Emission Mitigation in Indonesia: Challenges and Opportunities towards the Net-Zero Emission

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Abstract

In 2021, Indonesia announced that it would expand its climate change mitigation commitment with an eye to achieving net-zero emissions by 2060 while at the same time continuing to strive to achieve its medium-term emission reduction target, which is stated in its Nationally Determined Contributions (NDC). However, over the last few decades, there has been no significant reduction in emissions, and this has become a signal for Indonesia to accelerate its emission reduction actions. This study aims to summarize the dynamics of emission mitigation policies in Indonesia and the various constraints accompanying them. Some of the most frequent key challenges are technical constraints at the sectoral level, limited funding, knowledge gaps at the local level, land acquisition and public acceptance. However, apart from the complexity of these problems, Indonesia has also gradually made some progress, such as improving and maintaining communication among stakeholders, formulating mitigation policies that involve more local community participation, and seeking alternative financing to support the country's emission mitigation projects.

Key words: emission mitigation, Indonesia, nationally determined contributions (NDCs), net-zero emissions

1. Introduction

Among the countries of the Southeast Asia region, Indonesia has the largest economy, but also the highest GHG emissions (Giwangkara & Dolan, 2021). This draws perpetual attention to Indonesia's policies, including its emission mitigation policies, both regionally and worldwide. The Indonesian government is aware of the importance of emission reduction measures, not just because Indonesia continues to draw public attention but also because its geographic location makes it susceptible to the effects of climate change, necessitating the implementation of all possible mitigation measures. Therefore, the government has regularly issued emission reduction plans, including mid- and long-term mitigation targets.

However, despite its economic scale, Indonesia is still a developing country, where environmental policies, including emission mitigation, are generally not the top priority and still have to compete with other socioeconomic policies that remain the government's primary duty. Indonesia's emission reduction policies are undergoing dynamics that have not been widely discussed in the existing literature. By gathering some literature and statistical information on emission levels, this paper will try to list and explain the challenges Indonesia faces in achieving its emission reduction targets. Apart from that, this paper also describes some progress the country has made, as well as the potential that can still be developed to increase Indonesia's success in achieving emissions targets.

2. Policy Developments Related to Emission Mitigation in Indonesia

Indonesia has a long history of formulating emission mitigation policies (Table 1). Concern about emission mitigation has been growing rapidly since the early 1990s, when Indonesia signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and ratified it in 1994, after which, it started calculating emissions and reporting them through its 1st National Communication on Climate Change. Until 2009, however, Indonesia had no specific emission reduction targets related to emission reduction.

In 2009, concurrently with the G-20 meeting in Pittsburgh, Indonesia stated that it would reduce emissions by 26% unconditionally or 41% conditionally

Table 1 Timeline and summary of the development of emission mitigation policies in Indonesia.

Date or Year	Policy/meeting/document related to emission mitigation	Emission mitigation policy and target	Sectoral reduction target-unconditional (Mton CO_2eq) [1), 2)]					Sectoral reduction target-conditional (Mton CO_2eq) [3)]				
			AGR	FOLU	ENE	IPPU	WAS	AGR	FOLU	ENE	IPPU	WAS
5 June 1992	Indonesia signed the United Nations Framework Convention on Climate Change (UNFCCC)											
1 August 1994	President of the Republic of Indonesia approved the Act of Ratification of UNFCCC Number: 6/1994.	Importance of reducing emissions stated, but no specific target announced yet; the government started to report its GHG emission inventory.										
	First National Communication on Climate Change											
25 September 2009	G-20 meeting in Pittsburgh, USA	Indonesian President Soesilo Bambang Yudhoyono stated his commitment to reducing GHG emissions by 26% unconditionally, 41% if support was available by 2020 compared to the BAU level.	8	672	38	1	48	11	1,039	56	5	78
20 September 2011	Presidential Regulation (PERPRES) concerning the National Action Plan for Reducing Greenhouse Gas Emissions (RAN-GRK)	The official regulation for all sectors in Indonesia became to reduce total emissions by 26% unconditionally (or 41% conditionally) by 2020 compared to the BAU level.										
2012	Each province started to develop its own Regional Action Plan for Reducing Greenhouse Gas Emissions (RAD-GRK)	Following the national mitigation target (RAN-GRK).										
2015	1st Indonesia Biennial Update Report	Following RAN-GRK.										
November 2016	1st Nationally Determined Contribution of the Republic of Indonesia (1st NDC)	29% unconditional, 41% if support available by 2030 compared to the BAU level.	9	497	314	2.75	11	4	650	398	3.25	26
27 December 2018	2nd Indonesia Biennial Update Report	Some adjustments to that stated in the 1st NDC.	9.27	508	314	2.75	11	3.8	655	398	3.25	26
22 July 2021	Long-Term Strategy for Low Carbon and Climate Resilience 2050 (Indonesia LTS-LCCR 2050)	Indonesia announced its vision to achieve long-term emission mitigation by extending the NDC targets.										
November 2021	UN Climate Change Conference (COP 26)	Indonesia announced its ambitious objective to reach net zero emissions by 2060.										
20 December 2021	3rd Indonesia Biennial Update Report (BUR)	Some adjustments to the BAU level that were stated in the 2nd BUR.	9	497	313	3	12	4	678	398	3	27
23 September 2022	Enhanced Nationally Determined Contribution (NDC) of the Republic of Indonesia	31.89% unconditional, 43.20% if support available by 2030 compared to the BAU level.	10	500	358	7	40	12	729	446	9	43.5

Notes: AGR: agriculture, FOLU: forestry and land use change, ENE: energy, IPPU: industrial process and product use, WAS: waste.
[1)] The target year in RAN-GRK was 2020, but in the NDC and Enhanced NDC, 2030. [2)] Unconditional targets represent the country's emission reduction by its own effort, [3)] Conditional targets represent additional reduction when foreign support is available. Source: Author's compilation

by 2020 compared to the BAU level. Later, in 2011, the national emission mitigation target was stated through the Presidential Regulation concerning the National Action Plan for Reducing Greenhouse Gas Emissions, better known as RAN-GRK (*Rencana Aksi Nasional-Penurunan Gas Rumah Kaca*), which was then followed by the requirement for each province to prepare a provincial mitigation action plan (RAD-GRK) early in 2012.

To convince the global world of its emission mitigation commitment, the government then decided to expand RAN-GRK and considered adding more policies to reduce emissions over a longer period. In 2016, Indonesia declared an increase in its emission reduction target through its first Nationally Determined Contribution (1st NDC). It stated that Indonesia would reduce emissions by 29% unconditionally and 41% if support were available by 2030 compared to the BAU level. Despite several updates and modifications to the baseline and sectoral emission mitigation targets, this NDC target continues to serve as a benchmark for Indonesia's medium-term emission reduction programs through 2021. The forestry and land use (FOLU) sector is an example of a sector that has undergone several adjustments to its emission reduction target. In the 1st NDC (2016), this sector was targeted to achieve emission reductions of 497 M ton CO_2eq (for the 29% target), 650 M ton CO_2eq (for the 41% target), while in the 2nd Biennial Update Report (BUR) report under UNFCCC, the targets were 508 M ton CO_2eq (29%) and 655 M ton CO_2eq (41%) and in the 3rd BUR, the 29% reduction target was set back to 497 M ton CO_2eq but the 41% reduction target increased to 729 M ton CO_2eq.

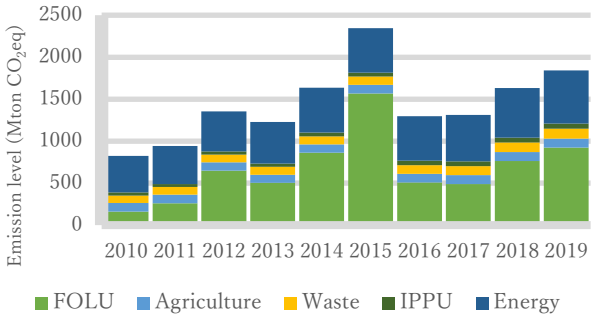
At the end of 2021, Indonesia stated an even more ambitious emission reduction target. During COP 26, Indonesia announced its goal to reach zero emissions by 2060. With this ambitious target, the government realizes that the present mid-term emission reduction target needs to be revised to achieve the net-zero emission target. Therefore, Indonesia has revised its NDC through the "*Enhanced NDC of the Republic of Indonesia*." revising the mitigation target to 31.89% unconditionally and 43.20% if support is available by 2030, compared to the BAU level.

3. Emission Profile in Indonesia

3.1 National Emission Profile

Although Indonesia's emission reduction targets are trending toward more ambitious figures, if we look at the actual emission levels in Indonesia, there has been no significant reduction over the past ten years (Fig. 1).

In general, 50% of Indonesia's emissions come from the FOLU sector, followed by the energy sector, which contributes around 30 to 35% of emissions.



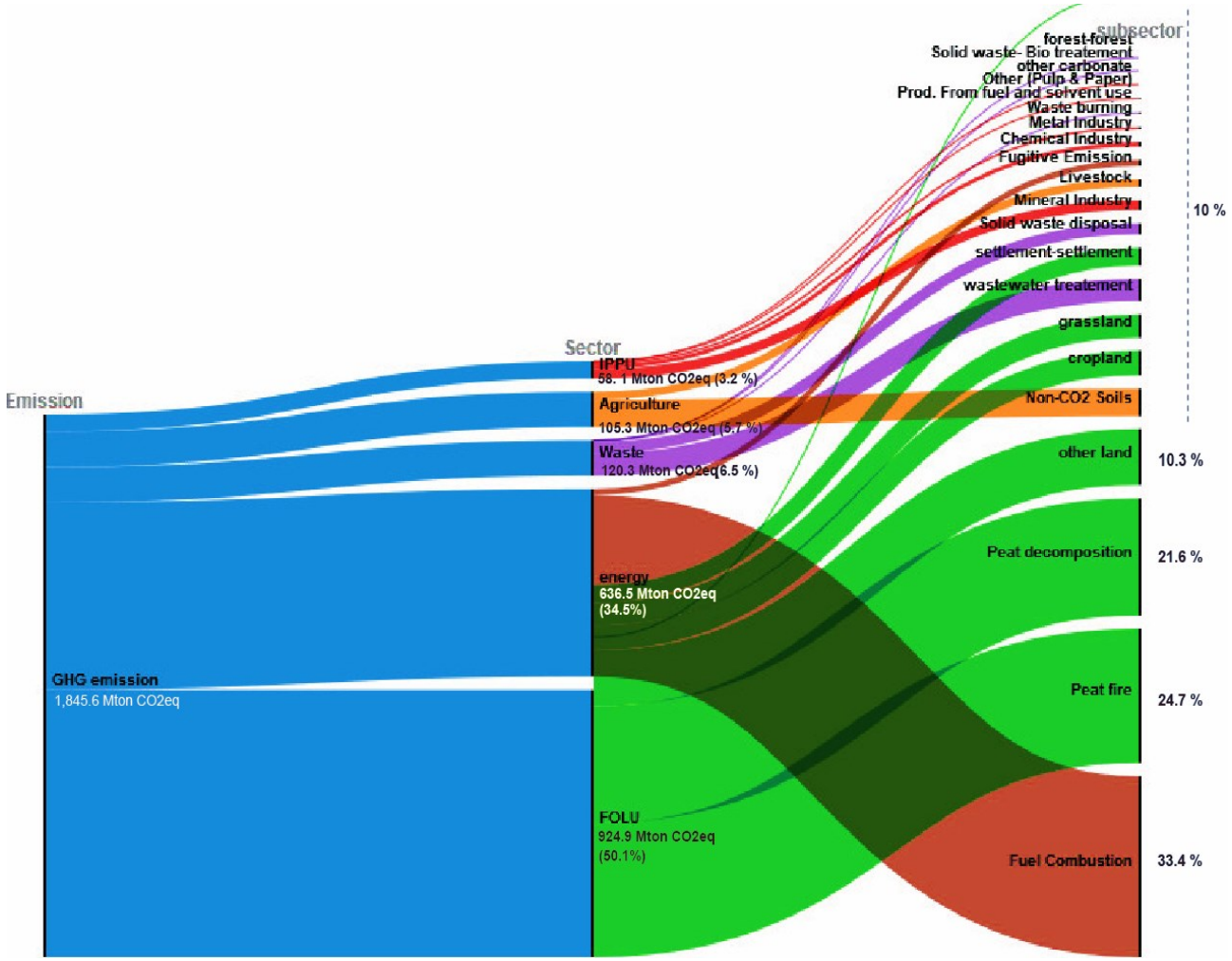
Notes: FOLU: forestry and land use change,
IPPU: industrial process and product use.

Fig. 1 National emission trends in Indonesia 2010–2019. (KLHK, 2021)

Based on the 2019 GHG inventory, the high level of emissions from the FOLU sector is a result of emissions from peat fires, decomposition of peat and land use change, especially land use change to degraded land (classified as other lands) (Fig. 2). As the home of *a third of the world's* tropical peatlands which are prone to peat fires, emissions from the FOLU sector not only dominate but also fluctuate (Evans, 2020). This also causes some difficulties in projecting Indonesia's emissions, necessitating revision of its emission projection and baseline several times. Besides the FOLU sector, about 35% of Indonesia's emissions come from the energy sector, particularly from fuel combustion processes. This is driven by increasing energy demand as a result of increasing economic growth. As the world's third-largest *coal producer* after China and India, its energy mix, especially for electricity production, still relies on coal.

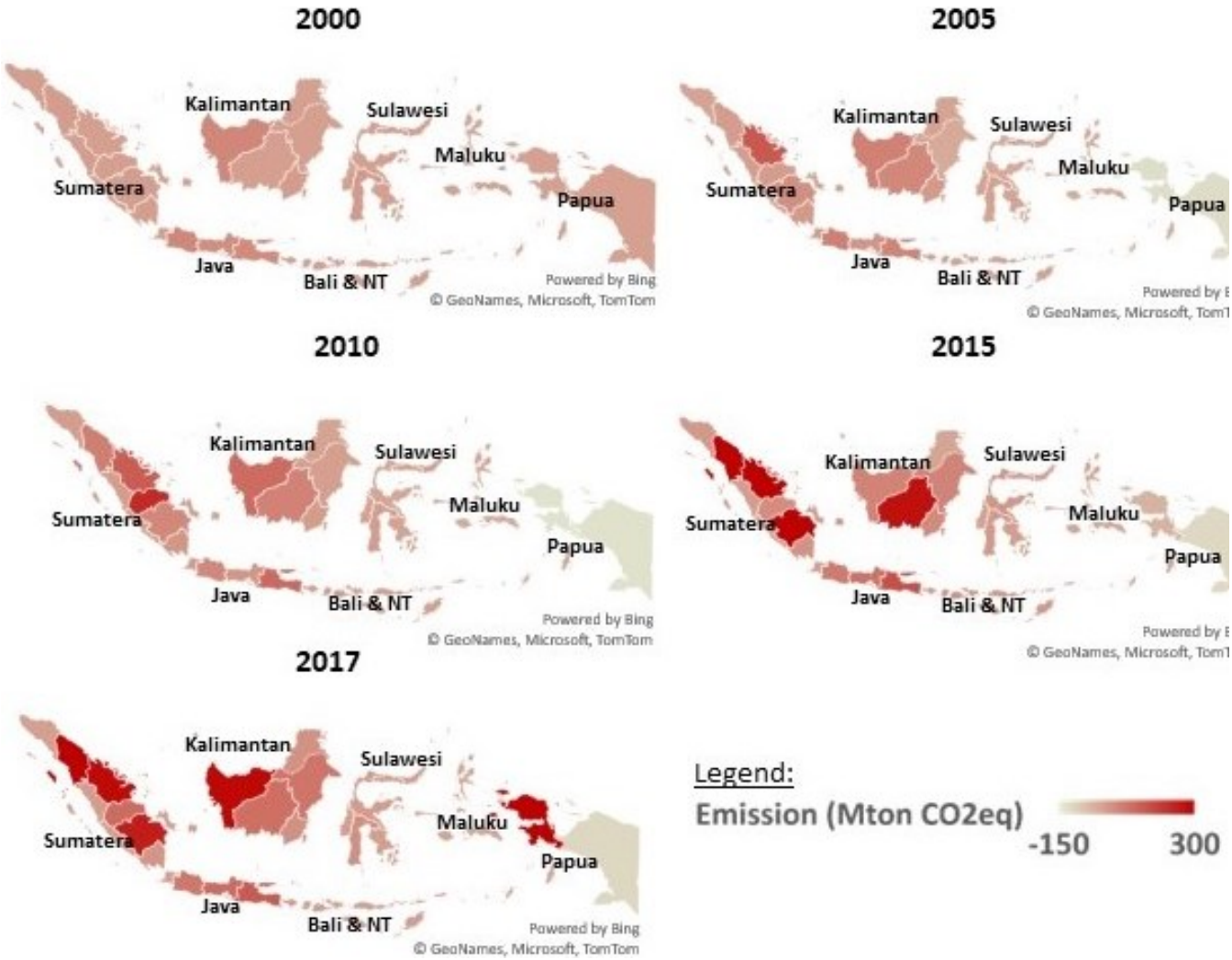
3.2 Local (Provincial) Emission Profile

Success in reducing Indonesia's emissions also depends on each province's success in carrying out emission reductions. The recent data on Indonesia's local emissions shows that in the past two decades (2000–2017), higher emission intensities have been found in western Indonesia (Sumatra, Java-Bali, & Kalimantan) due to



Notes: FOLU: forestry and land use change, IPPU: industrial process and product use.

Fig. 2 Indonesia's emission flows based on emission levels in 2019. (KLHK, 2021)



Notes: Some data discrepancies may apply, considering some provinces have not reported their emissions yet or these have not yet been recorded in the national database.

Fig. 3 Geographic variability of GHG emissions in Indonesia 2000–2017. (KLHK, 2022)

higher population growth and development rates. In addition, there are many areas with peat or deforestation in Sumatra and Kalimantan. In contrast to the western part, Eastern Indonesia (e.g., Papua, Sulawesi, and Maluku) functioned more as a carbon sink. However, in recent years, the Indonesian government has been trying to reduce economic and development disparities between western and eastern Indonesia, so there have been many new infrastructure development projects in the eastern part, followed by a rapid increase in GHG emissions in that area. Therefore, there is a visible increasing emission trend in Eastern Indonesia (Fig. 3). The clearest example can be seen in West Papua province. Following the information from the Indonesia Ministry of Environment, this province experienced negative emissions from 2000–2015 and absorbed around 70 Mton CO_2eq of emission each year, thanks to the abundance of protected forests in this province. However, governmental development projects for trans-Papua road construction and extension since 2015 (Rudi, 2021) led West Papua's emissions to shoot up to 150 Mton CO_2eq in 2017.

4. Challenges to Achieving NDCs and Net-zero Emission Targets

4.1 Sectoral Challenges

The most important thing that needs to be addressed by Indonesia is to look at the core problems in each sector, especially in the energy and FOLU sectors, which are the main contributors to GHG emissions in Indonesia. Dewi and Siagian (2022) stated that, technically, there are many challenges to achieving emission reduction targets in the energy sector. One of the main challenges is the availability and accessibility of renewable energy. As previously mentioned, Indonesia's energy mix relies on fossil fuels, especially coal. Using renewable energy and replacing fossil fuels will become the crucial key to reducing emission levels from this sector, especially considering Indonesia has a lot of potential natural resources that can replace fossil fuels if utilized. However, besides the non-technical aspects, many technical aspects also need to be addressed. For example, in the case of renewable power plants (hydro, micro-hydro and

geothermal power plants), although in general, these power plants have relatively low investment costs, the potential areas to build these power plants are mostly located in remote areas that are far from the load center (which is mostly agglomerated in Java and Sumatra). Power plant construction takes a relatively long time and requires additional investments, making the development cost significantly higher than initially projected. In addition, due to the challenging geographical conditions, the distribution of energy from generators to consumers is less efficient. Some areas (for example, those with a high degree of steepness) are also considered at risk of suffering from natural disasters if exploited (Pribadi, 2020).

There is also the trade balance problem. Although Indonesia has abundant resources to produce energy from renewable resources, most of the technologies for that are still imported. The provision of solar energy is an example. It is a global trend that the price of renewable energy, especially solar panels, is getting cheaper (Stefani et al., 2022). However, Indonesia still needs to import most spare parts and components of solar panels if it wants to expand its solar energy utilization. Besides, due to Indonesia's climatic and geographical conditions, solar power plants are prone to damage. They quickly become covered with dust due to Indonesia's high humidity levels. Therefore, although renewable energy generation costs are getting cheaper, Indonesia must always consider maintenance costs, which are also quite high. With all costs that may arise, electricity generation with renewable energy is still not competitive in Indonesia (Sambodo et al., 2022).

Energy transition is also hampered by the country's already heavy reliance on fossil fuels. Achieving net-zero emissions in the future means Indonesia needs to reduce coal (coal phasedown) gradually and, in the end, stop using it altogether (coal phase-out). The implication is that Indonesia needs to modify most machinery in every sector so it can work using renewable energy sources. Thus, it needs massive investments and it will by a lengthy process.

4.2 Financing

Besides technical problems, financing will also be a major challenge for Indonesia's emission mitigation. As a form of Indonesia's commitment to supporting climate change mitigation, the government has specifically allocated several parts of its national budget (Indonesian: *Anggaran Pendapatan & Belanja Negara*/APBN) to fund climate change projects. About 5% of the APBN is allocated for climate change, of which 74% of the funds are used to finance mitigation projects. So far, funding from the state budget is still the main source for mitigation projects. The problem is that the amount of APBN is very limited. Also, when needed, the government can always reallocate the funds.

In 2020, before the COVID-19 pandemic, the government initially allocated a "climate fund" for 89.10 trillion IDR (1 USD = around 15,000 IDR), which could be used for any climate-change-related projects, including emission mitigation. However, when the pandemic occurred, the government decided to cut that climate fund by 12.7% and reallocate it for other needs during the pandemic (Kemenkeu, 2022). Learning from that experience, the APBN cannot be considered a stable funding resource for financing climate mitigation projects.

Referring to Indonesia's 3rd Biennial Update Reports, to achieve the NDC's target, Indonesia will need at least 305 billion USD by 2030, and twice that to achieve net-zero emission by 2060. Looking at APBN conditions, it is estimated that the government can only meet a maximum of 10% of the funding. The government then planned to collect carbon taxes to increase mitigation fund accumulation while reducing emissions. This policy was originally planned to be launched starting in 2022, but it was later postponed due to rejection, especially from the industrial sector, and public concern about a possible economic recession in 2023. In addition, the government also acknowledged insufficiency of related studies (Purwanti, 2022).

4.3 Knowledge Gap at the Provincial Level

As a big archipelagic country consisting of many provinces, it is obvious that Indonesia's national emission reduction target will not be achieved without mitigation action at the provincial level. Thus, since 2012, every province in Indonesia has been required to report their emission mitigation actions and submit their mitigation action plans to the national government through the RAD-GRK scheme. Unfortunately, RAD-GRK reporting often encounters problems. The problem that most often happens is capacity gaps between provinces. Knowledge on how to fill in data and calculate emissions is not evenly distributed throughout Indonesia (Gembira et al., 2019). The situation has forced several provinces to revise their baseline calculations because they had failed to consider important information. For example, for provinces with peatlands, it is necessary to carry out a more careful calculation of emissions from peat fires and peat decomposition, as this calculation uses a more specific method than calculating emissions in other sectors. Outside the capital area of Jakarta in Java, human resources in each region are still far from adequate in knowledge of climate change, implementation of long-term programs, proper understanding of tools and effective emission mitigation (Ridwan, 2018).

The uneven distribution of human resources cognizant of climate mitigation results in disparate regulations on emission reduction among provinces. Ideally, given the existence of RAD-GRK, each province should have established specific regulations and divisions of authority regarding climate change; but in reality, this

has not happened. In the Kalimantan area, for example, East Kalimantan Province has comprehensive climate change mitigation regulations covering the coordination, evaluation and funding processes. While in contrast, North Kalimantan Province has no clear regulations and a lack of data synchronization in calculating the greenhouse gas inventory. There is also some shifting of responsibility between local agencies regarding who is responsible for reporting emissions (Desdiani, 2022). As a result, there are some data discrepancies on GHG emission levels in Kalimantan and other parts of Indonesia due to regulatory inequalities related to reporting the emission inventory and implementing emission reduction actions.

4.4 Land Acquisition and Public Acceptance

Land acquisition is another common problem related to emission mitigation, specifically in Indonesia. More interestingly, this problem is faced not only by the agriculture and forestry sectors, which are directly connected to the land sector, but also other sectors, such as the energy, waste and industrial sectors. Related to the FOLU sector, reducing deforestation and managing land cover in peat and non-peat forests has become the key to mitigating emissions in this sector and transforming the forest area into a carbon sink. Therefore, the government is trying to manage some land areas for climate mitigation projects, such as establishing conservation areas and increasing reforestation in deforested forests and degraded land. However, many local communities occupy the areas where the projects are planned to be implemented, and the government has difficulty implementing them because they have to pay attention to living conditions in these local communities and, at the same time, deal with resistance from the communities around the area, even though those areas belong to the government according to the regulation (Boer et al., 2021).

Land acquisition problems also hamper many mitigation projects in the energy sector. For example, even though Indonesia has the largest geothermal energy reserves in the world (40% of total world geothermal reserves), most of these energy reserves cannot be utilized yet because many of the geothermal resources are located in conservation areas, and it is not easy to gain permits from the local government or the Ministry of Environment and Forestry. The same thing happened with the construction of solar power plants because many people were reluctant to have their land converted to power-plant land (ADB, 2018).

Difficulty in acquiring land in Indonesia is often caused by a lack of public acceptance of environmental projects. This is not without reason; the public considers that the central and local governments have been unable to develop environmentally sustainable projects. For example, in 2016, an explosion occurred at a geothermal power plant in Dieng, Central Java. As a result, Dieng residents have rejected similar projects because they believe that the government is still unable to ensure minimization of environmental damage during project development (Darmawan, 2022). Early in 2022, there was also public rejection of a construction project for an integrated waste management site in Bogor, West Java Province. Although the local government promised to build a waste management facility with more modern technologies and possibly a waste power plant if the project were established, the public still rejected the idea because, given the government's prior performance, many similar projects have been hindered (Sinaga, 2022). The Indonesian people themselves are generally aware of the importance of environmental sustainability. Looking at previous cases, however, the government has damaged the natural and cultural heritage of the surrounding area in numerous instances. Many people are disappointed and have become reluctant to support any government project, even if it includes the concept of sustainability (Hamdan, 2022).

5. Opportunities to Achieve Emission Reduction Targets

Despite all the challenges, Indonesia has also made some progress. Each related sector has shown good progress in achieving its target and minimizing its challenges. In the FOLU sector, to optimize the land's carbon-absorbing function, several schemes exist such as social forestry and agrarian reform (in Indonesian: *Tanah Objek Revolusi Agraria*/TORA). Under this scheme, agricultural land under forest cover is now receiving legal status and is eligible for incentive and/or capacity building programs run by the government. Local communities involved in the social forestry and TORA schemes have been trained to manage agricultural land effectively without destroying forested areas (Boer et al., 2021). This scheme allows the community to participate actively in forest management without sacrificing economic activity. So far, it has succeeded at increasing public acceptance and making the land acquisition process easier for developing the government's mitigation projects. In the industrial sector, this year, the Organization for Economic Cooperation and Development (OECD) assisted Asian countries by preparing a "Framework for industry's net-zero transition" to assist emerging and developing economies in designing financing solutions and improving the conditions that enable acceleration of industry's transition to the net-zero emission target. Indonesia has become the first country in Asia to receive assistance, possibly including technical and financial assistance. This has been a big help to Indonesia's industries in preparing for the transition (OECD, 2022). Meanwhile, for the energy and waste sectors, the government is preparing sets of policies and regulations, such as coal power plant retirement and the possibility of expanding waste-to-energy projects in Indonesia (IESR,

2021).

For financing, the government has also found some potential methods to help augment climate funds. In 2018, Indonesia issued its 1st Global Green Sukuk (*sukuk* = Islamic bond) to raise investors' funds for green projects in Indonesia. Unexpectedly, this green *sukuk* gained positive responses from global investors, so the has government continued to issue global green *sukuk* to date, issuing USD 750 million worth each year (MoF Indonesia, 2020). As a relatively new financial instrument, this instrument still has some drawbacks. For example, because the government issues it, funding from this instrument is still limited to mitigation projects owned by the government. But apart from all that, the procurement of green *sukuk* shows that the market responds positively to green financial instruments. Moreover, to close the knowledge gap, especially at the provincial level, the central government constantly maintains discussions and increases capacity building with multiple stakeholders at the provincial level (Dewi & Siagian, 2022).

6. Conclusion

Indonesia has ambitious targets for emission mitigation, including achieving net-zero emissions by 2060. However, based on national emission trends in recent years, there have yet to be significant emission reductions. This indicates that Indonesia needs to accelerate implementation of concrete mitigation actions to reduce emissions, especially for the FOLU and energy sectors, which contribute almost 90% of Indonesia's total emissions. Several key challenges have hindered Indonesia's achievement of emission reductions, including sectoral challenges, financing, land acquisition, low-public acceptance and a knowledge gap at the provincial level. Even though there are many challenges, Indonesia has managed to stay on track with emission reduction actions. For example, from a financial standpoint, Indonesia is trying to find new sources to increase funding for mitigation projects by issuing global green *sukuk*. The government also seeks dialogue between stakeholders in each related sector at the national and provincial levels to achieve emission reduction targets. From this study, the government also tried to address all sectoral challenges related to emission mitigation. Although mitigation projects in Indonesia have not shown significant results in reducing emission levels, it is important for the government to convince all Indonesian people that the government can maintain the sustainability of its mitigation projects to increase the public trust and acceptance of the emission mitigation projects initiated by the government.

References

Asian Development Bank (ADB) (2018) *Developing Indonesia's Geothermal Power Potential*.ADB News. https://www.adb.org/news/features/developing-indonesia-s-geothermal-power-potential. (accessed 13 December2022)

Boer, R., Dewi, R. G., Siagian, U. W. R. and Anggraeni, L. (2021) Assessment of LTS: Indonesia. The 27th AIM International Workshop.

Darmawan, L. (2022) Warga Sejumlah Desa Tolak Pembangunan PLTP Dieng, Kenapa?, Mongabay.co.id. Retrieved from https://www.mongabay.co.id/2022/01/27/warga-sejumlah-desa-tolak-pembangunan-pltp-dieng-kenapa/ (accessed 13 December 2022)

Desdiani, N.A. (2022) Empat tantangan pemerintah daerah dalam menjalankan program lingkungan dan pengendalian perubahan iklim, The Conversation. Retrieved from https://theconversation.com/empat-tantangan-pemerintah-daerah-dalam-menjalankan-program-lingkungan-dan-pengendalian-perubahan-iklim-172852 (accessed 27 December 2022)

Dewi, R.G. and Siagian, U.W.R. (2022) GHG Mitigation and AIM in Asia: Roadmap to Indonesia Energy Net-Zero Emission, The 28th AIM International Workshop. National Institute for Environmental Studies (NIES).

Evans, M. (2020) *Progress and Perils in Indonesia's Peatland Restoration Journey*. CIFOR Forests News. Petrieved from https://forestsnews.cifor.org/68619/progress-and-perils-in-indonesias-peatland-restoration-journey?fnl=en. (accessed 14 December 2022)

Gembira, H., Puspita, H. I., Utomo, E. T., Hamumpuni, H. S., Paputungan, M. S. and Safitri, R. (2019) *Laporan Implementasi Perencanaan Pembangunan Rendah Karbon*. Indonesia National Development Planning Agency (Badan Perencanaan Pembangunan Nasional/*Bappenas*), Jakarta.

Giwangkara, J. and Dolan, M. (2021) ASEAN's Emerging Mission for a Low Carbon Energy Transition, ClimateWorks Australia. Retrieved from https://accept.aseanenergy.org/aseans-emerging-mission-for-a-low-carbon-energy-transition/ (accessed 27 December 2022)

Hamdan, H. (2022) Warga Kalumpang Tolak PLTA Sungai Karama karena Dinilai Ancam Situs Sejarah, detikSulsel. Retrieved from https://www.detik.com/sulsel/berita/d-6257887/warga-kalumpang-tolak-plta-sungai-karama-karena-dinilai-ancam-situs-sejarah (accessed 13 December 2022)

IESR (2021) Deep decarbonization of Indonesia's energy system A pathway to zero emissions by 2050 in cooperation with Deep decarbonization of Indonesia's energy system: A pathway to zero emissions by 2050, Jakarta.

Kemenkeu (2022) *APBN Menjaga Perubahan Iklim*. Visual Kemenkeu. Retrieved from https://visual.kemenkeu.go.id/apbn-menjaga-perubahan-iklim. Indonesia Ministry of Finance (Kementerian Keuangan/Kemenkeu). Jakarta. (accessed 13 December 2022)

KLHK (2021) *INDONESIA: Third Biennial Update Report Under the United Nations Framework Convention on Climate Change*. Indonesia Ministry of Environment and Forestry (Kementerian Lingkungan Hidup dan Kehutanan/KLHK). Jakarta. Retrieved from http://www.ditjenppi.menlhk.go.id (accessed 29 July 2022)

KLHK (2022) Total Emisi Nasional, SIGN SMART. Retrieved from http://signsmart.menlhk.go.id/v2.1/menu-emisi/ (accessed 14 January 2022)

MoF Indonesia (2020) Green Sukuk: Allocation and Impact Report 2020. Jakarta, Indonesia.

Organisation for Economic Cooperation and Development (2022) Framework for industry's net-zero transition Developing financing solutions in emerging and developing economies. 32.

Paris. https://doi.org/10.1787/0c5e2bac-en
Pribadi, A. (2020) Targetkan Tambahan 16,7 Giga Watt Pembangkit EBT, Menteri ESDM: Ini Tantangannya, Press Release Ministry of Energy and Mineral Resources. Retrieved from https://ebtke.esdm.go.id/post/2020/09/26/2634/targetkan.tambahan.167.giga.watt.pembangkit.ebt.menteri.esdm.ini.tantangannya (accessed 13 December 2022)
Purwanti, T. (2022) Pajak Karbon Ditunda Sampai 2025, CNBC Indonesia. Retrieved from https://www.cnbcindonesia.com/news/20221013175437-4-379582/pajak-karbon-ditunda-sampai-2025 (accessed 14 December 2022)
Ridwan, M. (2018) Prof. Rizaldi Boer: KPH Butuh Pengetahuan Resiko Emisi, Green Indonesia. Retrieved from https://greenindonesia.co/2018/06/prof-rizaldi-boer-kph-butuh-pengetahuan-resiko-emisi/ (accessed 13 December 2022)
Rudi, A. (2021) Sederet Fakta Jalan Trans-Papua, Panjangnya 4 Kali Lipat Jarak Jakarta-Surabaya, Kompas.com. Retrieved from https://nasional.kompas.com/read/2021/12/20/08060251/sederet-fakta-jalan-trans-papua-panjangnya-4-kali-lipat-jarak-jakarta (accessed 14 December 2022)
Sambodo, M. T., Yuliana, C. I., Hidayat, S., Novandra, R., Handoyo, F. W., Farandy, A. R., Inayah, I. and Yuniarti, P. I. (2022) Breaking barriers to low-carbon development in Indonesia: deployment of renewable energy. *Heliyon*, 8(4), e09304. https://doi.org/10.1016/J.HELIYON.2022.E09304
Sinaga, R. (2022) Tolak TPST Zonasi Rumpin, GETOP Gelar Aksi Di Komplek Pemkab Bogor, Radar Bogor. Retrieved from https://www.radarbogor.id/2022/02/03/tolak-tpst-zonasi-rumpin-getop-gelar-aksi-di-komplek-pemkab-bogor/ (accessed 27 December 2022)
Stefani, B. V., Hallam, B. and Wright, M. (2022) Solar is the cheapest power, and a literal light-bulb moment showed us we can cut costs and emissions even further, The Conversation. Retrieved from https://theconversation.com/solar-is-the-cheapest-power-and-a-literal-light-bulb-moment-showed-us-we-can-cut-costs-and-emissions-even-further-187008 (accessed 13 December 2022)

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