservation Report submitted by Indonesia in 2016 noted that scheduled satellite surveys were taking place with a view to improving conservation at the site.

By 2018, the property had been on the IDL for several years and IUCN and UNESCO's World Heritage Centre were increasingly concerned about the measures to remove it from the IDL. They recommended, which the Committee accepted, that Indonesia ensure that any new data on the extent of forest cover is derived from recent satellite imagery 'in a manner that can be repeated at regular intervals'.[43] These requests for more and better data from UNESCO and IUCN continued, including up until very recently. Whilst Indonesia has reiterated that forest cover has been relatively stable from 2011 to 2022, no satellite data was provided making it difficult currently for IUCN and UNESCO to verify Indonesia's claims.

Table 1 Key events since World Heritage listing of the Sumatran Rainforest (with an emphasis on satellite data)

Year	Event
2004	Tropical Rainforest Heritage of Sumatra inscribed on the World Heritage List under criteria VII, IX, and X. IUCN express concerns about logging and encroachment at the site.
2006	First Reactive Monitoring Mission conducted.

41 Ibid.

42 Ibid.

43 World Heritage Committee, Decision 42 COM 7A.40: Tropical Rainforest Heritage of Sumatra (Indonesia) (N 1167), (2018), available at https://whc.unesco.org/en/decisions/7213/.

2007	Second Reactive Monitoring Mission conducted.
2011	Property included on the World Heritage List in Danger (IDL) due to road development and agricultural encroachment.
2011	Satellite data obtained by Indonesian Government in collaboration with UNESCO's regional office in Jakarta determines the deforestation rate in the property.
2013	Third Reactive Monitoring Mission conducted.
2015	UNESCO and IUCN request 'time-series satellite imagery' for the period 2011-2015 to assess forest cover changes.
2016	State of Conservation Report notes scheduled surveys being conducted by Indonesia.
2018	Fourth Reactive Monitoring Mission conducted; UNESCO and IUCN emphasize the need for regular satellite data updates.
2022	Indonesia claims no net loss of forest cover from 2011-2022, though satellite data is not provided from Indonesian Government as evidence.
2024	Third party analysis (available from Forest Watch) confirms Leuser Ecosystem remains the most (relatively) intact area remaining in Sumatra, though it still remains threatened.

IV. DISCUSSION

The above gives rise to a few preliminary points about the use of technology in multiscale governance systems like World Heritage. First, the role of NGOs appears integral to the use of technologies and its support within the World Heritage decision-making system. In 2004, for example, it was reported that WWF (which has long held links to the World Heritage Convention) established Eyes on the Forest – a deforestation watchdog that utilised satellite imagery to monitor changes in forest systems.[44] More recent reports have noted other NGOs

[44] World Wildlife Fund, "The race to protect the forests and wildlife of Sumatra's Thirty Hills," (2018), WWF Magazine, available at https://www.worldwildlife.org/magazine/issues/fall-2018/articles/the-race-to-protect-the-forests-and-wildlife-of-sumatra-s-thirty-hills.

utilising similar technology, for example, to accuse landholders of continued deforestation within the GLNP.[45]

The local NGO known as HAkA - Hutan, Alam dan Lingkungan Aceh (Forest, Nature and Environment of Aceh) is supported by international resourcing like Norway's International Climate and Forest Initiative (NICFI). According to its website, NICFI was established in 2008 by the Norwegian government to combat deforestation and works with partners in Brazil, Indonesia and elsewhere.

HAkA describes its monitoring of the Leuser ecosystem as follows:

Monitoring is a critical component of HAkA's conservation strategy. The organization systematically observes and tracks changes in forest cover and land use within the Leuser Ecosystem using advanced technologies such as satellite imagery Planet and remote sensing like [Global Forest Watch's] - Forest Watcher. HAkA gets access to satellite imagery with a resolution of up to 3 meters and daily updates with Level 2 Planet imagery from NICFI. This continuous monitoring allows HAkA to detect threats early, assess the effectiveness of conservation interventions, and adapt strategies as needed. The data collected is rigorously analyzed and used to inform conservation actions, guiding decision-makers with accurate, up-to-date information on the state of the ecosystem. Through this scientific approach, HAkA ensures that its conservation efforts are grounded in evidence and can be adjusted to respond to emerging challenges. [46]

HAkA publishes its data freely on the internet. This includes analysis of the data, such as trends in forest cover.[47]

One observation from our case, therefore, is that satellite technology and its wide availability is empowering non-state actors like NGOs to act as 'surrogate regulators' by identifying and reporting non-compliance to international bodies like IUCN and UNESCO. Organizations such as HAkA and use satellite data supported by international efforts to monitor deforestation trends and advocate for stronger enforcement measures including public dissemination. This involvement broadens the regulatory landscape for World Heritage consistent with calls for an improved tripartite regulatory regime.[48]

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[45] Rainforest Action Network, "Illegal deforestation persists in Indonesia's Gunung Leuser National Park," (2024, March 5), Leuser Watch, available at https://www.ran.org/leuser-watch/illegal-deforestation-persists-in-indonesias-gunung-leuser-national-park/.

[46] HAkA, What We Do: Forest Monitoring, available at https://haka.or.id/en/what-we-do/forest-monitoring.

[47] Available at https://acehdata.digdata.id/.

[48] Hamman, E., "The role of NGOs in monitoring compliance under the World Heritage Convention: options for an improved tripartite regime," (2019) in Voight, C. (Ed.), International

A second observation from our study is that there appears to be scope for improvements in compliance on the part of States with regards to their international reporting obligations. The increased availability of satellite data can support States in meeting both Reactive Monitoring and Periodic Reporting obligations under the World Heritage Convention. This can be seen for example, in the collaboration between UNESCO (Jakarta) and Indonesia in supplying deforestation data in 2011. At the same time, the technology provides a further opportunity for States to collaborate with non-state actors (including 'big tech') as well as to seek new sources of assistance in their other conservation work. In the context of the World Heritage regime this may help Indonesia to build its own credibility and standing amongst other State Parties.

A third point to note is that the technology appears to be enabling the implementation of risk-based regulation, whereby scarce monitoring resources of the Indonesian government are focused on areas with the greatest threats. For example, Reactive Monitoring Missions for the Sumatran site appear to may utilise satellite data to prioritise interventions in regions most impacted by encroachment as well as those that represent the last remaining strongholds of OUV for the site. The reported stabilisation of forest losses in the Leseur Ecosystem may be, at least in part, due to a higher degree of vigilance driven by enhanced monitoring techniques.

Having said all that, despite the increased use of 'RegTech' to survey threats to World Heritage, the risks on the ground remain very real. Some of this can be understood, in the case of the Sumatran Rainforest, not because of poor data or lacklustre monitoring effort, but by administrative and political 'volatility' at the local scale driven by the allures of economic development.[49] Indeed, this is a problem facing World Heritage worldwide and a challenge that technology alone cannot resolve.

VI. CONCLUSION

The use of satellite data in a World Heritage context illustrates the potential of technological advancements to contribute to more effective multiscale governance. Satellite imagery seems to be useful in monitoring threats towards

Judicial Practice on the Environment: Questions of Legitimacy (Studies on International Courts and Tribunals), Cambridge University Press, United Kingdom, pp. 417-442.

[49] Sloan, S., Campbell, M. J., Alamgir, M., Collier-Baker, E., Nowak, M. G., Usher, G., and Laurance, W. F., "Infrastructure development and contested forest governance threaten the Leuser Ecosystem, Indonesia," (2018) 77 Land Use Policy 298-309.

OUV and providing relatively precise data improving the ability of both state and non-state actors to respond to environmental threats. In the case of the Sumatran Rainforest, the availability of earth observation appears to have strengthened monitoring effort especially through the empowerment of non-state actors, such as NGOs and the IUCN, to advocate for higher levels of compliance and accountability.

These positives notwithstanding, the challenges of capacity disparities, particularly for developing nations, and the limitations of 'top-down' high-tech solutions face ongoing obstacles. In the end, such technologies are not a panacea for declines in global biodiversity. At best they represent a useful tool in governance to shine a light on non-compliance, distribute information more widely and enhance our understanding of changes in ecosystems. Governance is ultimately about decision-making and these types of tools are increasingly useful to inform the basis on which decisions are made.

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The Impact of Illegal Mining on Environmental Damage in the Legal Protection Perspective

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ABSTRACT: This study aims to understand, evaluate and find the impack of illegal mining on environmental damage mainly related to legal protection for the community due to Environmental Damage caused by the illegal mining process. The importance of balance in natural resource management and human interests, as mandated by Article 28 H paragraph (1) of the 1945 Constitution. The presence of Law Number 32 of 2009 to guarantee legal certainty and provide protection for the rights of every person to obtain a good and healthy environment as part of protecting the entire ecosystem. However, this is often violated by illegal mining, the existence of this unauthorized mining activity mostly comes from C mining (sand, gravel, and fill soil) and metal (gold) as happened in Madura, Pacitan, and the "Tapal Kuda" area. The violation of these illegal miners is that after mining the geographical conditions of the area are not fixed and tend to be ignored. The impact on the location in the surrounding area is environmental pollution, loss of biodiversity, increased threat of landslides, forest damage, decreased air quality, sedimentation and decreased water quality, environmental pollution due to waste. The formulation of the problems presented are: 1. What is the form of environmental damage due to mining activities; 2. What is the strategy for resolving mining disputes regarding environmental damage. The research method is legal research uses empirical legal research. The research approaches used are the statute, conceptual, and sociological approaches. The interim results of the study indicate that natural resource management must be oriented towards natural resource conservation (natural resource oriented). Therefore, a strategy is needed to resolve mining disputes that result in environmental damage, both at the level of laws and regional regulations.

KEYWORDS: Illegal Mining, Environmental Damage, Legal Protection

I. INTRODUCTION

Indonesia is an archipelagic country that has abundant natural resource potential and has a variety of mineral resources, all of which are used for the welfare of the people as mandated in Article 33 paragraph (3) of the 1945 Constitution, which states that the earth, water and natural resources contained therein are controlled by the state, which confirms the greatest possible welfare for the people.[1] Earth's natural resources such as minerals and coal, are non-renewable natural resources, so they must be managed optimally in order to achieve the greatest benefits and welfare for the people. Furthermore, mining development must adapt to changes in the strategic environment, both nationally and internationally.

The main challenge for the mining and coal industry is the impact of globalization which encourages democratization, regional autonomy, human rights, the environment, technological and information developments, intellectual property rights and what is called a stronger role for the private sector and society.[2] Natural resources that are quite abundant imply the existence of large-scale exploration and exploitation efforts under the pretext of development needs. Mining means one of the efforts to utilize natural resources by carrying out activities ranging from searching, digging, processing to marketing mining products.[3]

The series of mining activities always intersect with the environment. The environment is a container for the interaction of living things in it to produce a network of life.[4] In environmental management, sustainable principles are needed for environmental sustainability. Good environmental management as a form of long-term development efforts for the welfare of life.[5] Law Number 4 of 2009 concerning Mineral and Coal Mining, which was last amended by Law Number 6 of 2023 (hereinafter referred to as the Minerba Law), states that mineral and coal mining business activities are mining business activities outside

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1 Abdul, K. (2021). Penyelesaian Sengketa Administrasi Izin Usaha Pertambangan Pasca Berlakunya Undang-Undang Nomor 3 Tahun 2020. Sultra Research of Law: Jurnal Hukum, 3(2), 25–36

2 Arief K. Syaifulloh, Dampak Kerusakan Lingkungan Akibat Penambangan Pasir Merapi di Klaten, Jurnal Penegak Hukum Dan Keadilan, Vol. 2 No. 2, September 2021, h. 147-161

3 Irawan P. Penelitian Kualitatif & Kuantitatif untuk Ilmu-Ilmu Sosial. DIA Fisip UI, Jakarta. 2006.h. 1

4 Uar, N. D., Murti, dan Hadisusanto, S. Kerusakan Lingkungan Akibat Aktivitas Manusia pada Ekosistem Terumbu Karang. Majalah Geografi Indonesia, 30(1), 2016. H.88–95

5 Riskanita, D., & Widowaty, Y. Upaya Pemerintah Daerah Mengatasi Kerusakan Lingkungan Akibat Alih Fungsi Lahan Berdasarkan Konsep Negara Kesejahteraan. Supremasi Hukum: Jurnal Penelitian Hukum, 28(2), 2019.h.123–134

geothermal, oil and natural gas and groundwater which have a crucial role in providing concrete added value to national economic growth and sustainable regional development.

In Article 2 of the Mineral and Coal Law, there are 4 principles for managing mineral and/or coal mining in Indonesia, namely: "(1) The principle of benefit, justice and balance; (2) The principle of siding with the interests of the nation; (3) The principle of participation, transparency and accountability; and (4) The principle of sustainability and environmental awareness. Mining activities under the pretext of development are inversely proportional to environmental conditions due to mining. Environmental damage is a crucial problem in human life and even a problem that has never been resolved.

The environment is a unity of space with all objects, power, conditions, and living things, including humans and their behavior, which affect nature itself, the continuity of life, and the welfare of humans and other living things. The environment is a chain that is never broken and greatly determines the continuity of human life. One of the sources of problems in human survival in an ecosystem is mining disputes that can cause environmental damage carried out by mining companies. Mining activities can cause changes in the environment such as changes in soil structure, changes in landscapes, changes in flora and fauna, changes in water flow systems and so on. In addition to changes in the physical environment, mining also causes changes in social, cultural and economic life.[6]

In a dispute, including an environmental dispute, it is not only the duration of the "dispute between the parties, but the dispute is accompanied by a "claim". A claim is the primary attribute of the existence of a dispute (conflict). The formulation of Article 1 number 19 of the Environmental Management Law only defines an environmental dispute as "a dispute between two or more parties..." without including a "claim" is incomplete and does not fully represent the existence of a dispute.

The dynamics of mining and environmental disputes occur in many regions in Indonesia, including East Java Province, which is one of the mining producing provinces. Starting from the thoughts contained in the background of the problem above, and in order to facilitate the writing of the research, from this background the writing will specify by identifying the problems which will then be used as issues in this research, namely : 1. What are the forms of environmental damage due to illegal mining. And 2. What is the strategy for resolving illegal

[6] Rachmad Safa'at dan Indah Dwi Qurbani, Alternatif Penyelesaian Sengketa Pertambangan (Studi di Kabupaten Lumajang Provinsi Jawa Timur), Jurnal Konstitusi, Volume 14, Nomor 1, Maret 2017, h. 151

mining disputes regarding environmental damage from a legal protection perspective.

II. METHODOLOGY

Examining the law is not only related to facts, regulations, and previous legal cases, some law books, and used as reference libraries in conducting pure legal research, distinguishing individual characteristics in the human environment in reality can be used in contemporary legal research, usually inspired by behavioral law, which is also often referred to as empirical/sociological/socio-legal/nondoctrinal legal studies.[7] This research uses empirical legal research, which is a method of legal research that attempts to view the law in a clear queue or can be discussed by observing and studying how the law functions in society.[8] The approaches used are the Legislation Approach, and Sociological Approach. The data sources used are Primary Data and Secondary Data. Data collection techniques used in the research are Field Studies and Literature Studies. Data analysis in this research uses a qualitative approach method, because it uses a research method that has a descriptive analysis nature.

III. FORMS OF ENVIRONMENTAL DAMAGE DUE TO ILLEGAL MINING

Mining is part or all stages of activities in the framework of research, management and exploitation of minerals or coal which include general investigation, exploration and feasibility studies, construction, mining, processing and refining, transportation and sales, and post-mining activities. The mining sector is a strategic sector, in addition for areas rich in natural resources, mining is the backbone of the region's income. Minerals are organic compounds formed in nature, which have certain physical and chemical properties and regular crystal structures or their combinations that form rocks, either in loose or solid form.

The written laws in the field of mining business that have been in force in Indonesia are as follows: Indische Mijn Wet Stb.1899 which came into force in 1907, Amendments to Indische Mijn Wet in 1899 which changed Article 5a (Article on Work Contracts). Furthermore, when we were independent, the Mining Law I in 1960 came into force, namely: Law Number 37 Prp. of 1960 concerning "Mining" and Law Number 44 Prp. of 1960 concerning "Oil and

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[7] Depri Liber Sonata. Metode Penelitian Hukum Normatif dan Empiris : Karakteristik Khas Dari Metode Meneliti Hukum. https://jurnal.fh.unila.ac.id/index.php/fiat/article/download/283/349 h.21

[8] Nurul Qamar dkk. 2017. Metode Penelitian Hukum (Legal Research Methods). CV.Social Politic Genius (SIGn). Makasar. h.52

Natural Gas". In 1967, in order to facilitate the entry of foreign capital, Law Number 11 of 1967 concerning "Basic Provisions on Mining" was issued as an improvement on Law Number 37 Prp of 1960, which was unable to attract the interest of foreign investors.

In accordance with the mandate of the Constitution, that the natural resources contained in the bowels of the Earth of Indonesia are "controlled" and used by the State for the greatest prosperity of the people. The meaning of controlled and used here is an order from all the people to the State to manage mining materials for the greatest prosperity of the people. So the "Public Nature" of the management of these mining materials. Has a very high legal basis, namely the Constitutional basis which is expressly stipulated in Article 33 paragraph (3) of the 1945 Constitution. All provisions governing mining business matters or the use of mining materials as referred to above are included in the scope of Mining Law.

Mining Law essentially has the scope of regulating the relationship between those who will mine and the state or government as the holder of mining authority regarding how to obtain the right to carry out mining business and the obligations of mining entrepreneurs to the state as the holder of mining authority rights. Mining is an activity carried out by digging into the ground (earth) to obtain something in the form of mining products. Based on Article 1 number 1 of the Mineral and Coal Law, mining is part or all stages of activities in the context of research, management and exploitation of minerals or coal which include general investigations, exploration, feasibility studies, construction, mining, processing and refining, transportation and sales, and post-mining activities. From this understanding, it can be interpreted that various mining activities can be carried out before mining, the mining process or after the mining process.

The definition of mineral mining and coal mining is clearly very different. Mineral mining is the mining of a collection of minerals in the form of ore or rocks, outside geothermal, oil and natural gas, and groundwater. While the definition of coal mining is the mining of carbon deposits found in the earth, including solid bitumen, peat and asphalt rock. In essence, the development of the mining and energy sector seeks a process of developing potential mineral and energy resources to be utilized economically and optimally for the greatest prosperity of the people. Mineral resources are a source that cannot be renewed. Therefore, its implementation is expected to be able to maintain the balance and

safety of performance and sustainability of the environment and the surrounding community.[9]

Indonesia is rich in natural resources, especially from mining products. Types of objects called mining goods. The classification of mining products according to the Mineral and Coal Law does not actually explicitly regulate the division of mining groups as in Law Number 11 of 1967. The classification of mining materials is regulated based on mining business groups, according to article 4, namely: a. Mining businesses are grouped into: 1) Mineral mining; and 2) Coal mining., b. Mineral mining as referred to is classified as: 1) Radioactive mineral mining; 2) Metal mineral mining; 3) Non-metal mineral mining; and 4) Rock mining.

Preparation of mining areas is carried out through mining area planning activities and determination of mining areas. Mining area planning is prepared through the mining potential inventory stage and the mining area plan preparation stage. Meanwhile, the determination of mining areas is carried out in a transparent, participatory and responsible manner in an integrated manner by considering the opinions of related government agencies, and by considering ecological, economic and socio-cultural aspects as well as being environmentally aware, and by considering regional aspirations.

Based on Article 13 of the Mineral and Coal Law, the form of mining areas is divided into 3 (three) parts, namely: Mining Business Areas (WUP), People's Mining Areas (WPR), and State Reserve Areas (WPN). Mining Business Areas are part of mining areas that already have available data, potential and/or geological information. The government can delegate some of its authority to the provincial government in accordance with statutory provisions. For 1 (one) WUP, it consists of 1 (one) or several Mining Business Permit Areas (WIUP) located across provincial areas, across district/city areas, and/or in 1 (one) district/city area. WIUP is an area given to holders of Mining Business Permits (IUP). The area and boundaries of WIUP are determined by the government in coordination with the regional government based on the criteria held by the government.

People's Mining Area (WPR) is part of the mining area where people's mining business activities are carried out. People's mining activities can only be carried out within the people's mining area. Meanwhile, the State Reserve Area (WPN) is part of the mining area that is reserved for national strategic interests. For national strategic interests in relation to mining, the government works together

[9] Jacky Miner, Teori Pertambangan I, (online) http://www.http./teori-pertambangan-i.html , diakses pada tanggal 25 Mei 2023 pukul 10.00 WIB

with the DPR by considering regional aspirations in determining WPN as an area reserved for certain commodities and a conservation area in order to maintain the balance of the environmental ecosystem. The WPN that is determined for certain commodities or for conservation changes its status to a Special Mining Business Area (WUPK). The government determines the WUPK after coordinating with the regional government. The implementation of mining business activities in the WUPK is carried out by granting a permit called a Special Mining Business Permit (IUPK).

In carrying out excavations or mining, it is regulated in the Mineral and Coal Law, that regarding the people's mining area (WPR), it is part of the mining area where people's mining business activities are carried out. Article 22 letter b of the Mineral and Coal Law states that metal or coal mining is only allowed to carry out mining with a maximum depth of 25 (twenty five) meters. While Article 1 paragraph (27) states that post-mining activities are planned, systematic, and sustainable activities after the end of some or all mining business activities to restore the function of the natural environment and social functions according to local conditions throughout the mining area. The article states that everyone who carries out mining is required to restore the function of the land where mining is carried out. Both people's mining that already has a mining business permit (IUP) and mining carried out by a business entity.

The principle of granting IUP regulated in the Minerba Law is one of the IUPs only allowed for one type of mine. One IUP is given for one type of mineral or coal. The granting of IUP may not be more than one type of mine. There are two types of IUPs, namely Exploration IUP and Production Operation IUP, the issuance of which is carried out in stages. The expiration of the mining business permit has been determined in Article 117 of the Minerba Law. Mining that has a mining business permit, then land restoration regulations are handed over to the regional government, as stated in the Minerba Law, Article 73 paragraph (2) of the Minerba Law that the district/city government is responsible for technical security in people's mining businesses which include: a. Occupational safety and health; b. Environmental management and c. Post-mining.

The carrying capacity of nature is very important for the survival of humans, so the carrying capacity of nature must be maintained so that it is not damaged and has bad consequences for humans. If damage occurs to the carrying capacity of nature, which is formed through a very long process, hundreds or even

thousands of millions of years, it is impossible to wait for its recovery naturally.[10] In general, environmental damage is caused by 2 factors, namely:[11]

1. Damage due to internal factors Internal damage is damage that originates from within the earth/nature itself. Damage due to internal factors to the carrying capacity of nature is difficult to prevent because it is a natural process that occurs in the earth/nature that is seeking its own balance. Damage to the carrying capacity of nature due to internal factors can occur due to: a) Volcanic eruptions that damage the surrounding natural environment. b) Earthquakes that cause dislocation of soil layers. c) Forest fires due to natural processes during the long dry season. d) Major floods and high sea waves due to storms Damage to the carrying capacity of nature due to internal factors is generally accepted as a natural disaster. This damage occurs in a short time but the effects can last for quite a long time.
2. Damage due to external factors Damage due to external factors is damage caused by human actions in order to improve the quality and comfort of life. Damage due to external factors is caused by humans, so it is the responsibility of humans to reduce or even, if possible, avoid damage caused by external factors. Damage to the carrying capacity of nature due to external factors such as mining to take natural resources (minerals) from the earth's interior.

Basically, environmental destruction and pollution do not contain any differences, because the essential elements of both are the same. Namely, there are actions that cause changes either directly or indirectly, in essence, destruction and pollution cause the environment to be less or no longer function. Damage or pollution is a condition where the condition of a habitat (a place where living things are) is no longer pure, because of the influence on the habitat. Environmental pollution and damage are caused by various things, especially caused by human actions and behavior that do not pay attention to the harmony of nature and its sustainability.

Behind the benefits of mining activities, it turns out that it also causes negative effects or impacts. Negative impacts certainly cause losses for all parties. Some forms of damage to the mining business for the environment:

1. Mining activities will certainly damage the environment. To obtain mining results, excavations need to be carried out into the earth. It is

[10] Wisnu Arya Wardhana, Dampak Pencemaran Lingkungan, (Yogyakarta: CV Andi Offset, 2004), h. 15

[11] *Ibid.*, h. 16

not surprising that the results of these excavations form holes, tunnels, and depressions that are not small in size. Many of these pools are not filled back with soil so that when it rains and for a long time, the former excavations eventually turn into pools. So it's not surprising that there are no more hills or mountains, as a result when it rains, natural disasters such as landslides and floods cannot be avoided anymore, because there no more rainwater catchment areas.

2. Changes in the structure of the earth's surface, mining activities will change the shape of the earth's landscape, especially for mining activities that use open pit techniques or open mining. For example, the disappearance of rivers due to piles of material or extreme shallowing and also hills that turn into roads or lowlands.
3. Environmental pollution occurs, it is countless how many cases are caused by mining activities, one of which is environmental pollution. For example, river pollution due to mining waste that is directly dumped into the river without any prior processing, the river flow that carries mining waste will continue to flow to the ocean. The consequences can be more fatal, namely the marine ecosystem is damaged, it is not surprising that many coral reefs and fish die due to mining waste poisoning. Not only are rivers polluted, large vehicles that transport mining products cause air pollution due to flying dust.
4. Safety is threatened, The negative impacts of mining can also threaten the safety of miners and residents living around the mine. When mining gold, miners will dig the earth to form a long, narrow and winding tunnel which of course the availability of oxygen in the tunnel is very small. It is not surprising that many workers suffocate due to lack of oxygen or other risks, namely the collapse of the tunnel, burying the workers.
5. Loss of biodiversity Before the discovery of natural resources located underground, namely mining, most of the areas were far from residential areas so that the fauna and flora that lived there were not disturbed. However, after mining activities began, many fauna and flora disappeared and even died due to the destruction of their habitat. So now many native Indonesian flora and fauna are threatened with extinction.
6. Decrease in air quality As when burning coal which releases toxic compounds including carbon monoxide, carbon dioxide, methane, benzene, toluene, xylene, sulfur, arsenic, mercury and lead. In addition, the decrease in air quality is caused by the dismantling and mobility of

mining products and mining equipment from inside and outside the mining location.

7. Sedimentation and decreasing water quality The high content of water pollutants is caused by coal mining and processing activities where pollutant materials are carried by surface run-off to lower parts and enter water bodies. Therefore, the water becomes cloudy and the disposal of residual soil from mining also increases the amount of sediment transport.
8. Environmental pollution due to waste, Mining waste is usually contaminated with sulfuric acid and iron compounds that can flow out of the mining area. Water containing these two compounds will become acidic. Acidic mining waste can cause corrosion and dissolve heavy metals so that polluted water is toxic and can destroy aquatic life.

Environmental damage caused by mining activities occurs in many areas in Indonesia, especially in the Besuki Residency area. The reason is, since being abandoned by illegal miners, the geographical conditions of the mining area have not been improved and tend to endanger local residents. The impact of environmental damage caused by illegal mining activities that have stopped operating, one of which is leaving behind a 100-meter deep excavation. Sadly, there is no security boundary around the illegal mining area.

The paradigm of natural resource management in the mining sector carried out by the government so far has given rise to various problems, including: increasing conflict, environmental damage and levels of poverty in the community that have not changed and ignoring the value systems, social, economic and cultural of the local community.[12] Mining activities also cause various environmental changes, including changes in the landscape, changes in flora and fauna habitats, changes in soil structure, changes in surface and groundwater flow patterns and so on.

In addition to changes in the physical environment, mining also causes changes in social, cultural and economic life. Based on observations related to mining activity conditions, the author found many facts of conflict regarding Mining Management. Mining entrepreneurs and workers often do not pay attention to the impacts of mining, especially often the excavation site is very close to residential areas, what's worse is that mining entrepreneurs often commit fraud against residents, thus triggering sporadic rejection movements by residents. Former mining land that uses deep excavation exploration methods always

[12] Rachmad Safa'at, 2016, Advokasi dan Alternatif Penyelesaian Sengketa, Surya Pena Gemilang, Malang, h. 137

leaves former land with uneven land surface conditions, and of course has an impact on the environment.[13] This condition will trigger horizontal conflict.

Mining activities that damage the environment, which have a very bad impact on human life. Various problems or damage caused by mining activities that are not managed properly and correctly will result in various environmental damage such as damage to land, water, air, sea, and forests. Therefore, we should be able to manage mining activities properly, so as not to have a bad impact and cause bigger disputes.

IV. STRATEGY FOR RESOLVING ILLEGAL MINING DISPUTES FROM THE PERSPECTIVE OF LEGAL PROTECTION

Disputes in the mining sector are disputes or conflicts that occur in the implementation of mining activities. Mining activities include activities to conduct general investigations, exploration, feasibility studies, construction, exploitation, refining and sales of natural resources, in the form of minerals, mineral collections, rocks, ores and coal. These five activities cannot always be carried out properly by the appointed contractor. In the implementation of mining activities, the appointed contractor always causes problems. These problems do not only occur between the community and the contractor, but also between the Government and the contractor.[14]

The addition of investment in the mining sector in a country can cause conflict. To understand the causes of mining conflicts, it is necessary to know first that in mining activities there is something called The Principle of Social Justice. This principle essentially requires that everyone has the right to equality to access welfare, health, justice, privacy, and opportunities, regardless of legal, political, economic status, and other conditions. The five principles are Access (gaining access), Equity (impartiality), Diversity (Diversity), Participation (Inclusion/participation), Human rights (HAM). These principles must be met to achieve social justice. These principles have developed into a philosophy, legal theory, and have even become an instinct.

The principle of social justice in terms of the utilization of natural resources (wealth) as a principle in relation to benefits. In terms of natural wealth owned by a region that is developed at social cost, everyone must receive benefits. The

[13] Rachmad Safa'at dan Indah Dwi Qurbani, Alternatif Penyelesaian Sengketa Pertambangan (Studi di Kabupaten Lumajang Provinsi Jawa Timur), Jurnal Konstitusi, Volume 14, Nomor 1, Maret 2017,h.151-167

[14] H. Salim H.S.dan Idrus Abdullah, Penyelesaian Sengketa Tambang: Studi Kasus Sengketa Antara Masyarakat Samawa Dengan PT. Newmont Nusa Tenggara, Jurnal MIMBAR HUKUM Volume 24, Nomor 3, Oktober 2012, h. 377 - 569

government is the party that is obliged to provide these benefits to the community. If the government fails to provide benefits, the community will demand these benefits from the developer of natural resources. Conflicts can occur because corporations are under pressure from the government, because of national interests that are prioritized and because the interests of society are neglected. Simon Fisher, who studied and analyzed the factors causing conflict, said that the causes of conflict are:[15]

a. On going polarization, mistrust and hostility between different groups in a society;
b. Inconsistent positions and differences in views on conflict by society;
c. Unfulfilled or obstructed basic human needs, both physical, mental and social;
d. Threatened identities, often rooted in the loss of something or suffering in the past that has not been resolved;
e. Problems of inequality and injustice that arise as social, cultural and economic problems;
f. Incompatibility in ways of communication between different cultures.

Dean G. Pruitt and Jeffrey Z. Rubin, as well as Nader and Todd put forward theories about conflict resolution strategies. Dean G. Pruitt and Jeffrey Z. Rubin put forward 5 strategies in resolving disputes/conflicts. The five strategies include:[16]

a. Contending, which is trying to implement a solution that is preferred by one party over the other;
b. Yielding, which is lowering one's own aspirations and being willing to accept less than what is actually desired;
c. Problem solving, which is finding alternatives that satisfy the aspirations of both parties;
d. Withdrawing, which is choosing to leave the conflict situation, either physically or psychologically; and
e. Inaction, which is doing nothing.

[15] Imam Taufik, "Relasi Negara dan Masyarakat dalam Diskursus Sengketa di Indonesia dalam Mengelola Sengketa Membangun Damai", dalam Mukhsin Jamil, 2007, Teori Strategis dan Implementasi Resolusi Sengketa,WMC (Walisongo Mediation Center) Semarang dan IAIN Walisongo, Semarang, h. 155-158

[16] Dean G. Pruitt dan Jeffrey Z. Rubin, 2004, Konflik Sosial, Pustaka Pelajar, Yogyakarta, h. 4-6

Mining conflicts are often seen as problems of governance in mining areas. The problem is like the absence of government in remote areas. In addition, the ability to provide services is low so that public trust in the government is also low. Low trust in local government also occurs because public expectations are unrealistic. So far, resolving mining conflicts through legal channels is not preferred. According to him, the best process is mediation.

This mediation process must be carried out by a neutral party, who masters and understands the problem. Indonesia still has few human resources who have expertise in mediating mining conflicts. So the resolution does not have to be done through legal channels. Mining conflicts actually occur because the process was problematic at the beginning, there were obstacles in social communication. For example, the company's communication relations who do not understand the social conditions of the community around the mine can actually cause conflict.

The mining sector has a special character. Meanwhile, sometimes mining problems are handled by other sector ministries, for example the Ministry of Environment. Mining inspectors are also not enough to handle mining sector problems. So there must be a special directorate of the Directorate General of Minerals and Coal that handles mining problems. Starting from conflict problems, worker health and also public health, environmental problems and other social problems. The directorate then synergizes with related ministries in order to prevent and resolve mining conflicts.

Legal protection must be reflected in the implementation of the law, the legal process and the consequences of the implementation or enforcement of the law. This can be seen from the diversity of relationships that occur in society. Relationships between communities give birth to laws that regulate and protect the interests of each community. With the diversity of legal relationships, members of society need rules that can guarantee balance so that in these relationships there is no chaos in society.[17]

Legal protection according to Philipus M. Hadjon is a subjective condition that states the presence of a necessity in a number of legal subjects to immediately obtain a number of resources for the continued existence of legal subjects that are guaranteed and protected by law so that their power is organized in the process of making political and economic decisions, especially in the distribution of resources, both at individual and structural levels.[18]

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[17] Philupus M. Hadjon, Perlindunga Hukum Bagi Rakyat di Indonesia, (Surabaya: Bina Ilmu, 1987), h.24

[18] *Ibid.*

Philipus M. Hadjon with a focus on "government action" (bestuurshandeling or administrative action) distinguishes legal protection for the people into two types, namely: a. Preventive legal protection aims to prevent the occurrence of disputes that give the people the opportunity to file objections (inspraak) or opinions before the government's decision gets a definitive form, which is very important for government actions based on freedom of action because the government is encouraged to be careful in making decisions based on discretion. b. Repressive legal protection aims to resolve disputes in a broad sense including handling legal protection for the people by general courts and administrative courts in Indonesia.

That the target of preventive legal protection includes every individual as a member of society who has the right to demand the fulfillment of their rights as an effort to realize justice (the right to be heard) and legal efforts made by the government by opening the widest possible access to the community to obtain information about the process of fulfilling their rights (access to information), as a manifestation of the implementation of good governance. The importance of the right to be heard is first, individuals affected by government actions can express their rights and interests so as to guarantee justice. Second, it supports the implementation of good governance.

Law as a norm is a guide for humans in behaving in their relationships in society. Law is also a guide to what should be done and what should not be done. Law also provides guidance on what should not be done, so that everything can run orderly and regularly. This is possible because law has the nature and time to regulate human behavior and has the characteristics of ordering and prohibiting, and law can also force so that the law can be obeyed by members of society. The perspective of mining governance in Indonesia cannot be separated from the spirit of mining legal politics in Indonesia. In principle, the direction of legal politics is a study of the integration of philosophical values of state goals into the legal ideals of a state by considering social dynamics. The goal is that the formation of legal policies always runs linearly with the philosophical goals of the state.

Synchronization of good mining governance system policies, then the spirit of the welfare state concept must reflect the philosophical values of Article 33 paragraph (3) of the 1945 NRI Constitution. In different language, according to Bernard Arief Sidharta, it is the basis for the realization of just welfare which contains the principle of democracy in it.[19] As previously explained, the character

[19] Bernard Arief Sidharta, Refleksi Tentang Struktur Ilmu Hukum, (Bandung: Mandar Maju, 2009), h. 49

of a good mining governance system is a system that reflects the concepts of a welfare state.

For every dispute that occurs, including disputes in mining activities, of course a good dispute resolution pattern is needed, with the hope that with the dispute resolution, the potential problems and losses that may arise due to the dispute will not disrupt the positive climate of mining business activities in Indonesia at this time with the opening of mining activities in many areas.[20] The development of business forms in Indonesia has consequences for the business itself, namely the hope of being able to resolve any disputes that may arise quickly, cheaply and as well as possible.[21]

In general, there are two ways to resolve disputes, namely through the courts and outside the courts. Litigation is a settlement that occurs between parties in court. The pattern of dispute resolution outside the courts is using ADR (alternative dispute resolution) or alternative dispute resolution (APS) is a set of procedures or mechanisms that function to provide alternatives or choices for a way to resolve disputes.[22] The basis for resolving mining and environmental disputes is as follows:

1. Article 1338 of the Civil Code states that all agreements made legally apply as laws for those who make them. This provision contains the principle of open agreements. This means that in resolving a problem, everyone is free to formulate it in the form of an agreement with any content that can be implemented in order to resolve the problem. Furthermore, as stipulated in Article 1340 of the Civil Code, an agreement only applies between the parties who make it. For non-litigation dispute resolution, this provision is important in terms of reminding the disputing parties that they are given the freedom by law to choose a path to resolve their problems that can be stated in an agreement, as long as the agreement is made legally, meets the requirements for a valid agreement as stipulated in Article 1320 of the Civil Code.
2. Article 1266 of the Civil Code states that the cancellation condition is considered to always be included in the reciprocal agreement, when one party does not fulfill its obligations. This provision is important to

[20] Sudikno Merokusumo, *Op.Cit.*, h. 134-135

[21] Komar Kantaatmadja, *Op.Cit.*, h. 37

[22] H. Priyatna Abdurrasyid, 2002, Arbitrase & Alternatif Penyelesaian Sengketa Suatu Pengantar, PT. Fikahati Aneska bekerjasama dengan Badan Arbitrase Nasional Indonesia (BANI), Jakarta, h. 17

remind the parties who make the agreement in resolving their problems that the agreement must be implemented consistently by the parties.

3. Article 1851 to 1864 of the Civil Code on Peace. That peace is an agreement, therefore a peace agreement is valid if it is made in accordance with the requirements for a valid agreement and is made in writing. Peace can be made in court or outside the court. In non-litigation dispute resolution, peace is made outside the court, which is more emphasized on how legal disputes can be resolved by means of peace outside the court and that peace has the power to be implemented.
4. Law No. 30 of 1999, states that arbitration is a method of resolving civil disputes outside the general courts based on an arbitration agreement made in writing before or after the dispute by appointing one or more arbitrators to make a decision on the dispute. Furthermore, what is meant by alternative dispute resolution is the resolution of disputes or differences of opinion through procedures agreed upon by the parties, namely settlement outside the courts by means of consultation, negotiation, mediation, conciliation or expert assessment.

Settlement of mining and environmental disputes outside the court is carried out to reach an agreement on the form and amount of compensation and/or on certain actions to ensure that negative impacts on the environment will not occur or recur. Settlement of mining and environmental disputes outside the court can be facilitated through the services of third parties, either those who do not have the authority to make decisions or those who have the authority to make decisions, to help resolve mining and environmental disputes, such as the Government and/or the community. In this case, the community can form an institution that provides mining and environmental dispute resolution services that are independent and impartial.

Settlement of mining and environmental disputes outside the court is the choice of the parties and is voluntary. The parties are also free to determine the service provider institution that assists in resolving environmental disputes. Service providers provide mining and environmental dispute resolution services using the assistance of arbitrators or mediators or other third parties. If the parties have chosen to resolve environmental disputes outside the court, a lawsuit through the court can only be taken if the effort is declared unsuccessful in writing by one or all of the disputing parties or one or all of the disputing parties withdraws from the negotiations.

Settlement of environmental disputes through legal means of the courts is carried out by filing an "environmental lawsuit" based on Article 34 UUPLH jo. Article 1365 BW concerning "compensation for losses due to unlawful acts" (onrechtmatigedaad). Based on this provision, it is still difficult for victims to succeed in environmental lawsuits, so the possibility of losing the case is very large. The main difficulties faced by victims of pollution as plaintiffs include: first, proving the elements contained in Article 1365 BW, especially the element of error ("schuld") and the element of causal relationship.[23]

Effective dispute resolution is the dream of every party involved in a business activity. Therefore, the disputing parties always try to find a way to resolve the dispute in order to always achieve a position of balance and to be able to survive. Basically there are three ways to resolve disputes, which are described as follows:

a. Dispute resolution through the courts, which is a pattern of dispute resolution that occurs between disputing parties, where in the settlement of the dispute is resolved by the court and its decision is binding.
b. Dispute resolution through ADR (Alternative Dispute Resolution) or alternative dispute resolution (APS), which is a set of procedures or mechanisms that function to provide alternatives or choices for a method of dispute resolution through the form of APS/arbitration in order to obtain a final decision and bind the parties.[24]

The dispute resolution mechanism through ADR is actually appropriate when applied to disputes arising based on legal relations from agreements (civil), as regulated by mining activities based on Law Number 11 of 1967 concerning Basic Provisions on Mining, namely Mining Contracts, Work Contracts, PKP2B. However, with the enactment of Law Number 4 of 2009 concerning Mineral and Coal Mining which regulates mining business activities based on permits, namely IUP, IPR, and IUPK, the dispute resolution mechanism through ADR is not appropriate. This is because licensing falls within the scope of state administration, so that dispute resolution must go through the State Administrative Court and arbitration as formulated in Article 154 of Law Number 4 of 2009 concerning Mineral and Coal Mining.

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[23] Siti Sundari Rangkuti, 1996, Hukum Lingkungan dan Kebijaksanaan Lingkungan Nasional, Surabaya: Airlangga Universityt Press, h. 247

[24] H. Priyatna Abdurrasyid, Arbitrase & Alternatif Penyelesaian Sengketa Suatu Pengantar, (Jakarta : PT Fikahati Aneska bekerjasama dengan Badan Arbitrase Nasional, 2002), h. 42.

The government has a primary role, both as a regulator, supervisor, facilitator and sometimes even as a party in mining disputes to act proactively, neutrally, impartially and fairly to increase trust in the government. Furthermore, the government must create a balance of stakeholder interests related to mining activities, so that each party will feel protected and accommodated in their interests to realize justice and legal certainty.

VI. CONCLUSION

Forms of environmental damage due to mining activities have negative impacts that are detrimental to all parties. Some forms of mining business damage to the environment: Mining activities will certainly damage the environment; Changes in the structure of the earth's surface; Environmental pollution occurs; Safety is threatened; Loss of biodiversity; Decrease in air quality; Sedimentation and decline in water quality; Environmental pollution due to waste. Mining activities that damage the environment will have a bad impact and cause bigger disputes. The strategy for resolving mining disputes against environmental damage through the principle of dispute resolution through the ADR mechanism, namely in the context of implementing justice from the parties through a third party, or negotiated between the disputing parties based on the principles of equality in certain cases. The direct participation of the parties in resolving and designing dispute resolution or direct dialogue between the disputing parties is a characteristic of ADR. Broadly speaking, ADR mechanisms are categorized into four, namely negotiation, conciliation, mediation, and arbitration.

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Integration of Law and Technology in Addressing Environmental Problems in the Digital Era

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ABSTRACT: The rapid development of digital technology provides opportunities for the use of supervision related to the management of environmental problems. However, the development of increasingly fast technology, especially in the field of digital technology, often exceeds the speed of laws and regulations in keeping up with existing technological developments. Thus, in the implementation of the use of technology to overcome environmental problems in the digital era, there are certainly several challenges such as the lack of balance of access to technology, the problem of cybercrime , the role of responsive law in supporting the application of digital technology and the need for harmony between the integration of law and technology in overcoming environmental problems and environmental sustainability risks arising from the use of digital technology. Therefore, the integration of adaptive law and technology in overcoming environmental problems in the digital era can improve the quality of human life and the environment, which includes air, water and soil quality. In this study, a juridical-normative type of research with a legislative and conceptual approach is used. In this study, the results were obtained that there needs to be a good harmony between law and technology where environmental law has a role in ensuring the implementation of technology to be on target in overcoming environmental problems. Therefore, it is necessary to apply adaptive and innovative laws to achieve solutions to environmental problems and it is hoped that it will provide new knowledge and information so that future regulations can support the integration of law and technology in efforts to overcome environmental problems and their preservation.

KEYWORDS: Legal Integration, Technology, Problem Management, Environment

I. INTRODUCTION

Environmental control and management are closely related to the welfare of the people of a country. It is through the control and management of the environment (where natural resources are in it) that the welfare of the people is realized. For a country that claims to be a welfare state, making the welfare of the people the goal of the state or living as a state. All activities of state administration are oriented towards efforts to achieve and fulfill the welfare of the people. Healthy and good environmental conditions are one of the basic needs for every community, especially the people of Indonesia. This need is guaranteed in the constitution, Article 28H of the 1945 Constitution.[1] Furthermore, Article 9 paragraph (3) of Law Number 39 of 1999 concerning Human Rights, affirms: "everyone has the right to a good and healthy living environment".

Based on the right to control the country, the Indonesian state has established various policies and regulations as *guidance* and legal *baseline* in the management of the environment and natural resources in order to realize the welfare of the people. In reality, environmental management in Indonesia still faces the same problem, namely the clash between various laws and regulations, especially between sectoral laws related to natural resources (which are more oriented towards the use of economic resources and environmental laws (which are considered to emphasize too much on the aspect of life protection). As a result, environmental management and control under government control through the provisions of laws and regulations as an umbrella provision have not been able to achieve the goals of environmental management, the realization of the sustainability of environmental functions and the achievement of people's welfare. To ensure legal certainty so that the community has the awareness to participate in preserving their environment, the government has prepared legal tools, especially environmental laws, to ensnare polluters and destroyers of the environment. The law in question is Law Number 4 of 1982 concerning the Environment (UULH) and Law Number 23 of 1997 concerning Environmental Management (UUPLH) and has been perfected with the latest Law, namely Law Number 32 of 2009 concerning Environmental Protection and Management (UUPPLH). The existence of this law is expected to be a reference for law enforcement officials to take action against parties who have intentionally or unintentionally polluted the environment. Law enforcers can solve cases of environmental crimes that occur, especially the problem of water pollution by industrial waste which is often rampant, especially in big cities. Humans and the environment have a close and inseparable relationship. The environment is a

[1] Udi Fahmi, 2013, "The *Principle of State Responsibility as the Basis for the Implementation of Environmental Protection and Management*", Law Journal, Vol. 18 No. 2 April, p. 2.

place where humans live, do activities, and get various resources to meet their life needs. However, along with the development of technology and industrialization, human activities have an increasing influence on the environment.

The digital era brings rapid development in various sectors, but it also raises major challenges related to environmental issues. Urbanization, industrialization, and consumption patterns of modern society are further exacerbating the impact of climate change, pollution, and degradation of natural resources. On the other hand, digitalization opens up new opportunities to monitor, manage, and address environmental issues more effectively.[2] The law has an important role in regulating human activities to protect the environment. However, traditional legal systems are often slow to respond to the rapidly evolving dynamics of technology. This results in a lack of regulatory effectiveness in responding to complex and cross-geographical environmental issues. Technology has proven to be a powerful tool in environmental surveillance and protection. For example, *the Internet of Things* (IoT) is used to monitor air and water quality, while drones can keep an eye on illegal activities such as illegal logging. The integration of these technologies must be supported by a legal framework that ensures their use ethically and responsibly. Artificial intelligence (AI) makes it easier to analyze environmental data quickly and accurately. AI can help detect violations of environmental laws by using satellite imagery and pattern recognition technology. However, the application of AI requires regulation to prevent abuse and ensure the accuracy of the results produced. Blockchain can be used to record carbon transactions and monitor the implementation of international environmental agreements such as the Paris Agreement. These technologies increase transparency and accountability, but they require regulations that ensure data security and prevent information manipulation.

The use of information technology can strengthen environmental protection by increasing transparency in the decision-making process. The public has the right to be informed about environmental policies and violations that have been committed. In this context, community participation is very important. Law Number 32 of 2009 concerning Environmental Protection and Management provides space for the community to be actively involved in supervision. The aspect of social justice must also be considered in the enforcement of environmental laws. Environmental damage often has a greater impact on

[2] Sinta Maulina, Building Policies to Face the Challenges of the Digital Era, https://unair.ac.id/post_fetcher/fakultas-vokasi-membangun-kebijakan-menghadapitantanga n-era-digital/

marginalized groups of people who lack access to resources. Therefore, law enforcement must consider the social impact of any policy or action taken. It is important to ensure that the rights of vulnerable communities are protected. Transparency in the law enforcement process is essential to build public trust. The public needs to know how the law enforcement process is carried out and get access to information on cases of environmental violations. Thus, community participation can be increased, and they can play an active role in preserving the environment. Supervision of environmental violations can be increased through the use of digital technology. Satellite-based monitoring systems and mobile apps can help people report violations directly to authorities. This kind of initiative not only increases the effectiveness of supervision but also empowers the community to participate in environmental protection.

Legal reform is needed to integrate technology into environmental management systems. Existing laws need to be revised to include new aspects that arise due to technological developments. In addition, a multi-disciplinary approach is needed to ensure that all aspects—legal, social, and technical—can be well integrated. The integration of law and technology in tackling environmental problems in the digital era is an important step towards a more sustainable future. By making wise use of technological advances, we can increase the effectiveness of law enforcement while protecting the rights of the community. Commitment from all parties—governments, law enforcement agencies, and communities—is urgently needed to realize this goal. Through a collaborative approach that involves all stakeholders, we can create an environmental management system that is more effective and responsive to the challenges of the times. Thus, the integration of law and technology is not just an option but an urgent need for the sustainability of our environment in the future. However, although information technology offers many benefits, its application in environmental issues in Indonesia still faces various challenges. Legal barriers, inadequate technological infrastructure, and lack of technical capacity and knowledge are some of the main obstacles that need to be overcome. Legal challenges include unclear regulations related to the use of technology in tackling environmental problems. In terms of infrastructure, many areas still lack access to the internet and other supporting technologies. In addition, the lack of training and human resources capable of operating and maintaining information technology systems is also a problem that must be overcome. Therefore, this study aims to analyze the existing legal framework, evaluate the impact of information technology on transparency and accountability, and identify

challenges and solutions in the application of information technology to overcome environmental problems. Using normative research methods, this research will examine various laws and regulations, legal documents, and relevant literature.

II. METHODOLOGY

This research uses a normative research method, which is a legal research approach that focuses on analyzing laws and regulations, legal documents, and related literature. This approach is used to evaluate the legal framework that regulates the use of information technology in addressing environmental problems. This research also includes a study of laws and regulations related to the topics discussed. In addition to the analysis of laws and regulations, this study also uses secondary data from various sources, including scientific journals, books, articles, and research reports related to this topic.

III. THE ROLE OF ENVIRONMENTAL LAW IN SUPPORTING THE APPLICATION OF TECHNOLOGY TO OVERCOME ENVIRONMENTAL PROBLEMS IN THE DIGITAL ERA

Indonesia is a country with a large enough area so that it has a lot of natural resources that need to be preserved. Based on data published by the Geospatial Information Agency, Indonesia has a large number of islands, namely 13,466 with a land area of 1,922,570 km^2 and a water area of 3,257,483 km^2.[3] The territory of Indonesia is not inhabited by living things in the form of humans alone, but there are also animals and plants to help humans in carrying out their lives such as in terms of oxygen. The dwelling place of these living things is also known as the environment.

The environment is the sum of the components and elements that exist around living things that affect the life and development of these living things.[4] In addition, Indonesia through its legal rules has explained about the environment which is specifically regulated in a law, namely Law Number 32 of 2009 concerning Environmental Protection and Management. Article 1 paragraph (1) of this law explains that "the environment is a spatial order with all objects,

[3] Yudi Irwanto, "BIG Submits Map of the Republic of Indonesia to the Ministry of Cooperatives", Geospatial Information Agency [Online], https://www.big.go.id/content/berita/big-serahkan-peta-nkri-kepadakemenkokesra#:~:text=Indonesia%20adalah%20negara%20kepulauan%20terbesar,luas%20perairan%203.257.483%20km2. Retrieved November 21, 2024

[4] Sabartiyah, "Environmental Conservation", Alpirin, Semarang, 2019

forces, circumstances, and living things, including humans and their behavior, which affect nature itself, the continuity of life, and the welfare of humans and other living beings".[5]

In the development of digital technology, there is a need for innovation from environmental laws that follow the development of existing technology and is getting more and more rapid. This is useful for ensuring and creating effective environmental conditions. Given the increasingly uncertain conditions and climate change, there is damage to the original habitat of living things. In addition, there are humans who do not care and do not comply with regulations and do not care about environmental conditions which makes the existence of various kinds of pollution such as water, air and soil pollution and other environmental problems that are increasingly urgent to be overcome immediately to the maximum and on target.[6]

Indonesia, which is a country of law as enshrined in article 1 paragraph (3) of the Constitution of the Republic of Indonesia, has specifically regulated this environment through its laws and regulations. The state is obliged to provide environmental protection and management which is carried out based on the following principles:

1. State Responsibility: The state is an important organ to prevent human behavior and human activities that can cause damage and/or pollution to the environment. This can be done through the application of legal rules that clearly and firmly regulate environmental protection. This makes the state able to guarantee citizens' rights to a good and healthy environment.

2. The principle of sustainability and sustainability: everyone who lives and lives in Indonesia is obliged and responsible to preserve the environment around them. This is a form that all levels of society have the same responsibility to shoulder together to improve the quality of the environment so that it remains good and healthy for the sustainability of its generation and future generations. With the awareness of every level of society, this can be carried out for the sustainability of life both for the previous generation, the current and the next generation without having to sacrifice a generation. So there

[5] Article 1 paragraph (1) of Law Number 32 of 2009 concerning Environmental Protection and Management

[6] Muhammad Rifki Adnan Ramadhan et al., "Environmental Law Innovation For The Digital Age: Towards a More Effective and Fair Environmental Maintenance", *Legal Bridge: A Study of Law, Social and State Administration*, Vol. 1, No.2, Year 2024 p. 1

needs to be justice by taking responsibility together in protecting the environment.

3. The principle of harmony and balance: in the use of the environment, it is also very necessary to look at various existing aspects such as economic, social and cultural as a balancer in the use of the environment. So that in the use of the environment there is no inequality in every aspect that exists.

4. The principle of integration: this is done by combining various components that are interconnected with the use of the environment. So, in environmental protection and management, it can harmonize various existing components.

5. Principle of benefit: all behaviors and activities carried out to the environment through the use of natural resources are carried out to improve the welfare of the community. This is done with various efforts carried out based on suitability with the potential of natural resources and human resources as well as the surrounding environment. This action is carried out in order to create harmony between humans and their environment so that welfare can be created that can provide benefits to humans. So that the potential of natural resources and the environment can be utilized to the maximum by existing human resources.

6. Principle of prudence: any form of uncertainty about activities due to the limitations of mastery of science and the use of technology is not a reason to avoid the threat of pollution and/or environmental damage.

7. The principle of justice: the protection and management of the environment must reflect justice for every citizen in Indonesia regardless of region, gender and generation. So that environmental protection and management must be given appropriately and proportionately to anyone who is part of Indonesian citizens fairly regardless of any differences.

8. Principle of ecoregion: characteristics of natural resources, ecosystems, geographical conditions, culture of local communities and local wisdom must be considered in environmental protection and management.

9. Principle of biodiversity: environmental protection and management must also pay attention to the existence, diversity, and sustainability of biological natural resources consisting of vegetable natural resources and animal natural resources as well as other non-biological elements to form an ecosystem. This principle requires integrated environmental protection and management to pay attention to and maintain every component of the existing natural resource dumber.

10. Principle of polluters paying: every citizen is obliged to bear the cost of environmental restoration for his or her activities or businesses that cause pollution and/or environmental damage.

11. Participatory principle: every citizen is encouraged to play an active role in the decision-making process and the implementation of environmental protection and management both directly and indirectly.

12. Principles of local wisdom: paying attention to the noble values that apply in the community's life system which is one of the principles to protect and manage the environment. This principle shows that the form of environmental protection and management must be formed and spiritualized in the form of principles that reflect participation, transparency, efficiency and justice.

13. Principles of good governance: environmental protection and management are carried out by the principles of participation, transparency, accountability, efficiency and justice.

14. The principle of regional autonomy: each region has the right to regulate and manage its own government affairs and in this case it is related to the protection and management of the environment which is mandatory within the framework of the Unitary State of the Republic of Indonesia. So that local governments are given the authority to regulate and manage themselves, including in the field of environmental protection and management while still paying attention to the diversity that is packaged in the unitary state of the Republic of Indonesia.

The government through article 63 paragraph (1) letter (v) of Law Number 32 of 2009 concerning Environmental Protection and Management explains that the

government has the duty and authority to coordinate, develop, and socialize the use of environmentally friendly technology. In the advancement of an era that has all been modern, it requires humans to use tools that can be more efficient to overcome this environmental problem, namely through the use of technology. The use of technology in overcoming environmental problems allows the adoption of a proactive approach in environmental monitoring.[7] This is very much needed by involving proactive actions before a problem arises. The problem in the use of technology is to make it easier for people to maintain it and help to minimize a loss that will arise. Because basically the use of technology as a tool to develop and explore various things and in this discussion is related to environmental problems.

Article 3 of Law Number 32 of 2009 concerning Environmental Protection and Management states that environmental protection and management aims to:

1. Protecting the territory of the Unitary State of the Republic of Indonesia from pollution and/or environmental damage;
2. Ensuring the safety, health, and life of humans;
3. Ensuring the survival of living things and the preservation of ecosystems;
4. Maintaining the sustainability of environmental functions;
5. Achieving environmental harmony, harmony and balance;
6. Ensuring the fulfillment of justice for the present and future generations;
7. Ensuring the fulfillment and protection of the right to the environment as part of human rights;
8. Control the use of natural resources wisely;
9. Realizing sustainable development;
10. Anticipating global environmental issues.

The various objectives expected by applicable regulations and laws for the creation of a country with a good environmental condition show that the state cannot run alone in order to realize various goals related to environmental protection and management. However, there needs to be active participation both from the community, the government and various kinds of solutions to overcome various problems related to the environment so that the goals as mentioned in Article 3 of Law Number 32 of 2009 concerning Environmental Protection and Management can be created. So, in the development of increasingly sophisticated technology in the digital era. The government and the

[7] *Ibid.,* p. 3

community can go hand in hand with technology to face the increasingly rapid digital era to regulate and manage the environment within the territory of Indonesia. Law enforcement is a tool and means used by the government or government organs to carry out their duties. This affects how technology develops and brings changes and becomes a new challenge, including environmental problems and their enforcement. Law and technology are two important things that must be easily adapted to new circumstances, changes or environments in this digital era so that this can be more efficient and effective for legal development.[8] Technological developments in the digital era can help increase transparency, law enforcement accountability and cost efficiency with the help of various parties such as the government, law enforcement agencies and the community.

The usefulness of technology to the development of science, especially in the field of law, is very large. Technology can strengthen the evidence used in law enforcement and also provide a deeper understanding of the environmental impacts caused by human activities.[9] The role of environmental law in supporting the application of technology to overcome environmental problems in the digital era is to utilize technology and innovation in increasing the effectiveness of environmental law enforcement. Some examples as a big step in the use of technology in this digital era for enforcement in environmental problems are:

1. ONLIMO or can also be called online *monitoring* which is a River Water Quality Monitoring System in *Real Time* is this technology developed by BPPT (Agency for the Assessment and Application of Technology) in the form of sensors consisting of sensors for shu parameters, electrical conductivity, TDS, turbidity, DO, pH, and nitrate.[10] ONLIMO is a water quality monitoring system that is carried out online or *online* based on a continuous application that is directly connected to the system owned by the Ministry of Environment and Forestry (KLHK) so that it can help in knowing and obtaining data related to water quality in *real time* and changes in water quality status in a short time. In addition, ONLIMO also functions as an *early warning system* when pollution occurs so that

[8] Dinda Fitri Yudha Yanti et al., "Challenges in Enforcement of Environmental Regulations in the Digital Era" *Multidisciplinary Journal of Academic Sciences*, Vol.1, No.3, Year 2024. p. 4

[9] Ayu Simanjuntak et al., "The Impact of Technology and Innovation on Justice in Law Enforcement in the Digital Era", *Journal on Education*, Vol. 6, No. 1, Year 2023, p. 4.

[10] Devi Ramadhawati, "Online Monitoring of Cisadane River Water Quality and Analysis of Water Quality Status Using the Storet Method", *Journal of Environmental Science and Technology*, Vol. 13, No. 2, Year 2021, p. 4.

it can reduce costs and time in sampling and laboratory analysis. ONLIMO was created as a form of innovation from technological developments because it saw very rapid population growth in various regions, including resulting in significant river pollution. Through the ONLIMO application, it makes it easier to monitor waste management and is very helpful in detecting environmental quality at all times so that if there is pollution, it can be overcome immediately and the risk due to pollution can be resolved appropriately and quickly.[11]

2. SPARING (Continuous and In-Network Wastewater Quality Monitoring System): a tool used to measure the level of a wastewater quality parameter and wastewater discharge through measurement and reporting of wastewater discharge automatically, continuously and in the network. This tool is specifically discussed in the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.93/MENLHK/SETJEN/KUM.1/8/2018 concerning Continuous and In-Network Monitoring of Wastewater Quality for Businesses and/or Activities. In order to maintain environmental sustainability in the present and future. The Ministry of Environment and Forestry (MoEF) requires each industrial sector to monitor the quality of wastewater regularly and ensure the quality of industrial wastewater so that it meets environmental quality standards. Because wastewater that is not properly managed can pollute the environment such as rivers, lakes, and seas which can result in the threat of various ecosystems that live in it. The importance of sparring monitors in wastewater quality management in various industries is:

   a. Measuring discharge levels: Sparing can measure the discharge level of wastewater discharge automatically, ensuring that the wastewater does not exceed the set limits.
   b. measure wastewater quality: Sparing can measure the amount and type of pollutant elements in wastewater, such as COD (*Chemical Oxygen Demand*), TSS (Total Suspended Solids), and NH3-N (*Ammonia Nitrogen*), allowing companies to monitor the quality of their wastewater.

3. SISPEK or *continuous Emission Monitoring System* which is an Automatic, Continuous and Integrated Industrial Emission Monitoring System: a system that receives and manages data from monitoring stationary source emissions or chimney emissions with continuous measurement

[11] Mertani, "ONLIMO" https://www.mertani.co.id/id/onlimo accessed November 22, 2024

or CEMS. This technology has specifically been contained in the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 13 of 2021 concerning Continuous Industrial Emission Monitoring Information Systems. There are 10 industrial sectors that are required by SISPEK, namely iron and steel smelting, pulp & paper, rayon, carbon black, oil and gas, mining, thermal waste processing, cement, thermal power plants, fertilizers and ammonium nitrate.

4. AQMS (Air Quality Monitoring System): an air quality monitoring system designed to calculate the levels of certain compounds in the air such as:SO_2, O3, NO2, CO developed by the Ministry of Environment and Forestry of the Republic of Indonesia. The benefits of AQMS are providing early warning to the community and the government, helping to formulate environmental policies, and reducing cases of respiratory disorders and cardiovascular diseases.

   The purpose of the Air Quality Monitoring System (AQMS) is to provide air quality information to the public automatically, continuously and in real time (24 hours) and as the basis for government policies in air quality control. In the AQMS, there is a list of colors indicating ISPU values or air pollutant standard indices that explain the color of the monitoring station location point, namely:

   a. If it is green, it indicates good condition;
   b. If it is blue, the condition is moderate;
   c. If it is yellow, the condition is not healthy;
   d. If it is red, the condition is very unhealthy;
   e. If it is black, the condition is dangerous.

   The local government can issue policies or appeals if the status of air conditions is at an unhealthy to dangerous level, such as:

   a. Issuing an announcement to the public regarding air pollution due to smoke disturbances that occur in their area.
   b. Urging the public to reduce outdoor activities and use masks to protect their outdoor activities.
   c. Create an emergency post for handling public health.
   d. Carrying out transportation and industrial governance efforts.

5. TMAT (Groundwater Level Monitoring System): a system used to monitor groundwater level, soil moisture, and peatland rainfall in an area. This system is critical to peat soils to ensure optimal groundwater availability for crop cultivation. This system is regulated in the Regulation of the Director General of Pollution and Environmental Damage Control Number P.3/PPKL/PKG/PKL.0/4/2019 concerning Guidelines for Monitoring Groundwater Level and Peat Subsidy on Community Land in Peat Ecosystems. The device is capable of collecting water level data independently and accurately, allowing for efficient and real-time monitoring of changes in water levels in rivers, lakes, or other bodies of water. TMAT is important because it can: Ensure optimal availability of groundwater for crops, Reduce and prevent forest and land fires, and support peat restoration activities.

6. SILAT (Open Access Land Information System): a system as a provider of information related to pollution and environmental damage due to mining. Open Access Land (LAT) is a plot of land used for mining activities without a permit and is abandoned. The use of open access land that is not in accordance with the designation and function of the land, has the potential to cause pollution and environmental damage. Land damage due to unenvironmentally friendly mining activities can cause topographic changes, such as undulating soil surface, the presence of former mining pits, erosion and sedimentation. The damage to the land will get worse if it is not handled immediately. Land restoration models that have been developed by the Ministry of Environment and Forestry include agroforestry or a cultivation system that combines forest or timber tree management activities with the planting of short-term commodities or crops, such as agricultural crops, agro-tourism, and environmentally friendly markets. With this land restoration, in addition to being able to restore or repair land damage, it is also expected to improve the environmental, social and economic functions of the surrounding community.12

7. SIKAL (Seawater Quality Information System)

8. SIMPEL (Electronic Environmental Reporting Information System): an online reporting application that replaces printed reporting that has been sent to the Ministry of Environment and Forestry. The SIMPEL

[12] DLH Probolinggo "Open Access Land Recovery Plan in Probolinggo Regency" https://dlh.probolinggokab.go.id/rencana-pemulihan-lahan-akses-terbuka-di-kabupaten-probolinggo/#:~:text=Lahan%20ini%20merupakan%20lahan%20bekas,sosial%20dan%20ekonomi%20masyarakat%20sekitar. Retrieved November 22, 2024

application is one of the government's ways to support environmental conservation in Indonesia. The application, which is run by the Ministry of Environment and Forestry of the Republic of Indonesia, replaces the print reporting system that was previously implemented. Thus, the person in charge of the business and/or activity no longer needs to send a printed or hardcopy report to the Ministry of Environment and Forestry, but only needs to fill out the report online and upload the necessary supporting files. The benefits of this SIMPEL application are:

a. Replace paper-intensive print reporting;
b. Reduce the buildup and waste of hardcopy reports;
c. Providing facilities to report water pollution, report air pollution, report B3 waste management;
d. Environmental damage control reporting.

The examples above are a manifestation of the development and application of technology to the role of law in environmental problems. In this digital era, the application of technology to law enforcement in environmental problems is an important key to ensuring and protecting environmental sustainability and ensuring justice for society.

Law Number 32 of 2009 has undergone legal updates in several articles contained in Law Number 6 of 2023 concerning the Stipulation of Government Regulations in Lieu of Law Number 2 of 2022 concerning Job Creation into Law. However, the articles related to the use of technology have not undergone significant changes so that the application of this can become a problem in the future.

IV. CHALLENGES IN FACING THE INTEGRATION OF LAW AND TECHNOLOGY IN OVERCOMING ENVIRONMENTAL PROBLEMS

The environment is a unit that cannot be separated from human life. So that protection of the environment is very important to ensure a safe, fair and prosperous life of the community and to preserve nature from the environment itself. The importance of an update to the norms that have been in force in society is crucial because it is influenced by the development of an increasingly modern era. Law Number 32 of 2009 concerning Environmental Protection and Management has undergone changes through Law Number 6 of 2023 concerning

the Stipulation of Government Regulations in Lieu of Law Number 2 of 2022 concerning Job Creation into Law.

The law on the environment itself clearly states that the scope of environmental protection and management includes:

a. Planning : In article 5 of Law Number 32 of 2009, it is stated that environmental protection and management planning efforts are carried out in three stages, namely:
    1. Environmental surveying is carried out to obtain data and information about natural resources. Investarization is carried out at the ecoregional, archipelagic and national levels.
    2. The determination of ecoregions is carried out by considering various aspects, such as landscapes, climate, flora and fauna, socio-cultural, economic, and so on.
    3. Preparation of RPPLH (Environmental Protection and Management Plan), carried out by preparing RPPLH at the national, provincial and district levels. This arrangement is adjusted to environmental investment.
b. Utilization : In Article 12 of Law Number 32 of 2009, it is stated that the utilization of resources is carried out based on the RPPLH that has been made previously. However, if the RPPLH has not been formed, then its use must pay attention to three aspects, namely the sustainability of environmental processes and functions, the sustainability of environmental productivity and the safety of the quality of life and the community.
c. Control : In Article 13 of Law Number 32 of 2009, it is stated that this control effort is carried out in three ways, namely prevention, countermeasures and recovery. Control focuses on efforts to prevent, reduce, and deal with environmental damage or pollution. This includes the implementation of emission standards, waste management, and the implementation of sanctions if there are violations.
d. Maintenance : In Article 57 of Law Number 32 of 2009, it is stated that efforts to preserve the environment are carried out in three ways, namely natural resource conservation, natural resource reserve, and or preservation of atmospheric functions. Maintenance involves activities to maintain and preserve the environment so that it continues to

function optimally. This includes reforestation, river cleanup, and rehabilitation of damaged ecosystems.

e. Supervision : In Articles 71 to 83 of Law Number 32 of 2009, it is stated that supervision efforts are carried out by officials or related parties regarding environmental protection and management. Not only that, the article also discusses the existence of administrative sanctions that will be given if violations are found. For example, through written warnings, government coercion, freezing of environmental permits or revocation of environmental permits.

f. Law enforcement : Law enforcement is mentioned as an action that will be taken if there is a party who violates the provisions that have been mentioned in Law Number 32 of 2009. Law enforcement includes actions to crack down on violations of environmental regulations, both administratively, civilly, and criminally. This aims to provide a deterrent effect and encourage compliance with environmental laws. For example, by providing a maximum prison sentence of 1 year and a maximum fine of Rp 1 billion, if anyone provides false, misleading information or provides false information related to environmental protection and management.

This entire scope aims to create a balance between development and environmental sustainability so that it can be passed on to future generations.[13]

This law enforcement is also strengthened in chapter 15 of this law regarding criminal provisions for violations of environmental problems that are considered a crime. However, in the digital era with the development of the world of technology that participates in advancing environmental protection and management has its own challenges. The lack of legal rules against the use of technology, one of which is the *Internet of Things* (*IoT*), can create legal loopholes that can be taken advantage of by irresponsible people to act arbitrarily against the environment. The great opportunity for the rapid development of the world of technology is not in line with existing laws and regulations, so the use of this technology is considered less than optimal due to the absence of a clear legal umbrella.[14] Of course, preventive law enforcement efforts are very important to

[13] Vanya Karunia, Nibras "Isi Aturan Tentang Lingkingan HiduP, UU No 32 Tahun 2009 https:// www. Kommpas.com/skola/read/2021/03/17/142637069/isi-aturan-tentang-lingkungan-hidup-uu-no-32 tahun-2009. accessed November 23, 2024

[14] Asti Sri Mulyanti and Syavira Azzahra, "Integration of the Green Constitution in the Society 5.0 Era: Challenges and Opportunities in Environmental Management", *Kertha Bhayangkara*, Vol. 18, No. 2, Year 2024, p. 7

be carried out as a form of preventing violations of the law in this environmental problem.

Environmental problems such as extreme climate change, increasing pollution both air, water and soil pollution and various other environmental problems that have an impact on human health and reduced biodiversity and animals due to the destruction of their ecosystems due to unmaintained environment. This needs serious attention both from the government and from humans themselves by utilizing various kinds of innovations, including technology that is developing rapidly and rapidly as a form of appropriate and sustainable environmental solutions.

Various kinds of innovative solutions that can be provided by technology are related to waste management and management, where we can know that waste is a significant challenge and has the potential to damage the environment and ecosystem if not treated properly. Humans by utilizing and empowering technology as a form of solution can produce modern technologies such as automatic recycling systems and environmentally friendly waste disposal methods that are able to reduce their negative impact on the environment and existing ecosystems. In addition, various other technologies that can be used by humans are environmental monitoring which can supervise various kinds of water, air and soil quality that can be reported in *real time* so that it can produce accurate data quickly and very importantly so that it can be informed to the public regarding how policies are taken to overcome environmental problems and maintain public health. There are various forms of technology that have often been encountered by the public, such as *drones* that can be used to monitor ecosystems and natural habitats located in hard-to-reach areas and can also monitor in detail related to forest conditions. So that it can help plan ecosystem restoration more effectively and can restore habitats that have been damaged on target.[15]

Environmental monitoring by utilizing technology can provide convenience in the form of environmental monitoring that can be carried out continuously where this monitoring can provide information in the form of data in a certain range and distance of time. In addition, technological developments also help to monitor the environment at remote locations *online* via the internet by utilizing computers or other *mobile* devices. The benefits provided by the appropriate use of technology through online environmental monitoring include:

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[15] Subkhi Mashadi "Utilization of Technology for Sustainable Environmental Solutions" Alma Ata University. https://almaata.ac.id/pemanfaatan-teknologi-untuk-solusi-lingkungan-yang-berkelanjutan/ accessed November 23, 2024

1. Easy access to data information that can be viewed anywhere and anytime;
2. It can monitor various points of environmental location at the same time, so that if problems are found at various points at the same time, they can be immediately known quickly and can be overcome appropriately;
3. Data can be obtained continuously and *in real time* and the required data collection time range can be determined;
4. It can send information and notifications in the form of alarms as a form of early warning so that preventive actions can be taken early to reduce the potential for greater damage;
5. The data and analysis results produced can be used for optimization and auditing as well as periodic monitoring in controlling water and air pollution.[16]

Technology that provides great benefits and opportunities provides new hope in various layers of life, one of which is the management and efforts to preserve the environment so that it remains sustainable for both current and future generations. This can be seen from the benefits provided by technology through various innovations for fast, responsive, and effective environmental monitoring as well as the fast and wide dissemination of information and the ease of access provided. However, it is not something new when existing technology also presents various new challenges both for humans and for the law in enforcing environmental regulations. It can be seen that technology is currently developing very quickly so that it often happens that technology exceeds the speed of laws and regulations in adapting and there is inequality which is a loophole for the law which is finally used by irresponsible individuals in damaging the environment and ecosystem because the law has not reached the regulations regarding the development of existing technology.[17]

Another challenge that must be faced with the existence of technology that continues to develop is the need for a balance between expert human resources and empowered technology. This needs to be done because data processing through technology to find out environmental conditions so that it can be known and accessed in *real time* requires special expertise from its own human resources in order to be able to run the system appropriately so that the information obtained is also valid and there is proper and adequate infrastructure.

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[16] M. Furoiddin Nais "Challenges and Opportunities for Indonesian Environmental Management in the Industrial Era 4.0" *Proceedings of the National Scientific Forum on Engineering.* Vol.1 No.1 of 2022 page 191

[17] Dinda Fitri Yudha Yanti et al., *Op.Cit,* p. 385

Seeing from the challenges that must be faced with the accelerating development of technology. This shows that the law must move adaptively to existing technological developments. So that law and technology can have harmonization and can run together. So that it can provide new opportunities to increase efficiency and effectiveness in solving various existing environmental problems.[18]

In the structure of community life, there needs to be rules that organize order and security to create balance and stability in people's lives. This shows that the law was born as a solution to solve a problem born in the middle of society. So the law needs to be responsive to the problems that must be solved by looking at what are the causes of environmental damage. Changes in the environment that change continuously can be a complicated and serious problem, because the object that is the focus of the problem is very broad, both from the ecosystem and human activities that make environmental changes change continuously. Therefore, there is a need for firm and binding legal protection to protect human rights and existing ecosystems and ensure that nature preservation is maintained for future generations. Therefore, this legal protection needs to be carried out firmly to suppress pollution, destruction of natural habitats, and large-scale exploitation of natural resources which are serious threats to nature conservation.

The enforcement of legal regulations that are carried out and implemented must be fair and equitable, so that no one is harmed by the community, considering that natural damage occurs unevenly. Many underprivileged people are the most disadvantaged victims. As a weak society, the laws and regulations applied must protect their rights by applying the concept of social justice.

Lack of human resources is a big reason for the difficulty of achieving success in environmental law enforcement.[19] In addition to the above, challenges in the application of technology in environmental issues in the digital era also include: data privacy and security issues, considering that in the use of information technology there is a need for data collection that requires a large base, especially related to environmental data problems. Because it can be seen that this environment is very broad. The existence of data insecurity can result in information misuse and data leakage which can have a negative impact on both society and the environment. In addition, the increasing complexity of

[18] Rame Atmo Pawiro "Digitalization in Environmental and Industrial Management: Challenges and Opportunities" https://kumparan.com/rameatmopawiro/digitalisasi-dalam-pengelolaan-lingkungan-dan-industri-tantangan-dan-peluang-20KDU3tivfi accessed on November 23, 2024

[19] Dinda Fitri Yudha Yanti et al., *Op.cit*, p. 7.

technology, the sustainability of resources.[20] As well as the risk that digital technology in it contains other crimes such as manipulating data so that the data provided and shared with the public is not valid data.

Seeing various problems and challenges related to technological developments on the environment. Therefore, there needs to be harmonization between laws and regulations and the technology used. So that there are strict regulations so that the existence of technology is not misused by irresponsible parties. Because the environment needs regulations that regulate responsively and can keep up with technological developments.[21]

Privacy and security issues that have a significant impact from the digital era raise concerns. The use of technology for law enforcement in environmental issues brings fear to the personal data of the people involved in it, but Indonesia through Law Number 27 of 2022 concerning Personal Data Protection has regulated data protection for everyone which is expected to protect everyone's rights. In addition, technological advances can also be costly and may result in limited resources available to invest in these new technologies, so it is very necessary to conduct an in-depth study of the use of these technologies

V. CONCLUSION

All activities of state administration certainly have a purpose that also includes the welfare of the people in it. Healthy and good environmental conditions are one of the basic needs for every community, especially the people of Indonesia. In this digital era, technology has also entered the environment, namely related to environmental supervision and protection through the Internet of Things (IoT) The use of information technology can strengthen environmental protection by increasing transparency in the decision-making process. Regarding the existing regulations regarding this matter, regulations regarding the Environment need to be revised to include new aspects that arise due to technological developments. A multi-disciplinary approach is needed to ensure that all aspects—legal, social, and technical—can be well integrated.

The Indonesian government has taken steps as the application of technology in environmental law to overcome existing problems, namely through: ONLIMO, SPARING, SISPEK, AQMS, TMAT, SILAT, SIKAL, and SIMPEL. However, there are challenges that hinder the implementation of the

[20] Ayu Simanjuntak et al., *Op.cit*, p. 5.

[21] Dea Septiyanti "Environmental Governance in the Digital Era: Challenges and Opportunities" https://kumparan.com/deaaa-septiyanti/governance-lingkungan-di-era-digital-tantangan-dan-peluang-23ghy7tVduF/3 accessed on November 23, 2024

above properly, namely the inconsistency between the rapid development of technology and existing laws and regulations. In addition, lack of human resources is the reason for the achievement of environmental law enforcement and also the problems of privacy, security, increasing technological complexity and resource sustainability are challenges in themselves. Therefore, revision is needed in laws and regulations, especially in the field of the environment, to include and regulate technological advances in it. artificial intelligence (AI) and scientific research and development are supporting in overcoming this problem. There are various problems and challenges related to technological developments on the environment. Therefore, there needs to be harmonization between laws and regulations and the technology used. So that there are strict regulations so that the existence of technology is not misused by irresponsible parties. Because the environment needs regulations that regulate responsively and can keep up with technological developments

Based on the discussion that has been described, several relevant suggestions or recommendations should be realized by the government, related institutions, and the community as participants in overcoming environmental problems in this digital era by increasing the accessibility and availability of environmental data to strengthen the quality of data and analysis carried out by technology used in addressing existing environmental problems. In addition, there needs to be a space for community aspirations to be obeyed by actors or parties who will carry out activities that intersect with environmental problems. The government needs to pay attention to ethical aspects and social justice in the development and use of technology and regulations so as not to eliminate the rights of vulnerable and environmentally damaged communities, such as avoiding discrimination and ensuring community participation in decision-making that affects the environment. Cooperate between related parties in the development and application of technology in environmental conservation. Also, evaluate and monitor the development and application of technology periodically in environmental conservation to ensure the effectiveness and sustainability of its use. In addition, there is a need for cooperation and increased awareness built through socialization and understanding related to the importance of protecting the environment for all levels of society, including the government and various related parties. This can be supported by regulations that are responsive to technological developments so that good harmonization is created and can create a good and healthy living environment for all humans and ecosystems as well as for all generations, both now and in the future.

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Framework Development for Business Contracts to Promote Investment in Eco-Friendly Technology

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ABSTRACT: This study aims to develop a comprehensive legal framework that encourages investment in environmentally friendly technology by designing business contracts rooted in sustainable principles. In the current era of rapid industrial development, integrating ecologically friendly technology into business practices is critical to balancing economic growth with environmental sustainability. Despite this need, the absence of robust contractual legal guidelines and incentives presents a barrier to adopting green technology within the business sector. This research adopts a normative legal approach, combining conceptual, legislative, and comparative analyses. The conceptual analysis identifies vital principles underpinning a contractual framework that promotes sustainable practices, while the legislative approach assesses the alignment of these principles with existing Indonesian regulations and standards. Comparative analysis is then applied to review international rules and best practices from various jurisdictions that successfully embed sustainability elements into business contracts. This analysis offers valuable insights for adaptation in the Indonesian context. Findings indicate that integrating sustainability into business contracts holds substantial potential to attract sustainable investments; however, realizing this potential requires targeted regulation, specific legal provisions, and clear incentives for businesses. This study concludes that the proposed legal framework can be a practical guide for business practitioners and legislators. By implementing this framework, stakeholders may achieve economically advantageous contracts and fulfil environmental responsibilities, contributing to a broader shift towards sustainable industry practices.

KEYWORDS: Business Contracts; Environmentally Friendly Technology; Investment; Legal Framework; Sustainability

I. INTRODUCTION

Environmental sustainability has become an urgent global concern, given the increasing environmental degradation and the need to mitigate the impacts of climate change.[1] A critical step in addressing these challenges is adopting green technologies that offer innovative solutions to reduce carbon emissions, optimize resource utilization, and preserve ecosystems. Despite their extraordinary potential, investments in green technologies still face many complex barriers, particularly from a legal and financial perspective. Regulatory uncertainty often creates legal risks for investors, while limited access to green financial instruments/financing reduces the attractiveness of these investments. In addition, the lack of trust between parties in business contracts further hinders the cross-sector collaboration needed to support the implementation of sustainable technology solutions. In this context, it is essential to develop a legal framework to overcome these barriers and accelerate the adoption of green technologies as part of global efforts to achieve sustainable development goals.[2]

Previous research has extensively discussed the role of legal frameworks in promoting environmental sustainability and its influence on green investment.[3] These studies highlight the importance of transparency in business contracts, financial incentives, and a supportive regulatory environment in reducing risk for investors and encouraging engagement in sustainable business activities.[4] However, many of these studies still have limitations, particularly in integrating legal principles with financial mechanisms that are relevant in real-life situations. Most research focuses on individual aspects, such as transparency or regulation, without considering how the three elements of law, finance and sustainability can be integrated to overcome barriers to green technology investment. In addition, discussions on innovative green financing instruments, such as green bonds and carbon markets, often lack concrete solutions to support the widespread adoption of these technologies.

This research aims to bridge the gap by developing an integrative legal framework, linking legal theory with its application in supporting green technology investments. With a focus on contract design, regulatory clarity, and

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1 Eduardo Medeiros et al, "Using the Impact-WEB_GIS Platform to Assess the Impacts of Environmental Sustainability Public Policies in the Lisbon Metropolitan Area" (2023) 15:24 Sustainability 16761.

2 Mohammad Wasiq, Mustafa Kamal & Nazim Ali, "Factors Influencing Green Innovation Adoption and Its Impact on the Sustainability Performance of Small- and Medium-Sized Enterprises in Saudi Arabia" (2023) 15:3 Sustainability 2447.

3 Huafang Huang, Sharafat Ali & Yasir Ahmed Solangi, "Analysis of the Impact of Economic Policy Uncertainty on Environmental Sustainability in Developed and Developing Economies" (2023) 15:7 Sustainability 5860.

4 Volker Brühl, *Green Financial Products in the EU – A Critical Review of the Status Quo* (Rochester, NY: Social Science Research Network, 2022).

access to green financing instruments, this research offers a novel approach that can address issues faced by investors and other stakeholders. The framework aims to create trust between parties and foster strong legal and financial incentives as crucial drivers of sustainability. In this regard, including sustainability clauses in business contracts is critical to ensuring that investments are aligned with long-term environmental protection goals.

The scientific novelty of this research lies in its holistic approach of combining legal, financial and sustainability perspectives to come up with practical solutions. Whereas previous research has only addressed these elements separately, this study demonstrates how integrating the three aspects can effectively address critical barriers to adopting green technologies. The research mainly contributes by offering concrete solutions to reduce regulatory uncertainty and improve access to green finance, which is often a significant barrier for industry players. By offering a comprehensive legal model, this research is expected to increase investor confidence, expand the scope of green investments, and promote sustainable development.

This research aims to propose a legal framework that supports the adoption of green technologies by addressing critical legal and financial barriers. The research also seeks to answer several key questions, such as how regulations can be standardized to reduce legal uncertainty, how business contracts can increase trust between parties, and how legal principles can support the development and accessibility of green financing instruments. By integrating legal and financial approaches, this study is expected to make a real contribution to driving sustainability transformation across sectors.

II. METHODOLOGY

This study uses a normative legal research method with a conceptual approach to develop a comprehensive legal framework to support green technology investment.[5] This approach focuses on analyzing legal instruments, doctrines, and principles relevant to business contracts, regulatory frameworks, and financial mechanisms related to sustainability. The research relied on primary legal sources such as national and international legal regulations and relevant jurisprudence, as well as scholarly articles and policy reports that address sustainability and green technology issues. The research also conducted an in-depth literature review to identify gaps in the existing legal framework. In addition, the research synthesized best practices from successful green

[5] Qin Liu et al, "Research on the Impact of Environmental Regulation on Green Technology Innovation from the Perspective of Regional Differences: A Quasi-Natural Experiment Based on China's New Environmental Protection Law" (2022) 14:3 Sustainability 1714.

investment initiatives in different countries to provide insights that can be applied to a broader range of situations.[6] This approach provides a basis for providing practically relevant recommendations to improve the existing legal framework.

The method used in this research is legal analysis, which involves an in-depth examination of legal texts to evaluate their adequacy in addressing issues related to the adoption of green technologies. This process includes analyzing existing regulations, identifying potential areas for improvement in legal implementation, and comparing with best practices from countries or regions that already have more mature regulatory frameworks. This research also adopts a comparative analysis, comparing jurisdictions with an established regulatory environment and those still developing. This comparative approach allows researchers to see universal patterns or principles that can be applied in different countries or regions. In this way, the research aims to develop a model legal framework that can be applied to different situations, address the problems that often occur in green technology investment, and provide more suitable solutions for businesses.

III. STRATEGIES FOR SCALING UP INVESTMENT IN CLEAN TECHNOLOGY OVERCOMING TRUST, REGULATORY, AND FINANCING CHALLENGES

Investments in green technologies play an essential role in global efforts to address climate change and preserve natural resources.[7] This research shows that despite the vast potential of green technologies, their adoption and implementation are often constrained by trust issues between parties in business contracts. The uncertainty of environmental regulations and policies is also a significant challenge exacerbating this situation, as it creates legal risks for investors. In addition, green financing instruments are also a significant barrier, given that investments in green technologies often require more extensive and longer-term financing than conventional investments.

Investments in green technologies are crucial to addressing the challenges of climate change and to ensure the sustainability of dwindling natural resources.[8]

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[6] Shangram Bahadur Shah et al, "A Systematic Review on Nexus Between Green Finance and Climate Change: Evidence from China and India" (2023) 13:4 International Journal of Energy Economics and Policy 599–613.

[7] Ranjan Aneja, Manisha Yadav & Sanjeev Gupta, "The dynamic impact assessment of clean energy and green innovation in realizing environmental sustainability of G-20" (2024) 32:3 Sustainable Development 2454–2473.

[8] Weiwei Fu & Muhammad Irfan, "Does Green Financing Develop a Cleaner Environment for Environmental Sustainability: Empirical Insights From Association of Southeast Asian Nations Economies" (2022) 13 Front Psychol, online:

In this context, clean technologies have enormous potential to reduce negative environmental impacts, such as greenhouse gas emissions, pollution, and ecosystem damage. However, while the benefits of these technologies are clear, their adoption can be challenging. Many parties are involved in business contracts related to green technologies, but mistrust between them often hinders a favorable agreement for all parties.

In addition to the mistrust between parties, the uncertainty of environmental regulations and policies is also a significant obstacle to green technology investment. Constantly changing regulations and lack of consistent policies create an unstable environment for investors, as they cannot predict with certainty the legal risks or rule changes that may affect the sustainability of their investments. These changing regulations often make investors reluctant to take long-term risks, given the potential losses incurred due to sudden or unclear policy changes.[9]

In addition, financing is also a significant constraint in the development of green technologies. Green technologies tend to require more considerable funds and longer time horizons than investments in conventional sectors.[10] However, suitable green financing instruments to support these businesses are limited, exacerbating the difficulty in attracting investors. With adequate financing, innovation and adoption of green technologies will be improved despite their potential for long-term success.

Governments and financial institutions need to actively participate in creating clear regulations and reducing legal uncertainties that can reduce investor confidence.[11] Therefore, to address these issues, more supportive policies and the development of better financing instruments are needed. In addition, collaboration between the public and private sectors should be enhanced to encourage the adoption of green technologies, with the common goal of creating a more stable and favorable investment environment.

<https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2022.904768/full>.

9 Yuan Lai & Muhammad Tayyab Sohail, "Revealing the Effects of Corporate Governance on Green Investment and Innovation: Do Law and Policy Matter?" (2022) 13 Front Psychol, online: <https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2022.961122/full>.

10 Mingwen Chen et al, "Green Investment, Technological Progress, and Green Industrial Development: Implications for Sustainable Development" (2023) 15:4 Sustainability 3808; Beatrice Orlando et al, "The Impact of R&D Investments on Eco-Innovation: A Cross-Cultural Perspective of Green Technology Management" (2022) 69:5 IEEE Transactions on Engineering Management 2275–2284.

11 Yanyu Zhuang & Hua Wei, "Early warning model and prevention of regional financial risk integrated into legal system" (2023) 18:6 PLOS ONE e0286685.

IV. DEVELOPMENT OF A BUSINESS CONTRACT FRAMEWORK TO IMPROVE TRANSPARENCY AND SUSTAINABILITY IN CLEAN TECHNOLOGY INVESTMENTS

This article proposes developing a business contract framework that aims to address the problem of uncertainty in investments in the green technology sector. This uncertainty is often a barrier for investors to invest due to a need for more transparency between the parties involved in a contract. By adopting a more transparent framework, all parties involved, investors and technology developers, can better understand their rights and obligations and the potential risks and rewards involved. This transparency is expected to reduce the uncertainty that has been a challenge in the sector.[12]

Increased transparency in contracts can also build mutual trust between the parties involved. This trust is critical in creating long-term, mutually beneficial relationships.[13] Investors who feel confident in the clarity and integrity of the contract are more likely to invest in business activities that support sustainability goals. On the other hand, technology developers who get support from trusting investors will be able to focus more on achieving the objectives of business activities without being burdened by doubts about potential problems that could arise. Therefore, transparent contracts benefit one party and encourage more productive and sustainable collaboration.[14]

The proposed contract model also includes an essential element of a sustainability clause that will form the basis for any investment activity.[15] The sustainability clause ensures that every investment decision aligns with the long-term goal of achieving environmental sustainability.[16] With this clause in place, investors can rest assured that their funds will not only deliver financial returns but also contribute to global efforts to address the challenges of climate change and environmental degradation. It also clarifies that sustainability is a side issue and part of a binding agreement between all parties.

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12 Luc Wynant, Sophie Manigart & Veroniek Collewaert, "How private equity-backed buyout contracts shape corporate governance" (2023) 25:2 Venture Capital 135–160.

13 Edward C Tomlinson & Andrew Schnackenberg, "The effects of transparency perceptions on trustworthiness perceptions and trust" (2022) 12:1 Journal of Trust Research 1–23.

14 Tarun Kumar Agrawal et al, "Demonstration of a blockchain-based framework using smart contracts for supply chain collaboration" (2023) 61:5 International Journal of Production Research 1497–1516.

15 I K Klyuchnikov, M V Sigova & O I Klyuchnikov, "Sustainable Financial Instruments: Their Current State and Prospects" (2024) 18:4 Economic Policy 78–107.

16 Sisi Zheng & Shanyue Jin, "Can Enterprises in China Achieve Sustainable Development through Green Investment?" (2023) 20:3 International Journal of Environmental Research and Public Health 1787.

In addition, sustainability clauses will incentivize green technology companies to pay more attention to the environmental impact of their products or services.[17] In the long run, this may encourage innovation in the green technology sector, as these companies will be motivated to develop more efficient and environmentally friendly solutions. Investors who see that the business activities they have secured funding for can positively impact the environment, thereby achieving the investor's objectives, can increase investor loyalty and interest in further involvement in the sector.

The proposed contract model will create transparency and trust between the parties involved and encourage more significant investment in green technologies.[18] By including sustainability clauses as an integral part of each contract, the model can ensure that the sector develops in a way that is financially beneficial and provides a broader positive impact on society and the environment. In a broader context, this could accelerate the transition to a more sustainable and environmentally friendly economy while creating new opportunities for investors and green technology companies.

V. BUSINESS CONTRACTING STRATEGIES TO IMPROVE ENVIRONMENTAL SUSTAINABILITY

Business contracts designed with environmental impacts in mind have great potential to encourage companies and individuals to invest in environmentally friendly business activities.[19] In this context, it is essential to ensure that contracts are financially beneficial and include incentives that motivate all parties to achieve broader environmental goals. Setting favorable terms and conditions for both parties, in the form of financial incentives and contract law, can give stakeholders a sense of security and confidence to commit to initiatives that positively impact the environment.

Such an approach can also help reduce risks, often the main reason for uncertainty in adopting green technologies. For example, applying clear incentives in contracts can reduce concerns about the high initial costs or uncertainty of long-term outcomes of using green technologies. The application of incentives enshrined in the contract, consequently for the parties, can be a

[17] Mahmoud Allahham et al, "The impact of fintech-based eco-friendly incentives in improving sustainable environmental performance: A mediating-moderating model" (2024) 8:1 105267/j.ijdns 415–430.

[18] Jiayang Xu et al, "Optimal government and manufacturer incentive contracts for green production with asymmetric information" (2023) 18:8 PLOS ONE e0289639.

[19] Aydin Teymourifar & Maria A M Trindade, "A Framework to Design and Evaluate Green Contract Mechanisms for Forestry Supply Chains" (2023) 15:9 Sustainability 7668.

strong incentive for firms to innovate and take more significant risks, which in turn can accelerate the transition to a sustainable economy.[20]

Furthermore, the findings suggest that designing structured and systematic contracts minimizes barriers to adopting green technologies. A comprehensive and transparent contract, which explicitly regulates the sharing of benefits, risks, and dispute resolution mechanisms, can overcome the uncertainty faced by business actors. Clarity on the rights and obligations of each party in terms of environmental management can open space for all parties to feel more comfortable participating in business activities that have long-term positive impacts.[21]

In a broader context, applying these principles can play an essential role in creating a business ecosystem that supports sustainability. As environmentally conscious contracts become the norm in business, there will be a more significant paradigm shift towards integrating economic profit and nature preservation.[22] Thus, efforts to include environmentally friendly elements in business contracts are essential for business activities' short-term success and broader long-term sustainability, both for the company and for life together.

Overall, the findings emphasize the importance of drafting business contracts that are financially beneficial and support environmental protection objectives. By designing contracts with explicit legal and financial incentives, parties involved will feel safer investing in business activities with positive environmental impacts. This designing contract suggests that a structured and systematic approach to business agreements can help overcome many barriers that hinder the adoption of green technologies.

VI. SIGNIFICANCE OF SUSTAINABILITY CLAUSES IN BUSINESS CONTRACTS TO ENCOURAGE GREEN TECHNOLOGY INVESTMENT

Green technology investments' sustainability is paramount, given the pressing global challenges of climate change and environmental degradation.[23] This research highlights that one way to mitigate the risks that often deter investors from investing in green business activities is to adopt a business

[20] Zhaozhen Zhu et al, "The Perspective of Long-Term and Short-Term Incentives on the Business Environment, Executive Incentive Contracts, and Enterprise Innovation" (2023) 13:4 Sage Open 21582440231206960.

[21] Alaa Aldowaish et al, "Environmental, Social, and Governance Integration into the Business Model: Literature Review and Research Agenda" (2022) 14:5 Sustainability 2959.

[22] Doo-Ho Lee & Jong-Chul Yoon, "Decisions on Pricing, Sustainability Effort, and Carbon Cap under Wholesale Price and Cost-Sharing Contracts" (2022) 14:8 Sustainability 4863; Aldowaish et al, "Environmental, Social, and Governance Integration into the Business Model", *supra* note 21; Teymourifar & Trindade, *supra* note 19.

[23] Aneja, Yadav & Gupta, *supra* note 7.

contract framework based on the principle of transparency. With transparency, investors can feel more confident that the allocation of funds and the use of resources are done in a way compatible with environmental conservation goals. [24]

One of the critical elements in this business contract framework is the sustainability clause. This clause serves as a guideline to ensure that every decision and step taken in the investment remains focused on long-term, environmentally friendly goals.[25] It also prevents potential deviations that could harm sustainability projects, such as using inefficient technologies or activities that damage the environment. With explicit provisions on sustainability aspects in the contract, stakeholders can more easily monitor and evaluate the impact of any decision-making.

Sustainability clauses can also increase trust between investors, government, and society by reducing risk.[26] This reduced risk creates a more conducive environment for the development of green technologies, as stakeholders feel assured that their business activities are not only economically profitable but also positively impact the environment. This clause, if properly implemented, can be a powerful tool to ensure that business activities based on green technologies are not only financially successful but also sustainable in the long term.

Commitment to sustainability through clauses in business contracts is a strategic step to overcome the challenges of investing in environmentally friendly business activities.[27] With clear and measurable clauses, stakeholders can work together to ensure that business activities provide short-term benefits and positively impact future generations, aligning with sustainability principles.

This study focuses on the enforceability of sustainability principles in green technology investments. The findings show that a business contract framework based on the principle of transparency can reduce the risks that often discourage investors from engaging in green projects. Sustainability clauses in business contracts play a vital role, ensuring that every investment step taken remains

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[24] Rizwan Ali et al, "Is biodiversity disclosure emerging as a key topic on the agenda of institutional investors?" (2024) 33:3 Business Strategy and the Environment 2116–2142.

[25] Tsimisaraka Raymondo Sandra Marcelline et al, "Impact of Green Construction Procurement on Achieving Sustainable Economic Growth Influencing Green Logistic Services Management and Innovation Practices" (2022) 9 Front Environ Sci, online: <https://www.frontiersin.org/journals/environmental-science/articles/10.3389/fenvs.2021.815928/full>.

[26] Yu A Danilov, "Building Long-Term Trust in Sustainable Finance" (2024) 18:5 Economic Policy 122–147; Maria Misiuda & Maik Lachmann, "Investors' Perceptions of Sustainability Reporting—A Review of the Experimental Literature" (2022) 14:24 Sustainability 16746.

[27] Obey Dzomonda, "Environmental Sustainability Commitment and Access to Finance by Small and Medium Enterprises: The Role of Financial Performance and Corporate Governance" (2022) 14:14 Sustainability 8863.

aligned with environmental conservation goals. By including such clauses, stakeholders can identify and avoid actions that could harm the sustainability of future business activities.

VII. A COLLABORATIVE STRATEGY TO ENCOURAGE INVESTMENT IN GREEN TECHNOLOGY

The results show that encouraging more investment in green technologies requires close collaboration between the government, regulators, and the private sector. This cooperation is essential to creating an ecosystem supporting innovation and wider green technology adoption. As the policy maker, the government has a crucial role in creating regulations that support and encourage green investments by providing attractive incentives. In addition, the private sector, which better understands market needs and technological innovations, can act as a driving force in successfully implementing green technologies.[28]

Appropriate regulation is one of the key factors in encouraging such investment. Therefore, it is essential for the government and regulators to jointly design policies that not only meet market needs but also ensure environmental sustainability.[29] The regulations should be innovative enough to give the private sector room to innovate and clear enough not to create uncertainty for investors. This regulation will minimize the risks that investors may face, choosing to invest in green technology-based businesses that may otherwise be perceived as riskier than other sectors.

One strategic step is to develop contract guidelines that focus on sustainability. In this case, the government can work with the private sector to design contracts that support sustainability principles and ensure that business activities provide long-term benefits to the environment and society.[30] Apparent and standardized contracts can also help investors feel more confident in investing, as they know the risks they face have been well considered.

Furthermore, the government needs to create a flexible yet standardized legal framework. This flexibility is essential to ensure that the legal framework adapts to rapid technological developments. Meanwhile, standardization is needed to

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[28] Oluwatobi Mary Owojori & Chioma Okoro, "The Private Sector Role as a Key Supporting Stakeholder towards Circular Economy in the Built Environment: A Scientometric and Content Analysis" (2022) 12:5 Buildings 695.

[29] Lei Du, Xing Liu & Helin Sun, "Corporate sustainable development strategies: Under the collaborative governance of government and the public" (2024) 32:4 Sustainable Development 3055–3064; Jingjing Liu et al, "Analysis of the Influence of Heterogeneous Environmental Regulation on Green Technology Innovation" (2023) 15:4 Sustainability 3649.

[30] Abimbola A Adebayo, Kris Lulofs & Michiel Adriaan Heldeweg, "Indicators, Strategies, and Rule Settings for Sustainable Public–Private Infrastructure Partnerships: From Literature Review towards Institutional Designs" (2023) 15:12 Sustainability 9422.

ensure uniformity in policy implementation across sectors and regions. A transparent and standardized legal framework will give investors confidence, making them feel safer investing in green technology-focused businesses.[31]

The importance of cooperation between the government, private sector and regulators must be considered, as each party has a complementary role.[32] The government as a policymaker must create a conducive climate for green investments, while the private sector with its technological capabilities can implement environmentally friendly solutions. Conversely, regulators play a role in ensuring that existing policies and contracts are properly executed. With solid cooperation, Indonesia can achieve its sustainability goals more efficiently and successfully.

In addition, the results show that collaboration between governments, regulators and the private sector is essential to encourage more investment in green technologies. This collaboration will result in innovative regulations incentivizing green investment and sustainability-focused contractual guidelines.[33] In this case, the government needs to create a flexible, standardized and transparent legal framework so that investors feel more confident in making decisions to invest in green technology projects.

VII. OPTIMISATION OF GREEN FINANCING INSTRUMENTS FOR ENVIRONMENTALLY FRIENDLY ACTIVITY INITIATIVES

This research emphasizes that developing adequate green financing instruments is critical to supporting environmentally friendly business activities. With suitable financial instruments, many high-potential initiatives in addressing climate change will be successful. This financing constraint is not only due to a lack of funds but also because there is no proper mechanism to allocate and manage these funds efficiently. A wide range of business activities based on green technologies have tremendous potential, but they need proper financial support to develop fully.[34]

The potential of green technology in climate change mitigation is enormous in terms of reducing carbon emissions and conserving natural resources. However, to maximize this potential, sufficient and efficient financing

[31] Liu et al, "Research on the Impact of Environmental Regulation on Green Technology Innovation from the Perspective of Regional Differences", *supra* note 5.

[32] Sandra Eckert, "European administrative networks, private networks and agencies: coexisting, cooperating or competing?" (2022) 29:10 Journal of European Public Policy 1610–1630.

[33] Tong Zhao et al, "Impact of Green Finance and Environmental Regulations on the Green Innovation Efficiency in China" (2022) 14:6 Sustainability 3206.

[34] Decai Tang et al, "Impact of Digital Finance on Green Technology Innovation: The Mediating Effect of Financial Constraints" (2023) 15:4 Sustainability 3393.

is required. More innovative and well-structured green financing instruments can unlock access to the resources needed by such projects. Properly designed green financing can ensure a sustainable flow of funds so that environmentally friendly business activities can flourish and have a broader positive impact, not only in environmental aspects but also in creating jobs and boosting the economy.[35]

Policies that support green financing should be seen as a long-term profitable investment for the country.[36] Policymakers and other stakeholders have a vital role in creating an environment enabling the development of green finance instruments. The right policies can incentivize the private sector to finance environmentally friendly business activities actively. In addition, collaboration between the government, financial institutions, and the private sector is also crucial to creating an inclusive and sustainable financing ecosystem.

This collaboration will encourage the development of green technologies and increase market confidence in broader economic and social sustainability. Thus, efficient green financing will be one of the critical pillars in meeting the challenges of climate change in the future.

The research also highlights the importance of developing adequate green financing instruments to support environmentally friendly business activities. With suitable financial instruments, many initiatives will be successful. Inadequate financing makes green technology projects unable to develop optimally despite their enormous potential in mitigating the impacts of climate change. Therefore, policymakers and other stakeholders need to develop financial instruments that can support financing these business activities more efficiently and positively impact environmental conservation.[37]

IX. CONCLUSION

A transparent and structured strategic contracting framework can address challenges such as mistrust, regulatory uncertainty, and financing barriers and encourage investment in green technologies. The inclusion of sustainability clauses in contracts aligns financial and environmental objectives and promotes innovation and collaboration between the public and private sectors. To

[35] Chenggang Li et al, "Impact of green finance on China's high-quality economic development, environmental pollution, and energy consumption" (2022) 10 Front Environ Sci, online: <https://www.frontiersin.org/journals/environmental-science/articles/10.3389/fenvs.2022.1032586/full>.

[36] Xuemeng Guo et al, "Green Credit Policy and Short-Term Financing for Long-Term Investment: Evidence from China's Heavily Polluting Enterprises" (2023) 15:24 Sustainability 16804.

[37] Viktor Koval et al, "Analysis of Financial Outsourcing Management in Regional Environmental Systems" (2023) 15:15 Sustainability 11966.

accelerate the transition to a sustainable economy, governments must develop contract guidelines prioritizing transparency and sustainability, engage investors and the private sector in contract drafting to reduce risk and provide education and technical support to increase confidence in green technologies.

Sustainability clauses in business contracts are a strategic tool to encourage investment in green technologies. They ensure transparency and accountability and align investments with long-term environmental conservation goals. Intensive collaboration between the government, regulators, and the private sector is intended to create an ecosystem that supports environmentally friendly investments. In addition, developing innovative and structured green financing instruments is a priority to strengthen the growth of sustainable business activities. These efforts help minimize risks, accelerate the advancement of green technologies, and provide broader environmental and economic benefits.

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Harmonization of Environmental Law and Technology Regulations in Climate Change Mitigation Efforts

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ABSTRACT: Climate change is one of the most pressing global challenges that requires an integrated response between legal and technological policies. In the effort to mitigate climate change, the harmonization of environmental legal regulations and the application of technology is a critical element that needs to be studied comprehensively. This research uses a normative legal approach by analyzing legal concepts, laws, and regulations and comparing regulations in various countries that have successfully integrated technology into their environmental policies. This research focuses on identifying existing legal gaps in accommodating technological developments for climate change mitigation. The findings of this research show that some developed countries have successfully harmonized environmental regulations with cutting-edge technologies, such as renewable energy and digital technology-based emission monitoring systems. However, in developing countries, there are barriers to implementing green technology policies due to nonadaptive regulations and limited technological capacity. This research underscores the importance of environmental law reform responsive to technological innovation and the need for international collaboration to create a consistent legal framework capable of effectively supporting climate change mitigation. In conclusion, harmonization between environmental law regulation and technology provides a potential solution to addressing climate change impacts but requires collective efforts to ensure proper and sustainable policy implementation.

KEYWORDS: Environmental Law, Climate Change Mitigation, Regulation, Technology, Green Technology.

I. INTRODUCTION

Climate change has become one of the most pressing global issues of the 21st century.[1] Its impacts directly affect the environment and cause various social, economic, and political problems.[2] Various mitigation efforts have been made worldwide, but the results still need to be improved. Rising global temperatures, rising sea levels, and more intense frequency of natural disasters indicate that current policies have not addressed the root of the problem.[3] Therefore, a holistic and synergistic approach between legal and technological policies is needed to address climate change.[4]

On the other hand, rapid technological development provides new hope in climate change mitigation.[5] Technologies such as renewable energy, digital-based emission monitoring systems, and innovations in waste management are becoming essential tools for reducing carbon emissions and other environmental impacts.[6] However, despite the availability of these technologies, their application has yet to be fully

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1 Gurdeep Singh Malhi, Manpreet Kaur & Prashant Kaushik, "Impact of Climate Change on Agriculture and Its Mitigation Strategies: A Review" (2021) 13:3 Sustainability 1318; Samer Fawzy et al, "Strategies for mitigation of climate change: a review" (2020) 18:6 Environ Chem Lett 2069–2094; Mark Scott et al, "Climate Disruption and Planning: Resistance or Retreat?" (2020) 21:1 Planning Theory & Practice 125–154.

2 Jesse Ribot, "Violent silence: framing out social causes of climate-related crises" (2022) 49:4 The Journal of Peasant Studies 683–712; Simon Dietz et al, "Economic impacts of tipping points in the climate system" (2021) 118:34 Proceedings of the National Academy of Sciences e2103081118; Ioana Agache et al, "Climate change and global health: A call to more research and more action" (2022) 77:5 Allergy 1389–1407.

3 Dervis Kirikkaleli & James Karmoh Sowah, "Time-frequency dependency of temperature and sea level: a global perspective" (2021) 28:41 Environ Sci Pollut Res 58787–58798; Robert J Nicholls et al, "A global analysis of subsidence, relative sea-level change and coastal flood exposure" (2021) 11:4 Nat Clim Chang 338–342.

4 William Baldwin-Cantello et al, "The Triple Challenge: synergies, trade-offs and integrated responses for climate, biodiversity, and human wellbeing goals" (2023) 23:6 Climate Policy 782–799; Chiara Macchi, "The Climate Change Dimension of Business and Human Rights: The Gradual Consolidation of a Concept of 'Climate Due Diligence'" (2021) 6:1 Business and Human Rights Journal 93–119.

5 Pontus Braunerhjelm & Cameron Hepburn, "Climate change, complexity, and policy design" (2023) 39:4 Oxford Review of Economic Policy 667–679.

6 Muhammad Khalid Anser et al, "The role of information and communication technologies in mitigating carbon emissions: evidence from panel quantile regression" (2021) 28:17 Environ Sci Pollut Res 21065–21084; Hui Liu, Lili Wang & Yang Shen, "Can digital technology reduce carbon emissions? Evidence from Chinese cities" (2023) 11 Front Ecol Evol, online: <https://www.frontiersin.org/journals/ecology-and-evolution/articles/10.3389/fevo.2023.1205634/full>.

optimized. This technology is due to the need for more harmonization between legal policies and existing technologies. Regulations that are not adaptive to technological change are often obstacles to the effective implementation of green technologies.

One of the key challenges in climate change mitigation is ensuring that environmental legal regulations can keep up with technological development.[7] With flexible and adaptive regulations, technological innovations will be optimally implemented. Some developed countries have successfully integrated technology into their environmental policies, but in many developing countries, existing regulations are still rigid and do not support the implementation of green technologies.[8] This policy creates a massive gap in the effectiveness of climate change mitigation policies globally.

In addition, developing countries often face technological and resource limitations in implementing effective green policies.[9] These obstacles are further exacerbated by legal regulations that have yet to be able to accommodate technological developments. The mismatch between the legal framework and technological needs makes climate change mitigation in these countries more difficult to realize.[10] Therefore, legal reforms that are responsive to technological innovation are needed to ensure the achievement of sustainable development goals.

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7 Fawzy et al, "Strategies for mitigation of climate change", *supra* note 1; Zhenyu Zhang & Xumin Ren, "Multidimensional Legal Research on the Transfer of Environmentally Sound Technologies in China" (2023) 15:3 Sustainability 2151.

8 Yanli Ji, Jie Xue & Kaiyang Zhong, "Does Environmental Regulation Promote Industrial Green Technology Progress? Empirical Evidence from China with a Heterogeneity Analysis" (2022) 19:1 International Journal of Environmental Research and Public Health 484; X Cai et al, "Can direct environmental regulation promote green technology innovation in heavily polluting industries? Evidence from Chinese listed companies" (2020) Science of the Total Environment, online: <https://www.sciencedirect.com/science/article/pii/S0048969720343345> Citation Key: pop00010; Xiaoxiao Zhou & Juntao Du, "Does environmental regulation induce improved financial development for green technological innovation in China?" (2021) 300 Journal of Environmental Management 113685.

9 Zahid Hussain et al, "Green Growth, Green Technology, and Environmental Health: Evidence From High-GDP Countries" (2022) 9 Front Public Health, online: <https://www.frontiersin.org/journals/public-health/articles/10.3389/fpubh.2021.816697/full>; Edward B Barbier, "Is green rural transformation possible in developing countries?" (2020) 131 World Development 104955.

10 Chaewoon Oh, "Discursive Contestation on Technological Innovation and the Institutional Design of the UNFCCC in the New Climate Change Regime" (2020) 25:4 New Political Economy 660–674; Jason Hickel et al, "Urgent need for post-growth climate mitigation scenarios" (2021) 6:8 Nat Energy 766–768.

Previous research has highlighted the importance of technology integration in environmental policy. Studies conducted in developed countries show that renewable energy technologies and digital-based monitoring systems significantly reduce greenhouse gas emissions.[11] However, these studies mainly focus on the technological aspects without examining in depth how legal regulations support or hinder the application of these technologies. On the other hand, several studies on environmental policies in developing countries show that existing legal regulations can berate green technologies effectively.[12]

Other research shows that there are still gaps in the implementation of environmental policies in different countries, especially regarding green technology.[13] While many countries have adopted more progressive environmental regulations, implementation on the ground is often hampered by rigid and inflexible regulations.[14] This gap becomes even more apparent when comparing regulations in developed and developing countries, where developing countries often lag in green technology development and implementation.

Based on the problems described, this research aims to answer two main questions: How can current environmental legal regulations be harmonized with technological

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[11] Assaad Ghazouani, Mehdi Ben Jebli & Umer Shahzad, "Impacts of environmental taxes and technologies on greenhouse gas emissions: contextual evidence from leading emitter European countries" (2021) 28:18 Environ Sci Pollut Res 22758–22767; Stephen Taiwo Onifade & Andrew Adewale Alola, "Energy transition and environmental quality prospects in leading emerging economies: The role of environmental-related technological innovation" (2022) 30:6 Sustainable Development 1766–1778.

[12] Kyle S Herman, "Green growth and innovation in the Global South: a systematic literature review" (2023) 13:1 Innovation and Development 43–69; Yunqiang Liu et al, "Environmental regulation, green technological innovation, and eco-efficiency: The case of Yangtze river economic belt in China" (2020) 155 Technological Forecasting and Social Change 119993.

[13] Sher Jahan Khan et al, "Green process innovation: Where we are and where we are going" (2021) 30:7 Business Strategy and the Environment 3273–3296; Fan Wang et al, "Environmental Regulation, Tenure Length of Officials, and Green Innovation of Enterprises" (2020) 17:7 International Journal of Environmental Research and Public Health 2284; Xiaoqing Li, Zongyi Hu & Qing Zhang, "Environmental regulation, economic policy uncertainty, and green technology innovation" (2021) 23:10 Clean Techn Environ Policy 2975–2988.

[14] Marie-France Waxin et al, "Drivers, Challenges and Outcomes of Environmental Management System Implementation in Public Sector Organizations: A Systematic Review of Empirical Evidence" (2023) 15:9 Sustainability 7391; Gustavo Facincani Dourado, Anna M Rallings & Joshua H Viers, "Overcoming persistent challenges in putting environmental flow policy into practice: a systematic review and bibliometric analysis" (2023) 18:4 Environ Res Lett 043002; Jingxiao Zhang et al, "The impact of environmental regulations on urban Green innovation efficiency: The case of Xi'an" (2020) 57 Sustainable Cities and Society 102123.

developments for climate change mitigation? Second, what barriers do developing countries face in harmonizing environmental regulations and technology? This research will identify existing legal gaps and propose law-based solutions to improve the effectiveness of climate change mitigation policies globally.

The first research gap identified is the need for comprehensive studies on harmonization between environmental law and technology regulation in developing countries. Second, there needs to be more research examining technology's role in environmental policy from a legal perspective, especially in the context of climate change mitigation. Finally, more research needs to be done to compare the effectiveness of environmental regulations in developed and developing countries in adopting green technology for climate change mitigation. This research seeks to fill this gap by focusing on the harmonization of legal and technological regulations in facing the challenges of climate change.

This research aims to analyze and evaluate the harmonization of environmental law regulations and technology applications in climate change mitigation efforts, focusing on developing countries that still face various barriers to implementing green technology policies. In addition, this research also aims to identify gaps in the existing legal framework and offer law-based solutions that are more adaptive to technological developments. The expected benefits of this research are to make a real contribution to the development of environmental legal policies that are more responsive to technological innovation and to assist governments and stakeholders in drafting regulations that support sustainable development.

The main contribution of this research lies in the comparative approach used to examine environmental law and technology regulation in developed and developing countries. This research offers a new perspective by exploring the differences in the implementation of environmental regulations related to green technology and highlighting the factors that influence the effectiveness of such policies. In addition, this research provides a deeper analysis of how developing countries can learn from best practices in developed countries while considering each country's limited resources and capacities. This analysis makes the research relevant to various stakeholders, including policymakers, academics, and international organizations focusing on climate change issues.

The novelty of this research lies in its systematic approach to identifying the legal gaps in implementing technologies for climate change mitigation. While many

previous studies have focused on aspects of the technology itself, this research highlights the role of legal regulation as a catalyst or inhibitor in implementing green technologies. By combining normative, comparative, and statutory analyses, this research makes an essential contribution to the environmental law literature by offering law-based solutions that are more adaptive and in line with the latest technological developments.

II. METHODOLOGY

This research uses a normative legal research method that focuses on analyzing applicable legal norms and legal concepts relevant to harmonizing environmental law and technology regulations in climate change mitigation. The normative approach was chosen because this research does not require empirical data or interview results but examines legal rules, statutory documents, and the views of relevant legal experts. This approach includes a conceptual approach, which aims to understand the harmonization of law and technology; a statutory approach, which analyses various relevant regulations in several countries; and a comparative approach, which compares the effectiveness of regulations in developed and developing countries.

The sources of legal materials used in this research include primary and secondary legal materials. Primary legal materials include legislation related to environmental law and technology at the national and international levels, such as laws on the environment, green technology regulations, and international agreements on climate change mitigation. Meanwhile, secondary legal materials are in the form of literature, books, scientific articles, and the views of relevant legal experts. Legal data or materials were collected by searching legal documents in law libraries, legal journals, and credible online sources. The collection of legal materials was carried out systematically by referring to the criteria of relevance and validity.

III. CURRENT ENVIRONMENTAL LEGAL REGULATIONS BE HARMONIZED WITH TECHNOLOGICAL DEVELOPMENTS FOR CLIMATE CHANGE MITIGATION

The study of the harmonization of environmental law and technology regulations in climate change mitigation is based on legal concepts that emphasize the critical role

of law in creating policies responsive to technological developments.[15] One of the theories underlying this study is the Responsive Law Theory proposed by Philip Selznick. This theory emphasizes that law must respond flexibly to social, economic, and technological changes to achieve justice goals.[16] In the context of climate change mitigation, environmental law regulations must be responsive to the growing development of green technologies, such as renewable energy, digital-based monitoring systems, and other innovations. This linkage between law and technology is the main foundation for formulating effective policies for climate change mitigation.

Furthermore, Neil Gunningham's Environmental Law Theory is also relevant to this study. Gunningham emphasizes the importance of a command-and-control regulatory approach to environmental management, where the government has a central role in setting environmental standards and overseeing compliance with these standards.[17] However, facing complex climate change challenges, this theory must be combined with market- and technology-based approaches. Environmental legal regulations should set limits and sanctions and encourage technological innovation through incentives and adaptive regulatory frameworks. These regulations show that legal policy cannot be static but must constantly evolve with technological change.

The theory of technological innovation proposed by Joseph Schumpeter is also relevant to this discussion. Schumpeter argued that innovation is a significant factor

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15 Brendan Moore et al, "Transformations for climate change mitigation: A systematic review of terminology, concepts, and characteristics" (2021) 12:6 WIREs Climate Change e738; Nicolae Stef & Sami Ben Jabeur, "Climate Change Legislations and Environmental Degradation" (2020) 77:4 Environ Resource Econ 839–868.

16 Arief Budiono et al, "Legal Conscience and the Pressure of the Formal Law System" (2022) 22:2 WISDOM, online: <https://wisdomperiodical.com/index.php/wisdom/article/view/790>; John M Gallagher & José B Ashford, "Perceptions of legal legitimacy in veterans treatment courts: A test of a modified version of procedural justice theory" (2021) 45:2 Law and Human Behavior 152–164.

17 Hong-li Tang, Jian-min Liu & Jin-guang Wu, "The impact of command-and-control environmental regulation on enterprise total factor productivity: A quasi-natural experiment based on China's 'Two Control Zone' policy" (2020) 254 Journal of Cleaner Production 120011; Kai Tang, Yuan Qiu & Di Zhou, "Does command-and-control regulation promote green innovation performance? Evidence from China's industrial enterprises" (2020) 712 Science of The Total Environment 136362.

in economic and social progress, including in the environmental context.[18] Green technological innovations, such as renewable energy and emission reduction technologies, are crucial in mitigating climate change. However, more than technological innovation is required with regulatory support that encourages the application of these technologies. In this case, the law should serve as an instrument that supports and accelerates the adoption of green technologies through policies that facilitate technology transfer, fiscal incentives, and protection of intellectual property rights for green technologies.

In the international context, international environmental law theory is also relevant to understanding the importance of regulatory harmonization in climate change mitigation. Various international agreements, such as the Kyoto Protocol and the Paris Agreement, demonstrate that climate change is a transboundary issue that requires international cooperation.[19] However, the effectiveness of these agreements largely depends on each country's ability to effectively implement green technologies through national regulations that harmonize with international norms. Thus, this research will also examine how developing countries can integrate green technology into their domestic regulations due to existing international agreements.

In comparative law theory, this approach allows research to evaluate how developed and developing countries differ in implementing environmental regulations that support green technologies. According to this theory, comparing legal systems can provide valuable insights into best practices that can be applied in various jurisdictions.[20] For example, developed countries such as Germany and Sweden have successfully harmonized environmental regulations with renewable energy technologies through adaptive and progressive policies. Meanwhile, developing countries still face challenges in terms of rigid regulations and inadequate infrastructure to support the implementation of green technology. Thus,

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[18] Agnieszka Lipieta & Andrzej Malawski, *Eco-Mechanisms Within Economic Evolution – Schumpeterian Approach* (Research Square, 2020); Franco Malerba & Maureen McKelvey, "Knowledge-intensive innovative entrepreneurship integrating Schumpeter, evolutionary economics, and innovation systems" (2020) 54:2 Small Bus Econ 503–522.

[19] Alessandro Tavoni & Ralph Winkler, "Domestic Pressure and International Climate Cooperation" (2021) 13:Volume 13, 2021 Annual Review of Resource Economics 225–243; Surender Mor et al, "Kyoto Protocol and Paris Agreement: Transition from Bindings to Pledges – A Review" (2024) 15:4 Millennial Asia 690–711.

[20] Jorge E Viñuales, "COMPARING ENVIRONMENTAL LAW SYSTEMS" (2024) 73:1 International & Comparative Law Quarterly 247–258; Muhammad Imran Ali, "Comparative Legal Research-Building a Legal Attitude for a Transnational World" (2020) 26:40 Journal of Legal Studies 66–80.

comparative studies are essential to see the potential adoption of these best practices in developing countries.

Finally, Gro Harlem Brundtland's sustainable development theory is also essential to this research. This theory emphasizes that development should meet the needs of the current generation without compromising the ability of future generations to meet their own needs.[21] In the context of climate change, sustainable development requires integration between environmental policy and technology as a long-term solution. Harmonization between environmental legal regulation and green technology is one of the keys to ensuring that climate change mitigation efforts can go hand in hand with sustainable economic growth. This research will base its main argument on the principles of sustainable development in formulating policy recommendations that are more adaptive to the challenges of climate change.

IV. BARRIERS DO DEVELOPING COUNTRIES FACE IN HARMONIZING ENVIRONMENTAL REGULATIONS AND TECHNOLOGY

The results show a significant gap in the regulatory framework of environmental law in developing countries in accommodating the development of green technology. Based on the analysis of legal documents from several countries, it was found that existing legal regulations often need to be more flexible and able to keep up with the pace of technological development. In many developing countries, environmental regulation focuses on the traditional command and control approach without considering the flexibility needed to accommodate technological innovation.[22] This approach contrasts with findings in developed countries, where environmental regulations are adaptive and allow green technologies to develop faster.

One of the key findings of this research is that in countries such as Germany and Sweden, environmental legal regulation has been designed to adapt to technological developments. For example, Germany's renewable energy policy, Energiewende, provides solid regulatory support for green energy through financial incentives and

[21] Sophio Barnabishvili, "Comparative Analysis of Evidence Law Within the Civil Process Comparative-Legal Research" (2023) 32:46 Journal of Legal Studies 1–26; Ali, *supra* note 20.

[22] Muyao Li et al, "Opening the Black Box: The Impacts of Environmental Regulations on Technological Innovation" (2020) 17:12 International Journal of Environmental Research and Public Health 4365; Zhou & Du, *supra* note 8.

regulations encouraging innovation.[23] On the other hand, in developing countries such as Indonesia and Brazil, existing regulations still need to fully support the development of green technologies, especially in the renewable energy sector.[24] This difference reflects the need for regulatory reforms in developing countries to catch up with more advanced technological developments in developed countries.

The research also revealed that some regulations in developing countries still view technology as a secondary addition to environmental policy rather than a critical element that must be integrated from the start. This research is evident in some countries' low implementation of green technologies such as solar and wind energy. Previous publications have shown that countries that successfully integrate green technologies in their environmental policies are those with adaptive and innovation-responsive legal regulations.[25] This research supports these findings but also highlights that in many developing countries, adapting such regulations still lags far behind developed countries.

This finding is also supported by comparative data showing that countries with more flexible and technology-adaptive legal regulations tend to have higher rates of green technology adoption.[26] For example, in Western European countries, 70% of total energy production comes from renewable energy sources, while in Southeast Asian countries, the figure is still below 30%.[27] This data shows that harmonizing

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[23] Rudolf Rechsteiner, "German energy transition (Energiewende) and what politicians can learn for environmental and climate policy" (2021) 23:2 Clean Techn Environ Policy 305–342; Oliver Wagner & Thomas Götz, "Presentation of the 5Ds in Energy Policy: A Policy Paper to Show How Germany Can Regain Its Role as a Pioneer in Energy Policy" (2021) 14:20 Energies 6799.

[24] Umer Shahzad et al, "Do Environment-Related Policy Instruments and Technologies Facilitate Renewable Energy Generation? Exploring the Contextual Evidence from Developed Economies" (2021) 14:3 Energies 690; Yang Yu et al, "Achieving Carbon Neutrality Pledge through Clean Energy Transition: Linking the Role of Green Innovation and Environmental Policy in E7 Countries" (2022) 15:17 Energies 6456.

[25] Qin Liu et al, "Research on the Impact of Environmental Regulation on Green Technology Innovation from the Perspective of Regional Differences: A Quasi-Natural Experiment Based on China's New Environmental Protection Law" (2022) 14:3 Sustainability 1714; Yuanyang Wang et al, "Environmental regulation, environmental responsibility, and green technology innovation: Empirical research from China" (2021) 16:9 PLOS ONE e0257670.

[26] De Xia et al, "Research on Enterprises' Intention to Adopt Green Technology Imposed by Environmental Regulations with Perspective of State Ownership" (2021) 13:3 Sustainability 1368; Xingshuai Wang, Ehsan Elahi & Lianggui Zhang, "Mandatory Environmental Regulation and Green Technology Innovation: Evidence from China" (2022) 14:20 Sustainability 13431.

[27] Mohsen Khezri et al, "Assessing the Impact of Selected Determinants on Renewable Energy Sources in the Electricity Mix: The Case of ASEAN Countries" (2022) 15:13 Energies 4604; Rosa

legal regulations and green technologies is a critical success factor for climate change mitigation in many countries. It also shows that developing countries need faster and more flexible legal reforms to support the use of technology in climate change mitigation.

In addition, the results of this study show that although developing countries have great potential in natural resources for renewable energy, such as solar and wind energy, limitations in the regulatory framework constitute a significant barrier to the development and implementation of green technologies. This limitation is in contrast to the findings of previous publications that argue that economic factors are the main barrier to adopting green technologies in developing countries.[28] This research found that unfavorable legal regulations are also significant barriers that must be addressed in addition to economic factors.

Aligning environmental law regulations with technological developments is an effort to harmonize more adaptive regulations. As a concrete step, Indonesia can strengthen the implementation of Law No. 32/2009 on Environmental Protection and Management by implementing regulations that provide specific guidance on applying green technology. One option is drafting a Government Regulation regulating tax incentives and subsidies for green technology innovation. It is also essential to revise Government Regulation No. 79/2014 on the National Energy Policy to include concrete targets for using renewable energy, including developing digital-based technologies such as Internet of Things (IoT)-based emission monitoring systems. With this adaptive legal support, regulations can dynamically follow technological developments and improve the effectiveness of climate change mitigation policies.

Overall, this study's results highlight the importance of harmonizing environmental legal regulations with technological developments as the key to addressing the challenges of climate change. By adopting legal regulations that are more flexible and responsive to technological developments, developing countries can more quickly catch up with implementing green technologies. Implementing green

Puertas Medina & Luisa Martí-Selva, *Renewable Energy Production Capacity and Consumption in Europe* (Rochester, NY: Social Science Research Network, 2022).

[28] Serdar Durdyev et al, "Strategies for implementation of green roofs in developing countries" (2022) 30:6 Engineering, Construction and Architectural Management 2481–2502; Muhammad Ikram et al, "Enabling Progress in Developing Economies: A Novel Hybrid Decision-Making Model for Green Technology Planning" (2022) 14:1 Sustainability 258.

technologies will increase the effectiveness of climate change mitigation and strengthen the company's position in achieving sustainable development goals.

The results of this study identified several key barriers that hinder the harmonization process between environmental regulation and technology in developing countries. These barriers can be classified into three categories: rigid regulations, lack of institutional support, and limited technological resources. Developing countries often have nonadaptive legal frameworks, where environmental regulations tend to be static and need to be more flexible to accommodate technological innovations needed for climate change mitigation.

These regulatory barriers are exacerbated by slow bureaucracy and the need for coordination between agencies. For example, in some developing countries, environmental regulations favoring green technologies are often hampered by overlapping regulations between government ministries or agencies.[29] These regulatory barriers make policy implementation inconsistent and difficult to implement. Previous research has shown that overly complex regulations and excessive bureaucracy are significant barriers to environmental policy implementation in developing countries.[30] The results of this study corroborate these findings by emphasizing that these regulatory barriers do not only occur at the national level but also the regional and local levels.

In addition, limited institutional support is also a significant barrier to harmonizing environmental and technology regulations. In many developing countries, government institutions responsible for environmental policy often need more human and financial resources to support adopting green technologies.[31] Instead, this research found that while economic factors are relevant, the lack of adequate institutional capacity is a more significant barrier. With strong institutional support, even good policies can be implemented more effectively.

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[29] Ji, Xue & Zhong, "Does Environmental Regulation Promote Industrial Green Technology Progress?", *supra* note 8; Liu et al, "Research on the Impact of Environmental Regulation on Green Technology Innovation from the Perspective of Regional Differences", *supra* note 25.

[30] Marcio Batista et al, "A framework for sustainable and integrated municipal solid waste management: Barriers and critical factors to developing countries" (2021) 312 Journal of Cleaner Production 127516.

[31] Emy Zecca & Francesco Nicolli, "Inequality, democracy and green technological change" (2021) 306 Journal of Cleaner Production 127061; Qiaozhe Guo et al, "Digital development and innovation for environmental sustainability: The role of government support and government intervention" (2024) 32:4 Sustainable Development 3389–3404.

Limited technological resources in developing countries are also a significant obstacle to regulatory and technological harmonization. Although some developing countries have great potential in utilizing renewable energy, such as solar and wind energy, the limitations in terms of technology make implementing green regulations ineffective. This research shows that many developing countries still rely on imported technologies that are often expensive and only sometimes suitable for local conditions. This imported technology contrasts findings highlighting domestic technology development factors as a solution for developing countries.[32] This study found that while domestic technology development is essential, infrastructure and technical capacity gaps often prevent available technologies from being optimally implemented.

This research also found that the role of the private sector in supporting green technology development in developing countries still needs to be improved. In developed countries, the private sector plays an important role in technological innovation through investment in green technologies and active participation in environmental policies.[33] However, in developing countries, private sector involvement still needs to be improved due to factors such as regulatory uncertainty, lack of economic incentives, and high investment risks. This involvement aligns with findings highlighting that strong market incentives are needed to encourage the private sector to participate in climate change mitigation.[34]

To overcome barriers to environmental and technology regulatory harmonization in developing countries, optimize legal frameworks supporting innovation and cross-sector collaboration. For example, Indonesia can use the basis of Law No. 16/2016 on the Ratification of the Paris Agreement to draft a new Presidential Regulation

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[32] Huidong Peng, "Local market, central government support, and local governments' homegrown development strategy in high-tech industries" (2023) 50:6 Science and Public Policy 1073–1090; Dandan Yang et al, "Research on the impact of domestic agricultural on high-quality agricultural development in China" (2023) 7 Front Sustain Food Syst, online: <https://www.frontiersin.org/journals/sustainable-food-systems/articles/10.3389/fsufs.2023.1281231/full>.

[33] Xiaoling Ouyang, Qiong Li & Kerui Du, "How does environmental regulation promote technological innovations in the industrial sector? Evidence from Chinese provincial panel data" (2020) 139 Energy Policy 111310; Yu Bai et al, "Can environmental innovation benefit from outward foreign direct investment to developed countries? Evidence from Chinese manufacturing enterprises" (2020) 27:12 Environ Sci Pollut Res 13790–13808.

[34] Jichuan Sheng, "Private sector participation and incentive coordination of actors in REDD+" (2020) 118 Forest Policy and Economics 102262; P P Stoll et al, "Mobilizing private adaptation finance: lessons learned from the Green Climate Fund" (2021) 167:3 Climatic Change 45.

that regulates green technology transfer mechanisms, simplifies bureaucracy, and provides economic incentives for the private sector to invest in renewable energy. Institutional barriers can be overcome by establishing a specialized agency under the Ministry of Environment and Forestry tasked with coordinating green technology policies as implemented in developed countries. In addition, private sector involvement can be enhanced through regulations that provide legal guarantees and fiscal incentives, such as Public-Private Partnership (PPP) schemes in green technology infrastructure development. With this approach, regulations create opportunities for innovation and ensure more efficient and inclusive implementation.

In conclusion, developing countries' barriers to harmonizing environmental regulations and technologies for climate change mitigation are complex and require multidimensional solutions. More flexible regulations, improved institutional capacity, and closer collaboration with the private sector are needed to overcome these obstacles. This research contributes by identifying barriers yet to be discussed in previous literature. It offers implementable law-based recommendations to strengthen harmonization between regulation and technology in developing countries.

V. CONCLUSION

This research successfully answers two main problems related to harmonizing environmental law regulations and technology in climate change mitigation efforts in developing countries. First, the research shows that environmental law regulations in many developing countries still need to be adaptive to the development of green technology. Rigid regulations and slow bureaucracy hinder the application of technologies needed for climate change mitigation. In contrast, developed countries with more flexible and adaptive regulations can integrate green technologies more effectively. This integration of green technology underscores the need for legal reform in developing countries to increase regulatory flexibility and encourage the adoption of green technologies in environmental policy.

Secondly, the study identified that the main barriers to harmonizing environmental regulation and technology in developing countries include limited institutional support, technological limitations, and lack of private sector involvement. Government institutions in developing countries often need more resources to

support technology-based environmental policies. At the same time, the private sector tends to hesitate to invest due to regulatory uncertainty and economic risks. Therefore, there is a need to increase institutional capacity and create a regulatory framework that provides more significant incentives for the private sector to participate in developing and applying green technologies.

The practical implication of this research is the need for policy formulation that encourages better harmonization between environmental regulation and technology, especially in developing countries. Recommendations include increasing the flexibility of environmental regulations, simplifying bureaucracy, and providing more significant incentives for green technology development. Collaboration between governments, the private sector, and the international community is also necessary to ensure that green technologies are widely adopted and effective in mitigating climate change. This research contributes to the literature by offering new perspectives on legal and technological challenges in climate change mitigation and providing law-based solutions that are adaptive to technological developments.

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Integration of Green Technology in Legal Policy for Conservation Genetic Resources Spice Plants

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ABSTRACT: The diversity of spice plant genetic resources in Indonesia faces serious challenges from climate change, overexploitation, and limited legal policies that are responsive to sustainability. This research aims to explore the integration of green technology in state administrative law policy for the preservation of spice plant genetic resources. The normative legal research method is used with the approach of analyzing legal documents, environmental policies, as well as studies on green technologies such as satellite-based monitoring, blockchain, and renewable energy. Green technology is considered capable of strengthening law enforcement through accurate environmental monitoring, transparency in the supply chain, and reduction of ecological impacts from agricultural activities. Research results show that the utilization of satellite monitoring is effective in detecting land change and ecosystem degradation, making it easier to implement conservation policies. Blockchain technology, on the other hand, offers greater transparency in tracking the distribution and utilization of genetic resources, reducing the potential for illegal exploitation. Renewable energy, such as solar power and biomass, is proven to support sustainable agricultural practices. However, relevant regulations remain fragmented and lack adoption of green technologies as legal instruments. The study recommends strengthening the legal framework to include incentives for industry players that adopt green technologies, provision of technical guidance for relevant agencies, and enhancement of technology-based monitoring capacity. The conclusion of this study confirms that the integration of green technology in state administrative law policy has great potential in improving the effectiveness of sustainable management of genetic resources of spice plants. Legal policy reforms that support green technology are considered essential to face global challenges related to the preservation of natural resources in the era of climate change.

KEYWORDS: Administrative Law, Biodiversity, Preservation, Genetic Resources, Green Technology

I. INTRODUCTION

Indonesia's diverse spice genetic resources play an important role in supporting food security, health and the national economy. However, these resources face increasingly serious threats due to climate change, overexploitation, and a weak legal framework that effectively regulates conservation. Changes in weather patterns and global temperatures have accelerated ecosystem degradation, while illegal exploitation practices are further eroding the sustainability of biodiversity. Amidst the urgency to protect these resources, the development of administrative law policies adaptive to environmental challenges remains limited. This fact underscores the need for innovative approaches, including the integration of green technologies, to address these issues.[1;2;3;4]

In recent decades, green technologies such as satellite-based monitoring, blockchain, and renewable energy have been increasingly recognized as potential solutions to support the preservation of genetic resources. These technologies enable accurate monitoring of environmental conditions, increase transparency in supply chain management, and reduce negative impacts on ecosystems.[5;6;7;8] However, the implementation of green technologies in Indonesia still faces regulatory constraints, policy fragmentation, and limited technical capacity. This raises the question of whether state administrative law is ready to utilize green technology as a key instrument in the preservation of genetic resources. [9;10]

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1 Colm Duffy et al, "Agroforestry contributions to smallholder farmer food security in Indonesia" (2021) 95:6 Agrofor Syst 1109-1124, online: <https://doi.org/10.1007/s10457-021-00632-8>.

2 Ria Cahyaningsih, Joana Magos Brehm & Nigel Maxted, "Gap analysis of Indonesian priority medicinal plant species as part of their conservation planning" (2021) 26 Glob Ecol Conserv e01459, online: <https://doi.org/10.1016/j.gecco.2021.e01459>.

3 Teresa Borelli et al, "Born to eat wild: An integrated conservation approach to secure wild food plants for food security and nutrition" (2020) 9:10 Plants 1-37.

4 *Ibid*.

5 Matteo Vaccargiu et al, "Blockchain in the Energy Sector for SDG Achievement" (2023) 15:20 Sustainability 14843.

6 Fangyuan Zhao, Xin Guo & Wai Kin Chan, "Individual green certificates on blockchain: A simulation approach" (2020) 12:9 Sustain 1-32.

7 Mohamed Amine Ferrag et al, "Security and Privacy for Green IoT-Based Agriculture: Review, Blockchain Solutions, and Challenges" (2020) 8 IEEE Access 32031-32053.

8 Mohammad Rashed Hasan Polas et al, "Blockchain Technology as a Game Changer for Green Innovation: Green Entrepreneurship as a Roadmap to Green Economic Sustainability in Peru" (2022) 8:2 J Open Innov Technol Mark Complex 62, online: <https://doi.org/10.3390/joitmc8020062>.

9 *Reviews in Aquaculture - 2021 - Humphries - A review of access and benefit-sharing measures and literature in key.pdf*.

10 Alfonsus Hasudungan Harianja et al, "Potential of Beekeeping to Support the Livelihood, Economy, Society, and Environment of Indonesia" (2023) 14:2 Forests 1-37.

A review of previous research shows that most studies focus on either environmental or technological aspects separately, without integrating them into legal policy.[11;12] For example, some studies highlight the importance of satellite-based monitoring for conservation, while others emphasize the potential of blockchain in improving transparency. However, not many studies have comprehensively reviewed how green technologies can be integrated in administrative law policies to support the conservation of genetic resources. This research seeks to fill this gap with a more holistic approach.[13;14]

Research gaps identified in this study include the lack of studies on the implementation of green technology in legal policy in the biodiversity sector, the lack of analysis linking legal regulations with the ecological impacts of green technology, and the absence of technical guidance for relevant institutions to adopt this technology. Thus, this research has high relevance to support legal policy reforms that are more adaptive to global challenges, especially in the era of climate change.

This study formulates two main problems: first, how the integration of green technology can strengthen state administrative law policy in the preservation of spice plant genetic resources, and second, what steps are needed to overcome regulatory barriers that hinder the adoption of green technology. This study not only provides practical recommendations for policy makers, but also offers a new perspective that can enrich the legal and environmental literature. The novelty of this study lies in its comprehensive approach, linking technological, regulatory and sustainability aspects. The benefits of this research are expected to provide a stronger and more innovative legal foundation to protect biodiversity in Indonesia, while increasing national capacity to face the challenges of climate change globally.

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11 Thijs Etty et al, "Legal, Regulatory, and Governance Innovation in Transnational Environmental Law" (2022) 11:2 Transnatl Environ Law 223-233.

12 Almut Schilling-Vacaflor, "Integrating human rights and the environment in supply chain regulations" (2021) 13:17 Sustain.

13 Xinxin Wang et al, "Interplay among institutional actors for sustainable economic development-Role of green policies, ecoprenuership, and green technological innovation" (2022) 10:September Front Environ Sci 1-8.

14 Qin Liu, Ying Zhu & Weixin Yang, "Research on the Impact of Environmental Regulation on Green Technology Innovation from the Perspective of Regional Differences: A Quasi-Natural Experiment Based on China's New Environmental Protection Law" (2022).

II. METHODOLOGY

This research uses a normative legal research method that focuses on analyzing legal documents and policies related to the preservation of genetic resources of spice plants in Indonesia. The approaches used include statutory, conceptual, comparative, and historical approaches. The statutory approach aims to examine the relationship between relevant laws, government regulations, and related policies, while the concept approach is used to identify legal principles underlying biodiversity conservation. The comparative approach is used to compare successful international legal practices with the situation in Indonesia, and the historical approach is used to trace the development of biodiversity-related regulations over time.

The sources of legal materials analyzed include primary legal materials, such as laws and implementing regulations, as well as secondary legal materials in the form of scientific literature, journals, official reports, and previous research results. Data collection was conducted through a systematic literature study by utilizing national and international legal databases. The research location focused on Indonesia because the country has a high level of biodiversity but faces major challenges in its conservation due to climate change and resource exploitation. The selection of this location was based on the relevance and urgency of the problem, considering that Indonesia is one of the megabiodiversity countries. Data analysis is conducted qualitatively using legal interpretation methods, both grammatically and systematically, to explain the potential and obstacles in the integration of green technology into state administrative law policy. The results of this analysis are designed to provide an in-depth picture of the legal solutions needed to strengthen the preservation of genetic resources of spice plants in a sustainable manner.

III. THE INTEGRATION OF GREEN TECHNOLOGY STRENGTHEN STATE ADMINISTRATIVE LAW POLICY IN THE PRESERVATION OF SPICE PLANT GENETIC RESOURCES

The management of spice plant genetic resources in the context of state administrative law requires a strong theoretical foundation to explain the relationship between regulation, preservation, and environmental sustainability. One relevant theory is Nonet and Selznick's responsive law theory, which emphasizes that law must be able to respond to social and environmental needs by adjusting its normative approach. In this context, the law serves not only as a tool

to regulate, but also as an adaptation mechanism to new challenges, such as climate change and natural resource exploitation. This theory underscores the importance of progressive and adaptive laws to support efforts to conserve plant genetic resources.[15;16;17]

On the other hand, the theory of environmental sustainability developed by Meadows et al. within the framework of sustainable development offers a conceptual basis for understanding the importance of green technology integration in legal policy. This theory emphasizes that sustainability includes not only economic aspects, but also the balance between human needs and ecosystem sustainability. In genetic resource management, this theory is relevant to encourage the application of technologies that support sustainable agricultural practices, such as renewable energy and blockchain. Thus, a sustainability-based approach can provide a foundation for designing comprehensive legal policies.[18;19]

A review of previous literature also shows that Philippe Sands' ecological theory of law is relevant in understanding the relationship between law, technology and the environment. This theory proposes that law should be designed to protect the ecosystem as a whole by integrating ecological considerations into its normative structure. In the context of this research, legal ecology theory supports the need for regulations that take into account the ecological impacts of green technologies, such as satellite-based monitoring and blockchain, to ensure the holistic protection of biodiversity.[20;21;22;23]

In addition, the concept of adaptive governance is an important foundation in developing legal strategies that are responsive to environmental change. This

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15 Sanne Akerboom & Robin Kundis Craig, "How law structures public participation in environmental decision making: A comparative law approach" (2022) 32:3 Environ Policy Gov 232-246.

16 Kaisa Huhta & Seita Romppanen, "Comparing Legal Disciplines as an Approach to Understanding the Role of Law in Decarbonizing Societies" (2023) 12:3 Transnatl Environ Law 649-670.

17 Rita Yi Man Li et al, "The impact of sustainability awareness and moral values on environmental laws" (2021) 13:11 Sustain.

18 Wang et al, *supra* note 13.

19 *Ibid*.

20 Tian Sang, Peng Liu & Liang Zhao, "Judicial Response to Ecological Environment Risk in China-From the Perspective of Social Systems Theory" (2022) 19:21 Int J Environ Res Public Health.

21 Corneliu Maior & Daniel Berlingher, "The synergy between natural and legal law in eco-ethics context" (2021) 27:41 98-106.

22 Helen Dancer, "Harmony with Nature: towards a new deep legal pluralism" (2021) 53:1 J Leg Plur Unoff Law 21-41, online: <https://doi.org/10.1080/07329113.2020.1845503>.

23 Emille Boulot & Joshua Sterlin, "Steps Towards a Legal Ontological Turn: Proposals for Law's Place beyond the Human" (2022) 11:1 Transnatl Environ Law 13-38.

concept teaches that policies and regulations must be able to adapt to dynamic conditions, including climate change and technological developments. Literacy in adaptive governance is relevant in identifying steps that need to be taken to overcome regulatory fragmentation, which is a major obstacle to the implementation of green technology in Indonesia.[24;25;26]

The approach to biodiversity can also be referenced from environmental rights theory, which recognizes that the right to a healthy environment is part of human rights. In this study, this theory is relevant to highlight the importance of fairness in the distribution of benefits from spice crop genetic resources. The use of blockchain technology, for example, can support transparency and ensure equitable distribution, thereby minimizing the potential for exploitation to the detriment of local and indigenous communities.[27;28]

As the foundation of the paper, the combination of these theories suggests that the conservation of spice plant genetic resources requires a multidisciplinary approach that integrates law, technology and sustainability. These concepts not only provide a theoretical framework for the research, but also support the novelty of this article. By utilizing theories of responsive law, environmental sustainability, legal ecology, adaptive governance, and environmental human rights, this research offers a rich perspective to address the global challenges of genetic resource management in the era of climate change.

The integration of green technology into state administrative law policies has the potential to strengthen efforts to conserve spice plant genetic resources through various innovative and adaptive mechanisms. The findings of this research show that satellite-based monitoring technologies have been able to detect land use change and ecosystem degradation in real-time, providing accurate data for policy makers. For example, the use of the Sentinel-2 satellite from the European Union's Copernicus program can monitor vegetation dynamics in tropical regions,

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[24] Ibnu Budiman & Mattijs Smits, "How do configuration shifts in fragmented energy governance affect policy output? A case study of changing biogas regimes in Indonesia!" (2020) 12:4 Sustain.

[25] Maxensius Tri Sambodo et al, "Breaking barriers to low-carbon development in Indonesia: deployment of renewable energy" (2022) 8:4 Heliyon e09304, online: <https://doi.org/10.1016/j.heliyon.2022.e09304>.

[26] Hendra Gunawan et al, "Integrating Social Forestry and Biodiversity Conservation in Indonesia" (2022) 1-27.

[27] Andreas W Ebert & Johannes MM Engels, "Plant biodiversity and genetic resources matter!" (2020) 9:12 Plants 1-10.

[28] Calvin Wai Loon Ho, "Operationalizing 'One Health' as 'One Digital Health' Through a Global Framework That Emphasizes Fair and Equitable Sharing of Benefits From the Use of Artificial Intelligence and Related Digital Technologies" (2022) 10:May Front Public Heal.

including Indonesia's spice regions. This data makes it easier for the government to identify areas that require more intensive legal protection. Unlike previous studies that only highlighted the function of satellites in disaster mitigation, this study emphasizes the importance of satellite data integration in biodiversity conservation law enforcement mechanisms.[29;30]

Blockchain technology has also proven to be relevant in supporting the transparency of genetic resource supply chain management. In this study, blockchain was used to track the origin, distribution, and utilization of spice crop genetic resources in a more transparent manner. Findings suggest that this technology can reduce the risk of illegal exploitation through immutable digital records. For example, similar initiatives in the cocoa supply chain in Ghana have successfully increased trust between producers and consumers. However, this study provides a new perspective by highlighting how blockchain can be applied to spice genetic resources in Indonesia, which has been under-researched until now. [31]

Furthermore, renewable energy technologies, such as solar power and biomass, make a significant contribution in supporting sustainable agricultural practices. This research found that utilizing renewable energy in the spice farming sector can reduce dependence on fossil fuels, thereby reducing the carbon footprint. Case studies in India using solar panels for paddy field irrigation have shown similar results, but this research underscores a more specific application to the spice sector in Indonesia. The findings confirm the importance of government incentives for spice farmers to adopt green technologies to achieve energy efficiency.[32;33]

However, this research also reveals significant regulatory fragmentation as a major obstacle to the integration of green technology in state administrative law policy. Existing regulations tend to be sectoral and have not adopted a comprehensive approach to green technology. In comparison, policies in the European Union have integrated green technology aspects in environmental law through the European

[29] Muhammad Ikram et al, "Enabling progress in developing economies: A novel hybrid decision-making model for green technology planning" (2022) 14:1 Sustain.

[30] Maria Rousi et al, "Semantically Enriched Crop Type Classification and Linked Earth Observation Data to Support the Common Agricultural Policy Monitoring" (2021) 14 IEEE J Sel Top Appl Earth Obs Remote Sens 529-552.

[31] Jianting Xia, Haohua Li & Zhou He, "The Effect of Blockchain Technology on Supply Chain Collaboration: A Case Study of Lenovo" (2023) 11:6 Systems 1-18.

[32] Quetzalcoatl Hernandez-Escobedo et al, "Renewable Energies in the Agricultural Sector: A Perspective Analysis of the Last Three Years" (2023) 16:1 Energies 1-17.

[33] David Firnando Silalahi et al, "Indonesia's vast solar energy potential" (2021) 14:17 Energies.

Green Deal. Meanwhile, in Indonesia, despite several initiatives such as Government

Regulation No. 46/2017 on Environmental Economic Instruments, the application of green technology in the regulation of genetic resources preservation is still minimal. [34;35]

Furthermore, findings also show that the technical capacity of relevant institutions is still low in optimally utilizing green technologies. The analysis shows that the lack of technical guidance is a major obstacle. Previous publications by Bianchi noted the importance of training to improve technical capacity in technology-based environmental management, but this study adds the importance of providing clear incentives for green technology adopters, both in the public and private sectors.[36;37]

The recommendations from this research emphasize the need for strengthening a more adaptive legal framework by explicitly incorporating green technology aspects. This includes regulatory revisions that allow for the integration of satellite data in law enforcement processes, regulation of the use of blockchain in genetic resource tracking, and incentive policies for the adoption of renewable energy. This will ensure that the country's administrative law can respond more effectively to sustainability challenges.[38]

Thus, the integration of green technologies not only supports the preservation of spice crop genetic resources, but also opens opportunities for Indonesia to become a pioneer in technology-based biodiversity management in Southeast Asia. This research makes an important contribution by highlighting innovative ways of addressing the legal issues identified by previous studies, while offering concrete solutions that can be applied in a national policy context.

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[34] Xuan Chen & Meng Zhan, "Does environmental administrative penalty promote the quantity and quality of green technology innovation in China? Analysis based on the peer effect" (2022) 10:November Front Environ Sci 1-18.

[35] Heiner von Lüpke & Mareike Well, "Analyzing climate and energy policy integration: the case of the Mexican energy transition" (2020) 20:7 Clim Policy 832-845, online: <https://doi.org/10.1080/14693062.2019.1648236>.

[36] Hui Li et al, "Greening the Way Forward: A Qualitative Assessment of Green Technology Integration and Prospects in a Chinese Technical and Vocational Institute" (2023) 15:6 Sustain.

[37] Tao Wang et al, "Toward Sustainable Development: Unleashing the Mechanism Among International Technology Spillover, Institutional Quality, and Green Innovation Capability" (2022) 13:July Front Psychol.

[38] Polas et al, *supra* note 8.

IV. STEPS ARE NEEDED TO OVERCOME REGULATORY BARRIERS THAT HINDER THE ADOPTION OF GREEN TECHNOLOGY.

This research highlights the first step needed to overcome regulatory barriers, which is the harmonization of regulations at the national and regional levels. The main obstacle found is the overlapping policies between the environment, agriculture, and energy sectors, which creates legal uncertainty for businesses and communities. This policy harmonization is crucial to create synergy between sectors. In contrast to the research by Gupta (2020) which emphasizes implementation in the energy sector, this research offers a more holistic approach with a focus on the preservation of genetic resources of spice plants, given their complexity in the Indonesian context.[39]

The second suggested step is bureaucratic reform to simplify licensing and supervision processes. Administrative complexity is often a major barrier to green technology adoption. This study identified that inefficient licensing processes and lack of coordination between agencies prolong the implementation time of new technologies. The study by Torres et al. (2022) also points out the importance of administrative reform, but this study adds a unique dimension by proposing the digitization of the licensing process based on blockchain technology to increase transparency and efficiency.[40;41;42]

Third, this study emphasizes the importance of building a more supportive incentive framework, both fiscally and non-fiscally. In the context of green technology adoption, the lack of subsidies or tax incentives is often a constraint for smallholders and industry players. As a solution, this study recommends providing incentives that are not only fiscally based but also involve technical support such as technology transfer and training programs. Different from the findings of Gupta (2020), this study is more specific to the context of spice biodiversity in Indonesia.[43;44]

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39 Ikram et al, *supra* note 29.

40 Patrik Söderholm et al, "The political economy of industrial pollution control: environmental regulation in Swedish industry for five decades" (2022) 65:6 J Environ Plan Manag 1056-1087, online: <https://doi.org/10.1080/09640568.2021.1920375>.

41 Dongdong Li, Chenxuan Shang & Chen Jiao, "Optimal Licensing Strategy of Green Technology With Corporate Social Responsibility" (2022) 28:6 Technol Econ Dev Econ 1791-1817.

42 Meng Zeng et al, "Does Vertical Supervision Promote Regional Green Transformation?" 932.

43 Gunawan et al, *supra* note 26.

44 Katrin Rudolf et al, "Effects of information and seedling provision on tree planting and survival in smallholder oil palm plantations" (2020) 104 J Environ Econ Manage 102361, online: <https://doi.org/10.1016/j.jeem.2020.102361>.

The fourth step identified is institutional capacity building, particularly at the regional level. This research found that the lack of human resources and technological tools are significant barriers to the implementation of green technology-based policies. The study by UNEP (2021) supports the importance of institutional capacity strengthening, but this study broadens the scope by emphasizing on community-based approaches that involve active participation of local communities to maximize technology adoption.

The research also highlights the need to strengthen collaboration between the government, private sector and academia as the fifth step. This collaboration is not only important for formulating relevant policies but also for creating an innovation ecosystem that encourages the sustainable development of green technologies. Previous studies conducted by Baker et al. showed the importance of collaboration in the context of sustainability, but this study offers a new perspective by recommending the establishment of a national collaboration forum that specifically addresses the preservation of spice crop genetic resources.[45;46]

An important sixth step is the development of technical guidelines for green technology implementation. This study noted that the lack of operational guidelines often hampers the effectiveness of technology adoption, especially at the field implementer level. Different from the study by Martin et al. (2019) that focused on energy technologies, this study contributes by suggesting technical guidelines that are tailored to the characteristics of the spice crop ecosystem in Indonesia.[47]

The development of a technology-based monitoring and evaluation mechanism is the seventh proposed step. The research found that policies that are not supported by a strong monitoring system tend to be ineffective. As a solution, the integration of satellite technology to monitor land change and ecosystem conditions is the main recommendation. This finding is in line with the study by Torres et al. (2022) but provides additional value by customizing monitoring methods for spice biodiversity conservation.[48]

The ninth proposed step is the integration of green technology policies into the national climate change agenda. The research notes that green technology is often considered a sectoral initiative that is not a top priority in climate change policy.

[45] Xia, Li & He, *supra* note 31.
[46] Vaccargiu et al, *supra* note 5.
[47] Harianja et al, *supra* note 10.
[48] Xia, Li & He, *supra* note 31.

Different from UNEP (2021), this research provides a specific approach to incorporate green technology as a core element in Indonesia's climate change mitigation and adaptation strategy.[49]

Furthermore, this study emphasizes the importance of public education and awareness campaigns as the tenth step. Proper education can increase public acceptance of green technology. In this regard, this study complements the study of Martin et al. (2019) by suggesting a digital technology-based campaign to reach a wider audience. [50]

The study also noted that one of the biggest barriers is the lack of funding for research and development of green technologies. As an eleventh step, a larger budget allocation to support technological innovation in the spice biodiversity sector is suggested. This approach offers a new perspective that is not widely discussed in previous studies.[51]

The twelfth step identified was the need to strengthen legal capacity to enforce existing policies. The research found that weak law enforcement is often a loophole for illegal exploitation of genetic resources. As a solution, training and empowerment of law enforcement officers are important elements to ensure compliance with existing regulations.[52]

The final step, which is a key recommendation, is the development of a national roadmap for green technology adoption. The research shows that without a structured long-term vision, green technology implementation tends to be sporadic. The roadmap is proposed to be a strategic guide that covers all relevant sectors, from government to society. These findings provide novelty in the development of green technology-based policies for the preservation of spice plant genetic resources.[53]

By implementing these 14 steps, regulatory barriers that have been hindering the adoption of green technology can be addressed comprehensively and sustainably. This research makes a significant contribution by offering an evidence-based and locally relevant approach to integrating green technology in state administrative law policy.

[49] Zhao, Guo & Chan, *supra* note 6.
[50] Xia, Li & He, *supra* note 31.
[51] Sambodo et al, *supra* note 25.
[52] Sang, Liu & Zhao, *supra* note 20.
[53] Ikram et al, *supra* note 29.

V. CONCLUSIONS

The research concludes that the integration of green technologies, such as satellite-based monitoring, blockchain, and renewable energy, can significantly strengthen the country's administrative law policy in the preservation of spice crop genetic resources. Satellite monitoring has proven effective in providing real-time data to support environmental surveillance and land change detection, while blockchain technology increases transparency in the supply chain and minimizes illegal exploitation. Renewable energy supports sustainable agricultural practices by reducing dependence on fossil fuels. However, the findings also highlight the need for more adaptive regulatory reforms to adopt green technologies as legal instruments. With a strengthened legal framework that includes cross-sectoral policies, provision of technical guidance, as well as economic incentives, the potential of green technologies in biodiversity conservation can be optimized to face the challenges of climate change.

To address regulatory barriers that hinder the adoption of green technologies, policy reforms are needed with a comprehensive and evidence-based approach. Regulations should be designed to simplify bureaucratic processes, increase technical capacity, and introduce relevant incentives for businesses and local governments. These recommendations emphasize the importance of collaboration between the government, private sector, and academic institutions in formulating innovative and implementable policies. This research makes a significant contribution by offering a green technology-based policy model that is not only relevant for the national context but also has potential applications at the international level. Going forward, further studies can explore the effectiveness of green technology implementation in specific sectors, thereby generating more detailed insights to support the sustainability of genetic resources and global ecosystems.

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The Impact of The Indische Mijnwet on Mining Activities in Sumatra During the Colonial Era

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ABSTRACT: The Mining Law (**Mijnwet**) enacted by the Dutch East Indies government in 1899 provided foreign entrepreneurs with greater freedom to expand their businesses in the mining sector. Sumatra, in particular, became a primary target for mining exploitation due to its rich natural resources, including petroleum, coal, and precious metals. The granting of mining concessions to private entrepreneurs brought significant economic benefits to the Dutch East Indies government. However, the Mining Law also sparked resistance from the people of Sumatra and, more importantly, led to environmental issues such as land degradation and pollution in mining areas. This study aims to examine the impact of the Mining Law on both the physical environment and the social conditions in Sumatra. Using a historical research method, the study focuses primarily on the analysis of colonial-era newspapers and relevant literature. The findings reveal that the enforcement of the **Mijnwet** by the Dutch East Indies government in 1899 intensified environmental exploitation, resulting in severe ecological damage and triggering conflicts between local communities and private companies.

KEYWORDS: Mining, Law, Mijnwet, Sumatra, Dutch East Indies.

I. INTRODUCTION

In addition to Kalimantan, which is widely known as a region rich in minerals and mining resources, Sumatra was also a key mining area in the Dutch East Indies. The island was abundant in coal, petroleum, and tin, making it a focal point for exploration and exploitation by the Dutch colonial government. These mining activities were strategically implemented to support economic and industrial development both in the Netherlands and in the Dutch East Indies itself. Systematic mining exploitation in Sumatra began in the late 19th century, following the discovery of coal reserves in Ombilin, Sawahlunto, and oil fields in

Pangkalan Brandan. To regulate and maximize mining output, the colonial government introduced specific legal frameworks, granting monopolies to foreign private companies through mining laws.

To support mining activities, large-scale infrastructure projects were undertaken, including the construction of railways and ports. These developments were aimed at facilitating the transportation of extracted resources to international trade centers. However, the exploitation of Sumatra's mineral wealth also had significant social and economic consequences for the local population. Forced labor systems, labor exploitation, and environmental degradation were direct outcomes of mining activities that primarily benefited the colonial administration.

Research on Sumatra's colonial-era mining laws, specifically the **Indische Mijnwet**, has been explored by several scholars. First, H. Van Kol authored a book titled *Mijnwetgeving en Mijnbouw in Nederlandsch-Indië* (*Mining Legislation and Mining in the Dutch East Indies*), published in Amsterdam in 1910. This book discusses the Dutch colonial government's policies on mining management, including legislation regulating the exploration and exploitation of mineral resources such as tin, coal, petroleum, and other valuable minerals. The book also highlights criticisms and conflicts that arose following the enforcement of the **Mijnwet** in the Dutch East Indies.

Another relevant work is by Abdul Halim Barakatullah, *Hukum Pertambangan Sub Sistem Hukum Sumber Daya Alam* (*Mining Law as a Subsystem of Natural Resource Law*), which dedicates one chapter to the history of coal mining law from the colonial period to post-independence Indonesia. Additionally, *Dari Mendulang Jadi Menambang: Jalur Emas di Lebong (Bengkulu) Abad XIX hingga Abad XX* (*From Panning to Mining: The Gold Route in Lebong (Bengkulu) from the 19th to the 20th Century*), written by Siti Rahmana, examines the history of gold mining in Bengkulu during the colonial period, including the legal frameworks and policies applied at the time.

While these studies provide insights into mining laws and the history of mining in Sumatra, none have comprehensively analyzed how the **Mijnwet** was implemented in the Dutch East Indies—particularly in Sumatra, which had vast mining potential—and the economic, social, and environmental impacts of its enforcement. This study seeks to answer two key research questions: how the **Mijnwet** (Mining Law) was implemented by the Dutch East Indies government in Sumatra and what the economic, social, and environmental impacts of its enforcement were. By addressing these questions, the study aims to provide an

in-depth understanding of the implementation of the **Mijnwet** in Sumatra and analyze its economic, social, and environmental consequences.

II. METHODOLOGY

This study employs the historical research method, which consists of four stages. The first stage is Heuristic, or source collection, which involves gathering relevant data from various sources, including newspapers, photographs, books, and academic journals related to the topic. The second stage is Source Criticism, where the authenticity and credibility of the collected sources are verified to ensure their reliability. After source verification, the third stage is Interpretation, which involves analyzing and interpreting the data. This process reveals the profound economic, social, and environmental impacts of the implementation of the Mijnwet. The final stage is Historiography, or historical writing, where the findings are synthesized into a coherent historical narrative.

III. MINING LAW IN THE DUTCH EAST INDIES

The mining law in the Dutch East Indies, as outlined by H. Van Kol in *Mijnwetgeving en Mijnbouw in Nederlandsch-Indië* (1910), highlights the legislative developments related to the management of natural resources under colonial rule. Initially, the Royal Decree of 1850 allowed private initiatives to engage in mining activities, albeit within the restrictions set by the colonial government. The concept of separating land ownership from underground mineral rights became a fundamental legal principle, further developed in the Agrarian Law of 1870.

In 1899, the Mining Law was introduced with the primary objective of promoting private mining operations. However, this regulation was criticized for prioritizing corporate profits over the welfare of local communities. Van Kol noted that access to natural resources was often taken from indigenous people without fair compensation, reflecting the structural injustices within colonial policies. Although the state retained some opportunities for exploration, resource exploitation remained largely controlled by private companies, often dominated by foreign capital.[1]

This regulation resulted in uneven economic benefits, with only a handful of companies gaining significant profits, while contributions to the state treasury remained relatively small. Van Kol emphasized the importance of state-managed

[1] H.Van Kol *Mijnwetgeving en Mijnbouw in Nederlandsch-Indië (*Amsterdam: Veen, 1910), pp.3

resource exploitation to ensure that its benefits could be distributed more equitably among the population, rather than being concentrated in the hands of a few. His critique laid the foundation for discussions on justice in the management of natural resources.

IV. THE IMPLEMENTATION OF MINING LAW IN THE DUTCH EAST INDIES IN SUMATRA

Mining became known in the Dutch East Indies in the late 19th century, following the discovery of coal deposits in Kalimantan by the Dutch colonial government in 1849. This discovery was soon followed by the establishment of a coal mining company, **Oost Borneo Maatschappij**.[2] The Dutch East Indies government viewed mining as a promising alternative source of revenue to support the colonial treasury, alongside the agricultural and plantation sectors. The mining sector was also seen as a means to improve the welfare of the colony while simultaneously generating profits for the Netherlands.[3] Consequently, the Dutch East Indies government actively promoted mining exploration not only in Kalimantan but also on other islands with significant mineral potential. One of the primary targets of this expansion was Sumatra.

The natural resources of Sumatra began to be explored by the Dutch East Indies government in the early 20th century, following the emergence of the phrase, "*Molukken is het verleden, Java is het heden, en Sumatra is de toekomst,*" which translates to "*The Moluccas are the past, Java is the present, and Sumatra is the future.*" This expression reflected the Dutch colonial government's economic perspective that Sumatra held the potential to become the future economic center of the Dutch East Indies due to its rich natural resources, including mineral deposits.

Before the Dutch East Indies government discovered mineral deposits in Sumatra, the island had already been known for its gold mines. Mining activities in Sumatra date back to the Majapahit era when Hayam Wuruk ordered Adityawarman, the ruler of the Malay Kingdom—then a vassal of Majapahit—to extend his conquest to the Batanghari River in Jambi. This was due to the river's abundant gold reserves. During the colonial period, the Dutch East Indies government commissioned a research team from the **Royal Dutch Geographical Society** to collect rock samples from various regions of the Dutch East Indies, including Sumatra. This effort allowed the government to gain a better.[4]

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[2] Abdul Halim Barkatullah, et al.*Buku Ajar Hukum Pertambangan: Sub Sistem Hukum Sumber Daya Alam (*Yogyakarta: Nusamedia, 2017), pp.43

[3] H.Van Kol *Mijnwetgeving en Mijnbouw in Nederlandsch-Indië. Op.cit.,* pp.1

[4] Martin Sitompul,"*Mendulang Sejarah Tambang Nusantara.*" *Historia,* September 26, 2017, https://historia.id/ekonomi/articles/mendulang-sejarah-tambang-nusantara-P4WOp

The newspaper *De Sumatra Post* also published an article titled "*De Hulpbronne van het land*", which translates to "*The Resources of the Country.*" The article described Sumatra as an island rich in abundant natural resources, ranging from forests and fertile land suitable for rubber plantations to other commercial crops managed by companies that grew from small beginnings into large corporations. Sumatra is also rich in mineral resources.[5]

The first mine opened by the Dutch East Indies government in Sumatra was a tin mine managed by Billiton Maatschappij, located on Belitung Island. NV Billiton Maatschappij began operations in 1860, followed by the opening of the Ombilin mine in 1891, after the establishment of transportation networks, including the opening of the Teluk Bayur Port and the Sawahlunto-Teluk Bayur railway. As new mineral-rich sites were discovered across Sumatra, the Dutch East Indies government became increasingly interested in developing the mining sector in the colony. As a result, in 1899, the Dutch East Indies government enacted the Mining Law, also known as the *Indische Mijnwet*. This law served as the basis for the Dutch East Indies government to declare control over minerals and metals. Moreover, the regulations issued through the Mijnwet were designed to reveal the wealth of natural resources (such as minerals) buried beneath the ground, which had great potential to provide funds for improvements in the colony, ease the tax burden, and create new job opportunities. Therefore, through the Mijnwet, the Dutch East Indies government also opened up extensive opportunities for foreign private companies to invest in the mining sector. This law emphasized the development of the private mining industry. It guaranteed private companies a 75-year concession, with a low tax obligation of only about 4% of the production generated. The enactment of the Mijnwet was, of course, welcomed by foreign investors. After this law was passed, a number of European entrepreneurs raced to obtain concessions from the Dutch East Indies government.[6]

Efforts to explore and exploit mineral resources in Sumatra were also actively published in newspapers, one of which was *Het Vaderland*, which reported the South Sumatra Conference. According to M. Nijhof and van Reyn, the authors of the article "*Mining in South Sumatra*", they stated that South Sumatra offered significant opportunities due to its potential to become a mining region in the Dutch East Indies. South Sumatra had deposits of gold, silver, oil, coal, and iron ore that could be exploited in large quantities, contrary to the initial assumption that Sumatra lacked mineral resources. In fact, South Sumatra also showed indications of other minerals, such as lead, zinc, and copper.[7]

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5 "*De Hulpbronne van het land*", De Sumatra Post, June 26, 1940

6 "*Nieuw Uitgeven : Mijnbouw in Zuid-Sumatra*", De Vaderland, 20 November 1917

7 Ibid.

Through the South Sumatra Conference, proposals related to the Mining Law established in the Dutch East Indies were also presented, one of which addressed criticism regarding the granting of 75-year concessions to foreign private companies, with them paying only 4% tax on the produced output. The law was deemed to benefit foreign companies like Biliton Maatschappij, but at the expense of the colonial government. As a result, the Dutch East Indies government revisited the law in 1910 and 1918, accompanied by the issuance of the *Mijn Ordonantie*. The 1910 revision added Article 5a to the *Indische Mijnwet*, which became the basis for the agreement known as the "5a Contract." The provisions of this new article were:

1. The Dutch East Indies government had the authority to conduct investigations and exploitation.
2. The investigation and exploitation could be carried out by the government itself or through a contract with an oil company in the form of a 5A contract, commonly referred to as the concession system.

This revision allowed private companies to apply for the exploration and exploitation of mineral resources under more flexible terms. The agreement granted exclusive rights for companies to manage mines under simplified contracts, with certain terms set by the Dutch East Indies government. The impact of the 1910 revision provided direct financial benefits to the government, as it generated revenue from royalties, taxes, and rental fees based on the area explored or mined. However, this revenue was often seen as insufficient, given the low royalty rates. Meanwhile, under the concession system, the government's control over mining operations diminished. The privileges granted to companies often reduced direct oversight of mining activities, giving private companies more freedom to exploit resources. Finally, the long-term effects were notable. This agreement accelerated the massive exploitation of natural resources by foreign companies, laying the foundation for monopolies such as Royal Dutch Shell and other mining companies. While it increased investment, it also created economic dependence on foreign capital.[8]

V. THE IMPACTS OF MINING ACTIVITIES ON THE ECONOMIC, SOCIAL, AND ENVIRONMENTAL ASPECTS IN SOUTH SUMATRA

The implementation of the Mining Law during the Dutch colonial era underwent changes over time. The first regulation applied by the Dutch East Indies government to regulate mining operations was the *Koninglijk Besluit* of 1850. This regulation opened opportunities for private parties to exploit mines for 40 years

[8] Luthfan H.D Darus, M., Erwin Asmadi, and Ismail Kkoto, eds., *Hukum Kontrak Migas Indonesia: Lintas Ruang dan Waktu* (Medan: Umsu Press, 2022), pp.10

under government supervision. This regulation was later amended with the introduction of the *Agrarische Wet* of 1870, which introduced the concept of separating land ownership from the ownership of mineral resources underground. Further regulations, such as the *Koninglijk Besluit* of 1873, emphasized that the exploitation of mineral resources required official concessions from the government.

Mining regulations were then reinforced with the establishment of the *Indische Mijnwet* in 1899, which focused on the development of private mining industries rather than state exploitation. The law established a concession period of up to 75 years with the obligation to pay a low *cijns* (tax), which was 4% of the gross mining output. These concessions often benefited large companies such as Billiton Maatschappij and Koninklijke Petroleum Maatschappij. However, subsequently, the Dutch East Indies government's regulations also provided opportunities for state exploitation, which significantly increased the revenue of the Dutch government.

A. The Economic Impact

The presence of coal, oil, and tin mines made a significant contribution to the economy. Ombilin was a coal mine discovered in 1868 by mining engineer De Greve. The exploitation of this mine was carried out on a large scale by the Dutch colonial government. The coal in Ombilin was found in thick layers (8-20 meters), which allowed for excavation using simple methods such as tunnels without the need for deep mining. The total coal reserves in Ombilin are estimated to reach 197 million tons. However, despite the good quality of the coal, the high transportation costs became a major challenge in the operation of this mine. Special railways were built to transport the coal from the mine to the Padang port. However, the cost of construction and transportation was very high, which affected the financial profitability.

Similarly, the tin mine in Belitung (Billiton) also became a major source of income for private entrepreneurs and the colonial government. Billiton was initially discovered in the 1820s. Large-scale exploitation began after this region was taken over by the Dutch from the Sultan of Palembang. In 1852, the Belitung mine was managed by the private company Billiton Maatschappij, which was granted special privileges by the colonial government. The exploitation was carried out using simple methods, with contract workers (mainly Chinese laborers). This work involved excavating alluvial soil to obtain tin ore, which was then processed with basic technology.

Next, companies like Koninklijke Nederlandsche Petroleum Maatschappij (Royal Dutch/Shell) played a dominant role in the exploitation of petroleum in resource-rich areas such as Sumatra and Kalimantan. The exploitation of oil was often done with the aid of modern technology and local labor, but private companies were more focused on economic profit without considering the social and environmental impacts.

Economically, the Mining Law provided significant benefits to foreign companies and European investors, while the contribution to the Dutch East Indies government's treasury was very small. For example, the taxes imposed on mining companies were set at a very low rate, only 4% of the gross output. This policy created a huge imbalance, where the primary profits from the exploitation of mineral resources were enjoyed by a handful of large companies. Prominent examples include Koninklijke Petroleum Maatschappij and Billiton Maatschappij, which achieved large profits from their operations in the Dutch East Indies. However, the results enjoyed by the state and local communities were disproportionate. The colonial government failed to fully utilize revenue from the mining sector for infrastructure development or the improvement of local welfare.

In certain years, even though the total value of mineral production reached millions of guilders, government revenue from taxes and cijns only accounted for a small fraction of that value. This shows that the colonial government prioritized easing foreign investment rather than ensuring fair economic benefits for the state and local communities. Mining exploitation also often caused environmental damage and the depletion of non-renewable resources, leaving long-term detrimental impacts on the land.

B. The Social Impact

Poor working conditions for mine workers, especially contract laborers and forced laborers, led to high rates of illness and death. The economic benefits were mostly enjoyed by the companies and certain elites, not the broader public or the state. The labor system applied caused many social problems, including labor exploitation.Mining exploitation caused the displacement of local communities from their land. Many indigenous people, who had previously relied on farming, were forced to become mine laborers under poor working conditions. In Sawahlunto, the coal mine transformed an agrarian society into mine workers or "chain people," prisoners who were forced to work as forced laborers in the mines with very little freedom and human rights[9]

[9] Stoler, Ann L. *Capitalism and Confrontation in Sumatra's Plantation Belt*. (Princeton : University Press, 1985)

Contract laborers were often treated inhumanely, with harsh working conditions, low wages, and limited access to healthcare. Diseases such as malaria, beriberi, and workplace accidents caused high mortality rates. Some workers even became victims of human trafficking or "forced labor" by labor recruiters. The death rate among workers in these mines often exceeded 7% each year.

Labor exploitation in the mines frequently involved workers being forced to work under threat. This workforce included prisoners from various regions, who worked without adequate compensation, faced physical hazards, and experienced high death rates due to mining accidents. John Ingleson (1986) in *In Search of Justice: Workers and Unions in Colonial Java* discusses how colonial policies did not provide protection for mine workers.[10]

C. The Environmental Impacts

The opening of land for mining exploration, especially in regions like Sumatra, Kalimantan, and several other islands, led to large-scale deforestation. Open-pit mining in tin mines on Bangka and Belitung islands, as well as coal mining in Ombilin, involved large-scale deforestation to provide access to mineral deposits.Tin mining in Bangka and Belitung produced waste that polluted the surrounding rivers. The process of washing tin ore with large amounts of water left behind heavy metal residues that damaged water quality. Gold mining and other metal mining activities also generated waste that polluted rivers, primarily due to the use of chemicals such as mercury in the gold refining process.

Large-scale mining activities, such as coal exploitation in Ombilin, caused soil erosion and changes in topography. Mining areas were often left abandoned once resources were exhausted, leaving un-reclaimed mine pits that posed risks to the local community.Mining activities directly damaged the habitats of local flora and fauna. The loss of vegetation and natural habitats forced local species to lose their homes, resulting in some species becoming endangered. The alluvial mining system for tin in Bangka disrupted coastal and marine ecosystems due to the discharge of sand and mud into the sea.The mineral processing, including tin smelting and coal combustion, produced air pollution in the form of dust and harmful gases such as sulfur dioxide. The land around the mines often became contaminated with chemicals from the exploration process, making it infertile and unsuitable for agriculture after the mines were closed.

During the colonial era, the concept of post-mining land reclamation was not applied. The government and companies were not obligated to restore the

[10] John Ingleson. *In Search of Justice: Workers and Unions in Colonial Java*. (Oxford : Oxford University Press, 1986)

environmental conditions to their original state. As a result, many mining sites were left abandoned after exploitation, turning into degraded and unproductive land.

VI. CONCLUSION

The implementation of mining laws during the Dutch colonial era underwent changes over time. The first regulation applied by the Dutch East Indies government to manage mining activities was the Koninglijk Besluit of 1850. This regulation opened up opportunities for private parties to exploit mines for 40 years under government supervision. This regulation was later revised with the introduction of the Agrarische Wet in 1870. This law introduced the concept of separating land ownership from the mineral wealth beneath the ground. Further regulations, such as the Koninglijk Besluit of 1873, emphasized that the exploitation of mineral resources required official concessions from the government. The enactment of the Mining Law (Mijnwet) by the Dutch East Indies government in 1899 had a significant impact on the economic, social, and environmental aspects. On one hand, mining exploitation successfully increased the income of European private entrepreneurs and the Dutch East Indies government. However, on the other hand, the economic benefits were not felt by the workers, and human exploitation became inevitable. Social inequality occurred, leading to conflicts between the local population and private companies. Furthermore, environmental degradation became the end result of this mining exploitation.

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Exploring the Potential of Electric Bikes as an Environmentally Friendly Transportation Mode in Supporting the Green Economy Program

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ABSTRACT: The development of technology and environmental sustainability are two inseparable aspects that represent two sides of the same coin. Every technological advancement is accompanied by the fact that it can provide numerous benefits to humanity, while on the other hand, it may also have negative impacts on environmental preservation. In this context, there is currently a strong campaign promoting the concept of green technology or environmentally friendly technology. One of the efforts to support the campaign for green technology is the use of electric-powered vehicles, such as electric cars and electric bikes. This program aims to support the achievement of zero greenhouse gas (GHG) emissions, as innovation in electric vehicles is needed to address these issues and achieve the green economy program. This research aims to analyze transportation policies regarding the use of electric bikes as an environmentally friendly mode of transport to support green technology, as well as the challenges and opportunities in integrating electric bikes into the transportation system. The research employs a normative legal study approach, focusing on transportation policy analysis using legislative and comparative approaches. The findings indicate that electric bikes can reduce dependence on motor vehicles, lower carbon emissions, and enhance accessibility to sustainable transportation. The conclusion emphasizes the importance of policy support and infrastructure to maximize the benefits of electric bikes in achieving green economy goals.

KEYWORDS: Electric Bikes, Environmentally Friendly Transportation, Policy, Green Econom.

I. INTRODUCTION

In order to overcome the social, economic and environmental crisis, the concept of green economy is present as a government initiative that methodology, conceptualization, implementation and community techniques involved in sustainability efforts whose main goal is to eliminate poverty and social conflict as a whole. In launching a green economy program, it needs to be supported by significant changes aimed at protecting the economic ecosystem, which also means seeking welfare for future generations through production that does not harm natural resources.

Green economy is a concept that shows the relationship between economy and environmental protection. The definition of green economy in the United Nations Environment Programme (UNEP) in 2011, namely: "is one that results in improved human well-being and social equity, while significantly reducing environmental and ecological scarcities. It is low carbon, resource efficient, and socially inclusive".[1] Green economy is the concept of balancing the needs and wants of humans with regard to their economic behavior through regulation. In the understanding of UNEP, green economy is one of the solutions to environmental problems involving economic aspects that are currently faced by many industrialized countries in the world, namely environmental pollution.[2]

In the creation of green economy there are at least 5 principles that apply consistently, namely: the ability to create community welfare; achieve equality between generations; conserve natural resources; restore and invest in natural resources; and increase consumption to support the next generation. In this regard, the focus of the green economy stems from the idea of the importance of protecting natural resources in sustainable development aimed at ensuring the fulfillment of welfare, equality and sustainability. To realize this, an integrated system is needed in terms of both regulation and implementation. The establishment of a green economy involves ensuring that economic activities provide welfare to society, promote and maintain equality between generations, restore and invest in natural resources, increase consumption to support future generations, and have an integrated system that can take action.

The increasing use of two and four-wheel motorized vehicles in Indonesia is a significant trend. To support energy security in the transportation sector, the government is currently supporting the development of electric vehicles as a solution that helps generate clean and environmentally friendly energy by

1 Sunarti, "Peran Uni Eropa Dalam Penerapan Ekonomi Hijau Studi Kesepakatan Paris Tahun 2015-2018" (2018) J Hub Int 307–326, daring. H. 312.

2 Ibid.

promoting the concept that a green economy includes consideration of environmental impacts in addition to meeting people's needs. For example, the electric cars now that is not only related to people's transportation needs, but also the impact of pollution produced by vehicles on the environment. This is motivated by the conditions and facts in several related studies which show that, the majority say that air pollution occurs due to the discharge of residual gas from motor vehicles.[3] In fact, the source of air pollution from motor vehicles reaches 60-70% and 10-15% comes from industrial chimneys.

Indonesia is one of the contributors to global carbon emissions along with the increasing use of motorized vehicles including cars and motorcycles. Fossil fuels, such as gasoline and diesel, are often used in motor vehicles and cause air pollution and greenhouse gas emissions. To cope with the increasing carbon emissions, Indonesia has taken a number of measures such as creating a policy on the use of electric vehicles to overcome transportation difficulties while tackling air pollution. The use of electric vehicles is considered effective enough to address problems related to air pollution such as CO, NOx, HC, SO2, and PM. When looking at total CO2 emissions, the three main sectors that contribute the most to emissions are the electricity sector (42%), the transportation sector (23%), and the housing sector (6%). In Indonesia itself, the existence and development of electric vehicles, especially electric bicycles, has attracted considerable public interest. Electric bicycles support the green economy and considered to have high economic value. Therefore, the government and companies need to make significant efforts to develop matters related to the use of electric bicycles from policies and regulations. Based on these problems, this study aims to explore the potential of electric bicycles as a means of environmentally friendly transportation in supporting green economy programs, main talks about how the exploration of electric bicycles in supporting green economy policy programs in Indonesia and how does comparing the policy of using electric bicycles in Indonesia and China?

II. METHODOLOGY

This research uses a normative juridical research method with the approach used is a statute approach, and a comparative approach. This approach is used

3 Seka Arum Ferlia, Sudarti Sudarti & Yushardi Yushardi, "Analisis Efisiensi Kendaraan Listrik Sebagai Salah Satu Transportasi Ramah Lingkungan Pengukuran Emisi Karbon" (2023) 7:2 Opt J Pendidik Fis 356–365.

to analyze and review the discussion section. This research aims to explore and analyze transportation policies on the use of electric bicycles as environmentally friendly transportation to support green technology as well as challenges and opportunities in integrating electric bicycles into the transportation system considering that the use of electric bicycles has not been regulated in legislation which raises polemics regarding its legality. The data used in this research is obtained from library research, which is sourced from primary and secondary empirical data derived from books, legal doctrines, documents, journals, laws, articles, or other literature.

III. EXPLORATION OF ELECTRIC BICYCLES IN SUPPORTING THE GREEN ECONOMY POLICY PROGRAM IN INDONESIA

A. The Green Economy Policy Program in Indonesia

Green economy in Indonesia is defined as an economic development model to support sustainable development that focuses on investment, capital, infrastructure, jobs and skills to achieve social prosperity and a sustainable environment. This definition was adopted from UNEP which was then narrowed down to increase economic growth while prioritizing environmental sustainability and community welfare.

Green Economy Policy in Indonesia is contained in several documents. RPJMN 2020 - 2024 contains Low Carbon Development (PRK). PRK consists of three main strategies, namely net zero emissions in reducing greenhouse gases, green stimulus for economic recovery, and implementation of PRK to fulfill the 2020 - 2024 RPJMN.[4] There are 3 sectors that are key in realizing Indonesia's green economy, namely sustainable energy, sustainable landscapes , and sustainable infrastructure. Apart from that, the Indonesian government has also acted progressively to establish a green economy in various documents, one of which is in the 2020 - 2024 RPJMN which contains Low Carbon Development (PRK). There are three main strategies in low carbon development, including reducing greenhouse gases to reach net zero emissions, green stimulus to restore the economy, and implementing low carbon development to meet targets in the 2020 - 2024 RPJMN. GRRI also explained the principles of the Green Economy initiative. An initiative can be categorized as a Green Economy initiative if it meets the five principles of the Green Economy, as follows:

4 Bappenas, "Implementasi Ekonomi Hijau Melalui Pembangunan Rendah Karbon," daring: <https://www.bappenas.go.id/id/berita/implementasi-ekonomi-hijau-melalui-pembangunan-rendahkarbon-QPkoU> released on 27 August 2021.

1) Well-being
   It is necessary to create sustainable shared prosperity, more than just monetary wealth, to prioritize human development, health, education and community.
2) Justice
   Emphasizes equality, community unity, social justice, and supports human rights – especially for marginalized minority communities (transition can be fair for the benefit of the entire community and future generations).
3) Planetary Boundaries
   Realizing that human welfare depends on healthy natural conditions, by protecting the functions and limitations of nature, land, water, air and other ecosystems.
4) Efficiency and Sufficiency
   Has the key to low carbon, diversity and circularity. Recognizing that one of the economic challenges is the need to create prosperity within planetary boundaries, and aligning economic incentives with the costs of impact on society.
5) Good Governance
   Building institutions or institutions that combine dynamic democratic accountability, relevant measurements, sound science and local knowledge.[5]

Additional revenues from implementing carbon pricing can be allocated for productive purposes or better fiscal distribution and benefit the wider community. On the other hand, renewable energy and low-emission goods will become more competitive, ultimately driving low-carbon innovation and supporting emissions reductions.[6]

According to the Global Green Growth Institute, the main driving factors for Green Economic growth include several things. First, efficiency and good management of natural resources and environmental services, the continuous availability of natural resources and environmental services is important for long-term economic prosperity and quality of life. Second, investment in low-carbon and climate-resilient infrastructure, which supports modern economic growth. Third, stimulate innovation and private sector investment in new and

5 Green Economy Coalition (GEC), Principles, priorities and pathways for inclusive green economies: Economic transformation to deliver the SDGs (2020), h. 18.

6 Worlds Recources Institute, "Pricing Carbon in the United States," daring: <https://www.wri.org/initiatives/pricing-carbon-united-states>.

adaptive technologies to increase productivity which is important for sustainable economic growth. Fourth, focus on human capital to produce the skilled and educated workforce necessary for an economy less dependent on resource extraction, while driving better social outcomes. Fifth, overcome market failures in achieving economic, social and environmental goals, because economic growth is catalyzed by more efficient allocation of resources.[7]

Thus, referring to the Global Green Growth Institute study, Green Economic growth will require institutional support from both the government as a cornerstone supported by the involvement of the private sector who are committed to making a shift to cleaner business, governance, especially through the existence of adequate regulations to facilitate environmental sustainability efforts. , as well as the adoption of new technology and human resource development to realize more inclusive Green Economic growth.

B. Electric Bicycles as an Effort to Support the Green Economy Policy Program in Indonesia

In Indonesia, the large number of motorbikes and cars makes road congestion very serious. This problem also triggers air pollution due to the burning of fossil fuels which contain pollutants that are harmful to the environment. Moreover, if you see the increasing use of fossil fuel vehicles, this will definitely also increase air pollution. The contribution of air pollution from the transportation sector is also unmitigated, reaching 60-70%.[8] So, to reduce this problem, technological innovation is needed, such as making electric vehicles. This vehicle also encourages the growth of the green economy throughout the world, especially Indonesia.

In Indonesia, 90% of roads are dominated by transportation. That's what causes high CO2. Therefore, the existence of electric vehicles in Indonesia is also supported by other infrastructure. One of them is the existence of Public Electric Vehicle Charging Stations (SPKLU) which are spread across various locations in Indonesia. Indonesia can learn from other countries that have made transitions from conventional vehicles to electric vehicles and integrate electric vehicle

7 Pemerintah Indonesia, "Global Green Growth Institute (GGGI) Program, Mewujudkan Pertumbuhan Ekonomi Hijau di Indonesia: Peta Jalan untuk Kebijakan, Perencanaan, dan Investasi," (2015), daring: <https://gggi.org/country/indonesia/>. h. 4.

8 Safri Gunawan, Hanapi Hasan & Ria Dini Wanty Lubis, "Pemanfaatan Adsorben dari Tongkol Jagung sebagai Karbon Aktif untuk Mengurangi Emisi Gas Buang Kendaraan Bermotor" (2020) 3:1 J Rekayasa Mater Manufaktur dan Energi, h. 38–47.

policies into national transportation policies.[9] Indonesia has committed to reducing greenhouse gas emissions by 41% by 2030 and zero greenhouse gas emissions by 2060 in accordance with the 2016 Paris Agreement.[10] Electric vehicles are one way for humans to adapt to climate change.[11] This electric vehicle can be trusted to reduce carbon dioxide emissions.[12]

In Indonesia itself, transportation has developed into the creation of electric vehicles which people consider environmentally friendly. This electric vehicle is considered environmentally friendly because it uses batteries as its main energy source. Electric vehicles are also considered smart because the technology in these vehicles is considered to be able to recognize various objects and vehicle behavior in various conditions. The Ministry of Energy and Mineral Resources issued Minister of Energy and Mineral Resources Regulation Number 13 of 2020 concerning the provision of electric charging infrastructure for battery-based electric vehicles.[13] The electric vehicles that are being developed are part of innovation in increasing the achievements of the green economy program through the transportation sector. In Indonesia, battery-powered electric vehicles have support in reducing carbon dioxide emissions. As an economic product, electric vehicles will become part of environmentally friendly economic goods.[14]

Developing countries are actively encouraging the concept of a green economy with the aim of creating an economic system that prioritizes environmental sustainability and provides benefits to society. To support energy security in the transportation sector, the government currently supports the development of electric vehicles as a solution that helps produce clean and environmentally friendly energy, revealing that a green economy includes consideration of environmental impacts in addition to meeting people's needs. For example, electric bicycles which are now produced and sold in Indonesia aim to reduce

9 Meilinda Fitriani Nur Maghfiroh, Andante Hadi Pandyaswargo & Hiroshi Onoda, "Current readiness status of electric vehicles in indonesia: Multistakeholder perceptions" (2021) 13:23 Sustain 1–25.

10 Asif Raihan et al, "An econometric analysis of the potential emission reduction components in Indonesia" (2022) 3:March Clean Prod Lett 100008, daring: <https://doi.org/10.1016/j.clpl.2022.100008>.

11 Rahayu Subekti, "Urgensi Regulasi Kendaraan Listrik Untuk Pengendalian Iklim Dan Penggunaan Energi Terbarukan (Analisis Komparatif Antara Indonesia, China, Dan Amerika Serikat)" (2022) 11:3 J Rechts Vinding 435–450.

12 Jamie Morgan, "Electric vehicles: The future we made and the problem of unmaking it" (2020) 44:4 Cambridge J Econ 953–977.

13 Lily Choirun Nisa & Anita Susanti, "Strategi Penerapan Mobil Listrik di Surabaya Sebagai Smart Mobility" (2023) 1:55 J Media Publ Terap Transp 213–225.

14 Ibid.

pollution levels. This is not only related to people's transportation needs, but also regarding the impact of pollution produced by vehicles on the environment.[15]

The advantages of electric bicycles include high efficiency, minimal environmental impact, low noise levels, energy sources from various alternative sources, easy maintenance, and dependence on renewable power. [16] In Indonesia itself, the existence and development of electric bicycles has attracted quite a lot of public interest. Electric vehicles not only support the green economy, but are also considered to have high economic value. Therefore, governments and companies need to make significant efforts to develop charging stations to make charging easier for electric vehicle owners and users. Because it is easy to find electric charging stations, it makes people confident about owning electric vehicles, because their existence is highly paid attention to and supported by the government and companies.[17]

IV. COMPARISON OF ELECTRIC BICYCLE USE POLICIES IN INDONESIA AND CHINA

Electric bicycles are simple vehicles that can be used by all groups and are used regardless of age and are easy to use. In Indonesia, many people already use electric bicycles as daily vehicles. Reporting from katadata.co.id, the use of electric motorbikes in 2020 was only 1,947 units, which then increased significantly to 25,782 units in 2022.[18]

The increasing use of electric bicycles cannot be separated from the potential for violations committed by the public. Therefore, the Indonesian government has a policy that legalizes the use of electric bicycles including Presidential Regulation Number 55 of 2019 concerning the Acceleration of the Battery

15 Anom Priantoko Et Al, "Tinjauan Penerapan Ekonomi Hijau Dalam Pariwisata Di Provinsi Bali Review Of The Application Of Green Economy In Tourism In Bali Province" (2021) 75:17 Pharmacogn Mag 399–405.

16 Cakrawati Sudjoko, "Strategi Pemanfaatan Kendaraan Listrik Berkelanjutan Sebagai Solusi Untuk Mengurangi Emisi Karbon", Jurnal Paradigma: Jurnal Multidisipliner Mahasiswa Pascasarjana Indonesia," (2021) 2:2 J Paradig J Multidisipliner Mhs Pascasarj Indones 54–68.

17 M Ridho Mahaputra & Farhan Saputra, "Determination of Public Purchasing Power and Brand Image of Cooking Oil Scarcity and Price Increases of Essential Commodities" (2022) 1:1 Int J Adv Multidiscip 36–46.

18 Cindy Mutia Annur, "Riset Deloitte dan Foundry: Penggunaan Motor Listrik di Indonesia Naik 13 Kali Lipat dalam Dua Tahun," (2023), daring: databoks <https://databoks.katadata.co.id/transportasi-logistik/statistik/cd3975440c6d764/riset-deloitte-dan-foundry-penggunaan-motor-listrik-di-indonesia-naik-13-kali-lipat-dalam-dua-tahun>.

Electric Vehicle Program, Minister of Transportation Regulation Number 45 of 2020 concerning Certain Vehicles Using Motor Drives Electricity.

Policies regarding electric motorbike users and specifications are specifically regulated in Minister of Transportation Regulation Number 45 of 2020 concerning Certain Vehicles Using Electric Motor Drives, including:

1) Lane

   Electric bicycles have special lanes designated for them to pass through. As in Article 5 of the Minister of Transportation Regulation No. 45 of 2020, it is stated that electric bicycles can be operated in special lanes and/or certain areas. As regulated in paragraph (2), what is referred to as a special lane includes bicycle lanes or lanes that are specifically provided for certain vehicles using electric motor drives. However, if there is no special lane available, electric bicycles can be operated on sidewalks with adequate capacity and paying attention to pedestrian safety.

2) Region

   A region is an area that has a specific function and purpose. In terms of using electric bicycles, according to Article 5 paragraph (3) of the Minister of Transportation Regulation No. 45 of 2020, what is meant by certain areas are areas that include residential areas, roads designated for car-free days, tourist areas, areas around mass public transportation facilities as part of certain vehicles using integrated electric motor drives. , office areas, and off-road areas.

3) Minimum age for electric bicycle users

   The minimum age is the legal age for carrying out certain actions. When using electric bicycles, the minimum age for users is according to Article 4 paragraph (1) letter b Minister of Transportation Regulation No. 45 of 2020, namely 12 (twelve) years. Then in Article 4 paragraph (2) of the same regulation, it is stated that in the case of certain vehicle users aged 12 (twelve) years to 15 (fifteen) years, certain vehicle users must be accompanied by an adult.

4) Electric bicycle equipment

   To meet safety requirements, the equipment of electric bicycles is regulated in Article 3 paragraph (2) of the Minister of Transportation Regulation No. 45 of 2020, namely:

   a. headlight;
   b. light reflecting device (reflector) or rear position lamp;

c. properly functioning brake system;
d. light reflecting devices (reflectors) on the left and right;
e. horn or bell; And
f. the highest speed is 25 km/hour (twenty-five kilometers per hour).

Apart from that, the safety requirements for using electric bicycles are also regulated in Article 4 paragraph (1) which includes the use of helmets, prohibition on transporting passengers except for electric bicycles equipped with passenger seats, and prohibition on modifying motor power to increase speed.

Apart from Indonesia, in Asia, China is the country that has the most electric bicycle users. As reported on Shine.cn, it is stated that by the end of 2022, it is estimated that there will be 350 million electric bicycles in China, so one electric bicycle for every four people.[19] The large number of electric bicycle users in this country certainly cannot be separated from the rules that must be obeyed by users. Policies regarding electric bicycle users in China include:

1) Registration

China requires electric bicycle owners/users to register. Registration of electric bicycles can only be done by those who already have an Identity Card (KTP) or permanent residence permit, and the electric bicycle must meet national standards. The aim of registering electric bicycles is to:[20]

a. Avoid the risk of theft or loss of electric bicycles
b. Obtain protection under Chinese laws regarding vehicle ownership
c. Take advantage of insurance in case of a traffic accident

2) Safety standards

As regulated in GB (Guobiao) 42295-2022 which came into effect on January 1, 2024, there are several regulated electric bicycle safety standards that are specifically intended for electric bicycle manufacturers. These provisions include:[21]

19 Yang Jian, "The Rising Popularity of Electric Bicycles Triggers Public Fire Alarm," (2024), daring: Shine <https://www-shine-cn.translate.goog/news/in-focus/2403018531/?_x_tr_sl=en&_x_tr_tl=id&_x_tr_hl=id&_x_tr_pto=sge#:~:text=By the end of 2022,10.5 million registered electric bicycles.>.

20 S J Grand, "Electric Bike Regulations in China: What's New?," (2020), daring: S J Gd <https://sjgrand-cn.translate.goog/new-electric-bike-regulations-china/?_x_tr_sl=en&_x_tr_tl=id&_x_tr_hl=id&_x_tr_pto=sge#:~:text=Beijing: Denda bagi yang tidak,memeriksa kepatuhan dan mendaftar izin.>.

21 Safety Requirement for Electric Bicycles Electrical, 2022.

a. Signs and warnings
b. Installation of cables, wires, and connections
c. Voltage
d. Insulation resistance
e. Electrical voltage
f. Heating system
g. Protection
h. Temperature and humidity resistance
i. Vibration and shock

3) Charger for electric bicycles

GB 42295 also establishes requirements in charging protection for rechargeable battery systems installed on electric bicycles, which include:

a. Over-voltage protection: The battery system shall cut off the charge circuit within 1 second when the charge voltage is higher than the maximum voltage specified by the manufacturer.
b. Charge over-current protection: The battery system shall cut off the charge circuit within 1 second when the charge current is higher than the maximum current specified by the manufacturer.
c. Discharge over-current protection: The battery system shall cut off the discharge circuit within 1 second when the discharge current reaches 105% of the maximum working current or the upper limit of the discharge current specified by the manufacturer, whichever is greater.
d. Temperature protection: The battery system shall cut off charge/discharge current when the battery system is outside the operational temperature range specified by the manufacturer.
e. Abnormal temperature alarming function: The bicycle or battery system shall set off an alarm when the internal temperature of the battery system or any single cell exceeds the maximum allowable temperature.
f. Charger communication: The battery system shall communicate with the charger before the charge process begins.[22]

22 Daniel Vasquez & Yike Hu, "Mandatory Chinese Safety Standards for E-Bikes Soon Going into Effect," (2023), daring: Exponent.com <https://www-exponent-com.translate.goog/article/mandatory-chinese-safety-standards-e-bikes-soon-going-effect?_x_tr_sl=en&_x_tr_tl=id&_x_tr_hl=id&_x_tr_pto=sge#:~:text=Standar baru dan persyaratan yang,%2C3%25 dibandingkan tahun sebelumnya.>.

4) Limitations on use and user obligations

The Chinese government has imposed several restrictions on the use of electric bicycles. These restrictions include:

a. Maximum electric bicycle speed is 15 km/h
b. Prohibition on driving on motor vehicle lanes.
c. Prohibition on driving while drunk and against traffic.
d. Obligation to slow down and extend hand to signal before turning and must not turn suddenly;
e. Prohibition on blocking the path of vehicles being overtaken when overtaking other vehicles.
f. Prohibition on pulling or riding on other vehicles or being pulled by other vehicles, and drivers must not release their hands from the handle or hold objects in their hands;
g. Prohibition on driving parallel, chasing, or doing zigzag racing with other vehicles;
h. Prohibition on learning to drive on the highway;
i. Prohibition on riding electric bicycles on urban toll roads or highways;
j. Prohibition on carrying passengers, but electric bicycles equipped with safety seats can still carry children with a height of less than 1.2 meters;
k. In the case of carrying a load, the height of the load must not exceed 1.5 meters from the ground; the width of the load must not exceed 0.15 meters from the left and right handlebars; the length of the load must not exceed the wheels at the front end or exceed the body by 0.3 meters at the rear end;
l. Obligation to wear safety helmets for users and children who participate in driving.
m. Obligation to comply with other provisions in laws and regulations in the field of traffic safety.[23]
n. Restrictions on the use of electric bicycles in several core urban districts.[24]

23 Rules of Shenzhen Municipality on the Administration of Electric Bicycle (Trial)深圳市电动自行车管理规定（试行）, 2023.

24 Institute for Transportation & Development Policy, "The Lane Ahead: Challenges and Considerations for China's Cycling Sector," itdp-org (6 September 2023), daring: <https://itdp-org.translate.goog/2023/09/06/challenges-considerations-china-cycling-sector/?_x_tr_sl=en&_x_tr_tl=id&_x_tr_hl=id&_x_tr_pto=sge#:~:text=>.

o. Obligation to use the traffic police application to immediately check compliance and register permits.[25]

5) Minimum Age for Electric Bicycle Users

As in Article 26 Number 1 Section 3 concerning Lanes and Riding in Shenzhen City Regulation on Electric Bicycle Administration Number 521, electric bicycle users in China must be at least 16 (sixteen) years old, have an Identity Card and have a driving license.[26]

6) Fines and Sanctions

Since November 1, 2018, the Chinese government has set fines for electric bicycle users who commit violations with certain classifications. The fines are as follows:

a. A maximum fine of RMB 30,000 will be given to electric bicycle users who violate traffic rules.[27]
b. A fine of RMB 20-RMB 50 will be given to electric bicycle users who violate parking regulations.[28]
c. A fine of RMB 1000 will be given to electric bicycle users without a permit.[29]

Based on the regulations regarding the use of electric bicycles in Indonesia and China, you can see the similarities and differences between the two. Here is a comparison:

Policy	Indonesia	China
Legal Basis	Regulation of the Minister of Transportation Number 45 of 2020 concerning Certain Vehicles Using Electric Motor Drives	a. Rules of Shenzhen Municipality on the Administration of Electric Bicycle Number 521. b. GB 17761 of 2018 on Safety Technical Specifications for

25 Grand, supra note 20.

26 Rules of Shenzhen Municipality on the Administration of Electric Bicycle (Trial)深圳市电动自行车管理规定（试行）, supra note 23.

27 KumparanBISNIS, "Dilema Pemerintah China Hadapi Booming Sepeda Listrik," Kumparan.com (2018), daring: <https://kumparan.com/kumparanbisnis/dilema-pemerintah-china-hadapi-booming-sepeda-listrik>.

28 Ibid.

29 Grand, supra note 20.

		Electric Bicycles. c. GB 42295 of 2022 on Safety Requirements for Electric Bicycles d. GB 42296 of 2022 on Safety Technical Requirements for Chargers for Electric Bicycles. e. GB/T 36972 of 2018 on Lithium-ion Batteries for Electric Bicycles b. f. Traffic Regulations of China
Lane	Bicycle lanes/special lanes for certain electric vehicles, or on sidewalks with attention to pedestrian safety.	Electric bicycle users ride in bicycle lanes and are prohibited from riding electric bicycles on motorized vehicle lanes and urban toll roads or highways.
Region	Certain areas include residential areas, roads designated for car-free days, tourist areas, areas around integrated mass public transportation facilities, office areas, and areas outside the roads.	There are restrictions on the use of electric bicycles in some core urban districts.
Minimum Ages	Minimum age 12 years, for users aged 12-15 years must be accompanied by an adult.	Minimum age 16 years, have an Identity Card and driving license.
Safety Requirements	a. headlights; b. reflectors or taillights; c. good brake system; d. reflectors on the left and	a. Maximum speed of 15 km/hour. b. Prohibition on drunk driving and against traffic; blocking the path of

	right; e. horn or bell; and f. maximum speed of 25 km/h.	vehicles being overtaken. c. Prohibition on pulling or being pulled by other vehicles, and releasing hands from grips or holding objects in hands; d. Prohibition on parallel driving, chasing, or zigzag racing; e. Prohibition on learning to drive on the highway; f. Prohibition on carrying passengers, unless a safety seat is installed that can carry children less than 1.2 meters tall; g. Obligation to slow down and extend hand to signal before turning; h. Obligation to wear helmets for users and children; i. Obligation to obey traffic safety regulations.
Registration	No regulations yet	Owners/users are required to register electric bicycles on condition that they have an Identity Card or permanent residence permit, and that the electric bicycle meets national standards.
Fine and Sanction	No regulations yet	a. Maximum fine of RMB 30,000 for users who violate traffic rules. b. A fine of RMB 20-RMB 50 for users who violate

		parking regulations. c. A fine of RMB 1000 for users of electric bicycles without a permit.

Based on the table above, there are differences regarding the policies on the use of electric bicycles in Indonesia and China. In general, these differences are seen in the provisions on maximum speed limits, registration requirements, and the imposition of fines and sanctions for electric bicycle users who commit violations.

V. CONCLUSION

Green economy in Indonesia is an economic development to support sustainable development that focuses on investment, capital, infrastructure, employment, and skills to achieve sustainable social and environmental welfare. Electric bicycles, whose use is currently growing, are an innovative part of improving the achievement of green economy programs through the transportation sector as an environmentally friendly economic product. There are fundamental differences in the regulations regarding the use of electric bicycles in Indonesia and China. This difference is clearly evident in the minimum age requirement for riders, as well as the absence of regulations regarding the obligation to register and impose fines or sanctions for users who commit violations in Indonesian laws and regulations.

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org.translate.goog/2023/09/06/challenges-considerations-china-cycling-sector/?_x_tr_sl=en&_x_tr_tl=id&_x_tr_hl=id&_x_tr_pto=sge#:~:text=>.

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Bridging Legal Gaps: Advocating Green Technology Through Indonesia's Environmental Framework

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ABSTRACT: The effective implementation and enforcement of environmental law in Indonesia are pivotal for achieving sustainable development and addressing environmental challenges. Law No. 32 of 2009 on Environmental Protection and Management serves as the cornerstone of Indonesia's environmental legislation, primarily regulating pollution control, prevention of environmental damage, and the administrative aspects of Environmental Impact Assessments (AMDAL) and related licensing. Science and technology have significantly contributed to Indonesia's environmental law, particularly through research mechanisms such as Strategic Environmental Studies (KLHS), Environmental Impact Assessments (AMDAL), and Environmental Risk Assessments (ERA). These instruments are crucial for integrating scientific insights into policymaking and for assessing the potential environmental impacts of development projects. However, while the law introduces economic instruments aimed at environmental protection, it offers limited provisions to encourage innovation in green technology. This paper focuses on evaluating the existing Indonesian legal framework for advocating green technology, especially Renewable Energy. Employing a literature-based approach and analysing best practices from other countries, the study identifies significant gaps in the legal framework that hinder the promotion of green technology initiatives. Key challenges include the limited implementation of economic instruments, insufficient incentives for research and development in green technology, and regulatory overlaps that create barriers to innovation. The paper also highlights that while science and technology are embedded within environmental assessments and studies, there is a need to strengthen their role to effectively stimulate green tech innovation. The paper concludes with recommendations for policymakers to enhance and develop environmental laws that accommodate the development of green technology to provide solutions for environmental challenges. By reinforcing the role of science and technology and actively encouraging green technology initiatives, Indonesia can more effectively address its environmental problems and move towards sustainable development.

KEYWORD: Legal Gaps, Green Technology, Renewable Energy, Sustainable Development.

I. INTRODUCTION

Indonesia confronts critical environmental challenges that threaten its ecosystems and the wellbeing of its population. Key issues include persistent deforestation, widespread air and water pollution, climate change that amplifies climate injustice, and biodiversity loss. Driven mainly by palm oil plantation expansion and infrastructure projects, deforestation has drastically reduced forest cover. According to the Ministry of Environment and Forestry (KLHK), in 2020, Indonesia lost over 270,000 hectares of primary tropical forest, which has directly impacted biodiversity and led to significant habitat loss for endemic species.[1] In 2023, Indonesia lost 1.03 million hectares (Mha) of primary forest compared to 2001, equivalent to 842 million tons (Mt) of CO_2 emissions. Of this loss, 144 thousand hectares (kha) were found within Indonesia's official forest land cover classifications and involved land patches larger than two hectares, according to MoEF-WRI analysis.[2]

Additionally, air pollution from industrial activities and forest fires, along with water pollution from industrial and domestic waste, have degraded environmental conditions, posing risks to public health and aquatic ecosystems. The impacts of climate change manifested in natural disasters like floods and landslides have further intensified climate inequities across various regions.Furthermore, Indonesia ranks as the fourth largest country in terms of tropical forest loss, following Brazil, the Democratic Republic of Congo, and Bolivia. Deforestation driven by specific commodities has been a significant factor contributing to the loss of both primary and secondary forest cover in regions of Latin America and Southeast Asia. This trend highlights the urgent need for sustainable land management practices and regulatory frameworks to mitigate environmental degradation.[3]

There is an increasing need for the role of science and green technology in addressing environmental challenges in Indonesia, particularly through mechanisms such as Strategic Environmental Studies (KLHS), Environmental Impact Assessments (AMDAL), and Environmental Risk Assessments (ERA). Green science and technology provide tools and standards that aid in the sustainable monitoring and management of the environment. For instance, KLHS serves as a strategic tool for considering the environmental impacts of policies and

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1 D Syahni "Laporan Sebut Jutaan Hektar Hutan Primer Dunia Hilang pada 2020, Bagaimana Indonesia?". Mongabay. Accessed November 1, 2024. [Online], Available: https://www.mongabay.co.id/2021/04/02/laporan-sebut-jutaan-hektar-hutan-primer-dunia-hilang-pada-2020-bagaimana-indonesia/,

2 Global Forest Watch, Indonesia Primary Forest Loss 2001-2021, Accessed 1 November 2024. [Online], Available: https://www.globalforestwatch.org/dashboards/country/IDN/?lang=id

3 *Ibid.*

development plans across various sectors.[4] Additionally, AMDAL offers a scientific foundation for assessing the environmental impacts of major projects, while ERA assists in identifying and managing associated environmental risks. By utilizing environmental standards, such as environmental quality standards and industrial standards, green science and technology establish a framework for setting limits and criteria that industries and other stakeholders must meet to maintain environmental quality.[5]

ERA also functions in the identification and management of environmental risks associated with specific activities, ensuring that these risks can be addressed from the outset.[6] Through these various instruments, science serves as a guiding force in the evidence-based policymaking process for environmental governance.

In addition, science and technology contribute to the development of tools and environmental standards that help maintain environmental quality. For example, Environmental Quality Standards serve as an instrument to establish quality thresholds that industries and other stakeholders must comply with to protect environmental quality.[7] Industrial Standards, such as emission standards or waste management protocols, regulate industry practices to ensure they do not exceed safe limits for the environment and public health. These standards play a vital role in supervising activities that pose environmental risks, providing clear parameters for industries to operate sustainably.

This paper will discuss the general application of green technology while delving into the role of renewable energy in addressing environmental challenges in Indonesia. The discussion will include an analysis of the legal gaps present within existing environmental regulations and how these regulations are implemented in practice. By focusing on renewable energy as a key solution to reduce environmental impact, this study aims to explore how legal instruments can be strengthened to

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4 A. Polido, "Environmental Assessment for Sustainability in Urban Systems Transformation" https://link.springer.com/chapter/10.1007/978-3-031-20577-4_9

5 D.G.N Tarigan, "Effectiveness of AMDAL Implementation in Protecting Environmental Damage Due to Industrial", vol.01, no. 03, pp. 150-159, 2023, DOI:https://doi.org/10.22437/communale.v1i3.30375 https://www.semanticscholar.org/paper/Effectiveness-of-AMDAL-Implementation-in-Protecting-Tarigan/60de034f6b3179105e27c25d542a1892e0d9e165

6 A. D. Basuki, H. Herdiansyah and A. Wardhana, "Sustainable Development on Indonesian Environmental Risk Assessment" IOP Conference Series: Earth and Environmental Science, 2021, Sci. 819 012035, DOI: 10.1088/1755-1315/819/1/012035

7 Peris Frengki Butarbutar, Candra Fajri Ananda, Ferry Prasetyia, The Determinants of Environmental Quality in Indonesia, 2023, Journal of Indonesian Applied Economics 11(1):27-39 https://www.researchgate.net/publication/368900514_The_Determinants_of_Environmental_Quality_in_Indonesia)

support green technology innovation and maximize the contributions of science in addressing environmental challenges in Indonesia. This research is expected to provide valuable recommendations for policymakers to enhance regulatory effectiveness and improve Indonesia's preparedness in tackling environmental issues, advancing toward sustainable development. With this background, we conclude a research question, which is how legal instruments in Indonesia address the legal gaps in green technology innovation.

II. METHODOLOGY

This study employs a literature-based approach to analyze Indonesia's legal framework in promoting green technology innovation to enhance the effectiveness of addressing environmental challenges. This approach was chosen as it allows researchers to gain a deeper understanding of various aspects of environmental regulations in Indonesia and to compare best practices from other countries. Additionally, this approach involves reviewing data related to the effectiveness of green technology in Indonesia to provide a basis for identifying regulatory needs by highlighting gaps between existing regulations and their practical implementation.

III. THE NEED FOR INNOVATION IN GREEN TECHNOLOGY

A. Defining Green Technology, Provide A Clear Definition To Establish A Common Understanding.

Green technology refers to the use of environmental science and technology in the creation and implementation of products, equipment, and systems designed to preserve natural resources and protect the environment. It also aims to reduce or lessen the adverse effects of human activities on the environment. Although the term "Green Technology" is more contemporary, it essentially conveys the same concept as "Clean Technology" or the more established term "Environmental Technology".[8]

Green technology and renewable energy are closely interconnected concepts that play a vital role in promoting environmental sustainability and combating climate change. Green technology refers to the application of scientific knowledge and innovative practices aimed at minimizing the negative impacts of human activities

[8] UTAR Faculty of Engineering and Green Technology, "Research in Environmental Engineering & Green Technology," Universiti Tunku Abdul Rahman, 2024. [Online]. Available: https://news.utar.edu.my/news/2009/June/05/01/01.html

on the environment.Green technology and renewable energy are closely interconnected concepts that play a vital role in promoting environmental sustainability and combating climate change. Green technology refers to the application of scientific knowledge and innovative practices aimed at minimizing the negative impacts of human activities on the environment.

The energy of renewable sources originates from solar radiation (solar energy and its derivatives), geothermal heat (from the interior of the earth), and gravitational energy (mainly from the moon). The energy flow from these sources on Earth is abundant. Tapping just a small fraction of it would in theory be enough to deliver all energy services humanity needs.

1. Emphasize technologies that are environmentally friendly, reduce pollution, and promote sustainability.

The primary advantage of adopting environmentally friendly technologies is the enhancement of quality of life through the promotion of a more sustainable environment. Persistent issues such as air and water pollution, along with noise, can significantly diminish living standards. However, the implementation of green technologies minimizes these negative environmental impacts. Moreover, these sustainable innovations have considerable potential to drive national development. Industries that embrace or advance eco-friendly technologies not only contribute to reducing pollution but also create job opportunities for local communities, fostering both economic growth and environmental stewardship.

Green technologies have the capability to improve air quality by reducing emissions, slowing down environmental degradation, and increasing the atmosphere's capacity. Advocates have stated that green energy technologies can enhance environmental conditions and help alleviate air pollution. Research indicates that countries with a higher adoption of green technology and renewable energy sources experience lower levels of nitrogen oxides (NOx) and sulfur dioxide (SO2). Additionally, studies have identified a direct link between the implementation of green technologies and decreased carbon emissions, highlighting their effectiveness in combating fog and haze pollution. However, some research suggests that while technological advancements can boost productivity, they may also unintentionally increase energy consumption and environmental harm. It has been shown that progress in technology does not always lead to cleaner production methods, and

environmental pollution can escalate even with ongoing technological improvements.

2. Avoiding Greenwashing, Explain greenwashing and its negative impact on genuine sustainability efforts.

Greenwashing refers to the practice by organizations that misleads or deceives stakeholders about their inadequate environmental practices or the ecological advantages of their products and services, while also promoting a positive image regarding these aspects. This phenomenon is prevalent across various sectors and has attracted significant attention in the fields of ethics and marketing.[9]

Sustainability aims for a balanced approach that connects economic, environmental, and social dimensions, including economic growth, environmental protection, and social fairness. Companies that actively pursue sustainability and are recognized for their efforts can create value for all stakeholders and positively influence these areas through effective management. However, there is often a link between greenwashing and sustainability; companies may use greenwashing to hide their lack of genuine eco-friendly practices. This connection can harm sustainability performance because if a company's suppliers engage in greenwashing, the company might rely on misleading information about their environmental impact. Consequently, this can undermine the company's sustainability efforts and damage its reputation, leading consumers and stakeholders to doubt its environmental claims and making it harder to attract and keep environmentally conscious customers.[10]

3. Challenges in the use of renewable energy

Indonesia has set ambitious goals for expanding clean energy sources, aiming for at least 44% of its power mix to come from renewables by 2030 under the Just Energy Transition Partnership (JET-P), a significant increase from the previous target of 23% by 2025. By 2050, the goal is for modern renewable energy sources to account for at least 31% of the energy supply. However, these enhanced targets still do not fully leverage Indonesia's vast untapped renewable energy potential, which includes the world's largest geothermal reserves. Other renewable sources like solar and wind remain underdeveloped, with only 1.2 MW of installed wind power capacity

[9] C. Santos, A. Coelho, and B. L. Cancela, "The Impact of Greenwashing on Sustainability through Green Supply Chain Integration: The Moderating Role of Information Sharing," *Environmental Development and Sustainability* (2024): 5. https://link.springer.com/article/10.1007/s10668-024-05009-2

[10] *Ibid.*

compared to an estimated potential of 9.5 GW. Similarly, Indonesia's solar power potential is estimated at around 207 GW, with some estimates suggesting it could be as high as 500 GW.

To achieve its renewable energy goals, Indonesia must significantly accelerate investments; however, the focus should not only be on increasing funding but also on directing those investments effectively. This presents several critical challenges for the power sector and energy usage across different economic areas. In the power sector, issues include the fragmented nature of Indonesia's grid and operational difficulties in off-grid regions, along with limited financing options for new projects from local banks and challenges related to land acquisition. From the perspective of energy consumption, there are additional concerns such as inadequate design standards for thermal and water heating in industrial buildings, a lack of awareness regarding renewable energy potential, space constraints, and an emphasis on liquid biofuels.[11]

4. Stress the importance of authenticity in green initiatives.

The need for genuine authenticity in green initiatives in Indonesia is becoming more widely acknowledged as vital for achieving true environmental sustainability and effectively confronting the urgent challenges of climate change. As global awareness of environmental issues increases, skepticism about corporate sustainability claims is also on the rise. Authenticity plays a crucial role in addressing greenwashing, which occurs when companies overstate or misrepresent their environmental efforts. In Indonesia, where various industries contribute to deforestation and pollution, implementing genuine sustainability practices is essential for building consumer trust and ensuring that initiatives deliver real environmental benefits.

Indonesia has established bold climate goals, aiming to cut greenhouse gas emissions by 29% without conditions and by up to 41% with international assistance by 2030. To meet these targets, genuine involvement from both the public and private sectors is essential. Authenticity in green initiatives ensures that efforts are in line with these national objectives, promoting accountability and enabling measurable progress toward sustainability.[12]

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[11] V. Tachev, "Renewable Energy in Indonesia - Current State, Opportunities and Challenges" Accessed: November 14, 2024 [Online.] Available: https://energytracker.asia/renewable-energy-in-indonesia/

[12] Bappenas, "Updated NDC Indonesia untuk Masa Depan yang Tangguh Iklim", Accessed: November 11, 2024 [Online.] Available: https://greengrowth.bappenas.go.id/updated-ndc-indonesia-untuk-masa-depan-yang-tangguh-iklim/

5. Potential Benefits, How green tech can address specific environmental issues in Indonesia.

Jakarta has the highest annual PM2.5 concentration in Indonesia, according to the DKI Jakarta Provincial Environmental Agency. The World Health Organization warns that air pollution leads to respiratory and cardiovascular diseases, as well as cancer. Additionally, the Institute for Health Metrics and Evaluation reports that air pollution in Jakarta causes over 5,000 deaths and 168,000 years of illness each year. This situation drives Indonesia to adopt green technology to combat pollution and other environmental issues. Major sectors like industry, transportation, and agriculture contribute significantly to air, water, and land pollution in the country.[13]

Optimizing renewable energy sources for electricity generation is a key component of the strategic plan for developing net-zero emission (NZE) power plants. In 2022, performance targets for the renewable energy and energy conversion subsector included achieving a primary energy mix of 15.7%, with a production goal of 366.4 million barrels of oil equivalent (MBOE). Several renewable power plants are also aiding the government in reducing reliance on fossil fuels, such as coal in steam power plants and these include:[14]

a. hydro energy has a potential capacity of 95 GW, which includes 75,000 MW from large hydro sources and 19,370 MW from micro-hydro sources.
b. Geothermal energy sources are used in geothermal power plants with a potential of 23,965 GW. They are distributed on the islands of Sumatra, Java, Bali, Nusa Tenggara, Kalimantan, Sulawesi, Maluku, and Papua.
c. Bioenergy is used for several plants such as biomass, biogas, municipal waste, household, and power plants, etc. The total potential of bioenergy is 32,653.8 MW.
d. Solar energy has a potential of 207,898 MW at an average intensity of 4.80 kWh/m2/day.
e. Wind energy, from the latest data in the third quarter of 2021; Indonesia has an installed capacity of 154.3 MW, while the target in 2025 is 255 MW.

[13] J. Bella, and S. Yonglei "How New Green Technologies are Changing the Indonesian Economy.", vol.04, no. 03, pp. 231-245, 2023, DOI:10.46456/jisdep.v4i3.458.

[14] N. A. Pambudi, R. A. Firdaus, R.Rizkiana,D. K. Ulfa, M. S. Salsabila, Suharno, and Sukatiman. "Renewable Energy in Indonesia: Current Status, Potential, and Future Development" Sustainability Journal 2023, vol.15, no. 03, sci: 2342, DOI: https://doi.org/10.3390/su15032342

Renewable energy sources, when utilized effectively, align well with energy policies and environmental, social, and economic objectives. Key benefits include:

a. Diversification of energy carriers for heat, fuels, and electricity.
b. Enhanced access to clean energy.
c. Reduced reliance on fossil fuels for future generations.
d. Increased flexibility in power systems to adapt to changing electricity demand.
e. Lower pollution and emissions from traditional energy sources.
f. Decreased dependency on imported fuels and reduced costs.

6. Examples of successful green technologies globally. UFCC

TABLE 7.1. CATEGORIES OF RENEWABLE ENERGY CONVERSION TECHNOLOGIES

Technology	Energy product	Application
Biomass energy		
Combustion(domestic scale)	Heat (cooking, space heating)	Widely applied; improved technologies available
Combustion(industrial scale)	Process heat, steam, electricity	Widely applied; potential for improvement
Gasification/power production	Electricity, heat (CHP).	Demonstration phase
Gasification/fuel production	Hydrocarbons, methanol, H_2	Development phase
Hydrolysis and fermentation	Ethanol	Commercially applied for sugar/ starch crops; production from wood under development
Pyrolysis/production of liquid fuels	Bio-oils	Pilot phase; some technical barriers
Pyrolysis/production of solid fuels	Charcoal	Widely applied; wide range of efficiencies
Extraction	Biodiesel	Applied; relatively expensive
Digestion	Biogas	Commercially applied
Wind energy		
Water pumping and battery charging	Movement, power	Small wind machines, widely applied
Onshore wind turbines	Electricity	Widely applied commercially
Offshore wind turbines	Electricity	Development and demonstration phase
Solar energy		
Photovoltaic solar energy conversion	Electricity	Widely applied; rather expensive; further development needed
Solar thermal electricity	Heat, steam, electricity	Demonstrated; further development needed
Low-temperature solar energy use	Heat (water and space heating, cooking, drying) and cold	Solar collectors commercially applied; solar cookers widely applied in some regions; solar drying demonstrated and applied
Passive solar energy use	Heat, cold, light, ventilation	Demonstrations and applications; no active parts
Artificial photosynthesis	H_2 or hydrogen rich fuels	Fundamental and applied research
Hydropower	Power, electricity	Commercially applied; small and large scale applications
Geothermal energy	Heat, steam, electricity	Commercially applied
Marine energy		
Tidal energy	Electricity	Applied; relatively expensive
Wave energy	Electricity	Research, development, and demonstration phase
Current energy	Electricity	Research and development phase
Ocean thermal energy conversion	Heat, electricity	Research, development, and demonstration phase
Salinity gradient / osmotic energy	Electricity	Theoretical option
Marine biomass production	Fuels	Research and development phase

Renewable energy sources have played a crucial role in human civilization since its inception. For centuries, biomass has been utilized for various purposes, including heating, cooking, steam generation, and electricity production. Similarly, hydropower and wind energy have been harnessed for movement and later for generating electricity. Generally, renewable energy sources rely on energy flows

within the Earth's ecosystem, primarily from solar radiation and geothermal energy. The main types of renewable energy include:[15]

a. Biomass energy (energy from plant growth fueled by solar radiation).
b. Wind energy (energy from moving air masses driven by solar power).
c. Direct solar energy use (for heating and electricity generation).
d. Hydropower.
e. Marine energy (including wave energy, marine current energy, and energy from tidal barrages).
f. Geothermal energy (derived from heat stored in rocks due to the Earth's natural heat flow).

7. Evaluation of Existing Legal Frameworks

The Indonesian government has created various regulations to support green technology especially on renewable energy, but their implementation is often slowed by bureaucracy and complex rules. Confusing and uncoordinated licensing processes among different agencies can make it difficult for entrepreneurs and researchers to obtain necessary permits. This not only delays projects but also raises costs and risks. Furthermore, the lack of simplified and consistent regulations can lead to confusion and uncertainty, which may deter investments in green technology. The regulation and policies supporting the development and implementation of green technology in Indonesia include :

a. Law No. 30 of 2007 on Energy
b. Law No. 17 of 2019 on Water Resources
c. Goverment Regulation No. 79 of 2014 on National Energy Policy
d. Law No. 21 of 2014 on Geothermal
e. Law Number 30 of 2009 on Manpower as amended by Law No. 6 of 2023 on Job Creation Regulation
f. Regualtion of Minister of Energy and Mineral Resources No. 4 of 2020 on the Utilization of Renewable Energy Sources for Provision of Electricity
g. Presidential Regulation No. 112 of 2022 uon The Acceleration of Renewable Energy Develeopment for Supply of Electricity

[15] United Nations Development Programme "Renewable Energy Technologies"https://www.undp.org/sites/g/files/zskgke326/files/publications/chapter7.pdf

The government's vision for managing renewable energy has not yet been established in the form of legislation. In other words, there is still a need for a legal framework with the force of law that provides comprehensive regulations specifically regarding renewable energy, which would serve as a legal foundation and reference for subsequent regulations. This necessity is urgent, as various legal instruments are currently in effect, ranging from laws and government regulations to ministerial regulations, all of which simultaneously address renewable energy management. This situation has led to overlapping regulations that can hinder the acceleration of renewable energy management. Consequently, this brings about the first legal issue: a lack of legislation.

The government and the House of Representatives are currently dealing with the first problem by drafting the Renewable Energy Bill (RE Bill). However, the RE Bill has not fully regulated the management of renewable energy in Indonesia, because there are still a number of weaknesses in the text that can reduce the benefits that should be produced. This is the second legal problem, namely the weakness in the text of the RE Bill itself : [16]

1. Not paying attention to the concept of the energy trilemma, namely the fulfillment and equitable distribution of energy from a country. Energy must be able to have a balance between three aspects of energy, namely: 1) Energy security; 2) Energy Access; and 3) Environmental Sustainability.

2. The ambiguity of energy priorities is 40 articles contained in this bill, all terminology used in managing renewable energy sources cannot be separated from the management of new energy. Starting from planning, licensing, implementation, mastery, and many more. In fact, new energy comes from the processing of fossil energy, such as nuclear energy, coal methane (cool bed methane), and liquefied coal (liquefied cool bed).

[16] S. Y. Kalpikajati, and S. Hermawan, "Hambatan Penerapan Kebijakan Energi Terbarukan di Indonesia" *Batulis Civil Law Review* 2023, vol.03, no. 02, pp. 187-201, DOI:https://doi.org/10.47268/ballrev.v3i2.1012

B. Evaluation of Existing Legal Frameworks

1. Domestic Legal Framework, Law No. 32 Of 2009 And Other Related Regulations

Gustav Radbruch said that law has three principles, namely the principles of usefulness, justice and certainty.[17] Laws in Indonesia must always be reviewed to be able to adapt to the new era. Currently there are several legal regulations that work together to realize environmentally friendly technology, including:

a. Law No. 30 of 2007 on Energy
b. Law No. 17 of 2019 on Water Resources
c. Goverment Regulation No. 79 of 2014 on National Energy Policy
d. Law No. 21 of 2014 on Geothermal
e. Law Number 30 of 2009 on Manpower as amended by Law No. 6 of 2023 on Job Creation Regulation
f. Regualtion of Minister of Energy and Mineral Resources No. 4 of 2020 on the Utilization of Renewable Energy Sources for Provision of Electricity
g. Presidential Regulation No. 112 of 2022 on The Acceleration of Renewable Energy Develeopment for Supply of Electricity

Furthermore, the existence of regulations related to environmentally friendly technology has implications for the constitutional rights of the Indonesian people, namely the right to life. The right to life can be realized with regulations governing efforts to use environmentally friendly technology. This is not only important to protect the environment and the quality of people's lives but also to encourage innovation and green investment. With a relevant legal framework, Indonesia can move towards sustainable development that balances economic needs and nature conservation.

[17] A R. Ilahi, "Studi Pajak Karbon UU HPP Berdasarkan Asas Kepastian, Keadilan, dan Kebermanfaatan" Repositori Digital PKN STAN,, 2023, Accessed: November 14, 2024 [Online] Available: http://eprints.pknstan.ac.id/id/eprint/1462

2. Economic Instruments, Discuss Any Incentives Or Lack Thereof For Green Technologies (Verified If Relevant To The Topic)

Economic instruments are a supporting aspect to achieve the application of renewable energy. Article 1 in the Government Regulation of the Republic of Indonesia Number 46 of 2017 concerning Environmental Economic Instruments contains the definition of Environmental Economic Instruments, namely a set of economic policies to encourage the Central Government, Regional Government, or Everyone to Preserve the Functions of the Environment. One of the Environmental Economic Instruments is incentives. However, it was found that many of the incentives offered in PP IELH were not followed by adequate monitoring and evaluation mechanisms. This causes difficulties in assessing the effectiveness of these incentives. In addition, there are concerns that incentives only benefit a handful of large economic actors, while small businesses and local communities do not receive the same benefits. The criteria for obtaining incentives are often unclear or too complicated, so that many economic actors cannot utilize them optimally. This causes increasing and decreasing interest in participating in programs that support environmental sustainability. Meanwhile, in Republic of Indonesia Government Regulation Number 22 of 2021 concerning the Implementation of Environmental Protection and Management as a form of change, some of the existing regulations do not explicitly regulate IELH. So explicit changes are needed to guarantee legal certainty in the field of economic instruments.

One of the instruments regulated in PP IELH is the procurement of environmentally friendly goods and services. Through this instrument, the government encourages the use of products that use renewable energy, so as to increase the procurement of clean energy. Additionally, funding incentives such as the Recovery Guarantee Fund and the Response Fund are also designed to support renewable energy projects, providing financial support for initiatives that contribute to environmental recovery and preservation. Overall, PP Number 46 of 2017 functions as a regulatory framework that supports the transition towards the use of renewable energy in Indonesia.[18] By integrating appropriate economic instruments and ensuring that there are evaluation mechanisms and clear criteria, the government can increase the participation of various stakeholders in efforts to preserve the environment through the development of renewable energy.

[18] H. Oktiarifadah, C. D. Santika, and F. A. Zulhian, "Tinjauan Hukum Dan Implikasi Atas Investasi Asing Pada Proyek Energi Baru Terbarukan (Ebt) Di Indonesia," Padjadjaran Law Review, vol. 12, no. 1, pp. 46–59, 2024. Available: https://doi.org/10.56895/plr.v12i1.1647.

3. Regulatory Actions, How Current Laws Regulate Environmental Management.

Environmental management in Indonesia is regulated through various regulations that correlate with each other. In this discussion, the following is an overview of the laws currently in force and how they regulate environmental management:

In Indonesia, there are currently several regulations governing environmental management and renewable energy efforts. This is implemented through various regulations that are related to each other. The following are several regulations and a summary of renewable energy analysis:

1. Law Number 17 of 2019 concerning Water Resources

This regulation regulates the appropriate management of water resources to maintain water availability, considering the vital role of water in life. In the context of renewable energy, water resource management is very important for projects, one of which is hydroelectric power plants. Therefore, this regulation emphasizes the integrated use of water resources to support the development of sustainable renewable energy infrastructure

2. Government Regulation Number 79 of 2014 concerning National Energy Policy

This regulation sets guidelines for national energy policy, including making renewable energy a top priority. This regulation explicitly states in article 1 that renewable energy is energy that comes from sustainable energy resources if managed properly, such as geothermal heat, wind, bioenergy, sunlight, water flows and waterfalls, as well as movements and temperature differences in the sea layers.

3. Law Number 21 of 2014 concerning Geothermal Energy

Geothermal heat as a renewable energy source is vital for its exploitation to be regulated so that it is maintained and does not cause negative impacts. In the concept of renewable energy, this regulation plays a role in increasing renewable energy in the energy sector in the future. So it is important to continue to carry out further studies regarding relevant matters.

4. Law Number 30 of 2009 concerning Electricity

This regulation has been updated by Law Number 6 of 2023 concerning Job Creation. This regulation focuses on regulating the supply of electricity from various sources, including renewable energy sources. The aim of this regulation is to create a transition with sustainable and environmentally friendly resources. Reminding that electricity is an important part, so the availability of electricity needs to be maintained.

5. Minister of Energy and Mineral Resources Regulation Number 4 of 2020 concerning Utilization of Renewable Energy Sources for Providing Electricity

This regulation facilitates technical guidance for utilizing renewable energy sources in efforts to provide electricity, including procedures for licensing and incentives. The aim is to support increased use of renewable energy in providing electricity nationally.

6. Presidential Regulation Number 112 of 2022 concerning the Acceleration of Renewable Energy Development for the Supply of Electric Power

This regulation is a concrete strategy to achieve the goal of accelerating renewable energy development in Indonesia. This includes policies and programs related to increasing electricity generation capacity from renewable energy sources as well as encouraging technological innovation in the energy sector to support the use of renewable energy.

Overall, currently regulations in Indonesia have a vital role in environmental management efforts as well as encouraging the development of renewable energy. By having regulations that do not have multiple interpretations and are holistic, the government can create a balance between the need for clean and sustainable energy and environmental protection. This will be an important step to achieve the SDGs goals and meet society's energy needs in a sustainable manner.

4. International Agreements And Protocols, Paris Agreement Or Other Related Ones

The Cartagena Protocol on Biosafety Status is one of the international laws ratified in Indonesia. The aim of this Protocol is to contribute to ensuring an adequate level of protection in the field of movement, handling and safe use of genetically modified

organisms originating from modern biotechnology which may cause harm to the conservation and sustainable use of biological diversity, taking into account also the risks on human health, and specifically focuses on cross-border movement.[19] Several regulations in Indonesia are not yet fully in line with the provisions of the Cartagena Protocol regarding biosafety and management of genetically modified organisms (OHMG). First, Law Number 5 of 1990 concerning Conservation of Biological Natural Resources and Ecosystems includes the protection of biodiversity, but does not fully accommodate the provisions of the Cartagena Protocol regarding OHMG management. Some of its articles, such as the prohibition on the harvest and trade of protected plants, may conflict with the provisions of the Protocol permitting the use of OHMG. Furthermore, Law Number 32 of 2009 concerning Environmental Protection and Management regulates the environment in general, but does not specifically regulate OHMG supervision as regulated by the Cartagena Protocol, which has the potential to cause overlap in biosafety policies.

The Paris Agreement, which Indonesia also ratified, has a close relationship with green technology, where this agreement functions as a global framework to encourage the reduction of greenhouse gas emissions and the transition to clean energy. The Paris Agreement encourages developed countries to provide financial and technological support to developing countries so they can transition to low-carbon economies. This includes investment in research and development of green technologies that can help developing countries reduce dependence on fossil fuels. There are several aspects that Indonesia has not fully fulfilled in ratifying and implementing the Paris Agreement. Indonesia is committed to reducing greenhouse gas emissions by 29% with its own efforts and 41% with international assistance by 2030. However, this target is considered still not ambitious enough to achieve the Paris Agreement goal of limiting global temperature rise to below 2°C. Even though Indonesia has made various policies related to climate change, their implementation is still not optimal, especially in the forestry, energy and land use sectors. Indonesia's commitment has not fully adopted the principles of climate justice and does not yet have adequate participation mechanisms from various stakeholders. To fulfill its Paris Agreement commitments more effectively, Indonesia needs to increase its emission reduction commitments, align cross-sector policies, improve implementation, strengthen international cooperation, and ensure wider

[19] A. Larasati, "Standarisasi Keamanan Pangan Produk Rekayasa Genetika," Plaza Hukum Indonesia, vol. 1, no. 1, pp. 108–129, 2023. Available: http://jurnalplazahukum.com/index.php/jphi/article/view/6.

participation of various stakeholders in climate change mitigation and adaptation efforts.

5. The Influence Of Domestic Law To Shape National Policy.

The influence of domestic legislation on the formation of national policies regarding environmentally friendly technology in Indonesia is very large. This policy is influenced by various regulations, rules and international commitments taken by the government. The underlying legal framework, such as Law Number 32 of 2009 concerning Environmental Protection and Management, functions as the legal basis for environmental management in Indonesia. This law encourages the integration of environmental aspects in every development process, including the application of environmentally friendly technology. Through this regulation, the government is obliged to consider environmental impacts in every policy it takes. The Renewable Energy Policy shows the Indonesian Government's commitment to increasing the use of renewable energy through various initiatives, such as the 35,000 MW Program and the development of biofuels (B30, B100). This policy not only aims to meet energy needs, but also to reduce carbon emissions and negative impacts on the environment. Domestic regulations play a role in setting these targets and encouraging investment in environmentally friendly technologies.

In Indonesia, there are several significant gaps between the influence of domestic laws and the formation of national policies in the field of renewable energy. First, the unavailability of a comprehensive legal umbrella for the development of new and renewable energy (EBT) poses a threat to investors and industry players. Currently, existing regulations are sectoral and often overlap, giving rise to confusion in policy implementation.[20] For example, the New Energy and Renewable Energy Bill (RUU EBET) is still in the discussion process and does not yet provide the legal certainty needed to encourage investment in this sector. Second, even though Indonesia has great potential in EBT, support from policies and incentives is still minimal. This has resulted in slow development of the renewable energy sector, while dependence on fossil energy remains high. Third, existing regulations often do not support the development of new technology, such as in the case of solar power plants which are hampered by unrealistic domestic content level (TKDN) provisions.

[20] F. F. Busroh, F. Khairo, and P. D. Zhafirah, "Harmonisasi Regulasi Di Indonesia: Simplikasi Dan Sinkronisasi Untuk Peningkatan Efektivitas Hukum," Jurnal Interpretasi Hukum, vol. 5, no. 1, pp. 699–711, 2024. Available: https://doi.org/10.22225/juinhum.5.1.7997.699-711.

To overcome this gap, a special law is needed that regulates EBT as a whole, similar to the Renewable Energy Law implemented in other countries such as Germany and Malaysia. This will provide legal certainty and facilitate implementation. Reducing regulatory overlap by drafting more integrated regulations. This includes revisions to the Regulation of the Minister of Energy and Mineral Resources to better support the development of EBT without business actors.

C. Identifying Gaps In The Legal Framework

1. Insufficient Incentives (Verified)

The government does not factor in the environmental damage caused by burning fossil fuels when setting their prices. By neglecting these externalities, it discourages people from switching to cleaner forms of energy like renewables. Therefore, implementing policies that account for the full cost of using fossil fuels or offering support for research into sustainable alternatives are essential steps forward. Alternatively, a policy that provides subsidies and incentives for research and development of renewable energy sources and technologies should be enacted. [21]

Although there are supportive policies and regulations in place, the incentives offered are often seen as insufficient to attract the needed investment. Programs like tax breaks or subsidies may not be large enough to offset the high initial costs of green technology or to compete with cheaper, less environmentally friendly options. Additionally, some incentives may not be effectively communicated to businesses, particularly small and medium-sized enterprises, leading to missed opportunities. As a result, weak incentives can make the private sector hesitant to invest in green technology, which limits broader adoption and innovation in this area.[22]

Consequently, the advancement of renewable energy must be backed by cohesive policies and strategies. A robust regulatory framework will enable the government to ensure the sustainability of both current and future renewable energy projects. Furthermore, it is essential for the government to offer incentives and subsidies to

[21] Nugroho, Fathul, and Noor Syaifuddin. "The Economic Impact of Renewable Energy Development in Indonesia." *Hasanuddin Economics and Business Review* 1, no. 2 (2017): 126. DOI:10.26487/hebr.v1i2.1243

[22] A. Zuliah, "The role of law and government policy in supporting green technology: Challenges and solutions," Proc. Univ. Dharmawangsa, 2024. [Online]. Available: https://proceeding.dharmawangsa.ac.id/index.php/PROSUNDHAR/article/view/308/0.

organizations and companies that advocate for and utilize renewable energy sources and technologies, allowing them to offset their marginal costs.

2. Lack Of Strong Economic Incentives For R&D In Green Technology (Verified)

The lack of strong economic incentives for research and development (R&D) in green technology in Indonesia presents a significant barrier to progress in this sector. Despite the government's efforts to promote green initiatives, financial support mechanisms such as tax breaks and subsidies are often insufficient to cover the high costs associated with developing eco-friendly technologies. This inadequacy discourages private sector investment, as companies may find it more challenging to justify the expenses compared to cheaper, traditional alternatives.

The effective use of renewable technologies to lower the environmental impact of manufacturing depends on supportive government policies and incentives. These policies foster a positive environment for green initiatives, encouraging investment in the renewable energy sector. The adoption of renewable technologies has the potential to decrease reliance on nonrenewable resources and mitigate carbon emissions, but supportive government policies and incentives are necessary for their successful integration. [23]

To foster a more robust green technology sector, Indonesia must enhance its economic incentives for R&D by simplifying access to funding, improving coordination among government agencies, and reallocating financial support towards sustainable projects. By addressing these issues, Indonesia can stimulate innovation and investment in green technologies, ultimately contributing to its environmental sustainability goals.

3. Regulatory Overlaps And Barriers (If Any)

The shortcomings of the energy transition can be assessed through five indicators related to achieving energy justice: Procedural justice, Distributive justice, Restorative justice, Recognition justice, and Cosmopolitanism justice. Bottlenecks in procedural justice frequently arise from inconsistencies in policy. Such

[23] G. Rusmayadi, U. Salawati, A. Haslinah, and L. Judijanto, "The effect of investment in green technology and renewable technology adoption on energy efficiency and carbon emissions reduction in Indonesian manufacturing companies," West Sci. Interdiscip. Stud., vol. 1, no. 11, pp. 1175–1183, 2023. doi: 10.58812/wsis.v1i11.347. Available: https://doi.org/10.58812/wsis.v1i11.347.

inconsistencies occur when the priorities of decision-makers shift over time, leading to conflicting preferences across different periods. The failure of the energy transition may result in the abandonment of existing policies and the introduction of new ones, which can create confusion and disorder within the policy framework. This inconsistency often stems from policy reforms that disrupt the continuity of previous strategies and result in negative outcomes.[24]

Differences in interests between regulators and the companies they oversee can result in significant policy failures. In various countries, coal mining companies continue to receive investment support due to the extremely high demand from the investors' home countries.[25] Failures in transition can arise when all stakeholders are not fairly included, particularly during shifts to alternative energy or when issues of justice are overlooked. The policy-making process must be transparent and engage a wide range of participants, particularly user communities and those whose land is impacted by energy facilities. It is essential to facilitate socialization, dialogue, and consensus among all parties involved. Energy policies that neglect justice can lead to significant problems and conflicts.

According to the regulations 112/2022, coal-fired power plants (PLTU) can still be constructed if they are listed in the Electricity Supply Business Plan (RUPTL) before the Presidential Regulation 112/2022 was enacted on September 13, even if they have not yet reached financial closure. This contradicts President Joko Widodo's instructions in 2020 and 2021, which prohibited new coal-fired power plant projects unless they were already at the financial closure or construction stage. Several projects, such as Jambi-1 (600 MW), Jambi-2 (600 MW), and Sumbagsel-1 (300 MW), are ready to be built despite not having reached that stage.[26]

This regulation still allows for the issuance of permits for "captive" coal power plants that serve factories or industrial zones, provided they commit to limiting emissions and do not operate beyond 2050. However, the United Nations Environment Program encourages governments to immediately halt coal usage to prevent a climate crisis.

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[24] L. Loy, "Barriers to Indonesia's energy transition," The Indonesian Journal of Planning and Development, vol. 12, no. 1, pp. 1-15, 2023. [Online]. Available: https://ejournal2.undip.ac.id/index.php/ijpd/article/view/20301.

[25] Asian Power, "Policy gaps challenge Indonesia's $146B investment goal for renewable energy," Asian Power, 2024. [Online]. Available: https://asian-power.com/videos/policy-gaps-challenge-indonesias-146b-investment-goal-renewable-energy Accessed November 14, 2024

[26] https://dialogue.earth/en/energy/in-indonesia-regulatory-gaps-are-holding-back-renewables/ Accessed November 14, 2024

4. Challenges In Enforcing Existing Laws And Policies Of Renewable Energy

Green technology laws can create various legal challenges, such as issues with regulatory compliance, liability for environmental harm, and disputes over land use and access. It is important for project developers and stakeholders to understand how to resolve these disputes.[27]

Regulatory Compliance Issues: Project developers must follow a complex set of regulations, and failing to do so can lead to legal penalties. Common compliance problems include breaking environmental standards, land use rules, and green technology guidelines. These issues can often be resolved through negotiations with regulatory agencies, administrative hearings, or litigation if needed.

Liability for Environmental Damage: Developers may be held responsible for any environmental damage caused by their projects. Such liability claims can lead to significant financial losses and harm the developer's reputation. To protect themselves, developers should implement strong environmental management practices and keep thorough documentation to show they comply with environmental standards. Legal defenses might include disputing the cause of the damage and proving adherence to environmental practices.

Disputes Over Land Use and Access : Conflicts over land use and access can occur between stakeholders like landowners, project developers, and government agencies. These disputes may involve issues such as land acquisition, zoning regulations, and access to public lands. Legal strategies for resolving these conflicts can include negotiation, mediation, arbitration, or litigation.

Data from the International Renewable Energy Agency indicates that Indonesia has the capacity to generate 716 GW of energy through various renewable sources, including solar photovoltaic, hydropower, bioenergy, geothermal, ocean wave power, and wind : [28]

1. **Depending on Fossil Fuels :** The primary obstacle to Indonesia's shift toward renewable energy is its significant reliance on fossil fuels. Currently, the country's energy sources are predominantly centered around fossil energy.

[27] M. Green, "Green technology laws: Understanding regulations for sustainable innovation," Attorneys Media, 2023. [Online]. Available: https://attorneys.media/green-technology-laws/ .Accessed November 7, 2024

[28] Udin, Udin. "Renewable energy and human resource development: Challenges and opportunities in Indonesia." *International Journal of Energy Economics and Policy* 10, no. 2 (2020): 234-235. https://www.zbw.eu/econis-archiv/bitstream/11159/8287/1/175146539X_0.pdf

With fossil fuel reserves projected to last only another 10 to 13 years, they are insufficient to meet Indonesia's goals for 2045.

2. **Imbalance and Inequity of Subsidies :** Energy subsidies represent a substantial financial strain on the Indonesian government. In 2017, the country allocated 77.3 trillion rupiahs to energy subsidies, which accounted for 4.4% of its state revenue. These subsidies lead to lower tariffs for fossil fuels, making them more accessible to the public. In contrast, renewable energy remains more costly due to high investment expenses associated with technology, hindering its ability to compete with subsidized fossil fuels.
3. **Lack of Coordination between Agencies :** Ineffective coordination among ministries and agencies leads to inconsistencies in implementing established development plans. In Indonesia, seven institutions are tasked with overseeing renewable energy policies. Discrepancies in data between these institutions can result in suboptimal renewable energy development. Furthermore, policies concerning renewable energy development are subject to frequent changes, as exemplified by the fluctuating feed-in tariffs for renewable energy sources.

D. Learning From Best Practices

1. Case Studies From Other Countries, Examples Of Legal Frameworks That Effectively Promote Environmentally Friendly Technologies (E.G. German Renewable Energy Act Or Others)

Legal framework that promotes environmentally friendly technology One example of an effective legal framework in promoting environmentally friendly technology is the German Renewable Energy Act. Germany has implemented a policy known as the Energiewende, which aims to transition to a more sustainable energy system. This policy includes incentives for the use of renewable energy, reduced greenhouse gas emissions, and increased energy efficiency. Through this law, the government provides subsidies and tax incentives for individuals and companies that invest in green technologies such as solar and wind power. The environmental impact of the German Energiewende pioneering during 1973–2022 renewable energy shows a positive impact on the environment and further increases Germany's LCF 0.03% and

validates their role in the sustainable transition.[29] In contrast, fossil fuels reduce LCF to a much greater extent, underscoring the need for restrictions. The negligible impact of nuclear power shows that phasing out nuclear use is necessary. Therefore, strong evidence supports expanding renewable energy and limiting the use of fossil fuels to achieve Germany's decarbonization goals. Although contextual factors limit generalizability, insights from the complex transitions underway in industrialized countries such as Germany remain important for global policymaking.

Brazil is active in the Clean Development Mechanism (CDM) Program which aims to increase the use of environmentally friendly technologies through international cooperation. Until 2017, Brazil had 342 CDM projects, especially in the renewable energy sector such as hydroelectric power plants. Additionally, the REDD+ (Reducing Emissions from Deforestation and Forest Degradation) initiative provides financial incentives to preserve forests and reduce deforestation, with Brazil receiving $1.2 billion in aid from Norway as an offset to efforts to reduce deforestation. In the waste sector, Brazil maintains significant challenges as a source of methane emissions; by 2023, more than 200 organizations are demanding improvements in organic waste management. In response, Brazil's Ministry of the Environment signed a cooperation agreement with Instituto Pólis to advance organic waste recycling and greenhouse gas mitigation. Although there are various policies that support environmentally friendly technology. Therefore, the legal framework in Brazil shows great potential in promoting environmentally friendly technologies.[30]

Another country that also has a similar legal framework is Sweden, which implements a carbon tax and supports research and development of environmentally friendly technologies. Sweden's carbon tax has proven effective in reducing CO2 emissions and encouraging innovation in the renewable energy sector. Additionally, Denmark has strong laws regarding the use of renewable energy, including an ambitious target to achieve 50% of total energy consumption from renewable sources by 2030.

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[29] C.C. Chen, "Comparative impacts of energy sources on environmental quality: A five-decade analysis of Germany's Energiewende" vol. 11, no. 1, pp. 3550-3561, 2024, DOI: https://doi.org/10.1016/j.egyr.2024.03.027 [Online]. Available: Accessed, November 7, 2024

[30] B. Polat and N. Cil "Implementasi Protokol Kyoto Di Brasil," Environment, Development and Sustainability, vol. 23, no. 4, pp. 263–277, 2018. [Online]. Available: https://link.springer.com/article/10.1007/s10668-024-04583-9. Accessed: November 15, 2024

2. Application In Indonesia, How Can These Best Practices Be Adapted To The Indonesian Context.

Indonesia needs to formulate a clearer and more comprehensive policy regarding renewable energy, similar to Germany's Energiewende. This could include incentives for investment in renewable energy projects, although currently incentives and disincentives have been regulated, but the regulations are still not complete, containing criteria and mechanisms. Increasing public awareness about the importance of environmentally friendly technology through education and public campaigns, currently a holistic approach is really needed considering the need for a protected environment is not just for a few people. Adopt best practices from other countries through international cooperation, including technology transfer and funding for green projects. This can start from ratifying appropriate conventions or regulations.

3. Integration With Green Funding, The Role Of Financial Mechanisms In Supporting Green Technology Innovation

Green Funding plays a crucial role in supporting green technology innovation. Some important aspects of this integration include, providing financial resources for projects focused on sustainability, such as renewable energy, energy efficiency and waste management. The government can provide tax incentives for investors who fund green projects, thereby encouraging more investment in this sector. Creating a carbon market, companies can buy and sell carbon credits, providing additional incentives to reduce emissions. Encourage community participation in financing green projects through crowdfunding schemes or green bonds, enabling individuals to contribute directly to environmental sustainability. By integrating these financial mechanisms into public policy, Indonesia can accelerate the adoption of environmentally friendly technologies and achieve more ambitious sustainability targets. Integration with environmentally friendly funding is very important in supporting renewable energy because it allows the allocation of funds specifically for sustainable projects, including renewable energy. Through integration with environmentally friendly funding, financial mechanisms can play a central role in establishing a strong foundation for the growth of the renewable energy sector.

The results of the research entitled "Green finance and sustainable development goals in Indonesian Fund Village" show that environmentally friendly finance

(green finance) has an important meaning in achieving SDGs in terms of environmental sustainability and economic sustainability.[31] It was found that green finance can promote green technology innovation and environmentally friendly micro-enterprises, which in turn leads to achieving the SDGs through environmental sustainability and economic sustainability. There are varying and conflicting estimates about how much green finance is needed to transition Indonesia to sustainable development.[32] What is clear, however, is that current policies and incentives are insufficient to create the enabling environment necessary to meet Indonesia's future energy needs. Indonesia can go ahead with reforms by promoting voluntary principles for green finance, collaboration to facilitate international investment in green bonds, and by improving the quality of measurement of green finance activities and their impacts.

IV. CONCLUSION

Through a literature-based approach and comparative regulatory practices, it can be concluded that Indonesia faces various regulatory and implementation challenges related to green technology specifications, particularly in renewable energy, which is not yet comprehensively regulated. Many regulations are inconsistent, hindering its effective implementation. There is a strong connection between economic instruments and the execution of programs aimed at renewable energy, while the lack of incentives to support the development of eco-friendly technology poses a barrier to advancing green technology initiatives.

The recommendation for policymakers in addressing the challenges and regulatory gaps in the implementation of green technology, especially renewable energy, is to develop a comprehensive, dedicated regulation. This specialized regulation should not only cover technical aspects but also encompass various critical dimensions of green technology application in Indonesia, including all key areas such as licensing, funding, implementation effectiveness, benefits, and sanctions for violations and non-compliance.

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[31] Reza Ronaldo and Tulus Suryanto, "Green Finance and Sustainability Development Goals in Indonesian Fund Village," *Resources Policy* 78, no. December 2021 (2022): 102839, https://doi.org/10.1016/j.resourpol.2022.102839.

[32] Siti Nurul Hidayati et al., "Tantangan Dan Peluang Inovasi Keuangan Dalam Mendukung Transisi Ke Ekonomi Hijau Pada Pt Adaro Energy Indonesia," *Masharif* 9, no. 204 (2024): 1726–39, https://www.doi.org/10.30651/jms.v9i3.22853.

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C. C. Chen, "Comparative impacts of energy sources on environmental quality: A five-decade analysis of Germany's Energiewende," vol. 11, no. 1, pp. 3550–

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Measured Fishing as an Effort to Conserve the Sustainable Marine Environment in Indonesia

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ABSTRACT: Indonesia as the largest archipelagic country in the world has the potential for abundant marine biodiversity. The potential of natural resources, especially the area of 2/3 water. This is a problem in managing marine areas related to fishing, especially for provincial governments **characterized by islands**. The socio-legal method in this research is to see how the law is enforced in the research to obtain benefits related to fishing governance in the utilization of marine resources. The results of this study indicate that the enactment of Law No. 23 of 2014 concerning Regional Government which provides for the transfer of central government affairs to local governments in the implementation of activities in the fisheries sector given to provincial / regency/city regions through regional authority as a form of implementation of regional autonomy. This has an impact on uneven fishing results. Measured fishing arrangements in archipelagic provinces are expected to regulate the availability of fish sustainably in each fisheries area in Indonesia. This effort is carried out by determining the fishing area, fishing vessels, and fishing gear used the results of the catch obtained, and the fishing port determined according to the license. As for the results of the research, it is hoped that local governments can preserve fish resources in their respective regional fisheries areas with the hope that local governments characterized by islands can regulate Measured Fishing by planning and management as an effort to improve the welfare of the Indonesian people.

KEYWORDS: Measured Fishing, Environmental Sustainability, Indonesia.

I. INTRODUCTION

Indonesia has a water area of 3.1 million square kilometers and a coastline length of 81,000 kilometers, making Indonesia the largest archipelago in the world. Indonesia's marine area, consisting of territorial and archipelagic waters, covers almost two-thirds (2/3) of Indonesia's territory. Indonesia's location between the continents of Asia and Australia, as well as between the Pacific and Indian oceans, and between the North Natuna Sea and the East Asian Sea and the Indian Ocean, makes Indonesia's position as the world's largest island nation very strategic and important for regional and international political, economic and security stability. Therefore, Indonesia must be able to make optimal use of its natural resources, especially marine resources.[1]

As the world's largest maritime and archipelagic country, Indonesia has the potential for an abundant diversity of marine biological resources and marine ecosystems. This natural wealth is one of the basic capitals that must be managed optimally and sustainably to improve the welfare and prosperity of the Indonesian people. The sustainable potential of Indonesia's marine fish resources is spread across Indonesian waters and the Indonesian Exclusive Economic Zone (EEZ), and there are opportunities to utilize fish resources on the high seas. The marine and fisheries sector has complex problems due to its interrelationship with many industries and is also sensitive to interactions, especially with environmental aspects. Various fisheries management issues in Indonesia have the potential to threaten the sustainability of fish resources and the environment, the sustainability of community livelihoods in the marine and fisheries sector, food security, and economic growth derived from the utilization of marine and fisheries resources.[2]

Such great marine potential requires careful planning by regions that have marine areas. Areas characterized by islands have different governance needs from areas that are not characterized by islands. This is both a problem and a challenge in the management of Indonesia's provinces, some of which have archipelagic characteristics. Provinces with archipelagic characteristics are defined as provinces that have geographical characteristics with a larger sea area than land, where there are islands that form island groups, thus becoming a geographical and socio-cultural unit.[3] Referring to this definition, there must be strong connectivity between islands to form an integrated unit. The determination of provincial sea area is determined as far as 12 (twelve) nautical miles from the coastline towards the open sea and/or towards archipelagic waters.[4]

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1 Amiek Soemarmi, dkk., "Konsep Negara Kepulauan dalam Upaya Perlindungan Wilayah Pengelolaan Perikanan Indonesia", *Masalah-Masalah Hukum*, Vol. 48, No. 3, Juli 2019, hlm. 241-242, https://doi.org/10.14710/mmh.48.3.2019.241-248.

2 See the General section of the Elucidation of Government Regulation No. 11 of 2023 on Measured Fishing.

3 See Article 1 point 19 of Law Number 23 Year 2014 on Regional Government.

4 See Article 27 paragraph (3) of Law Number 23 Year 2014 on Regional Government.

In particular, Law Number 23 of 2014 concerning Regional Government regulates the Province characterized by Islands with provisions that distinguish the Province from other Provinces. However, technically, the determination of such areas uses the concept of "coastal state," as is the case with other provinces that do not have archipelagic characteristics. The determination uses provincial authority as far as 12 (twelve) nautical miles from the coastline. In determining the boundaries of the territory, the coastline used is the high water line found on the islands in the Province, so if there are more than 24 (twenty-four) nautical miles between the islands in the province, there will be gaps in the sea area that are not managed by the Provincial Government.[5]

The Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia as the government's representation in the marine and fisheries sector has five programs to achieve a Blue Economy that covers marine management from upstream to downstream. These programs are implemented in the span of 2021-2024. The five programs are:

1. conservation area expansion program;
2. development of sustainable aquaculture;
3. sustainable management of coastal and small islands;
4. quota-based measured fishing policy; and
5. handling of marine debris through the Love the Sea Month program.

One of the five work programs developed in the construction of legislative arrangements is a quota-based measured fishing policy. This is in line with the implementation of accelerating Indonesia's marine development. Indonesia's marine policy is regulated in Law Number 32 of 2014 concerning Maritime Affairs and Presidential Regulation of the Republic of Indonesia Number 16 of 2017 concerning Indonesian Marine Policy. There are 7 (seven) pillars of the Indonesian Marine Policy that form the basis for the formation of national marine policies. These principles then underlie the concept of national fisheries governance, with the hope that it will have a positive impact on the country's economic growth and the welfare of the marine and fisheries community.[6]

The challenges currently faced in marine and fisheries development, especially capture fisheries, include:

1. not yet optimal control of fishing that has the potential to threaten the sustainability of fish resources and ecosystems;

[5] E Djunarsjah dan A.P. Putra, The Concept of an Archipelagic Province in Indonesia", *IOP Conf. Series: Earth and Environmental Science*, The Second Maluku International Conference on Marine Science and Technology, Vol. 777, 2021. hlm. 2, https://doi.org/10.1088/1755-1315/777/1/012040.

[6] Marine Diplomacy

2. capture fisheries governance that has not been integrated and has not optimally grown the regional economy in accordance with the potential of its fisheries natural resources;
3. infrastructure and connectivity of Fishing Ports including other facilities and infrastructure that are inadequate and uneven; and
4. unstable availability of raw materials with inadequate competitiveness and quality of fishery products

To overcome the issues and challenges faced, the Government prepared a Measured Fishing policy as a reference for the management of capture fisheries in Indonesia while maintaining marine ecology that contributes to national economic growth and ensures the health of Indonesian seas. The Measured Fishing Policy is pursued with the aim of maintaining ecology and maintaining biodiversity, increasing regional economic growth, and fishermen's welfare. The Measured Fishing Policy is expected to eliminate the practice of illegal, unreported, and unregulated fishing activities. Based on this, it is necessary to formulate and stipulate a Government Regulation on Measured Fishing through Government Regulation No. 11 of 2023 on Measured Fishing to advance Indonesia's marine and fisheries sector by considering bio-ecological, economic, social, and food security aspects.[7]

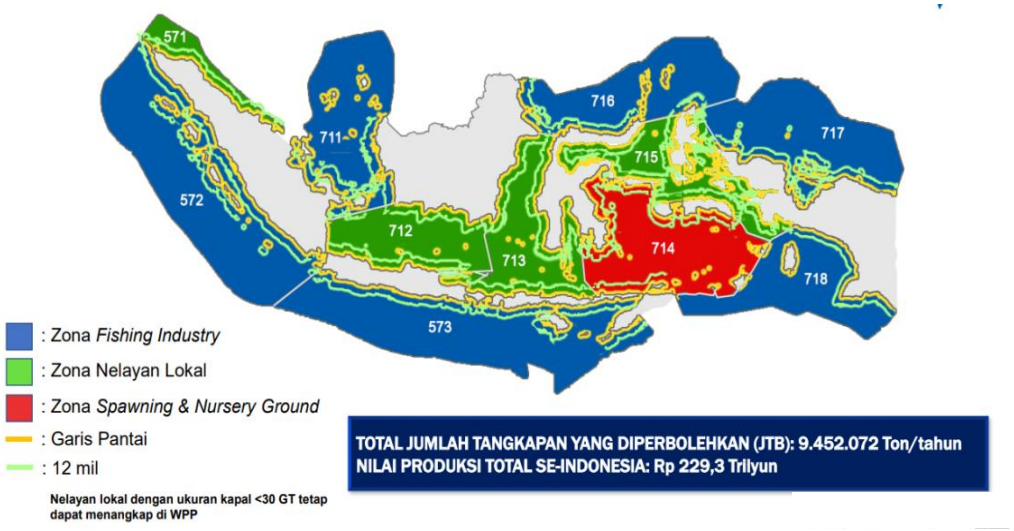

Figure 1. Zone Division of Measured Fishing Policy in WPP-NRI

(Source: Direktorat Jenderal Perikanan Tangkap, 2020)

[7] See the General section of the Elucidation of Government Regulation No. 11 of 2023 on Measured Fishing.

The implementation of output control regulations in Indonesia is established by a series of fishing zone policies on the number of fish and types of fish that can be caught with quotas collaborated with various regulations accompanied by a contract system that runs for a certain period. The policy classifies fishing zones for industry, local fishermen, and limited fishing within conservation areas. This zoning is named the Fisheries Management Area (WPP). This policy is based on Law No. 45 of 2009 concerning Amendments to Law No. 31 of 2004 concerning Fisheries, especially in Article 2 and Article 7, where both articles have provisions that implicitly regulate measured fishing.

The mapping of WPPNRI was carried out by producing 11 WPPs regulated in the Minister of Marine Affairs and Fisheries Regulation No. Per.01/Men/2009 which was updated by the Minister of Marine Affairs and Fisheries Regulation No. 18/Permen-Kp/2014, as follows:

1. WPP-RI 571 covers the waters of the Malacca Strait and the Andaman Sea;
2. WPP-RI 572 covers the waters of the Indian Ocean west of Sumatra and Sunda Strait;
3. WPP-RI 573 covers the waters of the Indian Ocean south of Java to the south of Nusa Tenggara, the Sawu Sea and the West Timor Sea;
4. WPP-RI 711 covers the waters of the Karimata Strait, Natuna Sea and South China Sea;
5. WPP-RI 712 covers the waters of the Java Sea;
6. WPP-RI 713 covers the waters of the Makassar Strait, Bone Bay, Flores Sea and Bali Sea;
7. WPP-RI 714 covers the waters of Tolo Bay and Banda Sea;
8. WPP-RI 715 covers the waters of Tomini Bay, Maluku Sea, Halmahera Sea, Seram Sea and Berau Bay;
9. WPP-RI 716 covers the waters of the Sulawesi Sea and the North of Halmahera Island;
10. WPP-RI 717 covers the waters of Cendrawasih Bay and the Pacific Ocean;
11. WPP-RI 718 covers the waters of the Aru Sea, Arafuru Sea and Eastern Timor Sea.

The policy on measured fishing has specifically been passed through Government Regulation No. 11 of 2023 on Measured Fishing, where Article 1 point 7 explains the efforts of local fishermen to organize fishing areas in the measured fishing zone up to 12 (twelve) nautical miles. This organizing effort for local fishermen is not easy and requires the involvement of all stakeholders to maintain their livelihoods. Based on Dian Nirmasari and Muhammad Bibin's research, efforts to improve the welfare of fishermen including in the aspect of fishing is one of the prioritized strategies.[8] In

[8] Doni Darmasetiadi, *dkk*., "Identifikasi dan Peran Stakeholder dalam Pengelolaan Zona Penangkapan Ikan di Kecamatan Samboja Kabupaten Kutai Kartanegara", *Jurnal Ilmu Perikanan dan Kelautan*, Vol, 5, No. 2, Juli 2023, hlm. 225, https://doi.org/10.36526/jl.v5i2.2745. Lihat juga pada

addition, Hidayatul Fajri, et al. explained that efforts to improve the quality of life of local fishermen are based on the goal of coordinating stakeholders with fishermen through various activities and programs, such as empowerment.[9]

A measurable externality of fishing is the limitation of the number of vessels that obtain a high fishing license (barrier to entry), due to fishing operational considerations that ultimately create an increasingly efficient fishing business that is in accordance with the status or condition of fish stocks. For example, fish entrepreneurs will reduce the number of crew members operating on a fishing vessel by considering operational cost efficiency and optimum profit against a given quota.

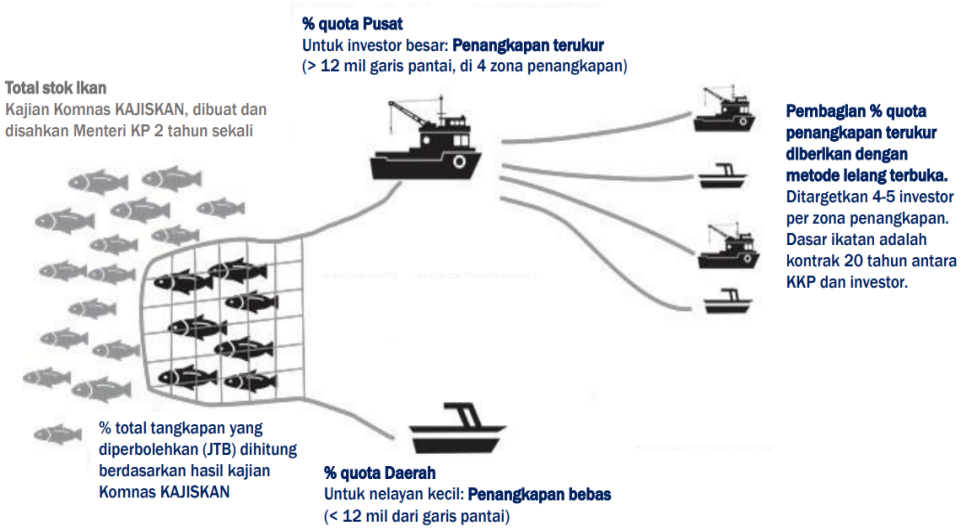

Figure 2. Indonesia's Measured Fishing Implementation system

(Source: Direktorat Jenderal Perikanan Tangkap, 2021)

Measured fishing also has key objectives that are expected to have a positive impact on its implementation. The main objectives of the Measured Fishing policy include:

1. The creation of a socially just fisheries business where local fishermen also get quota in the zone according to the designation, thus encouraging the improvement of the welfare of small fishermen;
2. Sustainable utilization of fish resources and preventing overfishing;

Dian Nirmasari dan Muhammad Bibin, "Strategi Peningkatan Kesejahteraan Nelayan Tradisional Di Kecamatan Wara Timur Kota Palopo", *Jurnal Sains Dan Teknologi Perikanan*, Vol. 2, No. 1, April 2022, hlm. 29–37, https://doi.org/10.55678/jikan.v2i1.640.

9 Hidayatul Fajri, *dkk*., " Collaborative Governance sebagai Solusi dalam Tata Kelola Pemberdayaan Nelayan", *Sosio Informa: Kajian Permasalahan Sosial Dan Usaha Kesejahteraan Sosial*, Vol. 7, No. 2, https://doi.org/10.33007/inf.v7i2.2713.

3. Increasing the profitability of the capture fisheries sector which can be seen as an increase in the contribution of capture business actors to the regional and national economy, which in turn stimulates regional economic growth.

Measured Fishing is also expected to have a multiplier effect, including the opening of employment opportunities, the development of the fishing industry in the fish landing area in accordance with the permit (fishing industry includes fish processing, shipyards, ice factories, cold storage, and so on), the development of logistics services, easier traceability of fishery products, improved credibility of the fisheries sector to the banking industry, and stimulus of the tourism industry.[10]

The integrity of the coastal ecosystem is very important for the health of the sea, so global warming, excessive and unsustainable economic activities, and coastal exploitation must be overcome, by improving the welfare of coastal communities, and efforts to increase income through fishing quotas, it is hoped that coastal areas will be maintained.

Previous research entitled Building Sustainable Climate Justice through Coral Reef Management in the Sawu Sea Waters National Park Area aims to determine the existing conditions related to conditions, potential and problems in managing coral reefs in the Sawu Sea Waters National Park (TNP) area, in East Nusa Tenggara Province, conducting an assessment of the coral reef protection model in the TNP area as an effort to realize climate justice sustainably. The results of this study indicate that there are various potential coral reefs in the Sawu Sea National Park area as one of the world's coral triangle areas, and there is local wisdom owned by the community around the area in utilizing fisheries resources, especially coral reefs, namely Tasaeb Talas, Kowa Hole, Panadahi, and Liku Ketuga.

The limitations in the previous research are related to the specification of the location, the object of research, and cost limitations, namely the specification of the research location that does not represent Indonesian waters in general, where the geographical conditions of Indonesian waters have different characteristics. Also, the object of research is different from the object of current research, namely coral reefs, and the high operational research costs required.

The benefits of this research are to provide analysis related to the implementation of Measured Fishing for small fishermen in catching fish to meet their daily needs and protect small fishermen from industrial vessels in catching fish. And aims to find out whether the Measured Fishing policy in Indonesia has been implemented optimally and maximally and can have a positive impact in the form of protection for small fishing communities in catching fish for their daily needs.

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[10] Sakti Wahyu Trenggono, "Penangkapan Ikan Terukur Berbasis Kuota untuk Keberlanjutan Sumber Daya Perikanan di Indonesia", *Jurnal Kelautan dan Perikanan Terapan*, Vol. 1, 2023, 1-8, hlm. 4, http://dx.doi.org/10.15578/jkpt.v1i0.12057.

Based on the description of the background, benefits and objectives above, the researcher formulates the following problems, first, why does Indonesia regulate Measured Fishing, and, second, how is the Implementation of Measured Fishing Regulations in Indonesia?

II. RESEARCH METHODS

The socio legal legal research method, which is a research method in the field of legal science that represents a way of looking at the law more in context than text, where with a socio legal approach, the problem to be studied is not sufficient to study legal norms or doctrines, but completely looks at the context of norms and their enforcement, as well as how the law works in society which will be studied with a socio legal approach.

This research is descriptive-analytical, aiming to obtain a complete and comprehensive description of the state of the law, juridical symptoms, or legal events that occur in society following the facts and data obtained through interviews at the research location to strengthen the analysis in the form of legal interpretation or interpretation in building a legal argumentation as a conclusion in the form of prescriptions that are researched and studied as a whole through a flow model of analysis. Meanwhile, research activities are carried out using a legal analysis approach in the form of a case approach, statutory approach, historical approach, conceptual approach, and analytical approach.

III. ARRANGEMENT OF MEASURED FISHING IN ARCHIPELAGIC PROVINCES

Article 18 paragraph (1) of the Constitution of the Republic of Indonesia (UUD NRI) states that the Unitary State of the Republic of Indonesia is divided into provinces, and the provinces are divided into regencies and cities, where each region has a regional government regulated by law. The division of authority is further elaborated in Article 2 and Article 3 of Law No. 23 of 2014 concerning Regional Government.

Based on Law No. 23 of 2014 concerning Regional Government, administrative regions in the form of Archipelagic Provinces are determined, namely provinces that have geographical conditions where the water area in the province is wider than the land area. This statement succeeded in establishing several island provinces and combining them into the Islands Regional Cooperation Agency (BKSDK), namely 8 (eight) provinces, namely Riau Islands, Bangka Belitung Islands, West Nusa Tenggara, East Nusa Tenggara, North Sulawesi, Southeast Sulawesi, Maluku, and North

Maluku.[11] Provinces with archipelagic characteristics, regulated in Article 27 of Law No. 23/2014, namely provincial regions are given the authority to manage natural resources in the sea in their territory no further than 12 nautical miles measured from the coastline towards the high seas and/or towards archipelagic waters, which regulates that the management of marine resources or fisheries is given authority to the provincial government. Archipelagic provinces are different from other general provinces, especially concerning the management of marine areas.[12] The management of marine resources in archipelagic provinces is further regulated in Law No. 32 of 2014 concerning Maritime Affairs and Presidential Regulation No.16 of 2017 concerning Indonesian Maritime Policy, which states that the central and regional governments under their authority carry out marine management for the greatest prosperity of the people by utilizing and exploiting marine resources with the principle of blue economy. This is strengthened in the mandate of Article 33 paragraph (3) of the 1945 Constitution of the Republic of Indonesia which reads, "The land, water and natural resources contained therein shall be controlled by the state and used for the greatest prosperity of the people". So it can be understood, that provinces characterized by islands should be able to manage and utilize their marine resources that refer to the prosperity and welfare of the Indonesian people.

The regulation of provinces characterized by islands is further regulated in Article 27 paragraph (2) of Law No. 23 of 2014 concerning Regional Government which stipulates that the Sea Province has provincial authority to manage natural resources in the sea which includes:

a) exploration, exploitation, conservation, and management of marine resources outside oil and gas;
b) administrative arrangements;
c) spatial arrangement;
d) participating in maintaining security at sea; and
e) participating in maintaining state sovereignty.

The regulation regarding Provincial Regions characterized by Islands is regulated in Article 28 paragraph (1) which states that the authority of provincial regions characterized by islands gets an assignment from the Central Government to carry out the authority of the central government in the marine sector based on the principle of Assistance Duty. In terms of the division of affairs between the Central Government,

[11] Ardini, "Pengelompokan Daerah Provinsi Kepulauan Indonesia Berdasarkan Karakteristik Ekonomi dan Potensi Perikanan Tahun 2020", *Prosiding Seminar Nasional Official Statistics 2022*, Vol. 2022, No. 1, 2022, hlm. 1053.

[12] Imasti Dhani Pratiwi, "Kajian Penegasan Batas Kewenangan Pengelolaan Laut Provinsi Berciri Kepulauan Pasca Berlakunya UU No. 23 Tahun 2014 (Studi Kasus: Provinsi Nusa Tenggara Timur)", *Skripsi S-1 Teknik Geodesi*, (Yogyakarta: Universitas Gadjah Mada, 2017), hlm. viii.

Provincial Regions, and Regency / City Regions, especially in the marine and fisheries sector regulated by the Law, there is no granting of management authority to Regency / City Regions which is taken over by the Central Government and provincial regions.[13]

Based on the arrangement of provincial areas characterized by islands, it then produces fishing industry zones which include Fisheries Management Areas (WPP) that can be utilized by business entities in the form of cooperation contracts for the utilization and management of fish resources and some fish resources can still be utilized by local/local fishermen utilizing measured fishing. Measured fishing is controlled and proportional fishing per certain quotas and zones regulated in Government Regulation (PP) Number 11 of 2023 concerning Measured Fishing as a form of implementation of Law (UU) Number 6 of 2023 concerning Stipulation of Government Regulation in Lieu of Law Number 2 of 2022 concerning Job Creation into Law to create fishing that preserves fish resources and the environment, provides business opportunities while improving the welfare of fishermen and parties related to fisheries activities.

IV. IMPLEMENTATION OF MEASURED FISHING IN INDONESIA

Indonesia's marine waters have the potential for high fish resource wealth, reaching 12 million tons per year, as stipulated in the Decree of the Minister of Maritime Affairs and Fisheries No. 19 of 2022,[14] which is spread across eleven State Fisheries Management Areas of the Republic of Indonesia (WPPNRI). Indonesia's high fish resources must be balanced with measurable fish capture/management. Fishing activities in Indonesia are still dominated by small-scale fishery, while industrial-scale fishery is unevenly distributed in WPPNRI. For example, WPP 712 (Java Sea) and WPP 718 (Arafura Sea) are the highest fishing grounds in Indonesia, with the number of active licensed vessels reaching 2300 fleets. In contrast, WPP 717 (North Pacific Ocean of Papua) and WPP 716 (Sulawesi Sea) have only dozens of active licensed fishing vessels.[15] This shows that fishing in Indonesia has not been evenly distributed in the Indonesian Fisheries Management Area.

Measured Fishing as stipulated in Article 1 paragraph (1) in Government Regulation Number 11 of 2023 concerning Measured Fishing is "Controlled and proportional fishing, carried out in measured fishing zones, based on fishing quotas to preserve fish resources and the environment and equitable national economic growth". This means

[13] Mawarfi Khairi, "Kewenangan Pemerintan Daerah Provinsi dalam pemeberian izin pengelolaan perairan di wilayah pesisir dan pulau-pulau kecil", *Jatiswara,* Vol. 35, No. 3, 2020, hlm. 269. v

[14] Sakti Wahyu, "Penangkapan Ikan Terukur Berbasis Kuota untuk Keberlanjutan Sumber Daya Perikanan di Indonesia", *Jurnal Kelautan dan Perikanan Terapan,* Vol. 7, No.1, 2024, hlm.2, yang tersedia pada http://ejournal-balitbang.kkp.go.id/index.php/jkpt.

[15] *Ibid*

that Measured Fishing is a fishing policy based on quotas (catch limits) and zoning, where the number of catches and fishing zones are regulated and limited. Measured Fishing Policy is an effort made to change the management of national fisheries so that fish stocks are maintained and provide optimal economic benefits for fishermen and fisheries business actors. The regulation of fishing activities in the PIT policy includes the number of vessels, the number of catches, the regulation of the types of fish caught, the regulation of Fishing Gear, the time of fishing, and the suitability of the landing port. A measured Fishing Policy has benefits and impacts for coastal areas, including:[16]

1. Preservation of fish availability and marine health;
2. the ability of entrepreneurs to determine the optimal allocation of vessels to maximize profits;
3. the achievement of equity and regional economic growth (the port adjusts to the fishing area);
4. accuracy of data collection;
5. optimization of industry in the landing port; and
6. high non-tax state revenue (PNBP).

Based on lessons learned from Anderson, et al, the implementation of quota-based fishing is proven to support the sustainability of fish resources and provide economic incentives to fishers.[17] A study by Sakti Wahyu Trenggono showed that fishermen's income increased by 18 percent and avoided crew layoffs by 8 percent in the multispecies fishing industry in New England. The case of fisheries in Japan is also similar, where quota-based fisheries are able to increase revenue per unit of vessel and increase job creation in the fishing and fisheries processing sectors. Further studies have also proven that quota-based fisheries prevent "race-to-fish" behavior, reduce production costs, increase business profits, and improve the quality of fishery products.[18]

Another quota-based fishery study was also conducted in China. Since 1949, China's fisheries management has gone through 4 (four) phases to try the right fisheries management model. The initial phase was similar to fisheries in countries with minimal management and open access. However, in the final phase (currently) the Chinese government implemented a quota limitation system on the amount of fish caught or in other words known as the Total Allowable Catch (JTB) or quota-based. In general, China's fisheries management includes input control, output control,

[16] *Ibid,* hlm.4
[17] Christopher M. Anderson, *dkk*., "How commercial fishing effort is managed", Fish and Fisheries, Vol. 20, No. 2, 2018, hlm. 268-285, https://doi.org/10.1111/faf.12339.
[18] Trenggono, "Penangkapan..., *Op.Cit*., hlm. 5.

technical control or management, economic control measures, aquatic fisheries system management, and international cooperation in fisheries management mechanisms.[19]

China's 2000 fisheries law mandates that the JTB system be adopted as one of the main tools for fisheries management in China. The implementation of JTB is able to provide extensive and high-quality data, which can be a source of scientific research and is the key to the successful implementation of JTB.[20] This can alleviate the problem of limited data needed to consistently and reliably provide a comprehensive picture of fisheries utilization in fisheries management. One of the challenges of current JTB pilots is the exclusive adoption in single-species fisheries, when in reality more than one species is caught at the same price. In addition, when one party utilizes a fishery resource to the detriment of another, it leads to economic inefficiency where each party will incur costs to obtain the maximum benefit regardless of the sustainability of the fishery resource.[21]

Measured Fishing can be a tool to obtain benefits in a controlled manner for national economic growth while maintaining the sustainability of nature. In addition, Measured Fishing can provide better utilization of catches with improved quality of fishery products and greater profitability. To get a deeper picture, it is necessary to understand that the development of government policies towards the fisheries sector in Indonesia has a long process. Policies passed in 2010-2014 have the scope to improve the fisheries sector in Indonesia, but are still lacking in water monitoring, such as the ratification of the Minister of Maritime Affairs and Fisheries Regulation No. 18/MEN/2012 concerning Guidelines for the Preparation of Minapolitan Area Development Master Plan, which aims to improve aquaculture in Indonesia.[22]

In developing the regulations in Measured Fishing, there are 6 (six) main principles that become the main direction of the stipulation of this regulation, namely:[23]

a. Ecology and sustainability become the commander, namely by ensuring fish production in accordance with the quota set to realize legal regulated fishing (LRF), and establishing limited fishing areas;

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[19] Shoulin Huang dan Yuru He, "Management of China's Capture Fisheries : Review and Prospect". *Aquaculture and Fisheries*, Vol. 44, 173-182, hlm. 177. https://doi.org/10.1016/j.aaf.2019.05.004. *Kelautan dan Perikanan*, Vol. 5, No. 1, 2019, hlm. 39-52.

[20] Trenggono, "Penangkapan..., *Loc.Cit*. Lihat juga pada Shu Su, *dkk*., " Evolution of marine fisheries management in China from 1949 to 2019: How did China get here and where does China go next?", *Wiley Fish and Fisheries*, Vol. 21, No. 2, hlm. 435-452, https://doi.org/10.1111/faf.12439.

[21] *Ibid*. Lihat juga pada Cornelia Mirwantini Witomo, "Pengelolaan wilayah pesisir dengan pendekatan instrumen ekonomi: sebuah review teori dan peluang aplikasi" *Buletin Ilmiah MARINA Sosial Ekonomi Kelautan dan Perikanan*, Vol. 5, No. 1, 2019, hlm. 39-52.

[22] Luthfia, "Mengupas..., *Op.Cit*., hlm. 487. Lihat juga pada Lailan Safina Hasibuan dan Salman Paris, "Analisis Komparatif Kebijakan Ekonomi Sektor Perikanan Pada Tahun 2010 – 2017", *Ekonomikawan: Jurnal Ilmu Ekonomi dan Studi Pembangunan*, Vol. 20, No. 1, 2020, hlm. 102–116, https://doi.org/10.30596/ekonomikawan.v20i1.4861.

[23] Mochamad Idnillah, "Penangkapan Ikan Terukur", makalah disampaikan dalam Seminar *Maritime Safety: Governance and Law Enforcement of Fisherman Fishing Vessels in Indonesia*, diadakan oleh HukumOnline.com pada 25 Mei 2023.

b. Maximum protection of small fishermen, among others; free to fish in accordance with the Measured Fishing zone, free from levies, and empowering small fishermen through the acquisition of Non-Tax State Revenue;
c. Pro to local economic development, among others by; requiring to land fish catches in accordance with the permitted zone, and requiring the crew to be Indonesian Citizens (WNI) and preferably domiciled in the administrative area in accordance with the Measured Fishing zone;
d. Based on the best available scientific database, among others in the form of statistical data, the results of the National Commission on Fisheries study, and so on;
e. Support for upstream-downstream governance reform and bureaucratic reform, among others by; business process efficiency, optimization of information technology in the upstream-downstream business chain with integrated applications and databases, monitoring through command centers, and single identification on fishing vessels; and
f. The principle of fish catch quota distribution, namely by dividing the quota into, namely industrial quota, fishermen quota, and non-commercial quota.

Measured Fishing is a representation of the Blue Economy. The Blue Economy is an idea that was first coined in 2009, at the United States Senate Committee on Commerce, Science and Transportation. There is also an opinion that the Blue Economy originated from the United Nations Conference on Sustainable Development (UNCTAD) held in Rio de Janeiro in 2012.[24] These ideas developed various views and definitions of the Blue Economy itself. In 2010, Gunter Pauli published a book entitled, "*The Blue Economy: 10 years, 100 innovations, 100 million jobs*" in which he discusses the Blue Economy as an economic model by taking what is needed from the ocean, so that it can be symbiotic with it, namely increasing technological innovation at low cost, providing jobs while always respecting the environment.[25] The meaning of Blue Economy in various studies, among others; Blue Economy is synonymous with the concept of generating wealth from ocean-related activities while protecting and preserving marine ecosystems.[26] Blue Economy offers

[24] Ki Hoon Lee, Junsung Noh, dan Jong Seong Khim, "The Blue Economy and the United Nations' Sustainable Development Goals: Challenges and Opportunities," *Environment International*, Vol. 137, Oktober 2019, hlm. 105528, https://doi.org/10.1016/j.envint.2020.105528.

[25] Marihot Nasution, "Potensi dan Tantangan Blue Economy Dalam Mendukung Pertumbuhan Ekonomi Di Indonesia : Kajian Literatur", *Jurnal Budget: Isu dan Masalah Keuangan Negara*, Vol. 7, No. 2, 2022, hlm. 340– 363, https://doi.org/10.22212/jbudget.v7i2.136.

[26] Anna Phelan, Lisa Ruhanen, and Judith Mair, "Ecosystem Services Approach for Community-Based Ecotourism: Towards an Equitable and Sustainable Blue Economy ," *Journal of Sustainable Tourism*, Vol. 28, No. 10, 2020, hlm. 1665-1685, https://doi.org/10.1080/09669582.2020.1747475.

the promotion of sustainable ocean economic development that can be described through 3 (three) dimensions of ocean utilization in the sustainable development paradigm, namely social, environmental and economic simultaneously.[27] In essence, the Blue Economy suggests a conflict between 2 (two) discourses, namely community growth-development and protection of marine resources. The application of the blue economy realized through Measured Fishing is expected to preserve coastal resources for food purposes while maintaining the sustainability of the marine ecosystem.

The implementation of Measured Fishing in Indonesia has not run optimally and has become a new problem. This can be seen from the regulation on measured fishing in PP No. 11 of 2023. First, the regulation on local fishermen zone for utilization of fish resources in WPP NRI only exists in WPP 711, 712 and 713, which means that the regulation on measured fishing is not oriented towards the welfare of local communities or local fishermen. Second, the fishing quota is the amount of fish that can be utilized in each zone of Measured Fishing by each party with a fishing quota based on the estimated potential and the amount of fish catch allowed, whereas Indonesia does not yet have data on fish resource stocks, so that it will have an impact on fishing that is not in accordance with the principles of sustainable management.

V. CONCLUSIONS

The results of this study indicate that efforts to realize the welfare and prosperity of fishing communities through regulations as regulations for Measured Fishing aimed at preserving fish resources and the environment of Indonesian waters and providing business opportunities for small fishermen who obtain catches for their daily needs.

The implementation of the Measured Fishing (PIT) regulation affects different geographical conditions, especially in provinces that are characterized by islands. This can be seen from 8 (eight) provinces characterized by islands that have different water areas. The Fisheries Management Areas (WPP) in Indonesia are regulated through the Minister of Marine Affairs and Fisheries Regulation No. Per.01 / Men / 2009 which was updated by the Minister of Marine Affairs and Fisheries Regulation No. 18 / PMEN-Kp / 2014 with the zoning division of fishing areas according to the conditions of different areas with 3 areas regulated by Law No. 2 of 2022 concerning Job Creation which was updated by Law No. 6 of 2023 whose implementation is regulated in PP No. 11 of 2023 and implemented in KKP Regulation No. 28 of 2023 which states that there are 3 zones for the division of Measured Fishing. WPP 711, 712, and 715 which are industrial zones intended for industrial fishing. This results in a measured fishing

[27] Pawan G. Patil, *dkk*., *Toward a Blue Economy: A Pathway for Sustainable Growth in Bangladesh*, (Washington, DC: The World Bank Group, 2018), hlm. 13.

policy that is not oriented towards the welfare of the local community or local fishermen.

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Implementation of Cooperative-Based Contract Farming for Sustainable Food Security in Indonesia

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ABSTRACT: Indonesia's struggle to achieve sustainable food security is hindered by inefficiencies in agricultural practices and the predominant role of intermediaries, which reduce farmers' profits and market access. This study explores the viability of cooperative-based contract farming as a sustainable solution to bolster food security and empower smallholder farmers. The objective is to evaluate how this cooperative model can mitigate issues inherent in traditional farming systems, such as price volatility, dependency on middlemen, and restricted access to broader markets. The research method used is normative legal research with a statute approach, and conceptual approach. The findings reveal that cooperative-based contract farming provides farmers with benefits, including price stability, increased income security, and improved access to advanced technology and larger markets. Furthermore, the cooperative structure allows for a more equitable distribution of resources, promoting social welfare within farming communities. However, challenges such as inadequate legal protections, low farmer awareness of cooperative advantages, and insufficient institutional support remain significant barriers to effective implementation and widespread adoption. In conclusion, cooperative-based contract farming presents a promising framework for advancing sustainable food security in Indonesia. Addressing identified barriers is essential for this model's success. This study recommends strengthening legal frameworks to ensure fair contracts and protection for farmers, enhancing cooperative management capacities, and implementing targeted education and training programs to foster higher farmer participation. By fostering collaboration among farmers, cooperatives, and governmental bodies, Indonesia can develop a resilient agricultural sector, secure food supplies, and support rural economic development, aligning with national food security goals.

KEYWORDS: Cooperative-Based Contract Farming, Sustainable Food Security, Indonesia, Legal Framework, Agricultural Policy.

I. INTRODUCTION

Food security constitutes a pivotal concern in global development, as articulated in the second objective of the Sustainable Development Goals (SDGs), which aims to eradicate hunger, attain food security, enhance nutrition, and foster sustainable agriculture.[1] Indonesia, an agricultural nation predominantly comprised of smallholder farmers, confronts significant obstacles in achieving sustained food security. Conventional agricultural systems, characterized by customized management and reliance on intermediaries, frequently fail to deliver maximum advantages to smallholders. Farmers frequently find themselves ensnared in inequitable patron-client relationships that restrict their access to cash, markets, and knowledge.[2] The contract farming model presents a viable answer in this situation. This concept facilitates direct connections between farmers and the market via formal agreements with partner corporations. The contract system provides farmers with price stability, access to advanced technologies, and crop purchases guarantee.[3] Nonetheless, the execution of contract farming in Indonesia encounters some challenges, such as corporate monopsony, disparities in contractual agreements, and farmers' insufficient comprehension of their rights and responsibilities.[4] Moreover, contract farming sometimes advantages huge corporations while failing to deliver equivalent benefits to smallholder farmers. In addressing these difficulties, cooperative-based contract farming, which integrates the contract model with a cooperative framework, presents a unique solution. This method enables smallholders to unite in cooperatives, enhance their negotiating power, access shared resources, and diminish reliance on intermediaries.[5] Studies indicate that cooperatives can significantly enhance economic, social, and environmental sustainability within the agriculture sector.[6]

Several prior studies pertinent to this research encompass (1) Ian Patrick et al., in their work titled "Contract Farming in Indonesia: Smallholders and Agribusiness Working Together," which examines the execution of contract farming in

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1 Nur Hikmah & Egy Oktavian Pranata, "Cooperative Farming: Sebuah Strategi Menuju Ketahanan Pangan Berkelanjutan" (2023) 4:5 TheJournalish Soc Gov 120–137.

2 Liya Agustina et al, "Analisis Ketergantungan Petani Padi Terhadap Tengkulak Dalam Sistem Pemasaran di Sentra Produksi Padi Kecamatan Pace" (2024) 5431 131–140.

3 *Contract farming in Indonesia : Smallholders and agribusiness working together*, by Ian Patrick et al (2004).

4 Sashi Sivramkrishna & Amalendu Jyotishi, "MONOPSONISTIC EXPLOITATION IN CONTRACT FARMING : ARTICULATING A STRATEGY FOR GROWER COOPERATION" (2008) 296:11 280–296.

5 Hikmah & Pranata, *supra* note 1.

6 Ahmet Candemir, Sabine Duvaleix & Laure Latruffe, "Agricultural Cooperatives and Farm Sustainability – a Literature Review" (2021) 35:4 J Econ Surv 1118–1144.

Indonesia, particularly in Bali and Lombok. The findings indicate that the contract system might enhance the revenue of smallholders; nevertheless, they also highlight that insufficient regulation may result in a power imbalance between farmers and partner firms.[7] (2) Vicol et al. conducted a study titled "Twenty-five Years Under Contract: Contract Farming and Agrarian Change in the Developing World," which investigates agricultural transformation via contract farming in developing nations. The primary conclusion is that contract farming frequently exacerbates power disparities within the value chain, particularly in the absence of institutional safeguards for smallholders.[8] (3) Pranata and Hikmah conducted a study titled "Cooperative Farming: Sebuah Strategi Menuju Ketahanan Pangan Berkelanjutan" This study examines the function of cooperatives in promoting sustainable food security in Indonesia. The findings indicate that the cooperative farming model aids smallholder farmers in surmounting obstacles related to money, technology, and market access.[9]

Numerous prior studies have examined contract farming and cooperative farming independently. Nonetheless, a void persists in the research about the merging of these two approaches to establish a more inclusive and sustainable system. Many studies are predominantly descriptive and fail to provide actionable recommendations to enhance the legal and institutional framework necessary for the adoption of cooperative-based contract farming models. This project seeks to establish a cooperative-based contract farming model that addresses the shortcomings of conventional farming systems, including reliance on intermediaries, and fosters a more equitable cooperation between farmers and partner corporations. This study has numerous primary contributions. This will offer novel insights on the application of the cooperative-based contract farming model in Indonesia to enhance food sustainability. Secondly, it will provide a pragmatic framework for the government, cooperatives, and the private sector to cultivate a more inclusive agricultural system. This research will fill a gap in the literature by offering an integrative approach that merges the advantages of contract farming with the institutional strengths of cooperatives. This methodology aims to develop a model that enhances the wellbeing of smallholder farmers while promoting sustainable food security in Indonesia.

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7 Patrick et al, *supra* note 3.

8 Mark Vicol et al, "Twenty-five years of Living Under Contract : Contract farming and agrarian change in the developing world" (2022) December 2021 3–18.

9 Hikmah & Pranata, *supra* note 1.

II. METHODOLOGY

This study employs normative legal research methodologies, utilizing statutory, and conceptual approach. [10] The statutory method seeks to examine the legislative frameworks regulating cooperative-based contract farming in Indonesia and its effects on food security and the welfare of smallholder farmers. This method will examine the significance of current rules in facilitating contract farming, particularly concerning legal safeguards for farmers and equitable contractual agreements among farmers, cooperatives, and partner firms. A conceptual framework is employed to identify and comprehend essential concepts pertaining to cooperative-based contract farming, monopsony, and food security. The study will investigate theories that elucidate how the cooperative model might rectify market inequities prevalent in conventional agriculture, including reliance on intermediaries and price fluctuations. This model will examine its contribution to the social and economic welfare of smallholders by highlighting equitable resource management within the agricultural community. This research seeks to examine optimal practices for enhancing this model in Indonesia, while also identifying obstacles and issues that may arise during implementation and broader adoption. This study utilizes secondary data acquired from literature reviews, including scientific publications, books, legislation, and pertinent research reports on contract farming, cooperatives, and food security in Indonesia and other nations. The data gathering approach involved the analysis of legal papers, policy reports, and case studies pertinent to the implementation of cooperative-based contract farming. This research employs three approaches to assess the potential and legal obstacles associated with cooperative-based contract farming to enhance Indonesia's traditional farming system, and to offer policy recommendations for addressing these challenges, particularly regarding legal protection and the fortification of cooperative management capacity.

[10] Deassy J A Hehanussa et al, *METODE PENELITIAN HUKUM*, 1st ed, Elan Jaelani, ed (Bandung: Widina Bhakti Persada Bandung, 2023).

III. IMPLEMENTATION OF A COOPERATIVE-BASED CONTRACT FARMING MODEL IN OVERCOMING THE PROBLEMS OF TRADITIONAL FARMING SYSTEMS IN INDONESIA

A. Implementation mechanism of the cooperative farming model

Cooperative farming emerged due to the insufficient and unmet needs of current service institutions. Consequently, farmers, as the entities tasked with ensuring food security, lack access to effective and sufficient information to address their requirements and resolve the challenges they encounter. The cooperative farming approach empowers farmers through collective groupings by facilitating social, economic, technological, and value-added engineering initiatives. Social engineering can be achieved through the enhancement of agricultural institutions, advisory services, and the development of human resources. Economic engineering involves facilitating access to finance for the procurement of production facilities and market access. Technological engineering can be accomplished by aligning suggested technology with agricultural practices. Ultimately, value-added engineering is achieved through the establishment of vertically and horizontally integrated off-farm enterprises.

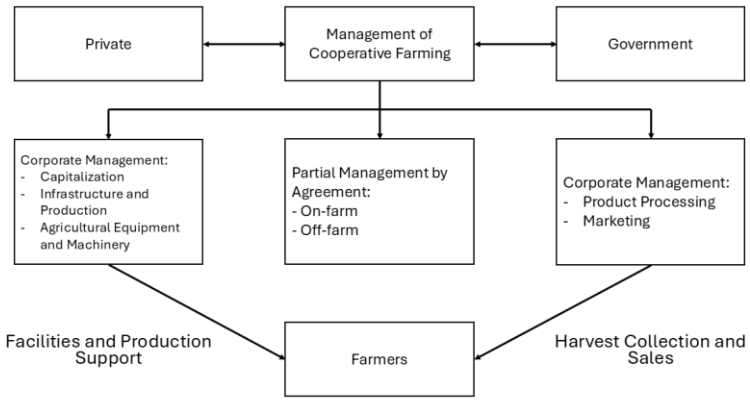

Figure 1 (Cooperative Farming Model)

Vertical and horizontal coordination will engage numerous stakeholders in a collaborative effort to execute the cooperative farming model (Figure 1).[11]

[11] I Made Mahadi Sanatana, "COOPERATIVE FARMING DALAM KEBIJAKAN PEMBERDAYAAN PETANI DI PROVINSI BALI" (2019) 03:2 CAKRAWARTI 16–27, online: <http://scioteca.caf.com/bitstream/handle/123456789/1091/RED2017-Eng-8ene.pdf?sequence=12&isAllowed=y%0Ahttp://dx.doi.org/10.1016/j.regsciurbeco.2008.06.005%0Ahttps://www.researchgate.net/publication/305320484_SISTEM_PEMBETUNGAN_TERPUSAT_STRATEGI_MELESTARI>.

Participants in the implementation of the cooperative agricultural model include farmers, the private sector, and the government. Farmers will serve as both participants and administrators. Farmers, as members, must engage in both on-farm and off-farm business planning, concur on the technology to be adopted, and execute its implementation. The private sector will function as investors via cooperative farming partnerships throughout upstream and downstream sub-systems. The private sector, as an upstream sub-system partner, invests by supplying agricultural production resources, specifically seeds, fertilisers, and farming medicines. The private sector, as a downstream sub-system partner, is accountable for manufacturing and marketing functions. The government will serve as a facilitator and catalyst in planning activities, formulating business strategies, implementing efficient location-specific technologies, securing capital, facilities, production resources, and agricultural tools and machinery, and enhancing the marketing process.[12]

Nonetheless, the presence of numerous difficulties in the field indicates that the aforementioned model is inadequately executed. This mostly results from farmers' limited educational resources, which significantly hampers the implementation of a management system in agricultural practices. Furthermore, the private sector exerts a monopoly in partnerships. The involvement of agribusiness businesses does not enhance the status of smallholders. They often ascend as the new authorities in all affairs, hence widening the divide with the smallholder segment. Despite the transmission of information from larger farmers to smaller agricultural producers, the latter continue to receive no excess due to the sluggishness of the process. So that the government acts as a facilitator, enabling the private sector to assist farmers in enhancing their human resources and augmenting their income, which then boosts the revenue of the partnering enterprises.[13]

B. The Role of Contract Farming in Implementation of Cooperative-Based Contract Farming in Indoenesia

Contract farming is a contractual agreement between farmers and companies that regulates the production, price, and sale of agricultural products. In the context of monopsony, contract farming has significant potential to provide price certainty and stability for farmers, thereby reducing their dependence on middlemen. Some of the key aspects of contract farming that contribute greatly to increasing farmer autonomy and reducing monopsony are price guarantees,

12 *Ibid*.
13 *Ibid*.

purchase commitments, and accessibility to technology and markets. One of the main advantages of contract farming is that a guaranteed price is agreed upon in advance between the farmer and the Company, giving farmers certainty about their income even before the harvest begins. This is very important to reduce the risk of price uncertainty that farmers often experience when selling crops to middlemen.[14] For example, the implementation of contract farming in India has shown that farmers involved in contract farming for products such as tomatoes and potatoes are able to get higher prices compared to non-contracted farmers. Farmers are also protected from price fluctuations that often occur in the open market.[15] Meanwhile, in Indonesia, the implementation of contract farming has shown favorable results. Rice farmers involved in partnerships with companies in Lombok and Bali receive more consistent selling prices, even during market downturns. Price security allows farmers to manage their finances more effectively and reduces pressure to sell their crops at lower prices to middlemen.[16]

In addition to price guarantees, contract farming also provides farmers with purchase guarantees, whereby the company commits to buying the farmers' entire crop according to agreed criteria. This guarantee reduces the uncertainty that farmers often experience in finding buyers for their crops. An example in the sweet corn farming sector in Ciamis, West Java, shows that with contracts in place, farmers no longer have to rely on middlemen to sell their crops. Guaranteed purchase by the company increases the stability of farmers' incomes and reduces monopsony practices, where middlemen can suppress prices knowing farmers have no other options.[17] In contract farming, companies often provide agricultural inputs such as seeds, fertilizers, and pesticides, and provide technical training to farmers. This transfer of technology and knowledge helps to increase agricultural productivity and crop quality, which in turn increases farmers' income.[18] An example of contract farming in Indonesia is where farmers involved in contracts for broiler production experienced increased productivity due to technological support and access to quality inputs. This not only increases farmers' independence in managing their businesses, but also reduces

[14] *Contract Farming: Risk and Benefits of Partnership Between Farmers and Firms*, by Nicholas Minot & Loraine Ronchi, Viewpoint: Public Policy for the Private Sector 344 (Washington DC: World Bank, 2014).

[15] Sivramkrishna & Jyotishi, *supra* note 4.

[16] Patrick et al, *supra* note 3.

[17] Ratih Tresnati, "Kajian tentang kemitraan guna meningkatkan pendapatan petani pada usahatani jagung manis di kabupaten ciamis" (2014) 11:2 J Manaj dan Bisnis Performa 1–12, online: <https://ejournal.unisba.ac.id/index.php/performa/article/view/3031>.

[18] Minot & Ronchi, *supra* note 14.

dependence on middlemen as providers of capital or raw materials.[19] Contract farming also allows farmers to engage in broader markets, including exports. When farmers have access to larger markets through contracts with companies, they are no longer completely dependent on local middlemen as their only sales channel.[20] For example, in the horticulture sector in Bali, some farmers involved in contracts for mangosteen production managed to export their products to international markets with the help of partner companies. This market diversification helps farmers get better prices and reduces the risk of exploitation from local monopsonies.[21] Therefore, contract farming has significant potential to increase farmers' independence and reduce monopolistic practices by offering price stability, guaranteed purchase, and access to technology and markets. Effective implementation and supervision will ensure that the benefits of contract farming are equitably shared by all farmers, especially smallholders, enabling them to break away from the cycle of dependence on middlemen.

Contract farming in Indonesia has significant potential to improve farmers' welfare and reduce dependence on middlemen. However, its implementation still faces various obstacles, including in terms of regulations, legal protection, and practices in the field. Therefore, it is important to review the relevant regulations that support contract farming, the challenges faced, and suggestions for prospective policy improvements. Several regulations in Indonesia support contract farming as part of the government's efforts to strengthen the agricultural sector and improve farmers' welfare. For example, Law No. 19 of 2013 on Farmer Protection and Empowerment encourages partnerships between farmers and third parties, such as agribusiness companies, which aim to improve farmers' accessibility to markets and technology.[22] In addition, Minister of Agriculture Decree No. 940/Kpts/OT.210/10/97 on Guidelines for Agricultural Business Partnerships.[23] The regulation provides guidance on farming partnerships, including contract standards and conditions that must be met by both parties. The regulation aims to establish a clear legal framework and prevent corporate malfeasance by adhering to the principles of equal standing, collaboration, and increased competence among partner entities through the actualization of partnership synergies, particularly relationships built on the basis of mutual need, mutual strengthening, and mutual benefit.[24]

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19 Patrick et al, *supra* note 3.
20 Vicol et al, *supra* note 8.
21 Patrick et al, *supra* note 3.
22 Law No. 19 of 2013 on Farmer Protection and Empowerment
23 Minister of Agriculture Decree No. 940/Kpts/OT.210/10/97.
24 Article 3 paragraph 1 Decree of the Minister of Agriculture No. 940/Kpts/OT.210/10/97 on Guidelines for Agricultural Business Partnerships

Agricultural business partnerships between farmers and companies can be implemented with the following partnership patterns:[25]

1. Core plasma pattern

A collaborative relationship between a partner group and a partner company, where the partner company functions as the core and the partner group functions as the plasma;

2. Sub-contracting pattern

A collaborative relationship between a partner group and a partner company, in which the partner group produces components required by the partner company for its manufacturing process;

3. General Trade Pattern

A collaborative relationship between a partner group and a partner company, where the partner company promotes the products of the partner group or the partner group supplies the needs of the partner company;

4. Agency Pattern

A collaborative relationship where the partner group is granted exclusive rights to promote the products and services of the partner company.

5. KOA Pattern

A partnership relationship where the partner group provides land, facilities, and labor, while the partner company contributes financial resources or capital and/or infrastructure for the cultivation of agricultural crops.

Decree of the Minister of Agriculture No. 940/Kpts/OT.210/10/97 concerning Guidelines for Agricultural Business Partnerships determines the conditions for agricultural business partnerships as follows:[26]

1. Requirements for Partner Companies

a. Good Faith: Partner companies must have a strong commitment to assist farmers, fishermen, and other small agricultural businesses in improving their capacity and market access.

[25] Article 4 paragraph 1 Decree of the Minister of Agriculture No. 940/Kpts/OT.210/10/97 on Guidelines for Agricultural Business Partnerships

[26] Articles 9-11 of Minister of Agriculture Decree No. 940/Kpts/OT.210/10/97 on Guidelines for Agricultural Business Partnerships

b. Technology and Management: Must have adequate technology and management systems to support the smoothness and sustainability of the partnership.
c. Partnership Plan: Prepare a clear and structured partnership plan as a guideline for the implementation of agricultural business partnerships.
d. Legal Entity: Must be a legal entity and have a good reputation (bonafitas) in order to be trusted as a partner.

2. Requirements for Partner Groups

The working group that will become a business partner is preferably one that has received guidance from the Local Government. This aims to ensure that the group has the readiness and ability to work together in a partnership pattern.

3. Partnership Agreement

a. Agricultural business partnerships must be accompanied by the signing of a partnership agreement that includes the time period, rights and obligations of both parties, partnership reporting mechanisms to relevant agencies, risk sharing, and conflict resolution in the event of a dispute.
b. The agreement must also have a legal certainty clause to protect the interests of both parties.

4. Financing and Capital Support

a. Partner groups are allowed to utilize credit facilities from government programs, such as KKPA, KUA, KUK, and other SKIM credits, with the partner company acting as a credit guarantor for the partner group.
b. Partner companies can also utilize credit facilities from banks in accordance with applicable regulations.

These conditions are designed to ensure a balanced and sustainable partnership between the partner company and the partner group, with each party receiving the benefits and support necessary to achieve their mutual goals.

B. Impact Analysis of the Implementation of Cooperative-Based Contract Farming in Indonesia

The cooperative-based contract farming model presents an innovative approach to address fundamental weaknesses in Indonesia's traditional agricultural system. By integrating the collective power of cooperatives and the formal mechanisms of contract farming, the model offers solutions to key challenges such as price volatility, dependence on middlemen, and limited market access. This section outlines how this approach addresses these issues while supporting sustainable food security.

1. Overcoming Price Volatility

A primary difficulty confronting farmers in Indonesia is the fluctuation of agricultural prices, resulting in income instability and financial precariousness. Cooperative-based contract farming has a predetermined pricing structure, mitigating the effects of market volatility. These contracts provide farmers a consistent price for their products, safeguarding them against market fluctuations caused by seasonal surpluses or deficits. This is particularly important for key food commodities, as price volatility directly affects farmers' welfare and national food security. In contrast to conventional systems dependent on spot markets, cooperative-based contract farming provides assurance to farmers. Research conducted by Patrick (2004) indicates that contract farming can stabilise prices by harmonising expectations between farmers and purchasers. This strategy offers economic advantages while fostering trust among cooperative members, so establishing sustainable economic security.[27]

2. Reducing Dependence on Middlemen

The reliance on intermediaries is a persistent issue in Indonesia's agriculture industry. Intermediaries frequently take advantage of farmers by imposing cheap acquisition prices and detrimental conditions. Cooperatives offer farmers a collective bargaining platform, enabling them to circumvent intermediaries. Through resource aggregation, farmers can attain economies of scale, secure improved terms, and reach more advantageous markets. Research by Agustina et al. (2024) demonstrates that cooperatives empower farmers to reduce reliance on intermediaries and get a greater portion of revenues. Cooperative-based contract farming incorporates smallholders directly into the value chain,

[27] Patrick et al, *supra* note 3.

preventing their marginalisation. This approach establishes a transparent method in which cooperatives serve as an equitable intermediary in pricing and resource allocation, as opposed to the asymmetry seen in conventional systems.

3. Expanding Market Access

Restricted market access continues to be a substantial impediment for smallholder farmers in Indonesia, frequently constraining their revenue potential and economic advancement. Contract farming, facilitated by cooperatives, gives access to both domestic and international markets. Cooperatives utilise collective bargaining strength to establish contracts with major purchasers, guaranteeing steady demand for agricultural products. The execution of contract farming in Bali and Lombok illustrates how cooperatives have effectively secured export agreements for high-value commodities. Utilising the cooperative concept, farmers acquire modern technology and training that enhances product quality, therefore augmenting competitiveness in the broader market. Research conducted by Pranata & Hikmah (2023) demonstrates that cooperatives may provide farmers the essential tools and expertise to comply with international market requirements, thereby substantially enhancing export potential.[28]

4. Supporting Sustainable Food Security

Cooperative-based contract farming not only tackles the immediate issues of conventional agriculture but also advances the overarching objective of sustainable food security. The cooperative framework fosters equitable resource allocation among members, enhances social cohesiveness, and mitigates economic disparity. Ensuring equitable contracts enables farmers to achieve enhanced income stability, so fostering rural development and alleviating poverty. Prior research (e.g., Vicol et al., 2022) indicates that contract farming methods combined with cooperatives enhance economic security and empower agricultural communities. Farmers are encouraged to implement sustainable farming practices, such as crop rotation, minimised pesticide application, and water conservation, through cooperative-supported initiatives that correspond with national objectives for sustainable agricultural development.[29]

[28] Hikmah & Pranata, *supra* note 1.
[29] Vicol et al, *supra* note 8.

IV. OBSTACLES AND STRATEGIES FOR IMPLEMENTING COOPERATIVE-BASED CONTRACT FARMING IN INDONESIA

The Implementation of cooperative-based contract farming in Indonesia encounters several intricate obstacles, including deficiencies in the legal framework, inadequate management of cooperatives, and limited farmer awareness and engagement. These obstacles impede the execution of this strategy and diminish its capacity to enhance the welfare of smallholders and promote sustainable food security. A primary impediment is weaknesses in the existing legal and regulatory framework. Contract farming in Indonesia sometimes fails to offer adequate protection for smallholders, rendering them susceptible to abuse. Numerous contracts are inequitable, privileging the partnering corporation at the expense of farmers, who frequently lack a robust bargaining stance. Moreover, ambiguous or insufficient legislation pertaining to the legal relationship among cooperatives, farmers, and partner firms can constitute a significant impediment. Current policies inadequately address critical elements, including price transparency, risk allocation, and dispute resolution systems.[30] The discrepancy between national policies and local requirements constitutes a substantial obstacle. National uniform regulations frequently overlook local social, economic, and cultural disparities. In particular regions, farmers encounter difficulties in comprehending or meeting specific legal obligations, resulting in frequent failures in contract execution.[31]

A further impediment is deficiencies in collaborative management. A multitude of cooperatives in Indonesia lack adequate managerial competence to efficiently administer contract farming projects. The deficiency of abilities related to administration, strategic planning, and contract negotiation with business partners impedes cooperatives from effectively acting as mediators between farmers and enterprises.[32] Furthermore, numerous cooperatives encounter capital limitations that hinder their capacity to deliver essential services to farmers, including crop storage facilities, agricultural equipment procurement, and product distribution to broader markets.[33] Infrastructure constraints represent a significant impediment. Cooperatives frequently lack sufficient infrastructure, including roads, irrigation systems, and storage facilities, which are essential for facilitating contract farming activities. Inadequate infrastructure hampers cooperatives' ability to fulfill member requirements and sustain efficient

30 Patrick et al, *supra* note 3.

31 Agustina et al, *supra* note 2.

32 *Ibid*.

33 Xiaoxue Du, Liang Lu & David Zilberman, *The Economics of Contract Farming: A Credit and Investment Perspective* (Philadelphia: Agricultural and Applied Economics Association (AAEA), 2013).

supply networks.[34] A significant number of smallholder farmers in Indonesia are unaware of the advantages of cooperative-based contract farming. Insufficient education and counseling contribute to their limited comprehension of contractual rights and obligations, as well as the potential benefits of cooperatives for enhancing their welfare. The absence of engagement is intensified by distrust in cooperatives, frequently stemming from previous negative experiences, such as opaque management or unfulfilled commitments to members.[35]

A. Strategies to Overcome Obstacles in the Implementation of Cooperative-Based Contract Farming in Indonesia

To surmount these challenges, a holistic and cohesive strategy is required, encompassing the enhancement of the legislative framework, the augmentation of cooperative capacities, and the education and training of farmers as detailed below:

1. Strengthening the Legal Framework

New regulations must be established to enhance protection for farmers. These policies must encompass price transparency, equitable risk-sharing procedures, and minimum criteria for contractual agreements. These regulations must guarantee that cooperatives function as equitable intermediaries between farmers and companies, while the government must enhance oversight of agricultural contract enforcement to ensure compliance with established regulations. Furthermore, an expedient and efficient dispute resolution procedure must be established to safeguard farmers' interests.[36]

2. Enhancement of Cooperative Capacity

Training programs for cooperative boards should emphasize the enhancement of managerial competencies, encompassing business planning, contract negotiation, and risk management. This would enhance the operational efficiency of cooperatives and fortify their standing in the supply chain; thus, the government and financial institutions must facilitate improved access to finance

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[34] Dindy Darmawati Putri et al, "The Perception of Contract Farming on The Sustainable Production of Potato in Indonesia" (2023) 1:1 J Nusant Agric 1–11.

[35] Hikmah & Pranata, *supra* note 1.

[36] *Ibid*.

for cooperatives. Infrastructure development, including roads, storage facilities, and irrigation, is essential to facilitate cooperative activities.[37]

3. Education and Training for Farmers

The extension for farmers should encompass an elucidation of the advantages of cooperative-based contract farming, the rights and responsibilities stipulated in the contract, and strategies for leveraging cooperatives to enhance income. It must be customized to the local situation to guarantee its efficacy. Education must prioritize fostering farmers' confidence in cooperatives by showcasing the achievements of effective cooperatives as concrete examples.[38]

Barriers to the execution of cooperative-based contract farming in Indonesia comprise deficiencies in the legal framework, constrained cooperative capacity, and insufficient farmer awareness. Nonetheless, these obstacles can be surmounted by a cohesive plan. By enhancing rules to safeguard farmers' rights, augmenting cooperative capabilities through training and infrastructural assistance, and providing education to farmers, this model can be effectively executed on a broad scale. This plan will enhance the welfare of smallholder farmers, bolster sustainable food security, and fortify Indonesia's agricultural economy in the future.

V. CONCLUSION

This study demonstrates that the cooperative-based contract farming model might serve as an innovative option to enhance sustainable food security in Indonesia. The approach integrates the advantages of cooperatives and formal contracts to tackle significant issues in conventional farming systems, including price volatility, reliance on intermediaries, and restricted market access. Significant findings highlight the advantages of price stability, assured crop purchases, and technological access for smallholder farmers, all of which enhance farmer incomes and bolster national food security.

Nonetheless, the execution of this model has several challenges, such as an insufficient legislative framework, managerial deficiencies within cooperatives, and little awareness and engagement among farmers. The recommended plan include enhancing the legislative framework, augmenting the capacity of cooperatives via training and infrastructural support, and educating farmers on

[37] Du, Lu & Zilberman, *supra* note 33.
[38] Putri et al, *supra* note 34.

the advantages and obligations inherent in this model. The cooperative-based contract farming model, utilising a holistic approach, possesses substantial potential for widespread implementation in Indonesia, yielding considerable economic and social advantages for smallholders.

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The Role of The Pandawara Group in Encouraging the Government and Society to Maintain Environmental Conservation

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ABSTRACT: The environment is something that cannot be separated from humans scientifically, because humans will continue to interact with their environment. And sometimes humans can also influence the environment itself. Where the environment can have a positive impact if it is well cared for and conversely it can have a negative impact if it is left polluted. There are currently many efforts to preserve the environment, one of which is through social media. The social media platforms that is currently often in demand or popular in Indonesia is TikTok. With TikTok, a person or group can become famous or go viral because of the content they create . One of the TikTok accounts that is currently viral is the Pandawara Group. The Pandawara Group itself is a group of young people from Bandung who create content on TikTok with clean up actions in various places. This research aiming to determine the influence of TikTok Pandawara's Group content on environmental care attitudes. The research method used is library research, namely a data collection technique carried out by collect research sources and data through books, journals and articles. The results of this research are the great influence of the Pandawara group's TikTok account in encouragement people to preserve the environment. apart from that, collaboration between society and government has a real and significant impact on creating a clean and healthy environment.

KEYWORDS: Pandawara Group, Public, Environment.

I. INTRODUCTION

The environment is an inseparable part of human life. The interaction between humans and the environment is reciprocal, where humans influence environmental conditions, and vice versa, environmental conditions also have an impact on human life. A healthy and well-preserved environment provides great benefits to humans, such as clean air, drinkable water, and biodiversity that

supports the sustainability of the ecosystem. However, along with increasing human activity, both in the form of industrialization, urbanization, and excessive consumption, threats to environmental sustainability are increasingly real. Air pollution, water pollution, illegal logging, and piling up of waste are serious problems that need to be addressed immediately. Indonesia, as a country with very rich biodiversity, faces major challenges in maintaining environmental sustainability [1]. Reports from various environmental institutions show that many areas in Indonesia are experiencing environmental degradation due to poorly managed waste. This problem is further exacerbated by the lack of public awareness of the importance of maintaining a clean environment. In this context, the role of social media is one of the innovative solutions to increase awareness and encourage public participation in efforts to protect the environment.

Social media has become a very effective communication tool in conveying information, building public opinion, and encouraging social action. One of the most popular social media platforms in Indonesia is TikTok. With a creative short video-based content approach, TikTok has succeeded in attracting the attention of various groups, especially the younger generation. In recent years, various social movements born from TikTok have proven that social media is not only a means of entertainment, but also a tool to encourage significant social change. One real example of the use of social media to support environmental sustainability is the Pandawara Group. This group consists of a group of young people from Bandung who use TikTok as their main platform to spread messages of environmental concern. Through the clean-up action content they upload, the Pandawara Group not only inspires people to care about the environment, but also drives real action to clean up trash in various locations. The skyrocketing popularity of the Pandawara Group on TikTok shows how much influence social media has in shaping public awareness of environmental issues.[2]

Pandawara Group has conducted various clean-up activities in places that are severely polluted, such as rivers, beaches, and other public areas. Their actions often attract wide attention and receive support from the surrounding community. Not only that, they have also succeeded in collaborating with the local government, non-governmental organizations, and local communities to expand the impact of their activities. This collaboration shows that efforts to preserve the environment require synergy between various parties, including the community, government, and private organizations. On the other hand, the

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1 Shabrina, A., Nuraini, K., & Naufal, A. (2023). Environmental cleanliness campaign strategy by Pandawara Group through *TikTok* media. Proceedings of the National Seminar of Surabaya State University, 1544–1556. ISSN 1234-5678.

2 Tamba, Relly & Sitorus, Hizkia & Situmorang, Lennai & Wahyudi, Arief & Ibrahim, Maulana. (2024). The Role of the Pandawara Community in Anticipating Environmental Pollution. Interdisciplinary Explorations in Research Journal. 2. 929-939. 10.62976/ierj.v2i2.584.

collaboration between Pandawara Group and the government is also a real example of how community movements can synergize with public policies to create a greater impact. The government has an important role in providing adequate waste management infrastructure, creating supportive regulations, and providing education to the community[3]. However, government efforts often face obstacles in terms of community participation. The presence of Pandawara Group as an initiator of environmental action can be a bridge connecting the community with the government, so that effective synergy is created in preserving the environment. Pandawara Group's efforts are not only about cleaning up trash, but also creating educational content that is easy to understand and interesting for the community. With a relaxed but meaningful delivery style, they have succeeded in conveying important messages about the negative impacts of waste on the environment. For example, they educate the public about the dangers of plastic waste that is difficult to decompose, its impact on marine ecosystems, and the importance of reducing the use of single-use plastic. In addition, Pandawara Group also encourages the public to participate directly in clean-up activities, both through invitations in their content and through activities they hold in various places. In addition to having a direct impact on the community, Pandawara Group's actions also inspire other groups to do the same. In recent months, various local communities in Indonesia have begun to adopt the movement model carried out by Pandawara Group. This shows that a social media-based approach can be a catalyst for building a broader environmental movement.

However, even though Pandawara Group's actions have a positive impact, the challenges in preserving the environment remain great. One of them is the sustainability of this movement. To ensure that efforts to protect the environment are not only temporary, there needs to be integration between community movements such as Pandawara Group and sustainable government policies. The government needs to see movements such as Pandawara Group as strategic partners in environmental conservation efforts. In addition, strengthening regulations, increasing waste management capacity, and more massive education for the community need to be a priority. Collaboration between the community and the government is also the main key in creating a clean and healthy environment.[4] The government has the capacity to make supportive policies, while the community has a role in implementing these policies at the local level. This synergy can create significant impacts, such as improving the

[3] Ahmad, R., Widjaya, RI, & Lita, TN (2023). NGO Pandawara Group's participation in managing the environment on Labuan Bay Beach as an effort to realize welfare state. Proceedings: 5th National Conference on Law Studies 2023.

[4] Shabrina, A., Nuraini, K., & Naufal, A. (2023). *Op., Cit.*

quality of the environment, reducing health risks due to pollution, and improving the welfare of the community as a whole.

Pandawara Group has proven that social media-based movements can be an effective tool in encouraging communities and governments to preserve the environment. With a creative, collaborative, and educational approach, Pandawara Group has had a real impact in increasing public awareness and participation in environmental issues. Based on the description above, this research raised the problem, first, Pandawara's role in encouraging the community and government to preserve the environment, and, second, what is the impact of collaboration between Pandawara and the government and community to maintain environmental sustainability?

II. METHODOLOGY

Research on the Role of Pandawara Group in Encouraging Government and Society to Guard Sustainability Environment with method study that is Literature study. Research method of study library namely the data collection technique used with gather source research and data through books, journals.

Literature review can translated as series related activities with method library data collection , such as record , process and analyze materials that will be will used in compile A research . Literature studies can also be interpreted as activity learn various book reference as well as results study previous similar and useful For get runway theory related with the problem that will researched.[5]

In this study, the author uses data in the form of related literature or journals. with role the panda groups on social media and sustainability environment.

[5] *Loc., Cit.*

III. PANDAWARA'S ROLE IN ENCOURAGING THE COMMUNITY AND GOVERNMENT TO PRESERVE THE ENVIRONMENT

The government plays an important role in environmental management. As a state institution, the government has the authority to regulate everything related to the environment. Indonesia is in a vulnerable position to the impacts of climate change such as declining food production, rising sea levels, sinking small islands, and development activities that require increasing natural resources. Meanwhile, development activities can cause the risk of pollution and environmental damage to worsen. This makes the Indonesian environment must be protected and managed properly based on the principles of state responsibility, the principle of sustainability, and the principle of justice.[6]

Governance based on the principle of good governance governance means democratizing the implementation of government functions by involving the private sector and the community, this aspect of democracy prevents the dominance of one party, especially the government, over other parties in managing public interests including the management of natural resources and the environment. Environmental management is basically a shared responsibility between the government (State), the private sector, and the community. Environmental management based on the principle of good governance can reduce environmental [7]conflicts.

In addition to the government, community participation is also needed in Environmental Management, which is related to the Right to the Environment. The Republic of Indonesia protects the right to the environment for its citizens as stated in the Constitution of the Republic of Indonesia 1945, Article 33 paragraph (3) which stipulates that the earth, water, and natural resources contained therein are controlled by the state and used for the greatest prosperity of the people because in principle Human Rights are a set of inherent and absolute rights that exist in humans as creatures of God Almighty and are a gift that must be respected, upheld and protected by the State, law, and every person. In addition to the many cases of environmental pollution that occur in Indonesia, it proves that there needs to be community participation to take part in protecting and managing the environment, because in addition to the very complex and multi-aspect life problems, in principle environmental management is carried out for

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[6] Rusyidi, J., et al. (2023). Government Responsibility in Enforcing Environmental Law Reviewed from the Perspective of State Administrative Law. Audit Et Ap, Volume 02, Number 01. Doi: https://doi.org/10.24967/jaeap.v2/01.2064, p54.

[7] Wibawa, KCS (2019). Developing Community Participation in Environmental Protection and Management for Sustainable Development. Administrative Law & Governance Journal, Volume 2, Number 1. Doi: https://doi.org/10.14710/alj.v2/1.79-92, p. 82.

the benefit of humans and the key to success in the field of environmental life is in the hands of the community itself.[8]

Young people are often more familiar with technology than previous generations. The advantage is that they can use the power of technology to create innovative solutions to protect the environment. Apps, software, and other technological innovations can contribute to monitoring and managing natural resources, reducing waste, and saving energy. In addition, young people can also play a role in better environmental policies, as Pandawara has done. They can participate in advocating for policy changes that promote environmental sustainability and address environmental challenges such as climate change. By voting, lobbying, or joining other environmental groups, young people can influence policymakers to take stronger action on environmental issues.

Youth play an important role in raising awareness about the importance of sustainable nature in society. Sharing information and educating people around them about the impact of human activities on nature and ways to reduce it. A better understanding of environmental issues helps people make more sustainable decisions. Youth are agents of change who have great potential in driving social change and influencing people's behavior. Pandawara Group acts as an effective education agent. Through their social media campaign, they have succeeded in conveying the message about the importance of waste management and the negative impacts that can arise if waste is not managed properly. They provide easy-to-understand and inspiring information to the public, thereby helping to increase the understanding and awareness of the government and the public.

Pandawara Group is a group with a TikTok account username @pandawaragroup from Bandung consisting of five young people, Pandawara Group is a group of young people whose activities include cleaning up trash in several places which they have been doing since August 2022 last year. This youth group consists of five young members, namely Gilang Rahma (22), Agung Permana (22), Rafli Pasya (22), Rifki Sa,dullah (22), and Muchamad Ikhsan (21), They have been friends since high school. [9]They have chosen to take unique action because of their concerns about the flooding that often occurs in their residential area, South Bandung. The background of the five young people forming the Pandawara Group is because of the impact of the waste problem in Indonesia that they feel directly, namely flooding. As flood victims, they feel

[8] Kawengian, GP (2019). Community Participation in Environmental Management and Conservation. Lex Et Societatis, Volume 7, Number 5. Doi: 10.35796/les. v7i5.24723, him. 55.

[9] Nuri, E. (2023). Pandawara Group: Viral Action of Young People Cleaning Up Garbage on *TikTok*. Narasi.tv. https://narasi.tv/read/narasi-daily/siapa-pandawara-group . Accessed on November 21, 2024 at 19.41.

unrest and empathy seeing the condition of the river filled with garbage. On that basis, they immediately took action to clean up the garbage in the gutters and rivers around their homes.

Their actions were then uploaded in the form of a video on one of the social media platforms, namely TikTok, and then ended up going viral because many people praised and supported their good actions. TikTok has become one of the most popular social media platforms in the world, bringing a wave of innovation in the form of short videos that are creative and rich in education. Pandawara Group leverages the power of this technology to share its actions with the wider community. This platform has changed the way people interact with digital content, embracing creativity, and expanding the boundaries of online entertainment. In this case, TikTok has become an important role for Pandawara Group in campaigning for environmental cleanliness and disseminating it to the public.

Pandawara Group can play a role in educating the government and the community about the importance of sorting, reducing, and recycling waste. They invite the community to contribute by cleaning up waste in an area through a platform, one of which is TikTok. Through the active role of Pandawara Group in encouraging public awareness of sustainable development through waste management, it is hoped that a more environmentally friendly behavioral change will be created. With strong participation from young people, a culture of waste management can be formed that has a positive impact and has a positive impact on the environment, health, and quality of life of the community as a whole.

Pandawara Group has played a significant role in educating the government and the public about the importance of sorting, reducing, and recycling waste. Through their social media campaigns, they have successfully conveyed the message about waste management and its negative impacts. This solution can be implemented by involving more groups or individuals who take similar initiatives in spreading information and raising public awareness about the importance of sustainable waste management.

TikTok has brought new innovations to the way we interact with the world around us. In addition to being a platform that allows for visual creativity, TikTok also provides a space for powerful verbal messages. The use of verbal voice in TikTok content creates a new gateway to positive social change. By engaging people directly through words, profound and inspiring messages can spread quickly and widely. Therefore, content creators have a responsibility to use the power of their voices to drive change, bring awareness, and support social

causes[10]. Through their verbal creativity, TikTok is not only an entertainment platform, but also an effective tool to make the environment a cleaner place through campaigns.

In this case, TikTok Content created by Pandawara Group refers to inviting people to join in social action. The verbal message conveyed can motivate people to participate in social initiatives, fundraising campaigns, or volunteer activities aimed at helping others or voicing neglected rights, especially in the area of sadness. One of the contents that had a significant impact was when Pandawara Group cleaned up the beach dubbed the dirtiest beach in Indonesia, namely Teluk Beach, Teluk Village, Labuan District, Pandeglang Regency, Banten.

Before the action began, the young man from Bandung uploaded content in the form of an invitation on his Instagram and TikTok accounts to take part directly in the garbage cleaning action. The invitation content displays a clipping of a picture when the beach has not been cleaned. The beach is full of piles of plastic waste, such as plastic bags to plastic bottles. The view in the video successively highlights the piles of plastic waste in the middle of the beach and the edge of the beach. In the previous upload, Pandawara Group had satirized the public who seemed not to care about the cleanliness of their beach and the beach full of garbage was used as the background.

In the caption of the Instagram photo they uploaded, Pandawara invited all levels of government and the community to help them clean up the piles of garbage that had piled up on the beach. The invitation succeeded in touching the hearts of all levels of government and the community to help their action. One of the Pandawara members said that the condition of the beach like this is not an opportunity for residents and the government to blame each other. But this condition is an opportunity for the community and government to work together to be more concerned about overcoming environmental problems.

After the video was shared and watched by millions of people, the community came together to clean the beach. The action was followed by thousands of people and succeeded in transforming the sea of garbage into a clean river. The cleaning action was also documented and then uploaded on social media TikTok pandawara and received much praise and support from the community and even the government. In the video, five young men are seen working together to clean up piles of plastic in a river whose water looks polluted and dark brown. They lift the trash with simple tools. The video also reveals *the before* and *after* the river

[10] M. Predy, J. Sutarto, T. Prihatin, and A. Yulianto, "Millennial Generation Ready to Face the Digital Revolution Era (Society 5.0 and Industrial Revolution 4.0) in Education Through Human Resource Development," 2019 .

was cleaned. From being full of trash, it became clean and only left behind the flow of water.

From this phenomenon, Pandawara uses his creativity to conduct a campaign on TikTok social media. It can be concluded that TikTok has the ability to make content go viral quickly. Unique or touching cleaning videos like those made by Pandawara can spread widely in a matter of hours, reaching millions of viewers worldwide. Thus, the message of cleanliness becomes easier to spread and be adopted by the community. This platform has transformed the act of cleaning from something ordinary into a dynamic and viral social movement.

IV. THE IMPACT OF COLLABORATION BETWEEN PANDAWARA AND THE GOVERNMENT AND COMMUNITY TO MAINTAIN ENVIRONMENTAL SUSTAINABILITY

Collaboration between Pandawara Group, the government and the community has had a positive impact on environmental conservation efforts. Pandawara Group, known through its social media content, such as TikTok, has succeeded in raising public awareness, especially the younger generation, of environmental issues. Through campaigns such as cleaning rivers, beaches and the general environment, this group not only promotes the importance of cleanliness but also exemplifies real actions that can be emulated by the wider community.

Environmental concern refers to ongoing attitudes and actions in preventing damage and improving the condition of the natural environment that has been damaged. Environmental care character reflects individual efforts to manage and maintain the environment in the right way, so that it can be used sustainably without causing damage, while ensuring the sustainability of its benefits for future generations.[11]

The importance of building an attitude of environmental concern is based on three main components of the attitude itself. According to Mar'at there are three main components, namely:[12]

1. Cognitive component (awareness), which is related to beliefs, ideas, and concepts;
2. The affective component (feelings), which involves the emotional aspects of a person;
3. The conative (behavioral) component, which is the tendency to behave.

[11] Purwanti, D (2017). Environmental Care Character Education and Its Implementation. DWIJA CENDEKIA: Journal of *Pedagogical Research*, 1(2), pp. 14-20.

[12] Narut, Y. F., & Nardi, M. (2019). Analysis Attitude Care Environment on Students Grade VI Elementary School in Ruteng City. *Scholaria: Journal of Education and Culture*, 9(3), pp. 259-266.

Thus, an attitude of caring for the environment is behavior that arises based on awareness and feelings towards the environment.

Maintaining environmental cleanliness is a responsibility that must be carried out by every individual. Awareness of the importance of cleanliness should start from oneself, because a clean environment contributes to the creation of a healthy life. In Indonesia, the problem of cleanliness is still a serious and urgent issue to be resolved. The high level of environmental damage and the increasing sanitation problems every year indicate a real threat to the community and the surrounding ecosystem.

People, especially those living in big cities, need to have a higher awareness to create a better life, because human activities are often the main cause of environmental damage. Currently, the level of public awareness of environmental cleanliness is still relatively low. Although many have maintained personal and family hygiene, most do not understand the importance of environmental sanitation. Household waste is the largest contributor to pollution in Indonesia, due to the lack of education about proper waste management. This triggers various problems, such as flooding and the spread of diseases, including dengue fever and Chikungunya. To overcome this, it is necessary to increase public awareness and the active role of the government in providing facilities such as trash bins in public spaces and effective education programs about waste management.[13]

Pandawara Group focuses on empowering local communities to raise awareness of waste issues in their environment. Inadequate waste management can pollute the environment and have a negative impact on the health of the surrounding community. Therefore, efforts are needed to build individual and collective awareness of the importance of maintaining environmental cleanliness. Environmental awareness reflects inspiration and understanding of the importance of a healthy and clean environment, which is then realized through real action. Pandawara Group also hopes that the government or related institutions can support this effort. Collaboration between various parties, including the community, government, and other sectors, is very important in overcoming waste management problems as a whole.

Pandawara Group's content is not only related to cleaning the environment, but also to education about the importance of maintaining environmental cleanliness, such as providing information related to the importance of maintaining environmental cleanliness. These videos also provide strategies on

[13] Chintya Noer Aisiyah, Qorruta A'vun, Siti Wulan Royani , Wafiyyan Mu'azirul Haq. (2024). The Influence of Pandawa Groups On Social Media Against Literacy Cleanliness Environment Among Students at the Indonesian University of Education. *Journal Devotion To the Independent Community (JPMM)*. Vol. 2. Pp. 87-97

how to maintain environmental cleanliness. As for the campaign content for the use of environmentally friendly products, in order to invite the public to use environmentally friendly products. In addition, Pandawara Group is also active in sharing useful content about waste and environmental cleanliness issues on social media. This content aims to increase public awareness about waste and environmental cleanliness problems. Pandawara Group wants the content created to inspire the public to take action towards a cleaner environment. They also want to create a clean and healthy environment for future generations.

One significant impact of this collaboration is the increase in community participation in environmental care. Direct involvement in activities such as river cleaning or waste management shows that awareness raised through education can be translated into collective action. Pandawara Group uses an innovative approach through social media to reach a wide audience, making their content an effective means of communication and education.

Government support, for example in providing facilities for waste management or collaboration in environmental campaigns, strengthens the impact of these activities. The government legitimizes the actions taken by the Pandawara Group and the community, thus creating synergy between public policy and social movements. The result is measurable environmental improvements, such as reduced waste in locations targeted by the campaign.

Pandawara Group uses social media, especially TikTok, as a platform for environmental education. Interesting and relevant content has reached millions of viewers, especially the younger generation who are often the main target group for behavioral change. They promote real-world actions such as cleaning rivers and beaches, providing direct examples of how individuals can contribute to environmental sustainability.

With a creative and proactive social approach, the campaign through the TikTok platform has had a huge impact in inspiring youth, government, and communities to collaborate. This collaboration brings real benefits to their environment. The social actions carried out encourage each party to feel that they have an active responsibility in protecting the environment where they live. This sense of ownership and responsibility is created through direct participation, such as cleaning up trash, which empowers all levels of society by giving them the belief that they are able to create positive change in their own communities.

The social activities carried out by Pandawara Group in cleaning up garbage are a significant contribution in creating a clean, healthy, and sustainable environment. With awareness, enthusiasm, and commitment, the younger

generation not only becomes a pioneer of change but also guides society towards a brighter and pollution-free future. Through the involvement of all levels of society, this effort brings optimism to create a green and sustainable environment for future generations.

The efforts made by Pandawara Group have had a significant positive impact on the environment in Indonesia. First, public awareness of the importance of protecting the environment and the dangers of pollution has increased. Through campaigns and activities involving the community, Pandawara has succeeded in making many people aware of the importance of maintaining cleanliness and preserving nature. Second, cleaning activities held by Pandawara, such as cleaning rivers, beaches, and public areas, have helped reduce the volume of waste that pollutes the environment. The impact can be seen from the reduction in waste in several areas that were previously heavily polluted. Furthermore, Pandawara's efforts have also contributed to improving environmental quality, especially in improving the condition of polluted water, air, and soil. These activities also lead to the restoration of ecosystems affected by pollution. Finally, Pandawara has inspired the emergence of many other environmentally conscious communities. Thanks to these initiatives, more and more groups are motivated to participate in environmental conservation, creating a stronger collective movement in various regions.[14]

Success in addressing environmental issues depends on collaboration between governments, the private sector, non-governmental organizations (NGOs), and civil society. Active corporate participation in social and environmental responsibility, coupled with close collaboration with NGOs and governments, can create more efficient and impactful joint initiatives. Governments have a critical role to play in creating an enabling environment for investment and partnerships with the private sector, especially those with the technology and resources to support infrastructure development and better waste management practices.

This collaboration has succeeded in encouraging community involvement in environmental conservation activities, especially waste cleaning. By inviting the community to participate directly, Pandawara Group not only raises awareness but also motivates them to take real action. Support from the government, such

[14] Relly Tamba, Hizkia Rolang Prawryra, et al. (2024). The Role of Community Pandawara In Anticipation Pollution Environment. *Interdisciplinary Exploration in Research Journal (IERJ)*. 2(2). Pp. 930-939.

as the provision of facilities, logistics, and relevant policies, helps create stronger synergy in the implementation of this environmental program.[15]

Through cooperation with the government, the movement gains wider legitimacy and recognition. The momentum created by the Pandawara Group can be used by the government to introduce or strengthen environmental policies, such as waste management, recycling campaigns, or reducing the use of single-use plastics. With high levels of community involvement, these policies become easier to implement and are accepted by the public.

This collaboration provides a real example that change starts from small actions that are carried out consistently. The recognition received by Pandawa Group, such as the Changermaker award of The Year[16], shows that community-based initiatives can have a big impact. Actions such as river and beach cleanups have resulted in real results in reducing waste in certain locations. This not only improves the aesthetics of the environment but also restores ecosystems damaged by pollution.

V. CONCLUSION

The collaboration between Pandawara Group, the government, and the community has had a significant positive impact on environmental conservation efforts in Indonesia. Pandawara Group, known through its social media campaigns, has succeeded in raising public awareness, especially the younger generation, about the importance of maintaining a clean environment. By inviting the community to be directly involved in activities such as cleaning rivers and beaches, they not only promote cleanliness but also inspire real action. Through this approach, environmental awareness is increasing, and more individuals and communities are motivated to participate in nature conservation. The involvement of the government in providing supporting facilities and policies further strengthens this movement. The impact is seen in the reduction of waste in several areas and the restoration of environmental quality affected by pollution. Pandawara Group has also succeeded in inspiring other communities to take action in the field of environmental conservation, creating a broader collective movement. Thus, this collaboration not only has a short-term impact in cleaning the environment, but also contributes to more sustainable behavioral changes in the future.

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[16] Muhammad Aufa Ibunu Faizal. (2024). Impact @pandawaragroup Social Media Content Against Massive Cleanup Action Trash in Rivers and Beaches. *Journal Ilmadika*. 1(1).

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Bridging Policy and Practice in The Role of Government and Society for Achieving Sustainable Agriculture

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ABSTRACT: Agriculture plays a central role in Indonesia, and various policies and strategies are converging to promote sustainable agriculture systems. Indonesia faces unique challenges and opportunities in its journey toward sustainable agricultural practices. This study explores the intersection of government initiatives, community action, and sustainable farming practices in Indonesia, assessing their synergy and impact. The methodology used is descriptive analytics, which employs a Likert scale. The data obtained through questions to key agricultural stakeholders (farmers, extension workers, sustainability workers, and suppliers). The Indonesian Government has introduced various programs, including organic certifications and financial support mechanisms, but the effectiveness of these interventions remains mixed. Findings reveal a high level of awareness (89.29%) of government-led sustainability programs among respondents, with a significant proportion (82.14%) adopting these practices. However, barriers such as limited resources and uneven program outreach persist. This study highlights the importance of clear regulations, community involvement, and consistent government support in promoting sustainable practices. The Government has established some laws regarding sustainable practice, such as Law Number 32 of 2009, Law Number 23 of 1997, Law Number 4 of 1882, Government Regulation Number 22 of 2021, and Law Number 22 of 2019. Using a Likert-scale analysis, the assessment of government effectiveness categorizes current efforts as "Moderately Effective," indicating room for improvement in outreach and implementation. Furthermore,

community participation, reflecting 51.7% engagement in sustainability initiatives, underscores the role of collective action in driving systemic change. Recommendations emphasize targeted education, improved access to resources, and collaborative stakeholder efforts to enhance the visibility and adoption of sustainable agricultural practices. The research aims to provide actionable insights and a roadmap for strengthening Indonesia's agricultural sustainability, supporting broader environmental and economic objectives.

KEYWORDS: Government Policy, Sustainable Agriculture, Community Involvement.

I. INTRODUCTION

Environmental sustainability refers to the ethical use of natural resources to meet present needs without compromising future generations. It has emerged as a critical issue worldwide, with the United Nations' Sustainable Development Goals (SDGs) placing it at the forefront of global development agendas. Sustainable environment and development are among the most challenging concepts for academic scholars and research communities.[1] One of the critical sectors where sustainability plays a vital role is agriculture.[2] Sustainability transitions in agriculture are complex and require a systemic approach, considering the many dimensions that must be addressed, such as environment, food, and economy.[3]

Indonesia is a country endowed with rich biodiversity and extensive natural resources[4]; achieving environmental sustainability is a national obligation and a global responsibility. Agriculture serves as the backbone of Indonesia's economy and sustains the livelihoods of millions. However, unsustainable agricultural practices, deforestation, and improper land use threaten natural resources.[5] The

1 Naser Valizadeh et al, "Agricultural sustainability assessment in Fars province of Iran through the lens of the elimination multi-criteria decision-making method" (2024) 24 Environ Sustain Indic 100505, online: <https://www.sciencedirect.com/science/article/pii/S2665972724001739>.

2 Slamet Eko Prastiyo et al, "How agriculture, manufacture, and urbanization induced carbon emission? The case of Indonesia" (2020) 27:33 Environ Sci Pollut Res 42092–42103.

3 Sylvain Dernat et al, "A sustainable game changer? Systematic review of serious games used for agriculture and research agenda" (2025) 222 Agric Syst 104178, online: <https://www.sciencedirect.com/science/article/pii/S0308521X24003287>.

4 Laely Nurhidayah & Shawkat Alam, "The forest and its biodiversity: Assessing the adequacy of biodiversity protection laws in Indonesia" (2020) 23:2 Asia Pacific J Environ Law 178–201.

5 Diane Osgood, "Government failure and deforestation in Indonesia" in *causes Trop deforestation* (Routledge, 2023) 217.

Indonesian Government has taken significant steps to address these challenges by formulating and enforcing policies to integrate sustainable practices into critical sectors, especially agriculture. Programs like organic certification by Badan Standarisasi Nasional (BSN) with SNI 6729-2016 regulation and other organic certification bodies accredited by Komite Akreditas Nasional (KAN) serve as environmentally friendly farming initiatives. Those regulations have become essential in promoting sustainable agriculture. Government efforts align with global targets, particularly SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production), and SDG 15 (Life on Land), among others. While government interventions are critical, the role of society through community-based initiatives, public awareness, and participatory governance cannot be overlooke. [6] Communities, farmers, and civil society organizations have contributed significantly to advancing environmental stewardship and sustainable farming practices nationwide.

Assessment of sustainability agriculture with a focus on its production implies that implementing sustainability of agricultural production practices results in higher yield productivity.[7] Economic impacts that arise related to the matter should also be considered.[8] However, regarding sustainability assessment in the agricultural sector, the environmental dimension tends to receive more attention.[9] This study explores the synergy between government initiatives and societal action in advancing sustainable agriculture in Indonesia. It aims to assess the level of awareness and adoption of sustainable agricultural practices among agriculture stakeholders, evaluate the effectiveness of government programs, and examine the role of community involvement in enhancing sustainability efforts. By leveraging primary data collected through a survey, this research provides empirical insights into the challenges and opportunities in promoting sustainable agriculture.

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6 Paul Shrivastava et al, "Transforming sustainability science to generate positive social and environmental change globally" (2020) 2:4 One Earth 329–340.

7 Valizadeh et al, *supra* note 1.

8 Ramoudane Orou Sannou, Sabrina Kirschke & Edeltraud Günther, "Integrating the social perspective into the sustainability assessment of agri-food systems: A review of indicators" (2023) 39 Sustain Prod Consum 175–190, online: <https://www.sciencedirect.com/science/article/pii/S2352550923001094>.

9 Andreas Stylianou, Despina Sdrali & Constantinos D Apostolopoulos, *Integrated Sustainability Assessment of Divergent Mediterranean Farming Systems: Cyprus as a Case Study* (2020).

II. METHODOLOGY

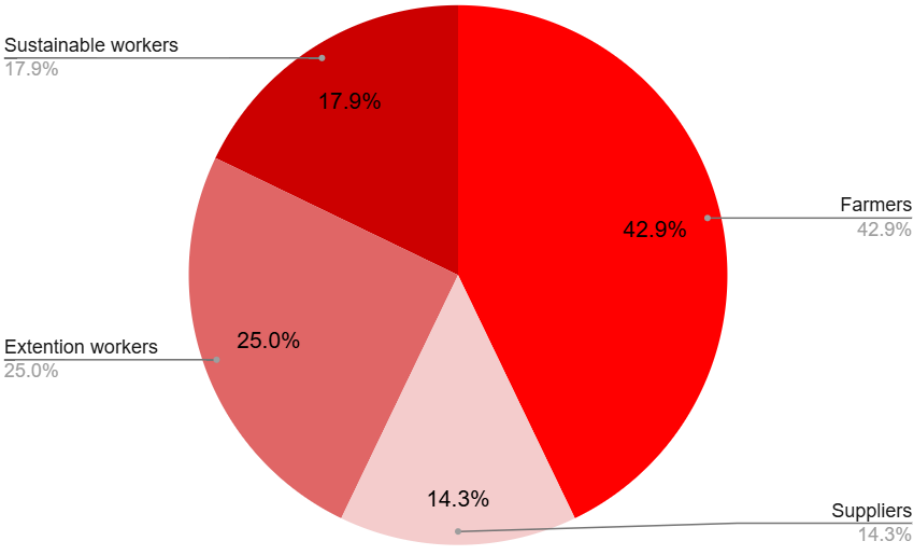
The research uses descriptive analytics to examine the primary data. The data collection is through surveys of selected samples. The study employed a purposive method in the sampling selection. Respondents consist of farmers, sustainability workers (environmental organizations, certification auditors), extension workers, and suppliers. Primary data was analyzed using descriptive statistics, empowered by Likert scale determination. The literature review was used to strengthen the justification of each finding. The literature review used was from a minimum of five years before the manuscript was written.

III. EXPLORES THE SYNERGY BETWEEN GOVERNMENT INITIATIVES AND SOCIETAL ACTION IN ADVANCING SUSTAINABLE AGRICULTURE IN INDONESIA.

The respondent profile offers valuable insights, as seen in Picture 1. The information provided includes the demographic and occupational characteristics of the surveyed population. The largest group, comprising 42%, is made up of farmers. Farmers act as primary actors in agricultural production and play a crucial role in implementing and adopting sustainable practices.[10] This makes their perspectives essential in understanding government-supported sustainability programs' practical challenges and benefits.[11] On the other hand, etension workers make up 25% of the respondents. Their work is to serve as a bridge between policy and practice providing not onlu technical support but also disseminating information in promoting sustainable agricultural methods.

[10] Lin Li, Jiliang Han & Yuchun Zhu, "Empowering sustainability: How digital agricultural extensions influence organic fertilizer choices among Chinese farmers" (2024) 371 J Environ Manage 123340, online: <https://www.sciencedirect.com/science/article/pii/S0301479724033267>.

[11] Kusnandar Kusnandar et al, "Understanding how governance arrangements within agricultural supply chains influence farmers' SAP adoption for adaptation and mitigation practices" (2024) 220 Agric Syst 104085, online: <https://www.sciencedirect.com/science/article/pii/S0308521X2400235X>.



Picture 1. Respondents distribution based on feld of work
(Source: Primary data processed, 2024)

Sustainable workers account for 17.9%, including individuals involved in environmental organizations, certification auditors, and other sustainability-focused roles. They have knowledge and experience in sustainability, providing critical insights into the effectiveness and impact of certification programs and environmental policies. [12] Meanwhile, suppliers, representing 14.3% of the respondents, contribute as key players in the agricultural value chain. Suppliers providing essential inputs like seeds, fertilizers, and equipment. Their role influences the adoption of sustainable farming practices, making their input significant for a comprehensive analysis.[13]

Respondent's average age is 35.96 years, indicating a relatively young and active demographic. This age group is often more adaptive and open to change, which is advantageous in driving the adoption of innovative and sustainable agricultural practices.[14] Additionally, the respondents have an average of 15.57 years of education, roughly equivalent to an undergraduate degree in Indonesia.

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12 Monica Fisher et al, "Awareness and adoption of conservation agriculture in Malawi: what difference can farmer-to-farmer extension make?" (2018) 16:3 Int J Agric Sustain 310–325.

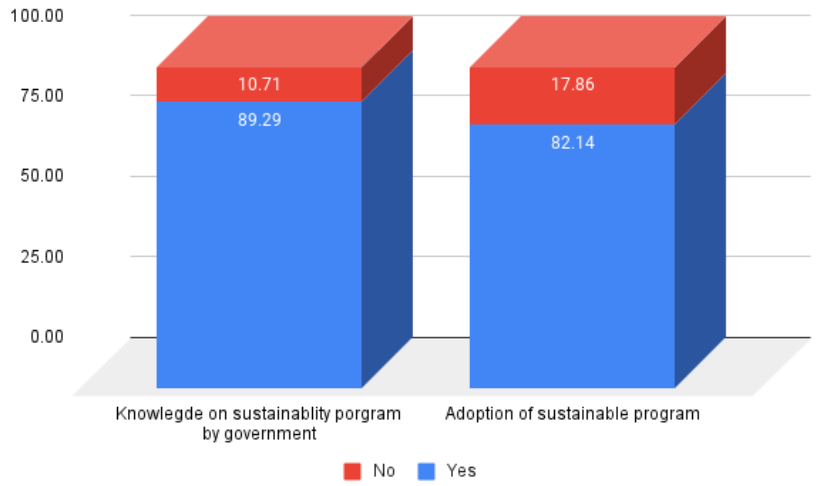
13 Angela Navarrete-Cruz & Athena Birkenberg, "How do governance mechanisms between farmer and traders advance sustainability goals and enhance the resilience of agricultural value chains?" (2024) 35 World Dev Perspect 100618, online: <https://www.sciencedirect.com/science/article/pii/S2452292924000559>; Daniel Alonso-Martínez, Beatriz Jiménez-Parra & Laura Cabeza-García, "Theoretical framework to foster and assess sustainable agriculture practices: Drivers and key performance indicators" (2024) 23 Environ Sustain Indic 100434, online: <https://www.sciencedirect.com/science/article/pii/S2665972724001028>.

14 Yang Gao et al, "Influence of a new agricultural technology extension mode on farmers' technology adoption behavior in China" (2020) 76 J Rural Stud 173–183.

This high level of education suggests that the participants have a strong foundation for understanding complex sustainability concepts and government programs, which may facilitate greater adoption of these initiatives.[15]

A. Adoption of Sustainable Practices

The survey results indicate a high level of awareness regarding government-led sustainability programs among respondents, with 89.29% reporting knowledge of such initiatives. This suggests that information about sustainable agricultural practices is being effectively disseminated. However, a smaller but still significant portion, 10.71%, remains unaware of these programs, highlighting the need for further outreach efforts.



Picture 2. Sustainable program awareness and implementation
(Source: Primary data processed, 2024)

Regarding implementation, 82.14% of respondents have adopted sustainable programs, reflecting a solid alignment between awareness and practice. The result demonstrates that once farmers and other stakeholders are informed about sustainability initiatives, they will likely incorporate these practices into their operations. However, the remaining 17.86% who have not adopted these programs could represent individuals facing barriers such as limited resources, lack of incentives, or insufficient support.[16]

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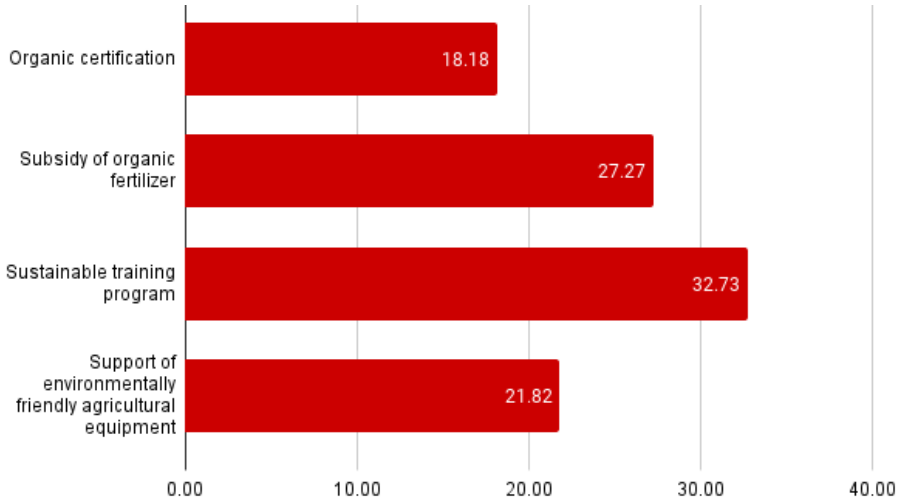
[15] Carlo Giua, Valentina Cristiana Materia & Luca Camanzi, "Smart farming technologies adoption: Which factors play a role in the digital transition?" (2022) 68 Technol Soc 101869.

[16] Valeria Piñeiro et al, "A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes" (2020) 3:10 Nat Sustain 809–820.



Picture 3. Knowledge of sustainability programs by Government
(Source: Primary data processed, 2024)

When examining specific types of sustainable programs, awareness is unevenly distributed. The most recognized initiative is the sustainable training program, known by 32.73% of respondents, indicating its relative prominence in government efforts. Subsidies for organic fertilizer are closely followed, with 27.27% awareness, showing that financial support mechanisms are reaching a fair portion of the target audience. Awareness of support for environmentally friendly agricultural equipment stands at 21.82%, while organic certification is the least known, with only 18.18% awareness. These findings highlight a need to enhance the visibility and accessibility of certain sustainability programs, particularly organic certification and environmentally friendly equipment support. Improving awareness and understanding of these programs could further boost adoption rates and strengthen sustainable agricultural practices across the sector.[17]

B. Effectiveness of Government Programs

The analysis of the Likert scale responses reveals a total score of 87, placing the perception of government effectiveness in the "Moderately Effective" category (see Table 1). It is suggested that while the Government's efforts in supporting sustainable agriculture programs are acknowledged, there is room for improvement. Respondents recognize the positive impact of initiatives such as training programs, subsidies for organic fertilizers, and support for

[17] Ratana Sapbamrer & Ajchamon Thammachai, "A systematic review of factors influencing farmers' adoption of organic farming" (2021) 13:7 Sustainability 3842.

environmentally friendly agricultural equipment. However, the classification indicates that these efforts have not yet fully met the expectations or needs of stakeholders.

Table 1. Likert scale classification of Government effectiveness in supporting sustainable agriculture program

Category	Interval Class
Very Ineffective	28 - 50.4
Ineffective	50.4 - 72.8
Moderately Effective	72.9 - 95.3
Effective	95.4 - 117.8
Very Effective	117.9 - 140.3

Source: Primary data processed, 2024

The "Moderately Effective" rating implies that government programs are progressing but still face challenges in outreach, accessibility, and practical implementation. This level of effectiveness highlights the need for more targeted and inclusive strategies to ensure that sustainability programs are widely known, effectively adopted, and integrated into agricultural practices.[18] Addressing these gaps could help elevate the perception of government efforts to higher levels of effectiveness, ultimately driving more substantial and widespread improvements in sustainable agriculture.

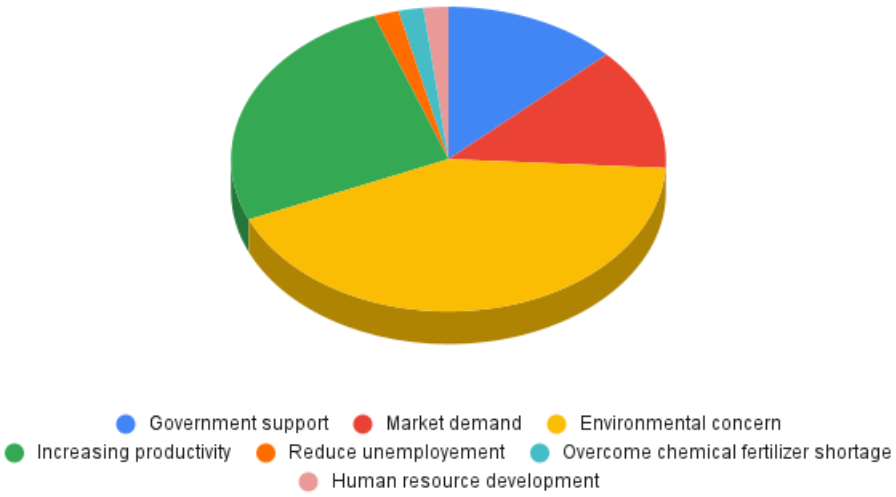
Despite the "Moderately Effective" rating of government support for sustainable agriculture programs, several challenges hinder the full realization of these initiatives. One of the primary issues is the accessibility of government programs, particularly in remote or less-developed regions. Farmers in these areas often face limited access to information and resources, which prevents them from fully understanding or benefiting from available support. Additionally, bureaucratic complexities and administrative delays can discourage stakeholders from

[18] Frank Eyhorn et al, "Sustainability in global agriculture driven by organic farming" (2019) 2:4 Nat Sustain 253–255.

participating in programs such as subsidies for organic fertilizers or grants for environmentally friendly equipment.[19]

Another challenge is the variability in program implementation across regions. Some areas may receive more comprehensive support, including regular training and consistent provision of resources, while others experience gaps in service delivery. This inconsistency can create disparities in the adoption of sustainable practices, limiting the overall impact of government efforts. Moreover, the technical knowledge required to adopt specific programs, such as organic certification processes, may be a barrier for farmers with limited education or training.

The lack of adequate monitoring and evaluation mechanisms further complicates the situation. Without regular feedback and assessments, it becomes difficult for the Government to identify and address shortcomings in their programs. Strengthening these aspects is essential to ensure that sustainability initiatives are not only accessible but also effectively tailored to meet the needs of all agricultural stakeholders.



Picture 4. Factors that motivate agriculture stakeholders in implementing sustainable practice (Source: Primary data processed, 2024)

On the other hand, motivation to continue implementing sustainability practices is mainly because of the urge to be responsible towards natural conditions (45.59%) (see Picture 4). Market demand and government support hold the same share of 24.1%, indicating that business conductivity thrives on stakeholders' continuous improvement besides their high awareness of natural conditions.

[19] Paul Hurley et al, "Co-designing the environmental land management scheme in England: The why, who and how of engaging 'harder to reach'stakeholders" (2022) 4:3 People Nat 744–757.

Maintaining agricultural sustainability means providing sustainable production in the long term, leading to increased productivity.[20] This also motivates stakeholders to implement good agriculture practices (25.93%). Meanwhile, reducing unemployment, human resource development, and overcoming chemical fertilizer shortages (both hold 1.85%) are positive side effects of sustainability practice. Indonesian Government has regulated some constitution regarding environmental sustainability as shown below:

Table 2. Indonesian Government regulation on environmental sustainability

No	Regulation Number	Description
1.	Law Number 32 of 2009	Regulates environmental protection and management
2.	Law Number 23 of 1997	Regulates the obligation to maintain environmental sustainability, prevent pollution, and combat environmental damage
3.	Law Number 4 of 1882	Regulates environmental management, including control of natural resources by the state

Source: Own Elaboration

Law Number 32 of 2009 (Table 2) uses three legal instruments for environmental law enforcement: administrative law, civil law, and criminal law. In addition to the law, there is Government Regulation Number 22 of 2021 concerning implementing Environmental Protection and Management. Moreover, Law Number 22 of 2019 regulates the Sustainable Agricultural Cultivation System. The law aims to achieve national development goals to create a just and prosperous society. The law carries a new paradigm in agricultural management called the Sustainable Agricultural Cultivation System. This system integrates four environmental, social, cultural, and economic aspects. Three principles of this law include paying attention to ecosystem carrying capacity, mitigation and adaptation to climate change, and community involvement in the implementation of agricultural cultivation.

[20] Karolina Pawlak & Małgorzata Kołodziejczak, "The role of agriculture in ensuring food security in developing countries: Considerations in the context of the problem of sustainable food production" (2020) 12:13 Sustainability 5488.

C. Community Involvement and Its Role

Community involvement plays a crucial role in the success of agricultural sustainability initiatives[21] as Indonesia as one of the countries where most of it citizens work in the agriculture sector. According to the survey, 51.7% of respondents have participated in sustainability initiatives, indicating a significant level of engagement. However, 48.3% have not been involved, highlighting a gap that can be addressed to ensure broader participation. The perceived importance of community involvement, as reflected in the Likert scale analysis, received a total score of 117, which falls under the "significant" category (see Table 3). This underscores the recognition among stakeholders that collective action is essential for the long-term success of sustainable agricultural practices.

Table 3. Likert scale classification of the importance of community involvement in supporting sustainable agriculture program

Category	Interval Class
Very insignificant	28 - 50.4
Insignificant	50.4 - 72.8
Moderately Significant	72.9 - 95.3
Significant	95.4 - 117.8
Very Significant	117.9 - 140.3

Source: Primary data processed, 2024

The survey also reveals diverse community-driven initiatives based on the respondents' occupations.[22] For instance, sustainable workers and auditors focus on projects like reforestation and carbon release reduction, while extension workers and farmers prioritize initiatives such as compost production from leaf waste, organic pesticide and fertilizer creation, and organic waste management.

[21] Karina Castro-Arce & Frank Vanclay, "Transformative social innovation for sustainable rural development: An analytical framework to assist community-based initiatives" (2020) 74 J Rural Stud 45–54.

[22] Juan D Machin-Mastromatteo, *Community-driven and social initiatives* (SAGE Publications Sage UK: London, England, 2023).

These efforts contribute to environmental sustainability, enhance soil fertility, and reduce dependency on chemical inputs.

Farmers and community groups are involved in practices like maggot farming as a decomposer to produce organic fertilizer, creating organic liquid fertilizers, and educating others about improving soil fertility through local microorganisms. Suppliers and agricultural groups drive initiatives to reduce synthetic fertilizer and pesticide use, promote zero-chemical cultivation, and encourage bio-pesticide adoption.

Moreover, community involvement is multifaceted and tailored to specific needs and capabilities. The role of the community extends beyond implementation to innovation and education, creating a ripple effect that encourages sustainable practices. By leveraging each group's unique strengths and perspectives, community-driven initiatives can significantly contribute to the broader goals of sustainable agriculture, ensuring both environmental and economic benefits.

D. Challenges and Recommendations for Improvement

Indonesia's transition toward sustainable farming faces many challenges rooted in economic, social, and environmental complexities. Despite government initiatives and community efforts, the widespread adoption of sustainable agricultural practices remains uneven. Key obstacles include limited access to information, inadequate financial support, and inconsistent implementation of policies at the grassroots level. Moreover, farmers often struggle to see the immediate benefits of sustainable methods, which can deter adoption.

Another significant barrier to Indonesia's sustainable farming transition is the dominance of traditional farming practices that prioritize short-term gains over long-term sustainability.[23] Many smallholder farmers rely on conventional methods due to cultural norms, limited training opportunities, and a lack of incentives to shift toward sustainable alternatives. This is further compounded by market pressures that often reward quantity over quality, making it challenging for farmers to justify the costs associated with more sustainable inputs and techniques. Supply chain constraints and insufficient infrastructure also impede farmers' connecting with markets, prioritizing sustainably produced goods. Addressing these issues will require coordinated efforts from policymakers, the private sector, and community organizations to create a

[23] Budiman Achmad et al, "Traditional subsistence farming of smallholder agroforestry systems in Indonesia: A review" (2022) 14:14 Sustainability 8631.

supportive environment for change, emphasizing education, market access, and innovative solutions.

Table 4. Challenges and Recommendations on Sustainable Practice in Indonesia

Category	Challenges	Recommendations
Knowledge and Awareness	Farmers' lack of strong motivation	Provide more training.
	Limited knowledge and facilities	Improve facilities and enhance government program monitoring at the farmer level through agricultural extetntion worker. Broaden the dissemination of certification of sustainable program information.
Access and Resources	Access to information and financial support	Increase practical training and expand support programs (funding, machinery, market access).
	Capital and price stabilization	Shift from subsidized fertilizers to agricultural capital aid, ensuring stable prices for farmers through partnership.
Policy and Governance	Government support and program transparency	Establish clear regulations. Create clear and consistent government programs. Foster collaboration across all stakeholders. Capital assistance, agricultural machinery, training

Agricultural Practices	Low organic farming adoption	Conduct frequent training and streamline bureaucracy.
	Immediate need for significant agricultural returns	Engage all stakeholders—agricultural agencies, farmer groups, and young farmers.

Source: Primary data processed, 2024

Challenges and recommendations related to sustainable agricultural practices in Indonesia, as outlined in Table 4, align with broader theoretical frameworks and recent studies on sustainable development. The lack of strong motivation and limited knowledge among farmers, for example, reflects the "knowledge-action gap"[24] often discussed in sustainability studies, where the absence of training, inadequate extension services, and limited access to reliable information impede the transition to sustainable practice. Sustainable adoption frameworks, such as Rogers' Diffusion of Innovations Theory, emphasize the critical role of knowledge dissemination, perceived benefits, and ease of implementation in influencing farmer behavior.

Moreover, the recommendations to enhance access to financial support and practical training resonate with research highlighting that financial insecurity often deters smallholders from investing in sustainable practices.[25] Studies indicate that creating stable financial structures and access to capital such as replacing fertilizer subsidies with broader agricultural aid can mitigate the impact of volatile markets and help stabilize farmer incomes.

Policy and governance issues underscore the significance of institutional support[26], as theorized in Ostrom's framework for collective action.[27] Clear regulations, transparent government support, and stakeholder collaboration are vital for building trust and enabling cooperative behavior among farmers and

[24] Emilie Ens et al, "Recognition of indigenous ecological knowledge systems in conservation and their role to narrow the knowledge-implementation gap" (2021) Closing knowledge-implementation gap Conserv Sci Interdiscip Evid Transf across Sect Spat scales 109–139.

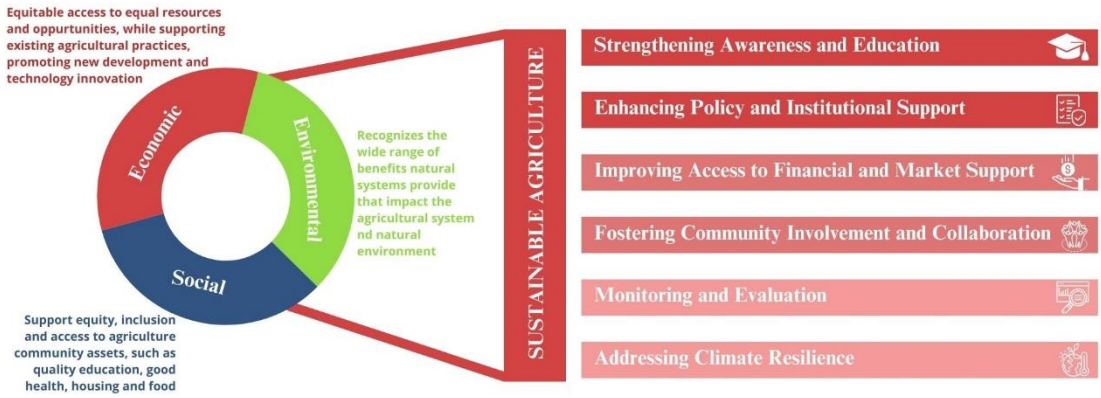
[25] Van Touch et al, "Smallholder farmers' challenges and opportunities: Implications for agricultural production, environment and food security" (2024) 370 J Environ Manage 122536.

[26] Chengli Shu et al, "Government institutional support, entrepreneurial orientation, strategic renewal, and firm performance in transitional China" (2019) 25:3 Int J Entrep Behav Res 433–456.

[27] Erik Nordman, *The uncommon knowledge of Elinor Ostrom: Essential lessons for collective action* (Island Press, 2021).

institutions. Similarly, the low adoption of organic farming practices demonstrates a need for continuous stakeholder engagement, consistent with systems thinking approaches emphasizing interconnected solutions involving multiple actors to drive systemic change (Senge, 2014). By implementing these integrated strategies, Indonesia can create an environment that encouraging sustainable agricultural practices, improving both environmental outcomes and farmer livelihoods.

Understanding these challenges is crucial to formulating actionable recommendations. By examining both the challenges and potential solutions, we aim to provide a roadmap for improving the implementation of sustainable agricultural programs (see Picture 5), fostering resilience in farming communities, and supporting Indonesia's broader environmental and economic goals. The main factors of all innovation-making rely on human resource quality. Strengthening awareness and education can be achieved through targeted campaigns and continuous training programs. Those will increase farmer awareness through localized campaigns and workshops focusing on the long-term benefits of sustainability. Resource must be supported by policy and institutional support. One of these is introducing financial incentives, such as tax breaks or grants, for farmers and organizations to adopt sustainable practices. Moreover, subsidy reallocation from chemical fertilizers to sustainable inputs like organic fertilizers, pest control, and environmentally friendly equipment.



Picture 5. Roadmap for improving sustainability agricultre practice
(Source: Own elaboration, 2024)

Not only the upstream, but the downstream process must be noticed. Improving access to financial and market support become crucial as capital is one of the main

problems of agricultural practice. This can be achieved by providing low-interest loans or grants for smallholder farmers to invest in sustainable farming technologies, creating better market access for sustainably produced goods through cooperatives, digital platforms, and partnerships with private sectors, and establishing systems to ensure stable and fair prices for sustainable agricultural products. All those processes must be sustained by maintaining monitoring and evaluation standards so the progress heads to desired direction.

V. CONCLUSION

The research underscores the critical role of sustainable agricultural practices in achieving Indonesia's environmental and economic goals, given the country's rich natural resources and dependence on agriculture. While government programs have contributed to raising awareness and promoting sustainable practices, challenges such as resource limitations, uneven program outreach, and inconsistent policy implementation persist. The "Moderately Effective" assessment of government efforts highlights the need for enhanced strategies, including targeted outreach, improved accessibility of support mechanisms, and consistent regulatory frameworks.

Community involvement emerged as a critical factor, with over half of the respondents engaging in sustainability initiatives. This engagement reflects the potential for collective action to drive systemic change when paired with practical institutional support. Strengthening awareness, providing continuous training, and addressing resource constraints can further bolster the adoption of sustainable practices across diverse farming communities. A multifaceted approach that leverages government initiatives, community action, and public-private collaboration will be essential to overcoming barriers and enhancing sustainable agriculture in Indonesia. Fostering a resilient, environmentally sustainable agricultural sector will ensure long-term productivity and contribute to national and global sustainability goals.

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