Qonun: Jurnal Hukum Islam dan Perundang-Undangan, 10 (1), 2026: 181-212
https://journal.uinsi.ac.id/index.php/qonun/index
DOI: https://doi.org/10.21093/qj.v10i1.12706
E-ISSN: 2774-3209

ALIGNING INTELLECTUAL PROPERTY RIGHTS WITH CLIMATE IMPERATIVES: A COMPARATIVE STUDY OF PLANT VARIETY PROTECTION

Lu Sudirman*
Universitas Internasional Batam, Indonesia
Rufinus Hotmaulana Hutauruk**
Universitas Internasional Batam, Indonesia
Agustianto***
Universitas Internasional Batam, Indonesia
Nurlaily****
Universitas Internasional Batam, Indonesia
Hari Sutra Disemadi*****
Universitas Internasional Batam, Indonesia

Abstract

Indonesia's agricultural sector has been ridden with stagnation and mismanagement, contrasting Singapore, which despite the lack of potential, has been able to facilitate its agricultural sector to thrive while aligning with sustainability. In this context, Indonesia's Plant Variety Protection (PVP) Law represents an IPR regime that can be analyzed further to explore the potential of helping Indonesia tackle climate change. This research analyzes the legal capacity of Indonesia's PVP regime to integrate climate action initiatives, which provides a novel perspective by bridging intellectual property rights and sustainability, with the added comparative angle of Singaporean perspective. The findings of this research indicate that Indonesia's PVP regime is outdated and ill-equipped to accommodate the regime's inherent potential in being a part of the climate action. In contrast, Singapore boasts a more robust legal framework that has facilitated the growth of its modern agricultural sector, despite resource constraints, along with the lack of direct normative connection between sustainability and the

* lu@uib.ac.id
** rufinus.hotmaulana@uib.ac.id
*** agustianto.lec@uib.ac.id
**** drnurlaily@uib.ac.id
***** hari@uib.ac.id

PVP regime, due to supporting normative architectures. The perspective from Singapore represents a potential model for Indonesia to consider as it seeks to enhance its PVP regime and align it with broader climate change mitigation strategies.

Keywords: Climate Action; Intellectual Property Rights; Plant Variety Protection; Biodiversity

A. Introduction

Biodiversity has long been an integral part of human civilization. Ensuring and enhancing biodiversity is important as it helps strengthen food and water security, along with ensuring balance within many ecosystems around the world. [1] Through the industrialization of the agricultural sector, biodiversity has now become an important part of the economy, particularly Indonesia with its thriving agricultural sector. [2] This was what necessitated the protection of biodiversity through the framework of intellectual property rights, through the regime of plant variety (PV).[3] While the connection is between PV as an IPR regime and climate change is not direct, the relationship between biodiversity and climate change is clear. Biodiversity plays an important role in supporting climate action, which is the concerted effort at various levels of spatial, temporal and institutional scale deliberately directed at preventing or reducing climate-related damages to society through mitigation and adaptation actions.[4]

---

1 Nathalie Seddon et al., "Getting the Message Right on Nature-Based Solutions to Climate Change," *Global Change Biology* 27, no. 8 (2021): 1518–46, https://doi.org/10.1111/gcb.15513.

2 Massimiliano Granieri, "Sowing and Cultivating the Seed of Diversity in Agri-Food: Intellectual Property Protection in Transnational and Comparative Perspective," in *GRUR International*, vol. 70, 2021, 744–53, https://doi.org/10.1093/grurint/ikab038.

3 Martin S. Wolfe and Salvatore Ceccarelli, "The Increased Use of Diversity in Cereal Cropping Requires More Descriptive Precision," *Journal of the Science of Food and Agriculture* 100, no. 11 (2020): 4119–23, https://doi.org/10.1002/jsfa.9906.

4 Jale Tosun, "Addressing Climate Change through Climate Action," *Climate Action* 1, no. 1 (2022): 1–8, https://doi.org/10.1007/s44168-022-00003-8.

A connection between PV and biodiversity can be drawn by utilizing the key element of PV itself, which is the development of plants as living organisms. The emphasis on "variety" here serves as an important legal norm that rewards novelty, which means it automatically adds to the broader concept of biodiversity. By promoting the cultivation of diverse plant varieties through protection and competition, PV contributes to more resilient agricultural systems that can withstand the challenges of changing climate conditions.[5] Not only that, developing new plant varieties can also help preserve biodiversity and even enhance it, which in turn reverse the impact of invasive and environmentally unsustainable agricultural practices, as a broader part of the climate action. This angle can be seen from the legal standpoint as a potential that needs to be utilized extensively, as the world continues to brace for more climate change impacts, [7] along with the subsequent mounting pressure to aggressively apply sustainability principles in all sectors.

In response to climate change, the development of new plant varieties, combined with the advances of science and technology, can give birth to plants that possess certain characteristics, such as less requirements for growth, which can increase productivity.[9] Not only that, it is also possible to develop plant varieties that target the capability of certain parts of the plants, such as the root, which can even help restore soil fertility. [10] However, plant variety as an IPR regime is inherently centered around individualistic interests to

---

5 Susanne Droege et al., "The Trade System and Climate Action: Ways Forward Under the Paris Agreement," *South Carolina Journal of International Law and Business* 13, no. 2 (2017): 195–262, https:// doi.org/ 10.2139/ ssrn.2864400.

7 Ampuan Situmeang and Ninne Zahara Silviani, "Sustainable Development and Climate Resilience 2050: Evaluating Indonesia's Environmental Legal Landscape," *Nurani: Jurnal Kajian Syari'ah dan Masyarakat* 24, no. 1 (June 2024): 151–64, https://doi.org/10.19109/nurani.v24i1.21878.

9 Y Durga Venkat Hemu et al., "Advance Research under Modern Techniques and Agricultural Practices in Agronomy: A Review," *Journal of Experimental Agriculture International* 46, no. 12 (December 2024): 435–43, https://doi.org/10.9734/jeai/2024/v46i123150.

10 Wu, "Balancing Protection of Plant Varieties and Other Public Interests."

award those behind the development of a certain plant variety for their contribution, while also incentivizing creativity and innovation for the broader market by ensuring the protection of commercial interests tied to that plant variety. The individualistic elements of the Plant Variety (PV) regime is perhaps most evident in the context of mass commercialization in the agricultural sector, which has turned the industry from one of the primary avenues to fight climate change to one of the leading producers of greenhouse gasses.[11] The agricultural sector is now often linked with the loss of biodiversity through forest degradation and deforestation, significantly accelerating climate change.[12]

Indonesia holds a particular importance in this development, due to its high level of biodiversity, comparable to some of the most biodiverse countries in the world like Brazil, Colombia, China, and many others.[14] Particularly in the regional context, Indonesia is the most biodiverse member of ASEAN, further emphasizing its role in preserving Southeast Asia's biodiversity.[15] However, Indonesia has also caused the biggest amount natural degradation, particularly forest degradation and deforestation, due to its mismanagement of natural resources and failed conservation.[16] Indonesia's agricultural

---

11 Muhammad Hafeez et al., "Evaluating the Relationship among Agriculture, Energy Demand, Finance and Environmental Degradation in One Belt and One Road Economies," *Carbon Management* 11, no. 2 (2020): 139–54, https://doi.org/10.1080/17583004.2020.1721974.

12 Bruno Locatelli et al., "Integrating Climate Change Mitigation and Adaptation in Agriculture and Forestry: Opportunities and Trade-Offs," *Wiley Interdisciplinary Reviews: Climate Change* 6, no. 6 (2015): 585–98, https://doi.org/10.1002/wcc.357.

14 Michael Purton, "World Environment Day 2024: 17 Megadiverse Countries," World Economic Forum, June 2024, https:// www.weforum.org/ stories/ 2024/06/environment-day-biodiversity-world-megadiverse-countries/.

15 Kristina von Rintelen, Evy Arida, and Christoph Häuser, "A Review of Biodiversity-Related Issues and Challenges in Megadiverse Indonesia and Other Southeast Asian Countries," *Research Ideas and Outcomes* 3 (September 11AD): e20860, https://doi.org/10.3897/rio.3.e20860.

16 Bernice Maxton-Lee, "Material Realities: Why Indonesian Deforestation Persists and Conservation Fails," *Journal of Contemporary Asia* 48, no. 3 (2018): 419–44, https://doi.org/10.1080/00472336.2017.1402204.

sector is widely considered problematic, as it is responsible for many kinds of environmental degradation, mainly through deforestation in the purpose of agricultural land expansion, which in itself causes a wide range of environmental consequences.[17] Therefore, there is a significant amount of pressure to be on ta specialized normative construction is required to navigate the legal challenges in a changing landscape, ensuring that these protections translate into tangible economic prosperity and legal certainty.[18]

On the other hand, Singapore as one of the countries with the least number of natural resources, focuses on inventing technologies that can increase efficiency of the utilization of its scarce natural resources.[19] Despite being a city state, Singapore surprisingly also has its own agricultural sector, through urban agriculture, utilizing high tech and minimum land use.[20] Singapore have been developing localized climate models that would provide better resolution on changes in temperature, rainfall and weather patterns, allowing more accurate predictions on regional crop and aquaculture yields.

Contrary to Indonesia's notoriously non-sustainable agricultural sector, Singapore's agricultural sector has been an important part of the country's climate action, while also further strengthening the country's food security. Singapore fully committed to this during

---

17 Nguyen Tien Hoang and Keiichiro Kanemoto, "Mapping the Deforestation Footprint of Nations Reveals Growing Threat to Tropical Forests," *Nature Ecology and Evolution* 5, no. 6 (2021): 845–53, https:// doi.org/ 10.1038/ s41559-021-01417-z.

18 Hari Sutra Disemadi and Lu Sudirman, "Unleashing Indonesia's Traditional Knowledge: Navigating Legal Challenges in a Changing Landscape," *Al-Risalah: Forum Kajian Hukum Dan Sosial Kemasyarakatan* 23, no. 1 (June 24, 2023): 33–46, https://doi.org/10.30631/alrisalah.v23i1.1334.

19 Wai Kit Mok, Yong Xing Tan, and Wei Ning Chen, "Technology Innovations for Food Security in Singapore: A Case Study of Future Food Systems for an Increasingly Natural Resource-Scarce World," *Trends in Food Science & Technology* 102 (2020): 155–68, https:// doi.org/ https:// doi.org/ 10.1016/j.tifs.2020.06.013.

20 Sean Olivia Nicholas, Shiloh Groot, and Niki Harré, "Understanding Urban Agriculture in Context: Environmental, Social, and Psychological Benefits of Agriculture in Singapore," *Local Environment*, July 2023, 1–17, https://doi.org/10.1080/13549839.2023.2238721.

COP24, by joining the Agriculture Innovation Mission for Climate (AIM4C).[22] This is also supported by its PV regime, which further enhances legal protection and fosters innovations. The contrast that the two countries provide represents a significant prospect of analysis, especially for Indonesia and how it can learn from a country whose agricultural sector is smaller in comparison, yet more capable in being a part of climate action and other sustainability goals.

The connection between PV and climate action has been discussed many times in the world of academics, but no clear connection has been established. A study has highlighted that the protection of PV through intellectual property mechanisms can be a significant step towards sustainable food security.[23] Supporting this finding, another study explained that PV protection is essential to incentivize breeders and researchers to develop new varieties that can adapt to changing environmental conditions.[24] Similarly, another research indicates that PVP can foster innovation in agriculture, leading to the development of climate resilient crops.[25] Despite the important findings, these studies inadequately highlight the connection between PV and climate action, often analyzing each in isolation to address specific problems, without a more holistic perspective.

There exists significant research gap in analyzing the potentials of PV as a tool to support climate action, especially in Indonesia.

---

22 National Climate Change Secretariat, "Singapore and International Efforts," NCCS Singapore, 2023, https://www.nccs.gov.sg/singapores-climate-action/singapore-and-international-efforts/.

23 Laetitia Lagarde, "IP and Climate Change: An Essential Practical Guide for Current and Future Generations," *Journal of Intellectual Property Law & Practice* 12, no. 4 (April 2017): 351–53, https:// doi.org/ 10.1093/ jiplp/ jpw195.

24 Niharika Sahoo and Sukanta S Bhattacharya, "Intellectual Property Rights Protection in Plants: Scopes in Lychee Commercialization," in *The Lychee Biotechnology*, ed. Manoj Kumar et al. (Singapore: Springer Singapore, 2017), 281–99, https://doi.org/10.1007/978-981-10-3644-6_10.

25 Karim Maredia et al., "Intellectual Property Management and Rights, Climate Change, and Food Security," in *Abiotic Stress Response in Plants*, 2016, 89–106, https://doi.org/10.1002/9783527694570.ch5.

Therefore, a reconstruction of the existing normative framework is a much-needed research development in the legal field to bridge the current legal isolation between the private nature of intellectual property rights and the public interest of environmental protection, ensuring they function synergistically to support sustainable development goals.[26] Comparative research using Singapore's model of PV protection is important in this research as it can contribute in understanding better management of agricultural resource, which has long been a problem in Indonesia. This research is done to address this gap, by focusing particularly on the potentials of expanding the normative framework of the PV protection as an IPR regime, to include climate conscious provisions, to support the broader goal of sustainability and climate actions.

This research utilized the normative legal research method by analyzing the existing positive laws in Indonesia. Normative legal research is a commonly employed methodological tool in legal studies that centers on the interpretation and analysis of the prevailing legal norms within legislations.[27] In this type of research, scholars meticulously examine, analyze, and gain a profound understanding of pertinent legal texts.[28] The primary objective of normative legal research is to comprehend the legal meaning and implications of these norms, to pinpoint weaknesses or ambiguities within regulations, and to contribute to a more comprehensive comprehension of the applicable legal system.[29]

---

26 Agustianto Agustianto et al., "Perlindungan Lingkungan Berbasis Indikasi Geografis: Tantangan Hukum Dan Implementasi Sustainable Development Goals Di Indonesia," *LITIGASI* 26, no. 1 (April 30, 2025): 448–76, https://doi.org/10.23969/litigasi.v26i1.19149.

27 Hari Sutra Disemadi, "Lenses of Legal Research: A Descriptive Essay on Legal Research Methodologies," *Journal of Judicial Review* 24, no. 2 (2022): 289–304, https://doi.org/10.37253/jjr.v24i2.7280.

28 Zoltán J Tóth, "Excerpts From the Development of Methods of Legal Interpretation," *Law, Identity and Values* 2, no. 1 (January 2022): 241–64, https://doi.org/10.55073/2022.1.241-264.

29 Benedict Sheehy, "Paradigms of Legal Research Connecting Theories, Methods and Phenomena: Doctrinal, Realist and Non-Law Focused Research," *Rutgers Journal of Law & Public Policy* 21, no. 1 (2023): 157–210.

This method is supported by the comparative approach, using secondary data in the form of primary law sources. These data are collected through literature review and analyzed descriptively to extract not just the relevant legal norms but also the underlying intention behind the norms and the implications of their assessment. The descriptive analytical framework is accommodated by first exploring the core legal implications and urgency involved, which are then used as metrics to assess the adequacy of the primary law sources. These primary law sources are UUD NRI 1945, Law No. 29 of 2000 on Plant Variety Protection, Law No. 23 of 1997 on Management of the Environment, Law No. 23 of 1997 on Management of the Environment, and Law No. 6 of 2023 on the Enactment of Government Regulation in Lieu of Law No. 2 of 2022 on Job Creation as a Law, along with Plant Varieties Protection Act 2004 from Singapore (accounting all of its amendments up to 2020).

B. Discussion

1. PVP Regime's Position in the Indonesian Legal System and Its Potential Ties to Climate Action

Indonesia, known for its wealth of natural resources, holds a significant importance in biodiversity. Due to its geographical locations and tropical climate, Indonesia has a really high level of biodiversity. Sitting at rank 2 of the most biodiverse countries with the Global Biodiversity Index of 418.78,[30] Indonesia is responsible for with protecting the nature, through its legal system. This is not an easy task due to Indonesia's economic reliance on its natural resources, forcing many compromises, which opened more possibilities on mismanagement. Blessed with fertile soil and vast arable land, agriculture becomes one of the most significant natural resources that sustain the lives of Indonesians at general. As of 2022, approximately 29.8% of Indonesia's land area is dedicated to agriculture. Although

[30] Matthew H. Nash, "The 201 Most (& Least) Biodiverse Countries," The Swiftest, 2022, https://theswiftest.com/biodiversity-index/.

this is below the world's average of 38.55%,[31] the figure nevertheless shows a significant role that the agriculture industry plays, particularly when the context of Indonesia's mostly water territories is taken into account. This figure shows a significant decrease in Indonesia's agricultural sector, as data from 2010 even showed a total summation of 37.93% of land for agricultural use,[32] which further necessitates normative intervention in any form to support the agriculture industry.

Nevertheless, Indonesia's agriculture remains an important sector of the country's economy, with data showing more than 13% contribution to the country's GDP on average, throughout 2010-2021.[33] Plant variety plays in important part in fostering the agricultural sector, by protecting the rights of breeders, who are responsible behind the distinct quality of crops produced. Indonesia does recognize plant variety as one of many IPR regimes within its legal system. It mainly uses Law No. 29 of 2000 on Plant Variety Protection (PVP Law) as its main normative basis for the protection of plant variety. Article 1 number 1 of the PVP Law provides that plant variety protection is "special protection given by the state, in this case represented by the Government and its implementation is carried out by the Plant Variety Protection Office, for plant varieties produced by plant breeders through plant breeding activities."

Another important fundamental definition provided by this law is perhaps the definition of plant variety, or specifically referred to by the law as variety. Article 1 number 3 states that variety is "A group of

---

31 The Global Economy, "Percent Agricultural Land by Country, around the World," The Global Economy, 2022, https:// www.theglobaleconomy.com/rankings/Percent_agricultural_land/.

32 Uly Faoziyah, Muhammad F Rosyaridho, and Romauli Panggabean, "Unearthing Agricultural Land Use Dynamics in Indonesia: Between Food Security and Policy Interventions," *Land* 13, no. 12 (2024): 1–29, https://doi.org/10.3390/land13122030.

33 Budy Viva Kusnandar, "Kontribusi Dan Pertumbuhan Sektor Pertanian Terhadap PDB Nasional (2010-2021)," databoks, February 2022, https://databoks.katadata.co.id/ekonomi-makro/statistik/ad7450924958754/ini-kontribusi-sektor-pertanian-terhadap-ekonomi-ri-tahun-2021.

plants of a type or species characterized by plant shape, plant growth, leaves, flowers, fruit, seeds, and the expression of genotypic characteristics or a combination of genotypes that can be distinguished from the same type or species by at least one defining trait and if reproduced does not change." This definition is close to how biodiversity is defined by many people, as a fairly recent study indicated that the most common element of how people define biodiversity is indeed "variety".[34] This common element bridges the main concept of PVP and climate action.

Furthermore, the PVP Law does stipulate firmly that the efforts to protect PV should never affect the environmental sustainability. Through Article 3, the PVP Law governs that a variety can't be given the right of PVP if it damages the environmental sustainability, which is in line with the basic principle of climate action. This is also in accordance with Indonesia's 1945 Constitution, which states through Article 28H that a good and healthy living environment is the right of everyone. Climate action does not focus only on the efforts to reverse the environmental damages done to the environment, but also minimizes the environmental damages caused by human activities, through mitigation and adaptation.[35] Climate action covers both mitigation and adaptation because while mitigation addresses the root causes of climate change by reducing greenhouse gas emissions, adaptation tackles the inevitable impacts that are already occurring, creating a comprehensive approach to climate challenges.[36] Plant variety protection is particularly relevant to climate action due to how

---

34 Briony A. Norton et al., "Definitions of Biodiversity from Urban Gardeners," *Journal of Urban Ecology* 7, no. 1 (2021): 1–10, https:// doi.org/ 10.1093/jue/juab005.

35 Negin Balaghi-Ficzkowski, Nidhi Nagabhatla, and Tariq A Deen, "Nature-Oriented Paradigms for Urban Water Security: Perspective on Framework, Scale, and Sector," in *Advances in Water Resources and Transportation Engineering*, ed. Yusuf A Mehta et al. (Singapore: Springer Singapore, 2021), 1–15.fro

36 Grigorios L Kyriakopoulos and Ioannis Sebos, "Enhancing Climate Neutrality and Resilience through Coordinated Climate Action: Review of the Synergies between Mitigation and Adaptation Actions," *Climate* 11, no. 5 (2023): 1–27, https://doi.org/10.3390/cli11050105.

it can encourage the development of new crop varieties that can better withstand climate challenges while enhancing agricultural productivity and sustainability. Therefore, the concerted efforts that are part of the broader climate action must be able to address all environmental issues, especially those that are related to plant variety protection, or at least does not go against the fundamental concept of sustainability in environmental management and protection.

Another important point regarding the PVP regime in Indonesia is that it explicitly mentions Law No. 23 of 1997 on Management of the Environment (Old Environment Law), which was an older version of the more recent Law No. 32 of 2009 on Protection and Management of the Environment (Environment Law). Not only that, the PVP Law unfortunately doesn't address anything regarding the environmental impacts of PVP normatively, other than the provisions stated before with Article 3. The indication that the PVP Law normatively bases its provisions in consideration of the old environment law that has been revoked by the establishment of the new environment law shows that the PVP Law needs a revision. Within the context of climate action, this is significantly problematic as the law is environmentally rooted in a framework that was enacted during a time when climate challenges were far different than what they are today. This means the PVP law is not aligned with the reality of climate-related challenges that Indonesia and the rest of the world face.

A significant but unfortunately not normatively utilized aspect is the provision in Article 11 paragraph (4), which governs that a statement of safety for the environment is required for transgenic varieties. This provision is not entirely utilized as it has no further normative support to detail the necessary informational or data requirements for a "statement of safety for the environment" to be made. Instead of building on this legal norm, the Indonesian government decided to amend the law through the Job Creation Law (finalized by Law No. 6 of 2023), removing the simplistic, yet at least explicit legal norm of environmental safety. This amendment is also not aligned with the development of synthetic biology, which has

gotten far more advanced and complex.[37] Synthetic biology is particularly relevant due to its capability of developing climate resistant crops, which can be extremely valuable as the climate change effects are taking place.[38] When this is replaced by a more simple version of provision in the Job Creation Law, the PVP regime is not only stripped of its capacity in becoming an essential part of climate action, but also its capacity to ensure intellectual integrity within the invention of a PV.

Furthermore, PVP Law also hasn't taken into account the significance of the creative industries through Indonesia's "MSMEs" business scale classification, which can be a significant catalyst of plant variety developments in rural areas. This is due to Article 7 paragraph (1), which states that "local varieties belonging to the community are owned by the state". This can be abused by the government to dominate the rights of plant varieties in rural areas as there's no normative basis to support local breeders to develop new variety using the existing local variety, which will deter innovation and significantly lowers the will to innovate among breeders.

Overall, the analyses highlighted that the relevant framework in Indonesia is fundamentally rooted in an environmentally conscious thought but remains indifferent to the threat of climate-relevant issues in the context of climate change, which requires further elaboration and more concrete manifestations. Its procedural framework offers minimal detail regarding formal objection proceedings, creating barriers for stakeholders challenging applications, which can in turn reduce the level of protection. Additionally, the system inadequately addresses international participation and lacks adequate respect for

---

37 Archana Chugh, Pooja Bhatia, and Aastha Jain, "Synthetic Biology for the Development of Biodrugs and Designer Crops and the Emerging Governance Issues," in *Systems and Synthetic Biology*, ed. Vikram Singh and Pawan K Dhar (Dordrecht: Springer Netherlands, 2015), 299–325, https://doi.org/10.1007/978-94-017-9514-2_16.

38 Augustine T. Zvinavashe et al., "Engineering the Plant Microenvironment To Facilitate Plant-Growth-Promoting Microbe Association," *Journal of Agricultural and Food Chemistry* 69, no. 45 (November 2021): 13270–85, https://doi.org/10.1021/acs.jafc.1c00138.

the complex nature of scientific rigor behind plant variety development, with the use of broad terms like "type" and the broad definition of propagating materials. Not only that, the lack of technicality is also pronounced in the simple requirement for examination, which is not followed by specific qualifications for the examiner. Despite the direct connection to environmental discourse, the framework is agnostic to the complex technical nature of plant varieties development and how they can impact the ecosystem.

2. Urgency of Climate Action and the Potential Role of the PVP Regime

Indonesia, the largest archipelago nation with over 17,000 islands, is in a challenging position in front of the threat of climate crisis.[39] Its distinct geographical conditions, amplified with its vast biodiversity and dense population, makes it particularly vulnerable to the adverse impacts of climate change. Indonesia's geography as an archipelago country is perhaps the biggest concern when it comes to climate change. With an extensive coastline spanning over 54,000 kilometers, Indonesia is under imminent threat from rising sea levels due to climate change.[40] Several of its islands are at risk of submersion,[41] with some already having disappeared.[42] Coastal communities, which take up a significant portion of the country's

[39] Atwar Bajari et al., "Climate Change Communication on Mitigation Policy and Its Challenges Towards Sustainable Development Goals (SDGs)," *International Journal of Advanced Science and Technology* 29, no. 6 (2020): 4054–62.

[40] Indra Overland et al., "The ASEAN Climate and Energy Paradox," *Energy and Climate Change* 2 (2021): 1–10, https:// doi.org/ https:// doi.org/10.1016/j.egycc.2020.100019.

[41] Iin Karita Sakharina et al., "Sinking or Not? An Indonesian Approach to Prevent the Rise of Sea Levels Due to Global Warming," in *ASEAN International Law*, ed. Eric Yong Joong Lee (Singapore: Springer Nature Singapore, 2022), 649–65, https://doi.org/10.1007/978-981-16-3195-5_36.

[42] Yulia Savitri, "Two Islands Vanish, Four More May Soon Sink, Walhi Blames Environmental Problems - Indonesia," ReliefWeb, January 2020, https://reliefweb.int/report/indonesia/two-islands-vanish-four-more-may-soon-sink-walhi-blames-environmental-problems.

population and affects economies, face displacement, loss of livelihoods, and increased vulnerability to storm surges and tidal flooding.[43]

Indonesia is also home to some of the world's most diverse rainforests. However, rampant deforestation, primarily driven by the palm oil industry, has led to significant habitat loss, endangering numerous species and releasing vast amounts of carbon dioxide into the atmosphere. The loss of these forests not only exacerbates global warming but also eliminates the natural buffer that protects many communities from flooding and other climate related disasters. This issue displays the country's lack of seriousness in protecting rainforests, which is a huge global issue in 2023, as wildfires are happening in many countries around the world.[44] The deforestation issue in Indonesia has even become an international issue as the hazes created by many occurrences of deforestation has caused significant problems to neighboring problems in South East Asia, with many ASEAN members seeking responsibility for the issue,[45] particularly due to the forest fire cases that happened around 2015-2016 in Riau Province in areas planned to be utilized for palm oil plantations.[46] This

---

43 Ma'ruf Kasim, "Measuring Vulnerability of Coastal Ecosystem and Identifying Adaptation Options of Indonesia's Coastal Communities to Climate Change: Case Study of Southeast Sulawesi, Indonesia," in *Climate Change Research, Policy and Actions in Indonesia: Science, Adaptation and Mitigation*, ed. Riyanti Djalante, Joni Jupesta, and Edvin Aldrian (Cham: Springer International Publishing, 2021), 149–72, https://doi.org/10.1007/978-3-030-55536-8_8.

44 Dan Bilefsky, Liam Stack, and Vjosa Isai, "Quebec Wildfires Contribute to Extreme Fire Season in Canada," The New York Times, June 2023, https://www.nytimes.com/2023/06/07/world/americas/canada-wildfires.html.

45 Greenpeace Southeast Asia, "ASEAN HAZE 2019: THE BATTLE OF LIABILITY - Greenpeace Southeast Asia," Greenpeace, November 2019, https://www.greenpeace.org/southeastasia/press/3221/asean-haze-2019-the-battle-of-liability/.

46 Miftah Ramadhan, "Juridicial Analysis of the ASEAN Agreement on Transboundary Haze Pollution and Its Implementation in Indonesia," *Lampung Journal of International Law* 1, no. 2 (August 2020): 55–62, https://doi.org/10.25041/lajil.v1i2.2025.

also shows Indonesia's lackluster commitment to the ASEAN Agreement on Transboundary Haze Pollution which it signed in 2002, or least this is the impression that its neighbors have with how Indonesia handled the Riau forest fire.[47]

While it is apparent that the agricultural sector is significantly responsible for the progress of climate change and further environmental degradation, the sector is also negatively affected by it, as climate change actively threatens the agricultural sector, which is a significant powerhouse within Indonesia's economy. Aside from its contribution to the nation's GDP, it also contributes significantly to Indonesia's export. Recent data shows that Indonesia has successfully exported agricultural commodities to 176 countries with a transaction value of IDR 12.45 trillion.[48] However, climate change impacts such as changing rainfall patterns, prolonged droughts, and increasing temperatures have negatively affected crop yields, threatening food security and the livelihoods of many people around the world,[49] while also potentially stunting the growth of the agricultural sector. Subsequently, widespread problems like these can negatively affect the price of the crops, leading to even more socio-economic issues.[50] Data also shows that every degree Celsius temperature increase, can

47 Alfajri, Azhari Setiawan, and Herry Wahyudi, "Civil Society Organizations (CSOs) Perspective and Haze-Free ASEAN 2020: Evidences from Riau," *Malaysian Journal of International Relations* 7, no. 1 (December 2019): 23–60, https://doi.org/10.22452/mjir.vol7no1.2.

48 Kementerian Pendayagunaan Aparatur Negara dan Reformasi Birokrasi, "Wapres Lepas Ekspor Sejumlah Komoditas, Representasi Semangat Kemerdekaan Di Bidang Pertanian," Kementerian Pendayagunaan Aparatur Negara dan Reformasi Birokrasi, August 15, 2023, https://www.setneg.go.id/baca/index/wapres_lepas_ekspor_sejumlah_komoditas_representasi_semangat_kemerdekaan_di_bidang_pertanian_1.

49 Sajjad Ali et al., "Climate Change and Its Impact on the Yield of Major Food Crops: Evidence from Pakistan," *Foods* 6, no. 6 (2017): 1–19, https://doi.org/10.3390/foods6060039.

50 Nur Rizqi Febriandika and Cahyaningtiyas Rahayu, "The Impact of Climate Change on Economic Conditions: Evidence in Indonesia," *JEJAK* 14, no. 2 (2021): 261–71, https://doi.org/10.15294/jejak.v14i2.29920.

decrease the Gross Regional Domestic Product (GRDP) level by IDR 102.1060 billion.[51]

From the perspective of the agricultural sector, developing plant varieties that are climate resilient and resource efficient plant varieties can be considered a viable solution to an increasingly challenging environment for crop survivability and overall sector productivity. Study indicating impacts of lowered soil quality by affecting its structure, composition, and ecosystems,[53] which are all important factors of breeding for developing plant varieties,[54] further confirm the need for a sector-wide development of PV that is sustainability-oriented. This can also be a way to support the broader sustainability agenda, which Indonesia has formally committed to, potentially covering even socio-economic impacts such as food security, along the prevention of famine and malnutrition. Seen from this perspective, the utilization of the Plat Variety Protection (PVP) regime is no longer framed as a viable option, but rather an essential path forward, due to its inherent benefits in covering a wide range of issues highlighted previously.

From the legal perspective, Indonesia needs to be driven by a concerted movements within its realm of legal politics to specifically address this problem. While this may seem like a daunting task, the highlighted cascade of positive impacts could potentially help with the move towards this sustainability-oriented agricultural sector, while also maintaining the incentivization of creativity and innovation through the PVP regime. This angle of the IPR domain is represents a novel perspective into this issue, particularly due to the fact that the country's evidently disastrous enforcement of key environmental provisions, with countless deforestations with impact reports that are

---

51 Febriandika and Rahayu.

53 D. G. Fischer et al., "Plant Genetic Effects on Soils under Climate Change," *Plant and Soil* 379, no. 1–2 (2014): 1–19, https://doi.org/10.1007/s11104-013-1972-x.

54 George N. Furey and David Tilman, "Plant Biodiversity and the Regeneration of Soil Fertility," *Proceedings of the National Academy of Sciences of the United States of America* 118, no. 49 (2021): 1–8, https://doi.org/10.1073/pnas.2111321118.

far worse than the official estimate.[55] Study proving this indicates that despite the government estimates showing some success in tackling forest fires, the method to support these estimates are not accurate.[56]

While these problems in mind, aligning the PVP regime with sustainability becomes a valid response in acknowledging and also directly tackling the issue of climate change and its increasingly felt impacts. The urgency is therefore not just tied to the fact that climate change impacts represent existential threats to the lives of many living organisms, but also to the fact that there is significant potential within the IPR realm that is not yet being utilized to its full capacity in dealing with multiple urgent environmental and economic problems. With these in mind, the question must be changed from "how can a legal system tackle climate change directly with environmental frameworks?" to "how can a legal system tackle climate change in any capacity it can while also ensuring alignment with the broader sustainability principle?", precisely because of the potential highlighted so far.

3. Comparative Analysis with Singapore's PVP Regime

Unlike Indonesia, Singapore is not mainly known for its wealth of natural resources. Dealing with such disadvantage, however, doesn't turn Singapore away from maximizing the natural resources that it has. Singapore is a city state consisting of one main island and sixty smaller ones, [58] making Singapore a country with a very limited amount of land for agriculture. Surprisingly, Singapore has a thriving

---

55 Fathin Ungku, "Indonesia 2019 Forest Fire Destruction Far Worse than Official Estimate - Study," Reuters, January 2022, https://www.reuters.com/world/asia-pacific/indonesia-lost-far-more-rainforest-2019-fires-than-official-estimate-study-2022-01-14/.

56 David L.A. Gaveau et al., "Refined Burned-Area Mapping Protocol Using Sentinel-2 Data Increases Estimate of 2019 Indonesian Burning," *Earth System Science Data* 13, no. 11 (2021): 5353–68, https://doi.org/10.5194/essd-13-5353-2021.

58 Kai Curry, "Singapore—the Island Nation with the Roar of a Tiger," Northwest Asian Weekly, May 2023, https://nwasianweekly.com/2023/05/singapore-the-island-nation-with-the-roar-of-a-tiger/.

agricultural sector, with urban food production supported by the country's approach with high-tech intensification.[59] This approach is taken with consideration of the country's extremely limited amount of land, which is a contrast difference of what Indonesia has.

Singapore's plant variety protection mainly revolves around its Plant Varieties Protection Act, which was passed in 2004 under the enactment of Act 22 of 2004. Singapore's PVP Act, contains a lot more details on the technical side of plant breeding processes, and complex biological taxonomies, than that of Indonesia's PVP Law. A crucial difference in the legal language used in the normative values from both Laws is the use of "general" and "species" in PVP Act, while the PVP Law "type" and "species". This is a significant difference due to the highly technical and scientific nature of plant variety protection. The term "type" is too general and gives room for way too many possible errors, which can be abused to infringe the rights of other breeders with established plant varieties.

Singapore has a firm stance on government's role through Article 3 of the PVP Act, by stating that the law binds the government, without making them liable to be prosecuted for an offence, based on the provisions of it. This state immunity grants the Singaporean government significant power, but also leverages in making sure that PV protection does not come at the cost of public interest. However, the problematic indication of this provision is that there's no further explanations on the full scope of the immunity that the government has, which can lead to unfair practices. In this aspect, Indonesia's PVP Law is better equipped to tackle this issue, especially in the case of abuse of power. However, the PVP Act does have a better framework of provisions governing the process of objection to denomination and grant of protection through Article 16. The provision states that there will be objection proceedings for this matter and even allows foreign individuals to propose the objection, with security for the costs of the proceedings. On the other hand, the PVP Law only provides that

[59] Jessica Ann Diehl et al., "Feeding Cities: Singapore's Approach to Land Use Planning for Urban Agriculture," *Global Food Security* 26 (2020): 1–11, https://doi.org/10.1016/j.gfs.2020.100377.

anyone can raise objection to an application for a grant of protection for a plant variety, and in turn this objection can be rebutted with written objections and explanations. There's no further provision that indicates any form of proceedings and the law doesn't facilitate any foreign individual in dealing with this matter. This makes Singapore's PVP Act a more robust legal source as it denotes more aspects of legality through proceedings and even giving room for foreign individuals who may feel that their rights are being infringed. It also opens more possibilities for foreign investments, especially considering the role of Singapore as one of the forefronts of high-tech urban agriculture and vertical farming.[60]

Not only that, Section 34 enables compulsory licensing "in the public interest," stating that "the Court may make an order for the grant of a compulsory licence... if, and only if, the Court is satisfied that the grant of a compulsory licence is in the public interest." This public interest criterion could reasonably encompass climate adaptation needs. Section 31(1) provides crucial research exemptions, ensuring that "acts for any experimental or research purpose" and "acts for the purposes of breeding any other plant variety" are not considered infringement, which enables scientists to develop climate-resilient varieties. Section 4 states that "This Act applies to all plant genera and species," ensuring comprehensive coverage for any climate-adapted varieties. Additionally, Section 28(7) extends protection to "harvested material, including entire plants and parts of plants," incentivizing investment in developing climate-resilient varieties that address environmental challenges. Despite the logical and normatively sound interpretation of these provisions, it is imperative to note that these provisions are only indirectly related to the integration of climate action, which could benefit from clearer and more direct acknowledgement of environmental discourse, something that Singapore's PVP Act is unfortunately lacking. Nonetheless, this wide

60 Kheir Al-Kodmany, "The Vertical Farm: A Review of Developments and Implications for the Vertical City," *Buildings* 8, no. 2 (February 2018): 24–59, https://doi.org/10.3390/buildings8020024.

coverage of technicality around PV presents an advantage of Indonesia's PV regime.

Another important provision is the provision for priority resulting from foreign application. Singapore's PVP Act has a far more robust normative structure than Indonesia's PVP Law as it's based on the country's International Union for the Protection of New Varieties of Plants (UPOV) membership. Article 14 of Singapore's PVP Act indicates that one of the requirements is that the foreign application has to be made in at least one UPOV member. UPOV countries have a higher standard for PVP and have greater access to new varieties and more mechanisms of benefit sharing from them.[61] This helps justify the priority rights and lower the risk of legal issues such as lawsuits or other legal proceedings of objections from foreign application, while also ensuring a higher quality of varieties from the stricter requirements among UPOV members. Indonesia unfortunately is not a member of the UPOV, despite its much bigger agricultural sector. This is ironic, considering Indonesia's high level of biodiversity which provides significant number of resources in many plant breeding mechanisms. This lack of international support normatively makes the provision in Article 14 of Indonesia's PVP Law baseless in some sense as it can't fully justify the priority rights it claims to support.

From the climate action standpoint, Singapore's PVP Act has lesser normative support for the environment, as it has no mention of it whatsoever. However, this doesn't denote legal ignorance as it implicitly implies the importance of the protection of the environment, with Article 36 paragraph (3) stating that an application that is against the public order or any written law shall not be approved. This means that all PVP shouldn't go against other laws such as the Environmental Protection and Management Act and Resource Sustainability Act, among many other environmental laws in Singaporean legal system. On the other hand, Indonesia's PVP Law isn't in any way better

---

61 Jorge Cabrera Medaglia et al., "Comparative Study of the Nagoya Protocol, the Plant Treaty and the UPOV Convention: The Interface of Access and Benefit Sharing and Plant Variety Protection," *SSRN Electronic Journal*, 2019, 1–49, https://doi.org/10.2139/ssrn.3393475.

equipped for climate action, despite having more normative support within the law itself. This is due to the fact that it's made in consideration of an old Environment Law which has already been revoked from the Indonesian legal system.

Furthermore, the UPOV membership plays a significant role for Singapore to use climate change as a way to force innovations, through collaborations with other UPOV members.[62] It's also responsible in making sure that Plant Genetic Resources (PGRs), the genetic information found in various plant species covers not just well known crops. This access to greater amount of information and recommendations provide the Singaporean government better references that are relevant in enforcing its PV regime, which can theoretically better support food security and other sustainability factors.[63] Furthermore, climate actions in Singapore are supported by the country's National Climate Change Secretariat (NCCS), which has been active in providing directions for the government and Singaporeans to take in tackling the issue of climate change.[64]

4. Recommendations for Indonesia's Legal Reconstruction

The same advantages highlighted within the Singaporean legal system unfortunately cannot be found in Indonesia. First, Indonesia's Directorate General of Climate Change Control has not provided any concrete guide for climate action. This lack of direction is coupled with the decentralized efforts to tackle climate related issues, followed by the lack of industry self-regulation. Without the support and resources

62 UPOV, "Climate Change: An Opportunity for Innovation in Agriculture," UPOV, October 2020, https://www.upov.int/meetings/en/doc_details.jsp?meeting_id=71391&doc_id=586863.

63 Aditi Mishra, "International Treaty on Plant Genetic Resources for Food and Agriculture," *SSRN Electronic Journal*, 2023, 1–17, https://doi.org/10.2139/ssrn.4474036.

64 Li Ching Ho and Tricia Seow, "Disciplinary Boundaries and Climate Change Education: Teachers' Conceptions of Climate Change Education in the Philippines and Singapore," *International Research in Geographical and Environmental Education* 26, no. 3 (2017): 240–52, https://doi.org/10.1080/10382046.2017.1330038.

that like the UPOV for Singapore, and with complicated bureaucracy, Indonesia doesn't have any real direction for climate action integration, despite having clearer normative support for environmentally-sound implementation of PV protection. This will further exacerbate the false dichotomy between sustainability and agricultural sector growth, where both are treated as competing interests instead of potential concepts that can work together in conjunction.

While there is an argument to be made that UPOV's restriction on the use farm-stored seeds may not fit the reality of Indonesia's agricultural systems, the reality is more nuanced. Being a part of UPOV would automatically demand a rigorous data collection, which is crucial for the overall modernization of the sector. Despite having a much bigger potential than Singapore, Indonesia's agricultural sector is not in anywhere near modernized in comparison to Singapore. This has negatively affected the efficiency of land use and restricted the spread of knowledge among local farmers despite the rising global competition. From the legislative standpoint, this also puts significant pressure on the political will of the Indonesian government to care more on the agricultural sector and to compete more aggressively with the global agricultural industry.

Most importantly, being a part of UPOV would also tie Indonesia's agricultural sector to a more concrete standard of sustainability, which is critical to address the normative deficiencies previously highlighted in the PVP regime. Seen from this perspective, the PVP regime can play a more proactive role in climate action, even without explicit normative ties. The legal reconstruction of the PVP regime is nevertheless seen by this study as a move that Indonesia must address, particularly the reference to old environmental framework and the problematic amendment to Article 11 by the Job Creation Law. Furthermore, the gap in addressing MSMEs also needs to be addressed by Indonesia to ensure that the monopoly created by the IPR protection of PV is within the healthy limit, to replace the current unethical and often exploitative monopoly held by actors often referred to as *"tengkulak"*, and subsequently empower local farmers.

C. Conclusion

Normative analysis of this research finds that Indonesia is restricted from fully utilizing the PVP regime as a part of climate action by the normatively deficient and outdated PVP Law. Singapore, on the other hand, is able to align its PVP regime withs sustainability despite paradoxically having lesser normative connections to environmental provisions, thanks to its high-tech approach and its wealth of informational resources from its UPOV membership. The novelty of this study is accentuated by the crucial findings that show how normative connections to environmental protection directly from the PVP regime does not always translate to better sustainability. The findings also highlight that the surrounding normative architecture is just as important in further operationalizing the PVP regime. Indonesia first needs to revise the outdated reference to the old environmental framework or remove it in replacement of a more rigorous standard for intellectual integrity, which would also mean revising the amendment made by the Job Creation Law. It is also important for Indonesia to seriously consider joining the UPOV membership, which would require further analysis by future research, to fully account the associated risks and implications to the broader agricultural sector and the protection of PV.

References

Agustianto, Agustianto, Hari Sutra Disemadi, Shelvi Rusdiana, and Winsherly Tan. "Perlindungan Lingkungan Berbasis Indikasi Geografis: Tantangan Hukum Dan Implementasi Sustainable Development Goals Di Indonesia." *LITIGASI* 26, no. 1 (April 30, 2025): 448–76. https://doi.org/10.23969/litigasi.v26i1.19149.

Al-Kodmany, Kheir. "The Vertical Farm: A Review of Developments and Implications for the Vertical City." *Buildings* 8, no. 2 (February 2018): 24–59. https://doi.org/10.3390/buildings 8020024.

Alfajri, Azhari Setiawan, and Herry Wahyudi. "Civil Society Organizations (CSOs) Perspective and Haze-Free ASEAN 2020: Evidences from Riau." *Malaysian Journal of International Relations* 7, no. 1 (December 2019): 23–60. https://doi.org/ 10.22452/mjir.vol7no1.2.

Ali, Sajjad, Ying Liu, Muhammad Ishaq, Tariq Shah, Abdullah, Aasir Ilyas, and Izhar Ud Din. "Climate Change and Its Impact on the Yield of Major Food Crops: Evidence from Pakistan." *Foods* 6, no. 6 (2017): 1–19. https://doi.org/10.3390/foods6060039.

Bajari, Atwar, Tria Patrianti, Herlina Agustin, and Iriana Bakti. "Climate Change Communication on Mitigation Policy and Its Challenges Towards Sustainable Development Goals (SDGs)." *International Journal of Advanced Science and Technology* 29, no. 6 (2020): 4054–62.

Balaghi-Ficzkowski, Negin, Nidhi Nagabhatla, and Tariq A Deen. "Nature-Oriented Paradigms for Urban Water Security: Perspective on Framework, Scale, and Sector." In *Advances in Water Resources and Transportation Engineering*, edited by Yusuf A Mehta, Iacopo Carnacina, D Nagesh Kumar, K Ramachandra Rao, and Madhuri Kumari, 1–15. Singapore: Springer Singapore, 2021.

Bilefsky, Dan, Liam Stack, and Vjosa Isai. "Quebec Wildfires Contribute to Extreme Fire Season in Canada." The New York Times, June 2023.https://www.nytimes.com/2023/06/07/world/americas/canada-wildfires.html.

Bryant, Andrew, Jennifer J. Griffin, and Vanessa G. Perry. "Mitigating Climate Change: A Role for Regulations and Risk-Taking." *Business Strategy and the Environment* 29, no. 2 (2020): 605–18. https://doi.org/10.1002/bse.2391.

Cabrera Medaglia, Jorge, Chidi Oguamanam, Olivier Rukundo, and Frederic Perron-Welch. "Comparative Study of the Nagoya Protocol, the Plant Treaty and the UPOV Convention: The Interface of Access and Benefit Sharing and Plant Variety Protection." *SSRN Electronic Journal*, 2019, 1–49. https://doi.org/10.2139/ssrn.3393475.

Chugh, Archana, Pooja Bhatia, and Aastha Jain. "Synthetic Biology for the Development of Biodrugs and Designer Crops and the Emerging Governance Issues." In *Systems and Synthetic Biology*, edited by Vikram Singh and Pawan K Dhar, 299–325. Dordrecht: Springer Netherlands, 2015. https://doi.org/10.1007/978-94-017-9514-2_16.

Curry, Kai. "Singapore—the Island Nation with the Roar of a Tiger." Northwest Asian Weekly, May 2023. https://nwasianweekly.com/2023/05/singapore-the-island-nation-with-the-roar-of-a-tiger/.

Diehl, Jessica Ann, Erin Sweeney, Bennett Wong, Ching Sian Sia, Haomu Yao, and Manasi Prabhudesai. "Feeding Cities: Singapore's Approach to Land Use Planning for Urban Agriculture." *Global Food Security* 26 (2020): 1–11. https://doi.org/10.1016/j.gfs.2020.100377.

Disemadi, Hari Sutra. "Lenses of Legal Research: A Descriptive Essay on Legal Research Methodologies." *Journal of Judicial Review* 24, no. 2 (2022): 289–304. https://doi.org/10.37253/jjr.v24i2.7280.

Disemadi, Hari Sutra, and Lu Sudirman. "Unleashing Indonesia's Traditional Knowledge: Navigating Legal Challenges in a Changing Landscape." *Al-Risalah: Forum Kajian Hukum Dan Sosial Kemasyarakatan* 23, no. 1 (June 24, 2023): 33–46. https://doi.org/10.30631/alrisalah.v23i1.1334.

Droege, Susanne, Harro van Asselt, Kasturi Das, and Michael A. Mehling. "The Trade System and Climate Action: Ways Forward Under the Paris Agreement." *South Carolina Journal of International Law and Business* 13, no. 2 (2017): 195–262. https://doi.org/10.2139/ssrn.2864400.

Faoziyah, Uly, Muhammad F Rosyaridho, and Romauli Panggabean. "Unearthing Agricultural Land Use Dynamics in Indonesia: Between Food Security and Policy Interventions." *Land* 13, no. 12 (2024): 1–29. https://doi.org/10.3390/land13122030.

Febriandika, Nur Rizqi, and Cahyaningtiyas Rahayu. "The Impact of Climate Change on Economic Conditions: Evidence in Indonesia." *JEJAK* 14, no. 2 (2021): 261–71. https://doi.org/10.15294/jejak.v14i2.29920.

Fischer, D. G., S. K. Chapman, A. T. Classen, C. A. Gehring, K. C. Grady, J. A. Schweitzer, and T. G. Whitham. "Plant Genetic Effects on Soils under Climate Change." *Plant and Soil* 379, no. 1–2 (2014): 1–19. https://doi.org/10.1007/s11104-013-1972-x.

Furey, George N., and David Tilman. "Plant Biodiversity and the Regeneration of Soil Fertility." *Proceedings of the National Academy of Sciences of the United States of America* 118, no. 49 (2021): 1–8. https://doi.org/10.1073/pnas.2111321118.

Gaveau, David L.A., Adrià Descals, Mohammad A. Salim, Douglas Sheil, and Sean Sloan. "Refined Burned-Area Mapping Protocol Using Sentinel-2 Data Increases Estimate of 2019 Indonesian Burning." *Earth System Science Data* 13, no. 11 (2021): 5353–68. https://doi.org/10.5194/essd-13-5353-2021.

Granieri, Massimiliano. "Sowing and Cultivating the Seed of Diversity in Agri-Food: Intellectual Property Protection in Transnational and Comparative Perspective." In *GRUR International*, 70:744–53, 2021. https://doi.org/10.1093/grurint/ikab038.

Greenpeace Southeast Asia. "Asean Haze 2019: The Battle Of Liability - Greenpeace Southeast Asia." Greenpeace, November 2019.https://www.greenpeace.org/southeastasia/press/3221/asean-haze-2019-the-battle-of-liability/.

Hafeez, Muhammad, Chunhui Yuan, Wasi Ul Hassan Shah, Muhammad Tariq Mahmood, Xiaolong Li, and Kashif Iqbal. "Evaluating the Relationship among Agriculture, Energy Demand, Finance and Environmental Degradation in One Belt and One Road Economies." *Carbon Management* 11, no. 2 (2020): 139–54. https://doi.org/10.1080/17583004.2020.1721974.

Hemu, Y Durga Venkat, Satish Kumar, Priyanka Gangele, Arem Sravani, Shipra Yadav, Shiv Kumar Ahirwar, and Shivani Sunil Tandle. "Advance Research under Modern Techniques and Agricultural Practices in Agronomy: A Review." *Journal of Experimental Agriculture International* 46, no. 12 (December 2024): 435–43. https://doi.org/10.9734/jeai/2024/v46i123150.

Ho, Li Ching, and Tricia Seow. "Disciplinary Boundaries and Climate Change Education: Teachers' Conceptions of Climate Change Education in the Philippines and Singapore." *International Research in Geographical and Environmental Education* 26, no. 3 (2017): 240–52. https://doi.org/10.1080/10382046.2017.1330038.

Hoang, Nguyen Tien, and Keiichiro Kanemoto. "Mapping the Deforestation Footprint of Nations Reveals Growing Threat to Tropical Forests." *Nature Ecology and Evolution* 5, no. 6 (2021): 845–53. https://doi.org/10.1038/s41559-021-01417-z.

Jonge, Bram De, Isabel López Noriega, Gloria Otieno, Ximena Cadima, Franz Terrazas, Siviengkhek Hpommalath, Frederik van Oudenhoven, et al. "Advances in the Registration of Farmers' Varieties: Four Cases from the Global South." *Agronomy* 11, no. 11 (2021): 1–20. https://doi.org/10.3390/agronomy11112282.

Kasim, Ma'ruf. "Measuring Vulnerability of Coastal Ecosystem and Identifying Adaptation Options of Indonesia's Coastal Communities to Climate Change: Case Study of Southeast Sulawesi, Indonesia." In *Climate Change Research, Policy and Actions in Indonesia: Science, Adaptation and Mitigation*, edited by

Riyanti Djalante, Joni Jupesta, and Edvin Aldrian, 149–72. Cham: Springer International Publishing, 2021. https://doi.org/10.1007/978-3-030-55536-8_8.

Kementerian Pendayagunaan Aparatur Negara dan Reformasi Birokrasi. "Wapres Lepas Ekspor Sejumlah Komoditas, Representasi Semangat Kemerdekaan Di Bidang Pertanian." Kementerian Pendayagunaan Aparatur Negara dan Reformasi Birokrasi, August 15, 2023. https://www.setneg.go.id/baca/index/wapres_lepas_ekspor_sejumlah_komoditas_representasi_semangat_kemerdekaan_di_bidang_pertanian_1.

Kusnandar, Budy Viva. "Kontribusi Dan Pertumbuhan Sektor Pertanian Terhadap PDB Nasional (2010-2021)." databoks, February 2022. https://databoks.katadata.co.id/ekonomi-makro/statistik/ad7450924958754/ini-kontribusi-sektor-pertanian-terhadap-ekonomi-ri-tahun-2021.

Kyriakopoulos, Grigorios L, and Ioannis Sebos. "Enhancing Climate Neutrality and Resilience through Coordinated Climate Action: Review of the Synergies between Mitigation and Adaptation Actions." *Climate* 11, no. 5 (2023): 1–27. https://doi.org/10.3390/cli11050105.

Lagarde, Laetitia. "IP and Climate Change: An Essential Practical Guide for Current and Future Generations." *Journal of Intellectual Property Law & Practice* 12, no. 4 (April 2017): 351–53. https://doi.org/10.1093/jiplp/jpw195.

Locatelli, Bruno, Charlotte Pavageau, Emilia Pramova, and Monica Di Gregorio. "Integrating Climate Change Mitigation and Adaptation in Agriculture and Forestry: Opportunities and Trade-Offs." *Wiley Interdisciplinary Reviews: Climate Change* 6, no. 6 (2015): 585–98. https://doi.org/10.1002/wcc.357.

Maredia, Karim, Frederic Erbisch, Callista Rakhmatov, and Tom Herlache. "Intellectual Property Management and Rights, Climate Change, and Food Security." In *Abiotic Stress Response in Plants*, 89–106, 2016. https://doi.org/10.1002/9783527694570.ch5.

Maxton-Lee, Bernice. "Material Realities: Why Indonesian Deforestation Persists and Conservation Fails." *Journal of Contemporary Asia* 48, no. 3 (2018): 419–44. https://doi.org/10.1080/00472336.2017.1402204.

Mishra, Aditi. "International Treaty on Plant Genetic Resources for Food and Agriculture." *SSRN Electronic Journal*, 2023, 1–17. https://doi.org/10.2139/ssrn.4474036.

Mok, Wai Kit, Yong Xing Tan, and Wei Ning Chen. "Technology Innovations for Food Security in Singapore: A Case Study of Future Food Systems for an Increasingly Natural Resource-Scarce World." *Trends in Food Science & Technology* 102 (2020): 155–68.https://doi.org/https://doi.org/10.1016/j.tifs.2020.06.013.

Nash, Matthew H. "The 201 Most (& Least) Biodiverse Countries." The Swiftest, 2022. https://theswiftest.com/biodiversity-index/.

National Climate Change Secretariat. "Singapore And International Efforts." NCCS Singapore, 2023. https://www.nccs.gov.sg/singapores-climate-action/singapore-and-international-efforts/.

Nicholas, Sean Olivia, Shiloh Groot, and Niki Harré. "Understanding Urban Agriculture in Context: Environmental, Social, and Psychological Benefits of Agriculture in Singapore." *Local Environment*, July 2023, 1–17. https://doi.org/10.1080/13549839.2023.2238721.

Norton, Briony A., Bowen Shang, Andrew D. Ramsey, and David Sheffield. "Definitions of Biodiversity from Urban Gardeners." *Journal of Urban Ecology* 7, no. 1 (2021): 1–10. https://doi.org/10.1093/jue/juab005.

Overland, Indra, Haakon Fossum Sagbakken, Hoy-Yen Chan, Monika Merdekawati, Beni Suryadi, Nuki Agya Utama, and Roman Vakulchuk. "The ASEAN Climate and Energy Paradox." *Energy and Climate Change* 2 (2021): 1–10. https://doi.org/https://doi.org/10.1016/j.egycc.2020.100019.

Purnomo, Eko Priyo, Rijal Ramdani, Agustiyara, Achmad Nurmandi, Dina Wahyu Trisnawati, and Aqil Teguh Fathani. "Bureaucratic Inertia in Dealing with Annual Forest Fires in Indonesia." *International Journal of Wildland Fire* 30, no. 10 (2021): 733–44. https://doi.org/10.1071/WF20168.

Purton, Michael. "World Environment Day 2024: 17 Megadiverse Countries." World Economic Forum, June 2024. https://www.weforum.org/stories/2024/06/environment-day-biodiversity-world-megadiverse-countries/.

Ramadhan, Miftah. "Juridicial Analysis of the ASEAN Agreement on Transboundary Haze Pollution and Its Implementation in Indonesia." *Lampung Journal of International Law* 1, no. 2 (August 2020): 55–62. https://doi.org/10.25041/lajil.v1i2.2025.

Rintelen, Kristina von, Evy Arida, and Christoph Häuser. "A Review of

Biodiversity-Related Issues and Challenges in Megadiverse Indonesia and Other Southeast Asian Countries." *Research Ideas and Outcomes* 3 (September 11AD): e20860. https://doi.org/10.3897/rio.3.e20860.

Sahoo, Niharika, and Sukanta S Bhattacharya. "Intellectual Property Rights Protection in Plants: Scopes in Lychee Commercialization." In *The Lychee Biotechnology*, edited by Manoj Kumar, Vivek Kumar, Ram Prasad, and Ajit Varma, 281–99. Singapore: Springer Singapore, 2017. https://doi.org/10.1007/978-981-10-3644-6_10.

Sakharina, Iin Karita, Farida Patittingi, Hamzah Halim, Marthen Napang, Juajir Sumardi, Andi Bau' Inggit, and Marcel Hendrapati. "Sinking or Not? An Indonesian Approach to Prevent the Rise of Sea Levels Due to Global Warming." In *ASEAN International Law*, edited by Eric Yong Joong Lee, 649–65. Singapore: Springer Nature Singapore, 2022. https://doi.org/10.1007/978-981-16-3195-5_36.

Savitri, Yulia. "Two Islands Vanish, Four More May Soon Sink, Walhi Blames Environmental Problems - Indonesia." ReliefWeb, January 2020. https://reliefweb.int/report/indonesia/two-islands-vanish-four-more-may-soon-sink-walhi-blames-environmental-problems.

Seddon, Nathalie, Alison Smith, Pete Smith, Isabel Key, Alexandre Chausson, Cécile Girardin, Jo House, Shilpi Srivastava, and Beth Turner. "Getting the Message Right on Nature-Based Solutions to Climate Change." *Global Change Biology* 27, no. 8 (2021): 1518–46. https://doi.org/10.1111/gcb.15513.

Sheehy, Benedict. "Paradigms of Legal Research Connecting Theories, Methods and Phenomena: Doctrinal, Realist and Non-Law Focused Research." *Rutgers Journal of Law & Public Policy* 21, no. 1 (2023): 157–210.

Situmeang, Ampuan, and Ninne Zahara Silviani. "Sustainable Development and Climate Resilience 2050: Evaluating Indonesia's Environmental Legal Landscape." *Nurani: Jurnal Kajian Syari'ah Dan Masyarakat* 24, no. 1 (June 2024): 151–64. https://doi.org/10.19109/nurani.v24i1.21878.

Su, Bin, B W Ang, and Yingzhu Li. "Input-Output and Structural Decomposition Analysis of Singapore's Carbon Emissions." *Energy Policy* 105 (2017): 484–92. https://doi.org/ https://doi.org/10.1016/j.enpol.2017.03.027.

The Global Economy. "Percent Agricultural Land by Country, around the World." The Global Economy, 2022. https://www.theglobaleconomy.com/rankings/Percent_agricultural_land/.

Tosun, Jale. "Addressing Climate Change through Climate Action." *Climate Action* 1, no. 1 (2022): 1–8. https://doi.org/10.1007/s44168-022-00003-8.

Tóth, Zoltán J. "Excerpts From the Development of Methods of Legal Interpretation." *Law, Identity and Values* 2, no. 1 (January 2022): 241–64. https://doi.org/10.55073/2022.1.241-264.

Ungku, Fathin. "Indonesia 2019 Forest Fire Destruction Far Worse than Official Estimate - Study." Reuters, January 2022. https://www.reuters.com/world/asia-pacific/indonesia-lost-far-more-rainforest-2019-fires-than-official-estimate-study-2022-01-14/.

UPOV. "Climate Change: An Opportunity for Innovation in Agriculture." UPOV, October 2020. https://www.upov.int/meetings/en/doc_details.jsp?meeting_id=71391&doc_id=586863.

Wolfe, Martin S., and Salvatore Ceccarelli. "The Increased Use of Diversity in Cereal Cropping Requires More Descriptive Precision." *Journal of the Science of Food and Agriculture* 100, no. 11 (2020): 4119–23. https://doi.org/10.1002/jsfa.9906.

Wu, Chenwen. "Balancing Protection of Plant Varieties and Other Public Interests." *Sustainability* 16, no. 13 (2024): 1–23. https://doi.org/10.3390/su16135445.

Zvinavashe, Augustine T., Ilham Mardad, Manal Mhada, Lamfeddal Kouisni, and Benedetto Marelli. "Engineering the Plant Microenvironment To Facilitate Plant-Growth-Promoting Microbe Association." *Journal of Agricultural and Food Chemistry* 69, no. 45 (November 2021): 13270–85. https://doi.org/10.1021/acs.jafc.1c00138.

Websites:

Bilefsky, Dan, Liam Stack, and Vjosa Isai. "Quebec Wildfires Contribute to Extreme Fire Season in Canada." The New York Times, June 2023. https://www.nytimes.com/2023/06/07/world/americas/canada-wildfires.html.

Curry, Kai. "Singapore—the Island Nation with the Roar of a Tiger." Northwest Asian Weekly, May 2023. https://nwasianweekly.com/2023/05/singapore-the-island-nation-with-the

roar-of-a-tiger/.
Greenpeace Southeast Asia. "ASEAN HAZE 2019: THE BATTLE OF LIABILITY - Greenpeace Southeast Asia." Greenpeace, November 2019.https://www.greenpeace.org/southeastasia/press/3221/asean-haze-2019-the-battle-of-liability/.
Kementerian Pendayagunaan Aparatur Negara dan Reformasi Birokrasi. "Wapres Lepas Ekspor Sejumlah Komoditas, Representasi Semangat Kemerdekaan Di Bidang Pertanian." Kementerian Pendayagunaan Aparatur Negara dan Reformasi Birokrasi, August 15, 2023. https://www.setneg.go.id/baca/index/wapres_lepas_ekspor_sejumlah_komoditas_representasi_semangat_kemerdekaan_di_bidang_pertanian_1.
Kusnandar, Budy Viva. "Kontribusi Dan Pertumbuhan Sektor Pertanian Terhadap PDB Nasional (2010-2021)." databoks, February 2022. https://databoks.katadata.co.id/ekonomi-makro/statistik/ad7450924958754/ini-kontribusi-sektor-pertanian-terhadap-ekonomi-ri-tahun-2021.
Nash, Matthew H. "The 201 Most (& Least) Biodiverse Countries." The Swiftest, 2022. https://theswiftest.com/biodiversity-index/.
National Climate Change Secretariat. "Singapore And International Efforts." NCCS Singapore, 2023. https://www.nccs.gov.sg/singapores-climate-action/singapore-and-international-efforts/.
Purton, Michael. "World Environment Day 2024: 17 Megadiverse Countries." World Economic Forum, June 2024. https://www.weforum.org/stories/2024/06/environment-day-biodiversity-world-megadiverse-countries/.
Savitri, Yulia. "Two Islands Vanish, Four More May Soon Sink, Walhi Blames Environmental Problems - Indonesia." ReliefWeb, January 2020. https://reliefweb.int/report/indonesia/two-islands-vanish-four-more-may-soon-sink-walhi-blames-environmental-problems.
The Global Economy. "Percent Agricultural Land by Country, around the World." The Global Economy, 2022. https://www.theglobaleconomy.com/rankings/Percent_agricultural_land/.
Ungku, Fathin. "Indonesia 2019 Forest Fire Destruction Far Worse than Official Estimate - Study." Reuters, January 2022. https://www.reuters.com/world/asia-pacific/indonesia-lost-far-more-rainforest-2019-fires-than-official-estimate-study-

2022-01-14/.
UPOV. "Climate Change: An Opportunity for Innovation in Agriculture." UPOV, October 2020. https://www.upov.int/meetings/en/doc_details.jsp?meeting_id=71391&doc_id=586863.