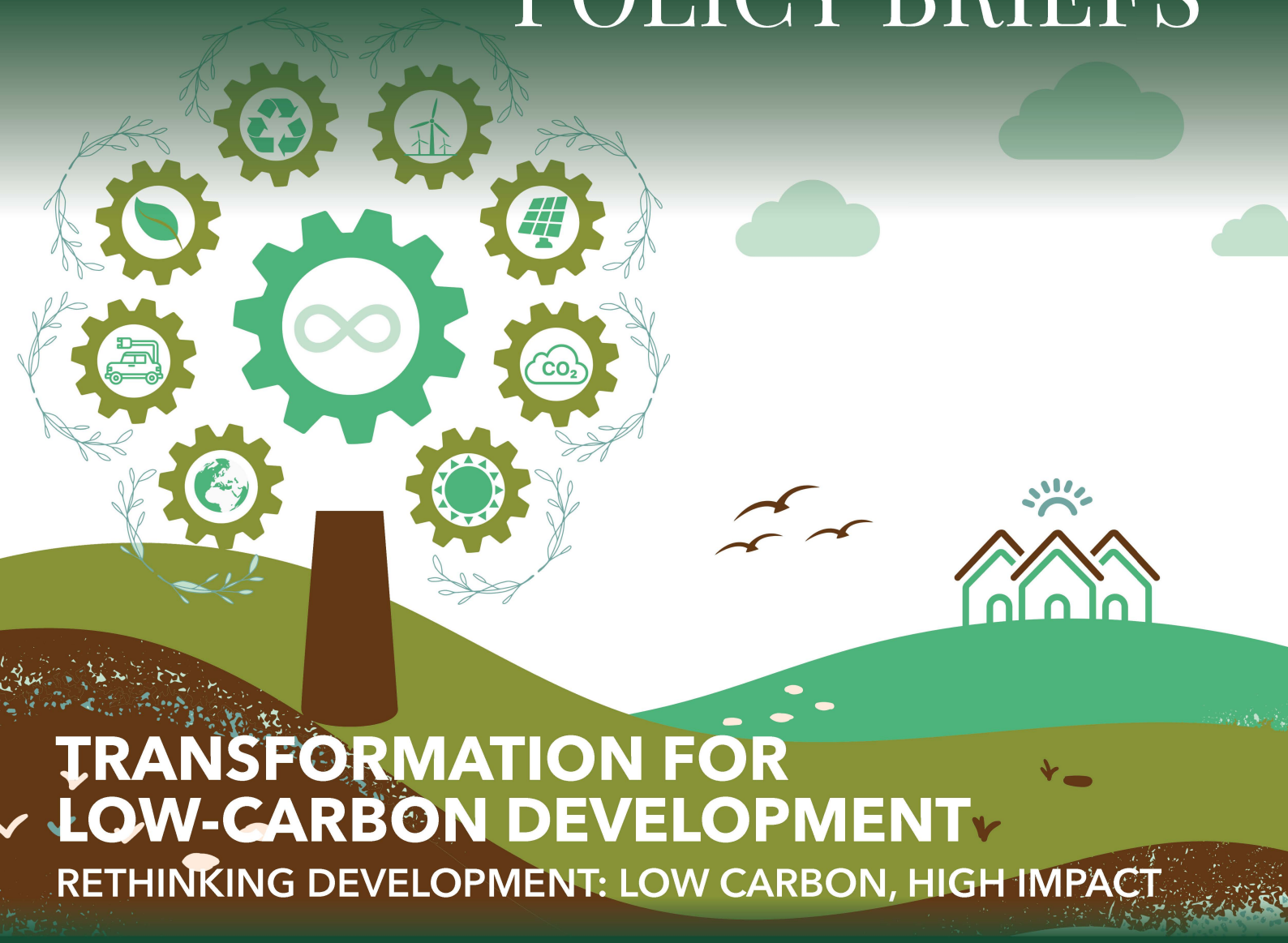
5th International Conference of Integrated Intellectual Community (ICONIC) 2024

BOOK OF ABSTRACTS AND POLICY BRIEFS



TRANSFORMATION FOR LOW-CARBON DEVELOPMENT

RETHINKING DEVELOPMENT: LOW CARBON, HIGH IMPACT

September 4th - 6th 2024
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Preface

The 5th International Conference of Integrated Intellectual Community (ICONIC) 2024 is a biennial international scientific conference in Germany that is initiated and held by PPI Jerman (Perhimpunan Pelajar Indonesia Jerman/ Indonesische Studenten Vereinigung e.V) as a platform to act as an academic bridge between Indonesia and Germany, facilitated by Indonesia's very own academia diaspora of high-spirited and motivated students currently pursuing their studies and research in Germany. The ICONIC 2024 stands as a beacon for students, scholars, researchers, and practitioners united in their commitment to confronting the pressing challenges of our time. This Book of Abstracts and Policy Briefs encapsulates the diverse and innovative research contributions that define the ICONIC 2024, which centers around the theme "***Transformation for Low-Carbon Development (LCD) - Rethinking Development: Low Carbon, High Impact*** ". The ICONIC 2024 took place on the campus of the University of Göttingen, Germany from September 4 – 6, 2025.

The theme underscores the imperative for a global shift towards sustainable, low-carbon futures, recognizing that such a transformation requires a multifaceted approach which focuses on four critical areas of study:

- **Economic and Social Implications of Low-Carbon Development** - Examining how transitioning to low-carbon systems affects economies and societies, with an emphasis on equity, inclusivity, and sustainable growth.
- **Political Economy of Low-Carbon Development within Global North and South Dynamics** - Analyzing the complex interactions between political and economic forces in different regions, and how these Dynamics shape the pathways to low-carbon development.
- **Technological Innovation for Low-Carbon Development** - Highlighting the role of technological advancements in driving decarbonization, from renewable energy solutions to innovative practices in industry and agriculture.
- **Low-Carbon Development in the Built Environment** - This focus area explores how urban planning, architecture, infrastructure, and land use can be reimagined to support sustainable, low-carbon living environments. It also delves into the interconnected fields of agriculture, livestock, fishery, and forestry, examining how these sectors can be integrated into low-carbon development strategies by rethinking agricultural practices, livestock management, aquaculture, and forest conservation.

These focal areas reflect the broad and interconnected challenges that must be addressed to achieve meaningful progress in low-carbon development. The abstracts in this volume have been selected through a rigorous peer-review process, ensuring that each contribution meets the highest standards of academic rigor and practical relevance. The structured approach—covering introductions, methodologies, results, and conclusions—allows for a comprehensive exploration of each research topic, offering readers a deep understanding of the issues at hand.

The ICONIC 2024 not only provides a platform for presenting cutting-edge research but also fosters critical discussions and collaborations that are essential for driving forward the low-carbon agenda. The insights and ideas generated here are expected to spark further innovation and action, contributing to the global effort to create a more sustainable and equitable world.

Gratitude is extended to the invited speakers, authors, reviewers, and organizing team whose dedication has been pivotal in the success of this conference and the creation of this Book of Abstracts and Policy Briefs. Special thanks are also due to the partners and sponsors whose support has made ICONIC 2024 possible, which enables us to maintain a free conference for all participants, i.e. presenter and observer.

As the conference unfolds, this Book of Abstracts and Policy Briefs will serve as both a record of the intellectual contributions made and a catalyst for continued dialogue and collaboration as well as policy recommendations with the goal of shaping Indonesia's development. It is with great anticipation that the outcomes of ICONIC 2024 are expected to influence the path towards a sustainable future, one that is firmly grounded in the principles of low-carbon development in Indonesia.

We sincerely thank you for your participations in Göttingen, Germany, and from various corners of the globe. We hope you had an inspiring and enriching conference experience.

On behalf of the ICONIC 2024 Organizing Team,

Risma Rizkia Nurdianti, M.I.L., M.Sc.

Head of Scientific Committee and Editor-in-Chief
5th International Conference of Integrated Intellectual Community (ICONIC) 2024

Sponsors:

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Policy Briefs ICONIC 2024

Introduction

Sekar Yunita[1]

[1]Director of ICONIC 2024

Since the dawn of the 21st century, low carbon development has emerged as a focal point in addressing pressing climate concerns. As policymakers face increasing pressure to take concerted action, decarbonization stands out as a promising solution to shield society from environmental catastrophes. The traditional trajectory of development, rooted in exploitation, has come under critical scrutiny and calls for change. Yet, transitioning to a low carbon pathway presents its own set of challenges and complexities. In particular, the costs and obstacles associated with implementing low carbon development are not easily navigated, particularly in vast developing nations like Indonesia.

Indonesia, the world's largest archipelago, finds itself increasingly vulnerable to the impacts of the climate crisis. Rising sea levels, intensified rainfall, and rampant forest and land fires are just a few of the consequences stemming from the escalating global temperatures. Over the period of 1990 to 2021, Indonesia endured over 300 natural disasters, affecting more than 11 million people. Notably, the country's greenhouse gas emissions have been on a steady incline since gaining independence in 1945. Land-based activities, particularly forestry and agriculture, have historically accounted for nearly 50% of Indonesia's overall emissions. The rapid deforestation, exacerbated during the authoritarian rule of the New Order regime, coupled with the expansive growth of oil palm plantations, has significantly contributed to this upward trend in emissions. Undeniably, these activities have fueled substantial economic growth for the nation, yet they've also posed a considerable dilemma. Indonesia now stands at a crossroads, torn between transitioning towards decarbonization across all sectors or prioritizing economic activities that come with inherent trade-offs in climate action. This complex dilemma persists, demanding critical decisions to navigate the path forward.

In contrast to high-income countries, Indonesia's historic contribution to global emissions is relatively modest. Globally, Indonesia contributes approximately 3.5% of greenhouse gases emissions. Despite this comparatively lower contribution, the interconnected nature of climate change compels countries to take collective action and commitments, including Indonesia. To address climate change as a global challenge, the United Nations Framework Convention on Climate Change has introduced the principle of "common but differentiated responsibilities". This principle recognizes that individual countries possess varying capacities to combat climate change and allocate obligations based on historical greenhouse gas emissions.

The nation ratified the Kyoto Protocol in 2004 and the Paris Agreement in 2016, demonstrating its strong commitment to international climate cooperation. In line with these global agreements, Indonesia has consistently set ambitious climate goals. In 2009, the country pledged to reduce its greenhouse gas emissions by 26% by 2020, or by 41% with international support. Building on this foundation, Indonesia reaffirmed its commitment in 2022, pledging a 43.2% reduction with international assistance, and even in the absence of external support, it remains determined to reduce emissions by 31.89% by 2030 compared to business-as-usual projections. These actions reflect Indonesia’s proactive stance in addressing climate challenges while emphasizing the importance of global collaboration.

This Book of Abstracts and Policy Briefs, based on the conference and panel discussion at ICONIC 2024, provides a brief summary of Indonesia's efforts to transition toward a low-carbon economy. It focuses on key sectors, including carbon capture and storage, the built environment, AFOLU (Agriculture, Forestry, and Other Land Use), sustainable investment, and decarbonization in industrial and transport sectors. The insights presented in this work aim to support Indonesia in addressing the challenges within these sectors while balancing economic development and greenhouse gas emissions. Ultimately, it is our hope that this compilation will inspire continued dialogue and concrete actions toward a resilient, low-carbon future for Indonesia.

Abstracts

Abstract ID 1

Implications of the European Union's Common Agricultural Policy on Indonesia's Livestock Sector: A Literature Review

Risma Rizkia Nurdianti[1]

[1]University of Hohenheim, Stuttgart, Germany

Abstract

Common Agricultural Policy (CAP) is a principal policy on agriculture production, trade, and rural development, which has an impact on the economy of the European Union (EU) member states. To date, no research has assessed the implications of the EU's CAP on Indonesia's livestock sector. Thus, a literature review was performed to collect information regarding the potential consequences of CAP implementation at the global level and in Indonesia. First, the indirect impact of CAP on the global livestock market interpretations into prices and the nausea of the production of price competitiveness in the Indonesian livestock sub-sector. Second, its plans and rules on biodiversity and environmental sustainability could create a chance for Indonesia and the EU to collaborate on conference agriculture deeds and biodiversity conservation. Lastly, the coordination of policy which might cover the CAP and Indonesian agricultural policies could contribute to coping with some challenges in some sectors i.e. agri-food, environmental and rural development. The study shows that Indonesia’s livestock production, trade patterns, and ecological conditions might very much be influenced by the EU’s CAP. However, further study is required to check the assumptions and determine the potential cooperation and alignment of CAP and Indonesian agricultural policies.

Keywords

Agricultural trade, common agricultural policy, Indonesia, livestock sector, sustainable agriculture

Focus of study

Political Economy of LCD within Global North and Global South Dynamics

Abstract ID 2

Impact of Low-Carbon Transition on Industry Transformation: Carbon Emission Reduction & Turnover Rate Correlation in Indonesia

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Abstract

The transition to eco-friendly practices leads to significant challenges, particularly in developing countries like Indonesia. Accelerating economic growth while pursuing environmental and social improvement is a trade-off. This affects various processes, mainly the extractive industry, known for its substantial environmental externalities. This study focuses on Indonesia's mining industry, analyzing the correlation between revenue and carbon emissions to understand sustainability's financial implications. We use primary data from corporate reports and employ bivariate analysis to scrutinize the relationship between the variables. Through simple linear regression analysis, we examine the period from 2019 to 2023. Preliminary results demonstrate a positive correlation, indicating a sector's financial dependence on carbon-intensive activities over the years. Despite the constraint of data access and less transparency, this research provides insights into the social and economic implications of sustainable industrialization. The findings support the existing knowledge and inform the stakeholders.

Keywords

Carbon intensity, corporate activities, industry transformation, transition, turnover rate

Focus of study

Economic and Social Implication of LCD

Abstract ID 4

Implementation of CSR Program to Reduce Carbon Emissions in the Mining Industry using LCA Approach

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[1]Agricultural Socio-economics Department, Gadjah Mada University, Sleman, Indonesia. [2]Operations and Sustainable Department, Ailesh | Your Sustainable Partners (PT Cipta Inovasi Berkelanjutan), Sleman, Indonesia

Abstract

Mining is currently responsible for 4–7% of global greenhouse gas (GHG) emissions from business activities. In Indonesia, the gold mining industry in West Java is primarily responsible for GHG emissions, with the main hotspot, the dewatering system unit (cradle), accounting for 48.37% of the total impact. As a result, the company initiated a corporate social responsibility (CSR) program that involved planting and seeding forest plants and invited vulnerable community groups. This research aims to develop a CSR program that employs a life cycle assessment (LCA) approach to a responsible environment. The research also enhances the existing CSR program, demonstrating a direct correlation between the program's outcomes and the company's reduction in carbon emissions. Some of the methods used include LCA (ISO 14040:2006, ISO 14046:2007), sensitivity analysis, allometric modeling, and carbon sequestration analysis based on the SNI 7724:2011 standard by IPCC 2006. The research demonstrates the effectiveness of the program Compared to other similar programs. CSR program can reduce the effects of eutrophication potential (EP) by 33% and freshwater ecotoxicity potential (FEP) by 70%, or 2.66 x 10-2 kg 1.4-DCB-eq. Additionally, using micro-hydro energy as a source of energy reduces the CSR program's emissions by 50%, or 1.84 x 10-2 kg CO_2-eq. This program has a positive correlation with absorbing 19,912.2 metric tons of CO_2, which lowers the main hotspots' effects by 87%. This integration can be a solution for creating low-carbon development in both the company and community environments.

Keywords

Community development, corporate social responsibility, life cycle assessment, mining industry, low carbon development

Focus of study

Economic and Social Implication of LCD

Abstract ID 7

Literature Review of Mitigating Carbon Footprint through Adoption of Precision Livestock Feeding Strategies in Indonesia

Riki Saumi Nuryana[1], Andreas Handoko[1], Risma Rizkia Nurdianti[2]

[1]University of Padjadjaran, Sumedang, Indonesia. [2]University of Hohenheim, Stuttgart, Germany

Abstract

Agriculture sector has been challenged to address the climate change issue to reduce the greenhouse gas (GHG) emissions, particularly livestock farming system which has been one of the contributing factors of GHG emissions. In many countries, precision livestock feeding (PLF) techniques have been known to minimize the environmental impacts. However, PLF strategies have not been adopted yet in Indonesia. A literature review was performed to gather information regarding advantages of PLF strategies to mitigate carbon footprint of livestock farming. The results showed the potential of PLF strategies which related to the environmental aspect might contribute to reducing GHG emissions, increasing efficiency of local feed resources, and fostering sustainable agricultural practices. Strategies of PLF are crucial to be implemented in Indonesia through optimizing local feed, enhancing utilization of nutritional composition, minimizing waste, and improving overall efficiency in livestock farming productions. It showed the benefits of PLF strategies, including reduced feed conversion ratios, lower GHG emissions from enteric fermentation, and decreased dependence on imported feed ingredients. However, further study is needed to evaluate the opportunities and challenges associated with implementing PLF strategies in livestock farming, particularly related to its economic and social aspects in Indonesia. Interdisciplinary collaboration research, technological innovation, and policy support in advancing sustainable livestock production practices might contribute to climate change mitigation and promote environmental protection in Indonesia's agricultural sector. This abstract is expected to inform policymakers, researchers, and industry stakeholders about the opportunities and challenges associated with implementing PLF strategies in Indonesia's livestock farming system.

Keywords

Environmental impact, environmental protection, greenhouse gas emissions, livestock farming system, precision livestock feeding

Focus of study

LCD of the Built Environment

Abstract ID 8

Carbon Offset Methodologies for Renewable Energy Sectors in Indonesia

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[1]Stromnesia, Tangerang Selatan, Indonesia

Abstract

The renewable energy sector is a focal point in Indonesia's efforts to reduce carbon emissions, with the aim of achieving Net Zero Emissions by 2060. However, the electricity monopoly tariffs imposed by PLN still pose a significant obstacle for renewable energy businesses seeking to expand their capacity in Indonesia. As an alternative revenue source, carbon trading presents itself as a viable option for the renewable energy industry. Additionally, these green portfolios offer companies the opportunity to secure green bond funding, facilitating the financing of renewable energy projects. Indonesia took a significant step forward by commencing its first carbon credit trading on September 26, 2023. With ambitious targets, Indonesia aims to establish a market to finance the reduction of greenhouse gas emissions and emerge as a key player in the global carbon trading arena. Indonesia possesses a diverse array of renewable energy sources, each with its own unique carbon offset quantification. Hence, it's imperative to establish suitable and accurate methodologies for each type to be "carbon certified." According to Regulation No. 21/2022 from the Ministry of Environment and Forestry, carbon emission offsets must meet one of the following criteria: 1) Regulated by the Directorate General, 2) Regulated by the National Standardization Agency of Indonesia, or 3) Acknowledged by the UNFCCC. As institutional review of Stromnesia, this paper thoroughly explores how carbon offset methods can be applied in Indonesia's renewable energy sector. Using a scoping review method, it aims to understand the extent of methodologies rooted in the CDM Methodology as established by the UNFCCC's. It then compares these with methods already used in Indonesia, as provided by SRN. Finally, the paper suggests ways to improve SRN's methods if there are any gaps.

Keywords

Carbon credit, geothermal, hydropower, renewable energy, solar energy

Focus of study

LCD of the Built Environment

Abstract ID 10

Carbon Reduction through Community-Based Biodiversity Conservation: A Dual Strategy for Supporting Migrants and the Environment

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Abstract

As both climate change and global migration intensify, innovative low-carbon development (LCD) models are essential. This review study emphasizes integrating community-based biodiversity conservation with carbon reduction strategies, focusing on the involvement of a specific group of migrants, namely refugees, as the forced nature of their movement, lack of resources and additional strain on (the environment of) the host country provides well-defined and unique circumstances for novel practices. We conducted a comprehensive review of academic literature, project reports, and past studies. We subsequently conducted comparative analysis in qualitative fashion using the SWOT (Strengths, Weaknesses, Opportunities, Threats) framework on nature conservation or rehabilitation projects that engage refugees. We compared various cases to evaluate potential effects across different projects. We oriented ourselves around both the concept and practice of “green” and “sustainable refugee camps”, such as most notably in the case of Minawao refugee camp, Cameroon, where refugees created a “Great Green Wall”. Our findings suggest that involving migrants in conservation aids their integration and economic stability while advancing carbon reduction objectives. Not just one, but all reviewed projects show that they both support biodiversity and reinforce human collaboration, contributing to the sustainability of low-carbon societies in more than just one aspect. Integrating biodiversity conservation with migrant community involvement enhances global LCD efforts. Scaling these models can be pivotal for environmental and socio-economic reform within migrant-inclusive frameworks. Migration, an inevitable aspect of our globalized world, could positively impact resilience and climate adaptation innovation.

Keywords

Carbon reduction, community conservation, low-carbon development, migrant integration, sustainable societies

Focus of study

Economic and Social Implication of LCD

Abstract ID 11

Exploring CO_2 Geological Storage Potential in the South Sumatra Basin: A Comprehensive Assessment

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Abstract

The issue related to carbon emissions is currently being widely discussed. One solution to address carbon emissions is by storing them in produced oil reservoirs, known as CO_2 geological storage or more precisely Carbon Capture and Storage (CCS). In Indonesia, there are many long-produced oil reservoirs. One of them is located in the South Sumatra Basin. Therefore, in this paper, we discuss the feasibility of CCS in this basin. The aspects covered include geological aspects, reservoir engineering, CO_2 sources, and the suitability of the basin for storing CO_2. From a geological perspective, this basin has been proven to have good trapping mechanisms. CO_2 can be trapped in the reservoirs effectively without significant obstacles. In terms of reservoir engineering, the oil reserves in Sumatra Island reach 4.6 billion barrels, equivalent to 61.8% of Indonesia's total oil reserves (Asian Development Bank, 2013), indicating a large capacity for storing CO_2 in Sumatra. In other aspects, this basin is among the top three candidates for CO_2 capture suitability in Southeast Asia and ranks highest in CO_2 storage capacity in Southeast Asia as well (Asian Development Bank, 2013). In terms of location, this basin is close to several CO_2 sources, such as gas fields and gas processing facilities, which make it easily accessible for transporting CO_2. Through this research, we hope to provide a clearer understanding of CO_2 geological storage in the South Sumatra Basin and to contribute additional knowledge for policymakers, industry stakeholders, researchers, and academia in efforts to reduce carbon emissions globally.

Keywords

CCUS, CO_2 geological storage, Indonesia's total oil reserves, South Sumatra basin, trapping mechanism

Focus of study

Technological Innovation for LCD

Abstract ID 12

Examining Policy Engagement of Indonesian Customary Communities in the Forestry Carbon Trading

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Abstract

Indonesia's Presidential Regulation 98/2021 on Carbon Economic Value is a critical step towards achieving Indonesia's climate targets outlined in the Nationally Determined Contribution (NDC), particularly within the forestry sector. This regulation mandates stakeholders to have legal tenure over specific land areas to participate in carbon trading, including those of indigenous communities. However, significant challenges in recognizing indigenous communities' legal land rights persist despite efforts by these communities to maintain forests (Hein, 2018). Even with statutory recognition, accessing the carbon trading mechanism remains difficult for indigenous groups due to its complexity (Cetera, 2022). This study dives into Indonesia's policies on enhancing Indigenous peoples' participation in carbon trading programs related to forestry. We use qualitative methods, including interviews and document analysis. Informants were chosen through convenience sampling to ensure accessibility and availability for researchers. Our findings highlight a fundamental gap in the successful involvement of indigenous communities in the carbon trading framework. Despite recognized customary rights, these communities' participation and benefits in forest carbon trading are still unclear, primarily due to the absence of national legislation protecting indigenous rights. Additionally, the complexity of local legislation coupled with overlapping land tenure issues, complicates their position in the carbon trading scheme (AMAN, 2021; Darmawan and Virgy, 2023). The limited availability of government officers and complex technical terminology in the carbon trading scheme hinder their involvement. (Putri and Zakiyah, 2023; Miles, 2021). This study underscores the need for robust legal frameworks to ensure indigenous communities' meaningful involvement in Indonesia's forestry carbon trading efforts.

Keywords

Carbon governance, customary communities, carbon trade, forestry sector, policy engagement,

Focus of study

Political Economy of LCD within Global North and Global South Dynamics

Abstract ID 14

Integrated Waste Management Solutions for Urban Areas in Indonesia

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Abstract

This paper examines waste generation patterns in Indonesia's urban areas and proposes integrated waste management solutions to address environmental and socio-economic challenges. The focus is on designing systems that include waste segregation, recycling, composting, and waste-to-energy technologies. Urban areas in Indonesia face significant waste management challenges due to rapid urbanization and growing populations. Our analysis identifies that inadequate infrastructure, limited public awareness, and weak policy enforcement contribute to these issues. To combat this, our approach involves community engagement, innovative technology, and close collaboration with local governments. The study finds that waste segregation at the household level can significantly reduce the amount of waste that ends up in landfills. Recycling programs targeting plastics, paper, and metals have shown success in reducing waste volumes. Composting organic waste helps to lower landfill burdens while providing resources for agriculture. Waste-to-energy technologies offer an additional solution by converting waste into energy, reducing the need for traditional energy sources and easing landfill demands. The key to success in integrated waste management is a multi-faceted approach that includes public education and awareness campaigns, which encourage communities to participate in waste reduction and recycling. Effective collaboration among policymakers, stakeholders, and communities is crucial for implementing these solutions and achieving a more sustainable urban environment. In summary, integrated waste management solutions in Indonesia's urban areas can lead to significant environmental and economic benefits. By addressing waste generation patterns and promoting sustainable practices, cities can move towards a cleaner, more sustainable future.

Keywords

Digitalization, recycle, urban area, waste management, waste segregation

Focus of study

Technological Innovation for LCD

Abstract ID 16

One-Step Synthesis of Biodiesel using a Simultaneous Adsorb-Transesterification System Assisted by Green Mussel (*Perna Viridis*) for Fisher Vessel Fuels

Nanda Delvina[1], Muhammad Ibnu Khawariz[1], Rindi Kirani[1], Wara Dyah Pita Rengga[1]

[1]State University of Semarang, Semarang, Indonesia

Abstract

Increased fuel demand leads to an energy crisis. The solution to the problem is to use biodiesel as an environmentally friendly and renewable fuel from used cooking oil processed using methanol and catalysts through transesterification. Catalysts, such as calcium oxide (CaO) heterogeneous base catalysts from green mussel shells, are important in biodiesel production. This research aims to analyze the results of characterizing green mussel shells' physical and chemical properties (*Perna Viridis*) and their performance in making biodiesel. This research used the continuous transesterification method. The variables of this research include the calcination temperature of the catalyst and the variation of a mole of methanol used in cooking oil—preparation and manufacture of CaO using cooking oil purification, biodiesel synthesis, consumption and emission tests. The calcination process of green mussel shells took place at 850°C, 900°C, and 950°C for 4 hours. Furthermore, the transesterification process was carried out at 65°C for 3 hours with a methanol ratio of 16:1, 18:1, and 20:1 and a catalyst weight of 5% (w/w). The best biodiesel has an acid number of 0.3 (mg KOH/g), viscosity of 3.05 mm^2/s, and density of 850.3 (kg/m^3); this biodiesel was obtained using a catalyst calcined at 900°C and scanning electron microscope-energy dispersive x-ray (SEM-EDX) analysis test resulted in Ca (57.83%) and O (42.17%) (w/w) content. GCMS test results showed that the maximum FAME content of biodiesel was 90-95%. The best biodiesel was obtained using a 900°C catalyst at an acid number of 0.3 mg KOH/g, a viscosity of 3.05 mm^2/s, and an 850.3 kg/m^3 density. These results have met SNI Biodiesel 7182: 2015. Biodiesel can reduce emissions by 22.4% and fuel consumption by the most due to its natural properties.

Keywords

Biodiesel, catalyst, green mussel, used cooking oil

Focus of study

Technological Innovation for LCD

Abstract ID 17

Green Synthesis of Tea Dregs-Based PGQD/GH Composite as Photocatalyst Material for Enhanced Hydrogen Gas Production through Water Splitting Method

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[1]State University of Semarang, Semarang, Indonesia

Abstract

Solar hydrogen production is very ideal as a renewable energy source, and graphene quantum dots (GQDs) have exhibited prospects to serve as photocatalysts for this process. There are several advantages of GQDs: biocompatibility, fluorescence and low toxicity. In the study of Tam et al. (2024), fabricated P-doped graphene quantum dots (PGQDs) and found PC3 bonding and tunable electronic structures, which resulted in observable photo absorption. The combination of PGQD and graphene hydrogel (GH) proved to be very stable and photocatalytic high hydrogen production rate demonstrated. GH acts as a good desalting membrane with porous structure, facilitates diffusion kinetics and enhances the transport of intermediates and electrolytes to the active sites. This combination resulted in a photocatalytic hydrogen production rate of 20.47 mmol/g/h, exceeded the yield of others obtaining compounds. However, the synthesis method used by Tam et al. (2024) did not utilize biomass precursors. In contrast, Abbas et al. (2023) presented a simple one-step synthesis of GQDs using green precursors from biomass residues and obtained a high quantum yield of 21%. Based on these results, the authors propose the synthesis of a new two-way synthesis, a PGQD/GH composite based on postharvest biomass precursors. This composite material holds great promise as a photocatalyst for the production of gaseous hydrogen using biomass waste as a precursor. This innovation has the potential to address dependence on fossil fuels by increasing hydrogen production through the water splitting method, supporting the transition to low-carbon development.

Keywords

Hydrogen, graphene quantum dots, photocatalyst, tea dregs, water splitting

Focus of study

Technological Innovation for LCD

Abstract ID 18

The Using Remote Sensing based Random Forest Algorithm to Retrieve Carbon Stock Value of Uncultivated Area

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[1]PT Kilang Pertamina Internasional, Jakarta, Indonesia

Abstract

Trees excel at capturing carbon, therefore reforestation can boost land's capacity to mitigate the effects of climate change. Moreover, trees can be utilized to generate economic value, such as oil palm which is notably one of the main traded commodities in Langkat Regency, North Sumatra, Indonesia. Recognizing these benefits, an idea emerged to develop a model which can predict the carbon stock of uncultivated land if it gets planted by palm oil. This model is made by using Random Forest algorithm on GIS and Remote Sensing data. The carbon stock of existing plantation areas is depicted using Landsat 8's Normalized Difference Vegetation Index (NDVI), as they are widely known to share positive correlation. On the other hand, the biophysical aspect is represented by Slope, Global Precipitation Measurement, Land Surface Temperature from Landsat 8, and soil types from the Indonesian Ministry of Agriculture. There are more than 1 million pixels of oil palm in the study area, thus stratified random sampling is used to accommodate any characteristics of oil palm plantations in Langkat Regency. 7834 samples are chosen for training data while 3357 are set aside to conduct validation. Judging from the RMSE, the model produces moderate error (0.077), but Rsquare shows that only 48% of variations could be illustrated. Based on those tests, the model can be used to get NDVI tentative values of idle land, but the moderate value of Rsquare and RMSE need to be considered. Adding other vegetation related spatial data like GEDI datasets may improve the model.

Keywords

Carbon stock estimation, Landsat 8, random forest, remote sensing

Focus of study

Technological Innovation for LCD

Abstract ID 19

Unleashing the Potential of Land Use Carbon Projects for Low Carbon Development in Indonesia

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Abstract

Indonesia aims to reduce its greenhouse gas emissions by 41% by 2030 as part of its mitigation strategy to contribute to the Paris Agreement. In total, 741 million tons of CO_2^e emissions from agriculture and forestry need to be reduced by 2030. The objective of this study was to assess the opportunities and challenges of carbon projects in the agriculture, forestry, and land use (AFOLU) sector to achieve the emission reduction target in Indonesia. A review of carbon projects in the AFOLU sector was conducted using projects registered in the VERRA database. VERRA is the largest certification body for AFOLU carbon projects. The carbon projects were scaled up to estimate the area needed to implement mitigation strategies and compared to the total land cover for different land uses in Indonesia. Currently, five peatland and mangrove restoration carbon projects are registered. Of all the projects, the potential emission reductions will be 19 million tons CO_2^e per year and these projects need to be scaled up to 14 million ha of peatland and 37,747 ha of mangrove to achieve the mitigation reduction target. As the feasibility of upscaling these carbon projects is unknown, the potential for emission reductions in other AFOLU sub-sectors, such as crops and livestock, is still underdeveloped. Voluntary carbon market (VCM) can drive implementation of carbon projects to contribute to Indonesia's target for climate mitigation and adaptation. To escalate VCM, Indonesia requires a strong regulatory framework and institutional arrangement to attract investors of carbon projects.

Keywords

Agriculture, carbon projects, emission reductions, forestry, land use

Focus of study

Political Economy of LCD within Global North and Global South Dynamics

Abstract ID 20

A General Engineering and Economic Assessment on the Potential Impact of Nusantara on Kalimantan's Infrastructure

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Abstract

The new capital of Indonesia, Nusantara, being moved to Borneo, East Kalimantan, is expected to present large logistical challenges and is sure to have massive repercussions across the region. One of these repercussions is in the infrastructure development of the region; at the moment, East Kalimantan has a distinctive lack of transportation infrastructure, something that has greatly hampered economic development in the region. It is then of great interest to conduct an assessment into how the new capital city of Indonesia can affect the infrastructure development of the region, in which this paper is based on. The research questions of this assessment will be on how the building of Nusantara will affect Kalimantan in economic and engineering terms, and the decisions that need to be taken for it to flourish as the new capital city. The engineering assessment will be centered on the decisions that need to be made to develop the infrastructure for Nusantara and its neighboring cities to function well with the utilization of operation research and optimization, while the economic assessment will focus on the use of social and economic variables (e.g., labor) adapted to Indonesia, with the aid of similar case studies from other countries who have chosen to completely build new capitals (Brazil, Nigeria). It is hoped that this paper will encourage further research into the changes that East Kalimantan will face in the coming future.

Keywords

Case study review, development economics, infrastructure engineering, operation research

Focus of study

Economic and Social Implication of LCD

Abstract ID 23

Energy-Independent, Pollution-Free Cities: An Urban Development Model that Integrates Filtration Systems

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Abstract

The concept of creating "Energy-Independent, Pollution-Free Cities" was developed to address energy and pollution issues in Indonesia, particularly in urban areas. This concept aims to use clean local energy sources and support net zero emission. The integration of AI is recommended for managing smart technologies connected through the Internet of Things (IoT) with the goal of enhancing energy and environmental management in urban areas. In addition, various renewable energy sources will be utilized using technologies such as solar panels, wind turbines, and micro hydro. This will involve the utilization of smart meters, smart grids, smart buildings, smart transport, smart waste, and smart cities to enhance efficiency and convenience. In modern society, waste has become a common problem. Currently, technology has developed by burning it using an incinerator. The problem is the pollution that arises due to the burning. For this reason, an integrated system is needed in the filtration process. Initially, it detects and measures pollutant concentrations in real-time from exhaust emissions through IoT. Subsequently, it will be applied to each industrial plant using eco-friendly elements as adsorbents like *Jatropha multifida* Linn plants, zeolite, and activated charcoal. These materials effectively absorb, gather, and decompose pollutants from industrial exhaust gases. Finally, feedback loops via artificial intelligence are employed to enhance the system's overall efficiency. With the implementation of this concept, it is expected to improve community well-being, generate clean energy, and assist the government in achieving its objectives of decreasing greenhouse gas emissions while meeting sustainable development targets.

Keywords

AI, energy, filtration, IoT, pollution

Focus of study

Technological Innovation for LCD

Abstract ID 24

Shoreline change analysis to support coastal and community sovereignty in the Northern Coast of Java, Indonesia

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Abstract

Considering how huge Indonesia is as an archipelago with untapped potential, Indonesia has the opportunity to be a leader in carbon solutions in the world. However, climate change has proven to undermine state sovereignty and impact societies, as well as mangrove forests, which can store 4-5 times more carbon than terrestrial tropical forests, are increasingly threatened. Using the End-Point Rate (EPR) technique of the Digital Shoreline Analysis System (DSAS), we calculated the accretion or erosion rates to determine shoreline change over time at 5-m intervals along the shoreline stretch from 2000 to 2020 in the Northern Coast of Java Island. This study revealed that Demak coasts experienced the most dramatic erosion with an average rate of -8.96 m/yr, followed by Banten coasts including -2.21 m/yr of eroding rates. Aside from that, Banyuwangi has the highest accretion rates, up to 8.96 m/yr, due to the mangroves' protection. It has also been found that local people in this area also established mangrove forest tourism villages and developed products such as syrup, coffee, chips, and flour which contribute to both conservation efforts and economic well-being. However, rising sea levels, shoreline erosion, and human activities pose threats to both territorial and community sovereignty along coastlines. Therefore, it is crucial to map the coastline changes in Indonesia with its thousands of islands, persistent monitoring, and engage local governments and communities in order to protect the coast and plan effective mitigation and adaptation approaches where various stakeholders can enhance resilience strategies towards Indonesia's green laws for economic decarbonization as already adapted in Banyuwangi.

Keywords

Climate change adaptation, low-lying coasts, mangrove vulnerability assessment, sea level rise

Focus of study

LCD of the Built Environment

Abstract ID 25

Colchicine-Mediated Polyploidization, A Potential Way to Enhance the Carbon Capture Capacity of Euglena Sp.

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Abstract

The global awareness of finding solutions to reduce carbon gas emissions and their consequences is greatly enhanced. Approaches using microalgae organisms are emerging due to their high carbon capture capability. Microalgae can sequester CO_2 gas 10-15 times faster than higher plants. While Euglena's have an ability to capture CO_2 reaches 0.03-0.06% (v/v) of atmospheric carbon. In our current study, we develop Indonesian polyploid Euglena sp. isolated from Dieng Plateau (IDN-26) to enhance its carbon capture capacity. Cell was cultured at 0.1%, 0.5%, 1.0%, and 5.0% colchicine for 24, 48, and 72 hours. The study parameters included morphology (cell area, cell length, and cell width), growth cell (cell number, optical density, and cell biomass), ploidy level, and performance of polyploid. We hypothesize that colchicine induction in Euglena sp. resulted in increasing ploidy levels in line with acceleration to their morphological size, biomass, and carbon capture productivity. Although the research is currently in progress, our hypothesis is based on previous microalgal research where polyploidization can increase the astaxanthin production of *Haematococcus lacustris* (Le-Feuvre et al., 2021), the growth rate of *Dunaliela salina* (Nezhad and Mansouri, 2019), and the lipids and biomass of *Nannochloropsis oculata* (Rahmawati et al., 2023). Therefore, there is an excellent potential for polyploid Euglena sp. to have better carbon sequestration ability, more abundant biomass, and secondary metabolites product.

Keywords

Carbon dioxide, carbon sequestration, chromosome duplication, local strain, polyploid Euglena sp.

Focus of study

Technological Innovation for LCD

Abstract ID 28

CarbLoc: Carbon Location App Web-based Geospatial Low Carbon Emission Monitoring Application Utilizing Big Spatial Data

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Abstract

One of the international-scale issues currently faced by Indonesia is climate change. The rise in global temperatures due to massive carbon exposure is now unavoidable. Therefore, there is a need for a tactical approach to identify the distribution of carbon emissions locations in order to take concrete actions to reduce these emissions, as addressing them can only be done gradually given Indonesia's extensive territory. This research aims to develop a web-based geospatial application for visualizing the spatio-temporal calculations of carbon emissions along with personalized action recommendations for each region's policymakers. The use of cloud computing-based calculations with Big Spatial Data is a novel aspect of this research. Specifically, spatial data used includes MODIS Gross Primary Production (GPP) and MODIS Net Primary Production (NPP) satellite imagery. These datasets are then utilized for calculating Carbon Storage in each region of Indonesia. Based on the calculated carbon storage levels, Nature-based Solutions recommendations are provided as carbon sequestration implementations, such as creating city parks, rooftop gardens, vertical gardens, and peatland restoration. This application is expected to act as a Decision Support System for policymakers to effectively reduce carbon emissions and contribute tangibly to global warming mitigation.

Keywords

Big spatial data, carbon savings, climate change, decision support system, geospatial applications

Focus of study

Technological Innovation for LCD

Abstract ID 29

Sustainable Family Farming and Low-Carbon Development in Indonesia: Insights from Literature

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Abstract

In Indonesia, sustainable family farming and low-carbon development influence on reducing global warming. However, research on sustainable family farms that use a low-carbon technology are limited. In this study, we explore the sustainable strategies of low-carbon technology to sustain their business by analyzing the strengths, weaknesses, opportunities, and threats of family farms. We used a scoping review to map the literature and describe methods and tools employed to assess sustainable family farms and low-carbon development and SWOT analysis to develop a conceptual framework. The literature search included peer-reviewed research articles using online databases through Web of Science and Scopus. The study findings indicate that promoting sustainable family farming has strength factors such as motivation and knowledge of low-carbon farming practices. Weaknesses refer to the limited frequency of interactions of agricultural extension services, the lack of funds to finance purchasing technological advances, and the higher cost and time-consuming nature of organic treatments. The opportunities involve participation in agriculture extension and awareness among farmers about low-carbon agricultural technology. Threats represent the high cost of food forces farmers to prioritize fulfilling their own food needs rather than adopting low-carbon farming technologies and climate change. Furthermore, conventional fertilizers and pesticides are more affordable compared to organic fertilizers. Strategies develop to the agriculture extension through farmers field schools, motivate farming family members to adopt low-carbon technologies, and support from the government in agricultural technology.

Keywords

Family farming, low-carbon development, sustainability

Focus of study

Economic and Social Implication of LCD

Abstract ID 30

Understanding Indonesian Behavior to Change the Mindset for A Better Low-Carbon Future

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Abstract

Despite being the 16th biggest economy, Indonesia still relies heavily on commodity trading of natural resources to drive its economy. Palm oil and coal are the most exported commodities on a regular basis. Although the price of commodities is driven by international market, the majority of Indonesian tend to follow similar business model exporting natural resources instead of thinking different to start business with greater economic moat. Herd behavior of Indonesian is very strong due to sociocultural influence from the Chinese, Indian, and Arab. By taking advantage of Indonesian behavioral pattern, private and public sector could make better decision and influence the perspective of locals. Established public transportation in Jakarta is one example which the public sector could implement nationally to decrease vehicle ownership, meaning less carbon is emitted. Private sector providing ride-sharing also raises social awareness, that owning private vehicle is not necessary due to traffic jam and parking fee. Majority of Indonesian customers are price sensitive. Public transportation and ride-sharing are chosen by some middle to lower class Indonesian in Jakarta due to cheaper cost including accessibility. Although the fees are cheaper, most Indonesian prefer private vehicle regardless of higher cost of ownership, indicating perception or trust regarding public transportation should be improved. Implementing current technology is not always the best solution to handle the climate problem. Cheaper and proven solution are existed yet are not implemented due to misunderstanding of local behavior. Solution on developed country does not always transferable to solve problem in developing country.".

Keywords

Human behavior, Indonesia, low-carbon economy, society, value,

Focus of study

Economic and Social Implication of LCD

Abstract ID 34

Sukamade Light Village: The Impact of State-Owned Enterprises in Empowering Isolated Communities at Meru Betiri National Park

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Abstract

Sukamade is a remote area inside Meru Betiri National Park which is often forgotten in regional development. Local communities have difficulty accessing various basic needs. To meet electricity needs, they rely on diesel generators whose operational capacity is limited. Meanwhile, the use of fossil fuels in national park areas is contrary to conservation principles and SDGs in reducing carbon emissions. This condition is ironic considering that Sukamade has a world tourist destination beach that is always "sold" by the regional government. The situation improved when the Indonesian Electricity Company (PLN) entered Sukamade with its philanthropic foundation offering the Sukamade Light Village program. This research aims to analyze the impact of PLN as a state-owned enterprise in empowering isolated communities in Meru Betiri National Park through the Sukamade Light Village program. This research uses a qualitative type where data is collected through observation, interviews, and documentation. The research results show that the program produced several positive impacts. Apart from providing an electricity network in the jungle, this program also increases the welfare and environmental awareness of the community. This program provides access to capital and assistance for businesses such as souvenirs, culinary, and animal husbandry. This program is also integrated with environmental conservation efforts, such as reforesting turtle nesting locations with sea pandanus seedlings involving tourists. However, this program also indirectly produces negative impacts. 24-hour electricity makes teenagers addicted to gadgets and the internet. Therefore, local community leaders encourage teenagers to be more active in empowerment activities.

Keywords

Empowerment, low-carbon development, state-owned enterprises, Sukamade light village

Focus of study

Economic and Social Implication of LCD

Abstract ID 35

Deforestation Discourse Gap: Playing Devil's Advocate for Energy Transition through EV Supply Chain

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Abstract

The electrification of transportation supports low-carbon transition. The European Energy Agency states electric vehicles (EVs) emit 17-30% less carbon compared to fossil-fueled vehicles. However promising, EVs come from the extractive nickel industry. In Indonesia, the problem arises when there are different definitions of deforestation in regulations and standards. Some define deforestation only within the scope of primary forest, whereas others include secondary forest. Companies may choose to adhere to no-deforestation principles that address the definition that caters to their interest. Studying discourse entails interpretive research on how regulators, CSOs, and companies give meaning to deforestation in the nickel mining context. This study sources publicly available data both spoken and written (e.g., public discussions, policies, regulations, and corporate publications, interviews), exploring how discourse is produced and reproduced through language-in-use and the observed discursive practices (e.g., public discussions, consultancy, IRMA certifications, and RMI assessment). Discourse analysis helps to understand how text and practices conceptualize the reality of deforestation, regulate the conduct of others – in mining operations and compliance assessment, and maintain or challenge existing power structures – how the institutionalization of deforestation discourse keeps nickel companies legally operational. This allows investors, lenders, buyers, media, and the general public to be critical in holding the companies accountable for their non-deforestation compliance and commitment claims. Unacknowledging this discourse gap plays the devil's advocate in sustaining the unclean low-carbon development. Leveraging companies and negatively affecting the environment and the community, as the forest they socio-economically and culturally connect with can be legally converted into mining concession.

Keywords

Deforestation, discourse analysis, electric vehicle, energy transition, nickel mining

Focus of study

Economic and Social Implication of LCD

Abstract ID 36

Promoting RES-E Market Integration in Indonesia and Vietnam: Options from Liberalized System

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Abstract

Aligning with net-zero targets, penetrating high amount of Variable Renewable Energy (VRE) into the electricity grid entails balancing of inflexible supply and demand. Drawing on pertinent liberalized power system experiences, restructuring the energy sector from vertically integrated utility (VIU) into a robust market is a cost-effective way to procure flexibility sources. Despite the reform in generation assets, many developing countries in Southeast Asia preserve the monopolistic single-buyer (SB) arrangement which negates VRE integration. Combining literature review and insights from local stakeholders through two rounds of the Delphi method, this research examines and compares the case studies of Indonesia and Vietnam, where the state-owned utility enterprises predominate the power market as the sole off-taker. It also discusses balancing approaches implemented by Germany, Japan, UK, and US, that are feasible to be learned by both countries on their way to reform. Results indicate that despite having distinct market structures, the lack of mechanisms, regulations, and incentives to support market-based balancing options act as the common VRE integration barriers. Several recommendations were offered with an emphasis on promoting a fair marketplace for independent market actors. Incorporating multiple electricity trading arrangements, dynamic tariffs, harmonized regional markets, and “risky” remuneration policies are some key steps that will contribute toward short-term flexibility resources in Indonesia and Vietnam. It discloses that the current SB models are not sustainable in the long run to balance mainstream VRE. Lastly, achieving the national renewables target requires commercial integration before, if not simultaneously, grid integration.

Keywords

Energy balancing, market reform, power system integration, single-buyer

Focus of study

Political Economy of LCD within Global North and Global South Dynamics

Abstract ID 37

Assessing the Impacts and Dependencies towards Natural Capital Across the Supply Chain: EU Oil Crop Consumption and Nutrient Retention

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Abstract

Understanding how the consumption of goods and services across the global supply chain impacts and depends on ecosystems is crucial for low-carbon development. Existing approaches tend to focus solely on the measurement of impacts, for example carbon emissions, while rarely looking at measuring dependence. To address this gap, we propose a new method that is able to quantify the dependence of consumption activities from specific country – economic sector combinations towards certain ecosystems globally. The proposed approach is applied to the case of the EU's dependence towards nutrient retention (NR) provided by different ecosystems caused by the consumption of oil crops. We found that the "livestock products," "oil crops," and "other industries" as the most nutrient retention dependent economic sectors in the EU. Interestingly, this dependence can be primarily traced back from outside the EU, particularly in Latin America (21%), Asia (20%), and North America (16%). The proposed approach could empower policymakers to better grasp the implications of supply chain policies on NR, such as the potential shift in dependence towards nutrient retention from Asia to Latin America if palm oil is banned. While this study is limited by the number of economic sectors it covers, it enables the way for a more comprehensive assessment of NR across the global supply in the future. A development which is critical towards achieving a more equitable low-carbon development.

Keywords

Dependence, ecosystem, low-carbon development, nutrient retention, supply chain

Focus of study

Economic and Social Implication of LCD

Abstract ID 38

Geodesy for Sea-Level Rise Monitoring as a Bridge to Low-Carbon Development in Coastal Areas

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Abstract

Accurate sea level monitoring is crucial to understand climate change impacts and to develop effective low-carbon development (LCD) strategies. Yet, in the Global South, accuracy of the estimation is left to be desired, widely due to the sparse nature of the dataset. This study presents a novel geodetic approach that combines sea level rise (SLR) data from altimetry, vertical land motion (VLM) data from GNSS and relative sea level rise (RSLR) data from tide gauges on the northern coast of Java. Our results reveal that throughout the northern Javanese coast, the SLR is twice as high as global average (approximately 6 mm/year). The synergistic approach provides a more comprehensive understanding of sea-level rise in the region, as perceived by the residents. By analyzing these datasets, policymakers gain access to high-accuracy data, empowering informed decision-making for LCD strategies such as constructing sea wall for areas with the highest risk. The focus remains on prioritizing nature-based solutions such as wetland restoration, while optimizing existing infrastructure and minimizing environmental impact. This approach enables effective coastal protection, resource management and ultimately, a sustainable future.

Keywords

Climate change, low-carbon development, sea level rise, tide gauge

Focus of study

Technological Innovation for LCD

Abstract ID 39

The Green Race: Global South as Beneficiaries in Green Energy Transition from Great Power Competition

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Abstract

The end of the Cold War was marked with multiple significant changes to the international system. These changes include the rise of American unipolarity and the growth of global concern on the impending climate crisis. Since then, international political economy (IPE) scholars in IR have studied the implications of these developments. An important IPE study highlighted a conflict between clean energy policies and global trade regimes known as "renewable energy protectionism," hindering progress toward climate targets. Escalated trade tensions are expected to increase both the economic and political costs of deploying clean energy technologies. Conversely, we offer a different perspective and argue that the arrival of the U.S and China's great power competition in the 2010s and scientific innovations in clean energy generation has unexpectedly made green transition easier for Global South countries shown in the case of Namibia. Facing energy insecurities, Namibia switched its focus to solar by utilizing their high sunlight rates and is currently on track to be a regional green energy hub. This article employs an IPE framework providing us with tools to understand the impacts of contemporary industrial policy trends, and latest breakthroughs in renewable energy technologies driving it. As we analyze our thesis, the term 'Global South' will refer to decolonized nations located south of the 'Brandt Line,' that illustrate global economic disparities. While noting China's role in South-South cooperation, this article will narrow its focus on specific beneficial mechanisms (e.g., cost reductions, friendshoring initiatives) emerging from the U.S.-China competition.

Keywords

Clean energy, friendshoring, great power competition, green transition, industrial policy

Focus of study

Political Economy of LCD within Global North and Global South Dynamics

Abstract ID 40

The Culture of Waste Burning in Kangkung District: Challenges and Solutions Towards Low Carbon Development

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Abstract

The culture of burning trash in Kangkung District, Kendal Regency, Central Java is quite prevalent. Household waste is more often burned or thrown into rivers rather than managed through the Village-Owned Enterprises (BUMDes) responsible for waste management. Problem: During observations from 2019 to 2024, it was found that the residents of Kangkung District still have a habit of burning trash, which causes environmental and health problems. This phenomenon has led to high levels of air pollution, resulting in an increase in cases of Acute Respiratory Infections (ARI). Objective: This study aims to analyze the steps taken by the government and residents of Kangkung District in implementing low carbon development. Additionally, it seeks to identify the challenges and solutions faced in realizing this concept. Method: This research employs a descriptive qualitative method, with data collected through interviews and field observations. Results: Although some villages have addressed the issue of waste burning through BUMDes waste management, the practice of burning trash still occurs in most villages. In addition, there is a community initiative called PT Variegrow Inovasi Pertanian, which aims to empower residents to process waste into organic fertilizer instead of burning it. However, the implementation of these activities has been less than optimal due to the limited number of team members. Conclusion: BUMDes waste management and PT Variegrow Inovasi Pertanian are currently the frontline initiatives in realizing low carbon development in Kangkung District. It is essential to implement BUMDes waste management in all villages in Kangkung District to minimize the culture of burning trash.

Keywords

BUMDes, Kangkung district, organic fertilizer, river pollution, waste burning

Focus of study

LCD of the Built Environment

Abstract ID 42

The Assessment of the Levelized Cost of Energy Technologies on Renewable Energy Island Solutions Based-Low Carbon Economy

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Abstract

Pulo Aceh is an island which is part of Aceh province in Indonesia. The island presents unique water conditions influenced by variations is bay depth, water clarity, and escpecially the strength of currents in the “Aroih Cut” strait. This study explores the potential for developing underwater resources like tidal current energy, wave energy, Ocean Thermal Conversion Energy (OTEC) and above-sea resources such as solar and wind energy as renewable energy solutions for the island. The aim is to assess the economic feasibility of low-carbon technologies in the “Aroih Cut” strait area using the levelized cost of energy (LCOE) as a key parameter. The study results indicate that LCOE for hybrid renewable energy technology, combining onshore wind and large-scale solar, has the more cost-competitive range compared to LCOE for fossil fuel technologies. In contrast, the LCOE for ocean energy technologies, including tidal current, wave, and ocean thermal energy conversion, is relatively high and less competitive. However, the overall LCOE for the renewable energy island solutions remains within the cost-competitive range. The assessment concludes that the significant levelized cost of energy value for low-carbon technologies in the “Aroih Cut” case study in the cost-competitive range.

Keywords

"Aroih Cut" strait area, levelized cost of energy (LCOE), low-carbon technology, renewable energy

Focus of study

Technological Innovation for LCD

Abstract ID 43

Designing Interventions for Sustainability Awareness in Marginalized Community: PULI Program Tec de Monterrey-Chiba University

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Abstract

Sustainability and LCD have emerged as significant topics globally, however, achieving widespread sustainability education within a country requires substantial effort. In many developing countries, awareness of sustainability within marginalized communities remains uneven due to limited access to technology and educational opportunities. These communities often lack the privilege to consider sustainability, make environmentally friendly choices, or even comprehend the importance of such decisions. Their primary focus is on survival, with little belief in policies aimed at sustainability. Addressing sustainability awareness in marginalized communities necessitates tailored interventions that consider the challenges these communities face. In a case study conducted by the PULI program in the Campana Altamira community near Tec De Monterrey, Mexico, the community faces significant risks related to natural disasters and health issues due to topographical conditions, unregulated housing construction, and inadequate basic services such as water, drainage, lighting, electricity, and waste management. To enhance the quality of life in the community over the long term, sustainability and education are two crucial topics that the PULI program in the Campana Altamira community is addressing through the design of a long-term intervention using a looping framework. This framework is an iteration of the top-down bottom-up looping system education model, with the goal of influencing how children in Campana Altamira perceive waste and micro-manufacturing education. Through the implementation of targeted educational programs and interventions, there is hope that it will be possible to gradually shift mindsets towards sustainability and empower communities to make greener choices for a more sustainable future.

Keywords

Design for social good, intervention design, marginalized community, sustainability awareness

Focus of study

Economic and Social Implication of LCD

Abstract ID 44

A Case Study of Komodo Water: Harnessing Low-Carbon Technologies for Sustainable Development in Indonesia

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Abstract

Integrating technology in Indonesia's low-carbon development presents significant challenges due to its complexities. However, Komodo Water, a social enterprise offering sustainable water management solutions, demonstrates successful implementation of low-carbon technologies (LCT). The study was conducted in Papagarang, Messa and Rinca islands through in-depth interviews with 60 respondents comprising small-scale fishermen and distributors. It was supported by Water Energy for Food and aimed to collect data on income, food processed, water and energy saving. Komodo Water emerged from the paradox of a fishermen village in Komodo National Park lacking clean water despite its tourism fame. It provides solar-powered reverse osmosis for drinking water and a solar-powered ice block machine. To date, it has impacted over 10,000 people by creating local jobs and producing more than 120,000 gallons of drinking water and 65.2 tons of ice. Additionally, it contributes to resource efficiency by saving 53,009 kWh of energy, 572,144 liters of water, and reducing 40 tons of fossil fuel consumption annually. Local fishermen have extended their catch's shelf life by 16% and reduced fuel usage, promoting sustainable fishing practices. Success factors include understanding local needs, selecting LCT that addresses local challenges, and empowering communities to take ownership of the technology and its benefits. Partnering with external organizations for funding and support has further strengthened the initiatives. These findings highlight LCT's potential to drive sustainable development. Policymakers are recommended to prioritize investments in LCT that address local needs, foster community engagement, and provide financial and technical support for successful adoption and scaling.

Keywords

Community empowerment, Komodo water, low-carbon technologies, sustainable development, sustainable water management

Focus of study

Technological Innovation for LCD

Abstract ID 45

A Sustainable Waste Management Model: Examining the Success of Panggungharjo's TPS3R Program

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Abstract

Indonesia faces growing waste management challenges due to improper disposal and limited landfill capacity. In 2013, Panggungharjo Village launched its TPS3R Program in response to challenges like littering in waterways, infrastructure delays, limitations on small business licenses, and a lack of inter-agency collaboration. This research aims to identify key stakeholders in waste management and highlight the success story of Panggungharjo's waste management. The research employs a mixed-methods approach, consisting of a literature review to identify key stakeholders and the significance of their roles; recent scientific article to validate findings and provide insights into real-world implementation; Social Network Analysis (SNA) modeling to visualize relationships among stakeholders; and a comparison of waste management in general and in Panggungharjo. Results indicate that TPS3R fostered collaboration among stakeholders such as government agencies, the community, intermediaries, the private sector, and business entities. In addition, the success story of Panggungharjo is represented by the village government and business entities (KUPAS) as the most important stakeholders. Good practices continue to be followed by the private sector and community, leading to Panggungharjo being recognized as a successful example of promoting sustainable development, including reducing landfill waste by 80%, producing 550 liters of tamanu oil per month, and more. To sum up, this research highlights the optimization of stakeholder collaboration to enhance effectiveness in similar communities. On the other hand, potential improvements in Panggungharjo include connecting unconnected actors, developing biodigester management, and cooperating with the energy industry.

Keywords

Governance, impact, socioeconomic, TPS3R, waste

Focus of study

Economic and Social Implication of LCD

Abstract ID 46

Leveraging Indonesia's Demographic Bonus: Repurposing Shipping Containers for Low-Budget, Low-Carbon Development in Housing

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Abstract

Indonesian government aims to achieve significant economic growth by 2045 or also called as "Indonesia Emas 2045" by leveraging its demographic bonus. To efficiently utilize the productive age group, the government planned to increase employment opportunities through equitable development across the archipelago, consequently creating the need for adequate accommodation. One strategy to support this vision while reducing carbon emissions is to address housing needs with sustainable and cost-effective solutions. The study aims to synthesize an adaptive modular container housing system that explores the potential of replacing conventional workers' housing. It conducts a comparative analysis by examining several similar repurposed shipping containers projects and concepts to assess their feasibility and benefits, considering Indonesia's geographical and environmental conditions. The study findings show that (1) The Indonesian government allocates around 35 trillion rupiah for infrastructure and public housing for civil servants. There are 47 apartments expected to be completed by December 2024, and construction of 16.000 houses set to begin in September 2024 in the new capital city; (2) Effective thermal insulation is crucial for repurposing shipping containers as housing to enhance durability and comfort to the climate condition; (3) Modular design allows for rapid deployment, making it suitable for time-sensitive housing demands. The results can be implemented as a recommended alternative design for workers' housing in Indonesia, especially in the undergoing new capital city, Nusantara. Manufacturing shipping containers as housing provides a feasible solution that offer versatile, low-budget, and low-carbon alternatives that align with the nation's economic and environmental goals.

Keywords

Container reuse manufacturing, low-carbon modular housing, Indonesia's demographic bonus, sustainable urban development, temporary housing solutions

Focus of study

LCD of the Built Environment

Abstract ID 47

Dual Solution for Increasing Oil Recovery and Reducing Carbon Emissions: CO_2-Enhanced Oil Recovery

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Abstract

The transition to low carbon development is a challenge for the world today. One way to achieve low carbon development is by applying Carbon capture and storage (CCUS). One of the CCUS methods is CO_2-EOR. This method is carried out by injecting CO_2 in the oil reservoir. Apart from reducing CO_2 emissions at the surface, CO_2-EOR will also increase oil recovery. This research discusses the potential for CO_2-EOR in the South Sumatra Basin, Indonesia. In this basin there are more than 100 oil and gas fields, all of which meet the criteria for CO_2-EOR. The aspects studied are geology, petrophysics, related literature studies, and distance to CO_2 sources. From a geological aspect, the South Sumatra Basin has been proven to effectively store large amounts of oil through its trapping mechanism. This condition causes CO_2 to be stored well in this basin. From a petrophysical aspect, the rocks that form the reservoir in this basin have good porosity which causes a large CO_2 storage capacity in this basin. In terms of distance, this basin is located with CO_2 sources, such as the Muara Enim power plant and several gas fields which produce CO_2 gas as a contaminant. This will result in lower costs and reduce problems in sending CO_2 to the South Sumatra Basin. From the research results, CO_2-EOR can increase oil recovery by 600 million barrels by injecting 243 million tons of CO_2.

Keywords

CCS, CCUS, CO_2-EOR, carbon reduction, enhanced oil recovery

Focus of study

Technological Innovation for LCD

Abstract ID 48

Tannin and other Phenolic Compounds Feed Additives to Reduce Methane Byproduct of Rumen

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Abstract

The objective of this article review is to determine the effects of tannin and other phenolic compounds inclusion in rumen digestion, mainly the reduction of methanogenesis and other benefits given, such as better proportions of unsaturated and saturated fatty acids in the rumen and the overall health of the animal. Recent (no less than 5 years) studies about the usage of phenolic compounds in ruminants will be reviewed. These studies are found in various sources (e.g., Science Direct) by searching the keyword combinations of "tannin", "methanogenesis", "rumen", and “phenolic compounds". These studies would then be reviewed by comparing the functional compounds included, methods including sources of functional compounds, results including methane yield in treated groups, and other beneficial effects. Reviewed studies have shown that the inclusion of phenolic compounds reduces CH_4, CO_2, and N_2O byproducts in ruminants. Some have shown higher proportions of omega 3, 9, and 12 PUFA (polyunsaturated fatty acids) in rumen that could affect beef and dairy end products. Tannin and other phenolic compounds could reduce methanogenesis in rumen while giving other benefits, such as increased unsaturated fatty acid composition in the end products of ruminants. This could address the growing carbon (and greenhouse gas) emissions in the future while also improving the quality of beef and dairy by increasing the unsaturated fatty acids that are beneficial to human health while providing a good source of animal protein.

Keywords

Feed additive, methane, phenolic compounds, rumen, tannin

Focus of study

LCD of the Built Environment

Abstract ID 49

Life Cycle Assessment of Rapeseed Oil Production and Packaging in Germany

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Abstract

Rapeseed oil is in great demand due to its consistent growth and competitive cost, making it a sustainable and versatile option in the volatile global vegetable oil industry. Production is expected to keep growing, resulting in greater environmental impact. Moreover, most rapeseed oil is packaged in polyethylene terephthalate (PET) bottles. This contributes to plastic waste, with only a small percentage recycled. In regard to these environmental concerns, this study uses a Life Cycle Assessment (LCA) with OpenLCA 2.0.3 and the Ecoinvent database version 3.8 to assess the environmental impact of rapeseed oil production and packaging in Germany. The assessment focuses on cradle-to-gate using midpoint indicators of global warming, fossil resource scarcity, marine ecotoxicity, and human carcinogenicity. The findings show that producing 1 liter of rapeseed oil contributes 2.87 kg of CO_2eq to global warming and 0.57 kg to fossil scarcity. The rapeseed oil production also impacts marine ecotoxicity by 0.23 kg of 1,4-DCB and human carcinogenicity by 0.24 kg of 1,4-DCB. Production phase, which includes cultivation and harvesting, is responsible for most of these impacts. The study analyzes different packaging materials and extraction processes, concluding that plastic bottles have lower environmental impacts in the production phase than glass due to lower energy consumption. In terms of extraction, the hot press method is less harmful to the environment than the cold press method. This LCA emphasizes the need to consider different environmental factors and feasible alternatives while producing and packaging rapeseed oil to reduce environmental impact.

Keywords

Environmental impact, life cycle assessment, rapeseed oil packaging, rapeseed oil production

Focus of study

Technological Innovation for LCD

Abstract ID 50

Hot Dip Galvanizing – A Long-Term Investment in the Built Environment

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Abstract

Steel as a main component in constructions contributes significantly to carbon emissions. Hot dip Galvanizing aims to reduce these emissions by setting a standard such as process optimization, green and high purity zinc usage, focusing on the 3Rs, and public awareness to Hot dip Galvanizing as a sustainable investment. Hot Dip Galvanizing could significantly prolong the lifetime of steel products. Analyzing the various methods to create a protective coating around steel could evaluate its effectiveness and impacts on reducing carbon emissions through its long-term benefit. This research uses a mixed-methods approach. Integrating qualitative analyses of steel projects using a variation of protection methods and quantitative calculation in the lifespan of construction projects. Many findings show that implementing Hot Dip Galvanizing is the best method to prolong the longevity of Steel products in construction as most industry standards are around 30-60 years of usage before it is recycled or reused. Its recyclability rate from production, end-of-life process, and byproducts has a 99% return rate. It has also shown that it is effective in implementing LCD practices and as an investment in the long term. Some difficulties in utilizing Hot Dip Galvanizing are a lack of awareness of its benefits, a higher initial cost, and less profitability in the short term. Low Carbon Development and Hot Dip Galvanizing are intertwined in promoting sustainability and reducing emissions in construction which has been proven in countless construction projects. Adopting this method of steel protection would align with the broader goals of Low Carbon Development.

Keywords

Hot dip galvanizing, mixed method research, niche industry, recyclability and reusability, sustainability in infrastructure

Focus of study

LCD of the Built Environment

Abstract ID 51

Positioning Urban Sprawl Research Discourses from Broader Perspectives

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Abstract

Urban sprawl presents environmental, economic, and quality of life challenges. This research aims to analyze urban sprawl through an integrated theory, examining its implications for land management and urban planning. It blends neoclassical, behavioral, structural, institutional, and evolutionary perspectives to elucidate the spatial dynamics and decision-making processes that drive urban growth. The research methodology involves a literature review to integrate these theories, followed by a critical analysis of current theories. This process highlights their limitations and proposes an integrated approach. The results reveal that urban expansion is not solely the outcome of rational economic decisions. Rather, it's an interaction of various factors, including perception, politics, technology, social structure, and innovation. For instance, the interplay between rational choices and regulatory frameworks, where government regulations influence rational economic decisions. For example, low taxes or subsidies in suburban areas incentivize rational investment decisions in those regions. The study identifies gaps in current urban expansion theories, particularly their failure to integrate dynamic factors. Consequently, it suggests a more comprehensive approach, incorporating theories from diverse fields, to better comprehend the factors propelling urban expansion. The study enriches the urban sprawl discourse by providing a framework that unifies different theoretical perspectives. It proposes a new, integrative approach to the interconnected nature of urban growth and changes in urban systems. This framework not only enhances academic understanding but also serves as a foundation for policy makers and urban planners aiming to understand and effectively regulate urban growth, thereby mitigating the adverse impacts of urban sprawl.

Keywords

Behavioral, evolutionary, institutional, neoclassical, sprawl, structural

Focus of study

LCD of the Built Environment

Abstract ID 52

Community-Based Renewable Energy Financing: Opportunities and Challenges

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Abstract

At least 4,400 villages in Indonesia are currently unelectrified. If by electricity, we mean electricity whose development and distribution is carried out by Perusahaan Listrik Negara (PLN), then more villages and households that are not yet electrified can be found. Ironically, electricity production is excessive on the one hand, but on the other hand, many villages do not have access to electricity. One of the factors that cause many areas not yet electrified is because the power plant is built centrally using fossil fuels. At the same time, Indonesia has great potential for renewable energy. The abundant potential of renewable energy is very adequate if only used to produce electricity to meet the community's electricity needs. Based on the background, this article explains the potential and challenges of large and ubiquitous renewable energy whose generation can be done and owned by the community. To accelerate the implementation of renewable energy generation at the community level, looking deeper into funding opportunities is necessary. One of the funding opportunities for community-based renewable energy is sourced from the village budget. The increase in village funds in the 2024 State Budget to 71 trillion IDR will be a strategic opportunity for communities, especially village communities, to develop small-scale renewable energy. However, it must be realized that the village fund allocation policy for renewable energy has several challenges related to human resource capacity, financial accountability and transparency, and program bureaucracy. This needs to be anticipated by the relevant government to optimize the use of the special budget.

Keywords

Collaboration, community, financial, regulation, renewable energy

Focus of study

Economic and Social Implication of LCD

Abstract ID 53

Optimizing Hybrid Wave and Solar Power Systems for Sustainable Energy in Remote Indonesian Communities

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Abstract

The lack of electricity availability in Indonesia's rural areas causes serious problems that impede growth. Combining and optimizing a hybrid energy system of solar power plants and wave power generator have high probability to ward off the problems. Enhancing energy output, reducing the amount of land required for ground-mounted solar arrays, and boosting the dependability of the energy supply are the main goals. Utilizing the complimentary qualities of solar and wave energy, wave generators provide continuous energy supply by producing power at night and in low light. Wave breakers are another function of wave generators, which prevent erosion in coastal locations. The methodology involves analyzing the energy potential from both wave and solar, by developing an optimization model to determine the ideal capacity for each component of the system. Wave generator was simulated by ANSYS, solar power by HelioScope, and optimizing them using MATLAB. The simulation parameters secondary data from selected areas in Indonesia, considering wave height, solar irradiance, and local energy consumption patterns. The optimized hybrid system beats solitary power systems, resulting in a remarkable increase in potential energy production. The presence of wave energy reduced the land area available for solar panels by up to 40%. Furthermore, the dependability of the energy supply improves. Wave power generators are also useful as coastal wave breakers, protecting the shoreline. In overall, integrating and optimizing wave and solar power systems offers a viable and efficient solution for sustainable energy to remote areas in Indonesia, supporting local development, educational, and coastal protection.

Keywords

Hybrid energy systems, remote Indonesian communities, solar power plants, sustainable energy optimization, wave power generators

Focus of study

Technological Innovation for LCD

Abstract ID 54

Determinants of Carbon Emissions in Indonesia from 1990 to 2020: An Error Correction Mechanism (ECM) Approach

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Abstract

According to the 2020 World Research Institute Report, Indonesia occupies the fifth position among the world's largest carbon emitters. This study aims to analyze the long-run and short-run impact of Foreign direct Investment (FDI), Gross Domestic Product (GDP) per capita, and Renewable Energy Consumption (REC) on carbon dioxide emissions in Indonesia. The analysis used in this study is time series regression using the Error Correction Mechanism (ECM) approach. The ECM method is used with the consideration that this analysis is able to cover many variables in analyzing long-term and short-term economics and this model is able to find solutions to non-stationary variable problems and spurious regressions. The data used in this study has been transformed to meet the main requirements for the ECM method, namely stationary data at the first difference or in the same order. The short-term equation model (ECM) formed is as follows:

$$\Delta\widehat{Ln\_Co2}_t = 0{,}009 + 0{,}00000189\Delta Ln\_FDI_t + 0{,}0295 Ln\_GDPcap_t - 0{,}6608\Delta Ln\_REC_t^* - 0{,}2223 ECT_{t-1}^*$$

The research shows that in the short-run only REC has a significant negative impact on the increase of carbon dioxide emission in Indonesia, while the FDI and GDP per capita have no significant impact. The REC has a coefficient of -0.6608, which means that a 1% increase in REC will decrease carbon dioxide emissions by 0.6608%. Based on the results of the research, the Indonesian government can intensify the importance of renewable energy consumption among the public to reduce the increase in carbon dioxide emissions.

Keywords

Carbon dioxide emissions, foreign direct investment, gross domestic product per capita, renewable energy consumption

Focus of study

Economic and Social Implication of LCD

Abstract ID 55

Cost-Effective and Energy-Efficient Inverter Off-Grid Solar Power Plant: Packed U-Cell 7-Level Inverter with Fuzzy Logic Controller to Regulate Output Voltage

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Abstract

One of the most essential and cost-significant components in a solar power plant is the inverter. Hence, one of the ways to reduce the green premium of the solar power plant is by using the most cost-effective yet energy-efficient inverter. Intermittency is another aspect that held back the solar power plan. Its dependence on the sunlight makes its energy production fluctuate. To reduce the price and boost the energy efficiency, the Packed-U Cell (PUC) Multilevel Inverter (MLI) with Fuzzy Logic Controller (FLC) is deployed in this research. With the same output voltage level, which is 7 levels, it requires a lesser number of switching components compared to other inverters. This reduces the cost of production of the PUC 7 level. To examine the voltage output stability, an intermittent scenario was presented by changing the input voltage gradually. The result shows that with the same level of voltage output but only with 6 switches, the PUC MLI hardware production is cheaper at 43.7% compared to the older MLI. PUC is also reducing the total harmonic distortion to only 19% without filter. This research also discovers that the FLC enables the inverter to maintain the voltage output at 97.6% of its desired value in fluctuated input, which represents intermittence. Hence, cost-effective and energy-efficient solar power inverters can be achieved with PUC MLI embedded with FLC.

Keywords

Fuzzy logic controller, green technology, multilevel inverter, solar power plant

Focus of study

Technological Innovation for LCD

Abstract ID 56

Mainstreaming Energy Sustainability (SDG 7) as a Strategy to Accelerate the Achievement of Sustainable Development Goals in West Java Post-COVID-19

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Abstract

The United Nations has launched seventeen Sustainable Development Goals (SDGs). Post-COVID conditions show the importance of sustainable ecosystem development. The researcher offers this research as a guide to direct the post-pandemic scenario to a sustainable strategy with energy sustainability to play an important role in realizing the SDGs in West Java. The analysis in this study begins with an assessment of the impact in the energy sector with its effect on progress towards sustainability. To realize energy implementation, a qualitative analysis was carried out with a parallel approach from the main point of view of the renewable and sustainable energy transition, digital sector energy transformation, and energy affordability in post-COVID West Java. The SWOT-AHP hybrid methodology is used to identify the importance of each strategy or problem that must be prioritized immediately in post-COVID West Java. This research also discusses energy sustainability from the perspective of political bodies and policy makers, and actual scenarios with the help of process tracking methods. In addition, a new quantitative analysis was created to show the interaction of the SDGs. The results show that SDG 7 is a set goal compared to other SDGs. Energy mapping towards sustainable development needs to be achieved. Therefore, ranking the SDGs through energy sustainability shows that sustainable West Java development can be realized after the pandemic. However, changes in market energies, investment preferences, and decisions influenced by political bodies in post-COVID West Java are decisive in achieving the SDGs within the allotted time frame.

Keywords

Energy policies, energy sustainability, renewable energy transition, sustainable development goals (SDGs), West Java

Focus of study

Economic and Social Implication of LCD

Abstract ID 59

Sustainable Energy Transition in Indonesia: Developing the Conceptual Framework

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Abstract

The transition to sustainable energy is a key element of Indonesia's development plan, which pursues a balance between social justice, environmental protection, and economic prosperity. As one of Southeast Asia's largest emerging economies, Indonesia has unique potential and challenges in transitioning energy to a more sustainable system. Along with increasing the share of renewable energy (RE) in Indonesia's energy mix, improving technological efficiency, lowering emissions, and implementing fair access are essential. Furthermore, to achieve a standardized quality of such RE, a comprehensive index covering a number of just transition-related in the energy sector is underscored. This preliminary research focuses on a semi-quantitative index generation, including a bibliometric analysis and literature review. 104 possible indicators were generated by extracting secondary data from 380 scientific publications on Dimension.ai covering ten Sustainable Development Goals (SDGs) and 14 research categories. Findings are filtered based on predefined parameters, such as year of publication, field of study, and SDG component. From these results, four components, grouped into 15 categories, are highlighted under the capacity pillar of the sustainable concept: environment, economy, and social impacts. Moreover, the policy aspect is also featured in this research as a pivotal concept. Ultimately, this index will serve as further insights for multidisciplinary stakeholders with multifaceted instruments to assess Indonesia's readiness for a sustainable energy future.

Keywords

Economy, energy, environment, social policy, sustainable energy transition

Focus of study

Economic and Social Implication of LCD

Abstract ID 60

Bridging the Divide: A Framework for More Equitable and Inclusive Climate Action

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Abstract

While the Global North Countries prioritize the carbon reduction strategies and promoting their solution to the global south countries. The global south countries, particularly those facing economic hardship, are still focusing themselves on high inflation, poverty and food security. The top 10% of global emitters were responsible for about 48% of all emissions, while the bottom 50% were only responsible for almost 12% of all emissions, implies that the global south countries often categorized as least developed countries have contributed far less to the global carbon footprints.

This disparity fact brings inequalities in the carbon sector to the surface. The Global South and the Global North face different realities, especially different resources, capacities and priorities on the political agenda. Over the past decades, many carbon reduction strategies have been suggested in the global discussion. However, the Global South Countries often feel excluded in the decision-making process of global action in carbon sector. Yet they also experience the increased extreme weather events.

This qualitative study, using document analysis like media reports and policy documents from credible sources, aims to identify key actions to achieve global climate goals while acknowledging historical responsibility and diverse needs of the Global North and South. By examining the perspectives from both regions, the gap in priorities can be bridged and inclusive solutions can be created. The solution to the problems might lie in other perspectives, not only from the first initiative of Global North Countries. Moving forward, let's reduce our carbon footprints with equity and inclusion.

Keywords

Climate equity, global climate cooperation, historical responsibility, inclusive climate solutions, North-South divide

Focus of study

Political Economy of LCD within Global North and Global South Dynamics

Abstract ID 61

Build to Last: Pioneering a Sustainable Transport Infrastructure Framework Towards Carbon Zero in PPP Project of TOD Poris Plawad Case

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Abstract

A critical necessity of urban area expansion is the development of transport infrastructure, leading to massive investment needs in this sector. However, this growth is always simultaneous with the environmental impact of construction sectors on GHG emissions. Despite this challenge, the emerging Public-Private Partnership (PPP) scheme for creative funding of infrastructure projects often put sustainability considerations into the end of attention as well as TOD Poris Plawad, a solicited initiation of mixed-use building with integrated bus terminal and railway station. This research aims to initiate a comprehensive sustainable infrastructure framework in the PPP workstreams of TOD Poris Plawad: planning, design, tender, procurement, construction, operational, maintenance, and transfer. The methodology comprises Causal Loop Diagram to know sustainable transport infrastructure indicators interconnection across regulations and research studies, scoring the consolidated indicators while comparing Dhoho Kediri and Banyuwangi Airport toward TOD Poris Plawad, analyzing environmental impact reduction, and conducting a cost-benefit analysis to comprehend the potential CAPEX optimization. The results show that the PPP TOD Poris Plawad is a feasible project that complies with 67% indicators in planning, but needs to be evaluated in the design workstream that only 23% and remaining 6 stages compared to other projects; with design comparison, the estimated reduction of GHG Emission is 38.31 Tonnes CO_2 Eq, SO_2 (0.20 µg/Nm^3), NO_2 (10.23 µg/Nm^3), CO (694.3 µg/Nm^3), TSP (52.7 µg/Nm^3); obtaining 2B Rupiah efficiency; and the most important thing is ensuring the internal government reviews PPP project quantitatively.

Keywords

Planning, PPP Project, solicited, sustainable transport infrastructure, TOD

Focus of study

LCD of the Built Environment

Abstract ID 63

Automated Eco-House: Sustainable Energy by AI-enabled Hybrid PVT Panels for Decarbonization

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Abstract

The construction and operation of the built environment contributes significantly to greenhouse gas (GHG) emissions, accounting for approximately 26% of total GHG emissions and 37% of combustion-related emissions (McKinsey Sustainability, 2023). According to McKinsey report, space heating and water heating are major contributors to household emissions, representing 53% and 22% of total household emissions, respectively. The challenges of non-renewable energy usage and high cost need a solution to achieve the net-zero emissions. Photovoltaic thermal (PVT) panels offer one such solution. However, PVT system that has been widely used, require manual activation, which limits their efficiency. Through Automated Eco-House system, the panels will be automatically operated and integrated to Artificial Intelligence (AI) that can significantly enhance the performance. AI enables remote monitoring and control, ensuring that PVT panels operate optimally. By automating PVT panels, the system's efficiency increases by up to 25% compared to manual operational and cut carbon emissions by up to 92% compared to natural gas heating systems. Through subscription-based service model, the system provides flexibility of integrating with cloud computing, enabling efficient remote monitoring and control. In conclusion, the Automated Eco-House system combines the Photovoltaic Thermal (PVT) panels with the Artificial Intelligence (AI) to achieve energy optimization. This solution could significantly support decarbonization and transition towards net zero emissions, paving the way for a more sustainable future.

Keywords

Artificial intelligence, cloud computing, energy optimization, household emissions

Focus of study

LCD of the Built Environment

Abstract ID 65

Community Spaces for Learning in Papela Fishing Village, Indonesia

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Abstract

Indonesia faces unique challenges in its rural areas due to its geographical situation. The southernmost island, Rote Island in East Nusa Tenggara, lies the Papela Fishing Village, a hub point for fishers from various regions. This study aims to identify the fundamental issues and needs of Papela Village to develop suitable architectural solutions considering its social complexity and unique requirements. The research uses a multi-method approach, including government data, academic research, and field observations. Qualitative and participatory urban research methodologies facilitate collaboration with local stakeholders and residents to establish trust and conduct a comprehensive analysis. The objective is to create sustainable intervention proposals that can drive village development and growth, addressing immediate challenges while ensuring long-term resilience and prosperity for the Papela Fishing Village community. Livelihood is identified as a central concern in the research, with three principal aspects emerging: education, economic development, and quality of life. Architectural interventions using local materials, like lontar palm trees, support sustainable development. These structures are tailored to local needs, such as a laboratory for exploring alternative livelihoods and a forestry program for sustainably sourcing building materials. These initiatives aim to foster a sustainable economic cycle, ensuring resource availability and promoting low-carbon development in Papela over the long term. This study provides a comprehensive framework for addressing Papela Village's immediate and long-term challenges, promoting sustainable growth and improved livelihoods.

Keywords

Community, development, education, livelihood, sustainable

Focus of study

LCD of the Built Environment

Abstract ID 66

Transnational Governance of Public-Private Partnership in Low Carbon Development Initiatives

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Abstract

Digital technology innovation is a new global dilemma between improving global trade cooperation through more sustainable business practices. Carbon emissions have been stated as a main issue during the digital implementation. Thus, many discussions developed to make sure the technology comes as a solution to carbon reduction. As one of the global poli-crisis, climate change has influenced many countries to strengthen the National Determined Contributions (NDCs) with various initiatives, such as the low-carbon development (LCD) approach. The design of low-carbon development can be connected to many sectors, such as city infrastructure and planning, corporate responsibility, also social development. Multi-actors must be involved in climate governance by implementing LCD initiatives, including government, private sector, non-government organizations, and local community/society. The connection between all actors shows the complexity of relationships that support the LCD implementation, starting to increase the Public-Private-Partnerships (PPP) in gaining the investment, developing the regulation framework, and implementing the LCD initiatives as a part of NDCs journey. The dynamic partnership in the digital era truly happened through an agile strategy to involve the digital aspect as a principal factor. During the implementation, power relations will affect the whole low-carbon development journey, especially with the presence of dominating global north countries in the global order. Finally, transnational governance should be focused on maintaining all actors involved in the low-carbon development initiatives.

Keywords

Carbon emission, digital innovation, public-private-partnership, transnational governance

Focus of study

Political Economy of LCD within Global North and Global South Dynamics

Abstract ID 67

Carbon Sequestration Valuation in the Forestry Sector for Fiscal Resilience

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Abstract

The forestry sector is crucial in providing environmental benefits, mitigating climate change, and supporting sustainable development goals. Achieving these objectives requires substantial funding for various activities, making the state's role in fiscal implementation essential to ensure public finances for climate action in line with economic stability and growth. This responsibility is undertaken by the Ministry of Finance, which formulates fiscal policy, and one of the potential areas to create fiscal space is through asset valuation in the forestry sector, particularly in conservation forests. In doing so, the valuation is conducted by Government Valuers at the Directorate General of State Assets Management (DGSAM), under the Ministry of Finance, Republic of Indonesia. Carbon valuation in the forestry sector aims to determine the value in conservation forest areas using a quantitative approach. At the first stage, Valuers collect and analyze data by using remote sensing at the specific area of the forest and then validate the dataset by doing field surveys for collecting the data of trees. Second, Valuers need to develop and conduct survey scenarios to estimate non-marketed ecosystem services; and for the final process, mathematically to calculate the carbon sequestration multiplied by carbon price. As the report of this valuation, policymakers are provided with much-needed information on the public value of the carbon sequestration in the forestry sector. The results provide a monetary value for potential fiscal space, particularly in public finances, which the Ministry of Finance can use to inform fiscal policy and manage the State Budget.

Keywords

Carbon Sequestration, fiscal, forestry, valuation

Focus of study

Economic and Social Implication of LCD

Abstract ID 68

Permeable Reactive Barrier for Acid Mine Water: A Sustainable Mine Water Conservation, Achieving the Low-Carbon Transition in Mining Industry

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Abstract

The need for critical minerals is rising swiftly, especially for lithium, cobalt, graphite, and other key minerals necessary for creating clean technologies. Most techniques used for mining critical minerals today need substantial amounts of water for mineral processing. However, the waste resulting from this activity presents several difficulties, such as acid mine water. Acid mine water contains a mix of organic carbon, nitrogen, and other pollutants, which can lead to the emission of greenhouse gases during the biochemical treatment process. In this study, an innovation proposed to prevent and reduce contaminants in acid mine water into surrounding water sources or the ground surface with Permeable Reactive Barrier (PRB) technology. The concept of PRB is to use physical porous media with certain chemicals through chemical, biochemical and geohydrological processes. This research uses a descriptive analytical qualitative method with data collection techniques in the form of literature studies. The framework integrates analysis of heavy metal content in acid mine water, selection of reactive media, creation of PRB design and generating economic opportunities for improving water efficiency from the technology itself. The result is that PRB can significantly reduce the acid and heavy metal content in acid mine water and can be used again for mining circular process. PRB shows possible synergies between strategies for mine water management and green processing schemes, which could be leveraged to achieve specific reductions in water use, carbon emissions and cost efficient for mining companies.

Keywords

Acid mine water, critical minerals, heavy metal, PRB, water efficiency

Focus of study

Technological Innovation for LCD

Abstract ID 69

Atelier Pirogue Architectural Design of a Participatory Plastic Upcycling Centre in Ganvié

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Abstract

Atelier Pirogue is an architectural project set in the lake-town of Ganvié, Benin, in West Africa. The project proposes a solution to several concerns that the town faces such as plastic waste, shortage of timber for building boats, the main transport in Ganvié and lack of basic public goods. The methodology implemented is an evidence-based and participatory social architectural design, involving a remotely conducted investigation of the trash supply, spatial morphology of the village, local socio-economic structure and practice, local custom as well as climatic conditions. Examples of community recycling initiatives were referenced, and interviews with local residents as well as international experts in plastic recycling were carried out to support a holistic design approach. The result is a community center for the participatory recycling of plastic. The design attempts to provide a community center, in which local plastic waste is upcycled to create plastic boats. Furthermore, public education regarding plastic and recycling is provided to the community. In addition, an appropriate spatial program and business model were conceived to institutionalize Atelier Pirogue and sustain the functioning of the building. The challenges Ganvié faces with plastic waste are common to many fishing towns and lake villages worldwide, including in Indonesia. This proposal offers a concept that could be implemented to address this ubiquitous problem in a sustainable way implementing the concept of circularity while creating value for local communities and rendering them more resilient.

Keywords

Architecture, participation, plastic, recycle, waste

Focus of study

LCD of the Built Environment

Abstract ID 70

Low-Carbon Energy Development Strategies for Small Hydropower in Indonesia

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Abstract

The growing demand for clean energy has driven global initiatives to accelerate the transition towards renewable energy sources. Indonesia is at the forefront of this transformation and is seeking innovative approaches to enhance its renewable energy capacity. With a potential energy generation capacity of over 75 GW from hydropower resources, Indonesia has significant untapped energy potential. However, constructing new hydroelectric infrastructures will raise environmental, social, and economic concerns, including increased carbon emissions during the construction phase. Therefore, this option may not be the most sustainable path to align with the low-carbon energy development. On the other hand, Indonesia has over a thousand weir structures nationwide with an extensive irrigation infrastructure used for agricultural purposes. These structures present an intriguing opportunity to leverage existing infrastructure for renewable energy generation by integrating small-scale hydroelectric turbines. This approach could significantly reduce the economic and environmental costs while serving the dual purpose of energy generation, electrification, and water management. However, there are challenges associated with structural-technical feasibility, grid integration issues, community acceptance, and policy support. Therefore, a well-designed strategy is needed to implement this sustainable energy transformation successfully. This study will explore the feasibility strategy with practical case studies in an ongoing project located at Serayu River Barrage in Central Java with a planned energy generation of 5 MW. This project can be a pioneer for future low-carbon energy development in Indonesia. In conclusion, this strategy can improve multipurpose river structures by supporting irrigation and energy generation, exemplifying a practical low-carbon development approach.

Keywords

Energy transition, hydropower, low carbon development, renewable energy, weir

Focus of study

Technological Innovation for LCD

Abstract ID 71

From Linear to Circular: Uncovering the Enablers and Barriers for Circular Economy Implementation in Indonesian Micro, Small, and Medium Enterprises

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Abstract

The circular economy (CE) has garnered significant attention due to its potential social and environmental advantages. However, CE implementation remains relatively rare, with many companies encountering significant obstacles. Therefore, understanding the drivers and barriers of CE implementation is crucial for developing an effective strategy to enhance its adoption. This present study aims to identify the barriers (lack of knowledge and skills, financial, government, and regulatory issues) and enablers (strategic orientation, green economic incentives, environmental commitment) of CE implementation in Indonesia's food and beverage (FnB) micro, small, and medium enterprises (MSMEs). Using an empirical survey, data were collected from a cross-sectional sample of N = 358 FnB MSME owners in Indonesia. The research instruments were analyzed using partial least squares structural equation modeling (PLS-SEM). Furthermore, circular economy practices, as the dependent variable, were measured by internal environmental management, eco-design, and corporate asset management. Extending the natural resource-based view theory, the results indicate that internal factors such as strategic orientation and environmental commitment are significant drivers of CE in MSMEs. Additionally, green economic incentives serve as external enablers for CE implementation, helping reduce the financial burden and encouraging MSMEs to invest in circular practices. On the other hand, the barriers for FnB MSMEs in Indonesia include a lack of knowledge and skills, financial constraints, and government and regulatory issues. Notably, the lack of knowledge and skills is identified as the most significant hindrance, limiting MSMEs' ability to adopt and get benefit from CE practices. To effectively transition from a linear to a circular business model, policymakers and entrepreneurs can utilize these findings to address barriers and strengthen the drivers of CE implementation. Implementing targeted policies, providing financial incentives, and offering educational programs are essential steps to support MSMEs in this transition.

Keywords

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Focus of study

Political Economy of LCD within Global North and Global South Dynamics

Abstract ID 72

Tackling the Solar Panels Waste Problem to Advance the Energy Transition: A Comparative Study of Indonesia and California

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Abstract

Solar development in Southeast Asia, particularly in Indonesia, has witnessed remarkable growth in recent years, driven by escalating demand and supported by adaptations in regulatory frameworks by Indonesia's Ministry of Energy and Mineral Resources. This reflects a broader regional shift towards renewable energy adoption. Despite this progress, Indonesia's installed solar capacity lags behind regional leaders like Vietnam, signaling significant potential for expansion. However, the rapid increase in solar installations has brought to the forefront concerns regarding the management of end-of-life solar panels. Proper handling of aging panels is crucial to mitigate potential environmental risks. California, a pioneer in solar energy with over two decades of experience, faces similar challenges in managing solar panel waste. The state, which saw a new solar project installed every minute in 2021, is actively developing recycling infrastructure to responsibly handle the anticipated surge in end-of-life panels. In Indonesia, while existing laws such as Government Regulation No. 22 of 2021 address environmental protection and waste management, specific regulations tailored to solar panel waste are still evolving. Recent guidelines introduced in 2022 focus on enhancing recycling processes, but comprehensive frameworks are yet to be fully established. Looking ahead, Indonesia's commitment to achieving Net Zero Emissions by 2060 underscores the urgency of effectively managing both hazardous and non-hazardous waste generated by solar panels. Drawing lessons from California's experiences can provide valuable insights into formulating robust waste management policies and establishing necessary infrastructure. This paper aims to explore these challenges and potential solutions regarding solar panel waste management in Indonesia. By examining current regulatory landscapes, international best practices, and the unique local context, this study seeks to propose recommendations for enhancing waste management strategies. Addressing these issues is pivotal for supporting Indonesia's ambitious renewable energy goals and ensuring sustainable development in the sector.

Keywords

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Focus of study

Political Economy of LCD within Global North and Global South Dynamics

Abstract ID 73

Biocharcoal from Community Household Wastes around PUSRI Factories

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Abstract

PT Pupuk Sriwidjaja Palembang (PUSRI) produces an average of ±30 tons of organic waste every month from water hyacinth in the gutter and around the Musi River, as well as dried leaves from the surrounding community household complex. Based on Indonesian Ministry of Environment Law No. 12 of 2023, biomass can be used for power plant purposes if it meets the suitable quality for co-firing. PUSRI's Creating Shared Value (CSV) team is determined to recycle this biomass into biocharcoal pellets made from these wastes, combined with 50% coal dust. These pellets are currently being used for household furnaces and electrical charging stations. Furthermore, biocharcoal with a GCV > 4,000 has the potential to be used for co-firing alongside primary conventional coal with a 0.5-1% usage rate, resulting in savings of 244,800,000 IDR per year due to reduced organic waste handling expenses and low production costs, which also generate circular economy benefits for the nearby community. Our team has successfully produced and utilized biocharcoal, currently using 0.5-1% in each firing in the Steam Turbine Generator (STG) Power Plant, with anticipated increased usage as our team ramps up biocharcoal production. Additionally, we are the first company among Indonesia's SEO fertilizer companies to implement co-firing in STG using agricultural waste.

Keywords

Agricultural residue, biomass, circular economy, co-firing, recycling

Focus of study

LCD of the Built Environment

Policy Briefs

Ministerial Talk

Financing Low-Carbon Development in Indonesia

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Introduction

Indonesia has voluntarily committed to achieving net-zero emissions by 2060 as part of its Nationally Determined Contributions (NDC), setting an ambitious target for its low-carbon transition [1]. This commitment is underpinned by three distinct development pathways within the Low Carbon Development Initiative (LCDI), which integrates economic growth with environmental sustainability to meet the nation's climate goals [2, 3, 4]:

- **Unconditional NDC** (Moderate Scenario): The Pathway taken through Indonesia's own efforts. Key actions include forest and peatland conservation, renewable energy adoption, and energy efficiency improvements.
- **Conditional NDC** (High Scenario): Under this scenario, Indonesia commits to higher reduction in emission, contingent on international financial and technical support. This approach scales up measures for ecosystem restoration and renewable energy expansion.
- **Long-term** (LCDI Plus Scenario): This pathway involves pursuing even more ambitious policies post-2024, including carbon pricing mechanisms, higher reforestation targets, and enhanced energy efficiency.

To achieve these goals, Indonesia has identified three critical sectors for decarbonization [2]:

- **Energy Transition:** Renewable energy's share is projected to grow from 8% in 2015 to 23% by 2030 and further to 40% by 2045. This shift includes reducing reliance on coal and accelerating investments in solar, wind, and geothermal energy.
- **Land Use and Forestry:** Policies, such as extending moratoria on mining and peatlands, aim to protect approximately 41.1 million hectares of primary forests, focusing on peatlands and mangroves.
- **Agriculture and Food Systems:** Land productivity is expected to grow by 4% annually while promoting sustainable agricultural practices to reduce environmental impacts.

The LCDI High Scenario envisions substantial socio-economic gains for Indonesia. By 2045, the country could sustain an annual Gross domestic product (GDP) growth rate of 6.0%, adding over 5.4 trillion USD to its economy. It also has the potential to create more than 15.3 million greener, higher-paying jobs, safeguard 16 million hectares of forestland, reduce poverty to 4.2% of the population, and prevent 40,000 deaths annually through improved air quality. However, achieving these outcomes requires significant financial commitments, with an additional 8 billion USD in annual investments from 2020 to 2024 and 30 billion USD per year from 2025 to 2045 [2].

The principle of common but differentiated responsibilities (CBDR), adopted under the Kyoto Protocol in 1997 [5], underscores the obligation of developed countries to support low-carbon development in nations like Indonesia. This principle recognizes the historical contributions of industrialized nations to global emissions since the Industrial Revolution. Currently, around 75% of global embodied emissions stem from land-use changes, with substantial transfers occurring from lower-income countries such as Brazil, Indonesia, and Argentina. These emissions are largely directed toward industrialized regions, including Europe, the United States, and China. In 2017, Brazil ranked as the leading net exporter of land-use emissions, followed by Argentina, Indonesia, Thailand, Russia, and Australia. On the consumption side, China was the largest net importer of land-use emissions that year, followed by the United States, Japan, Germany, the United Kingdom, Italy, South Korea, and Saudi Arabia. [6].

Despite the increasing share of emissions from Global South nations, the consumption patterns driving these emissions remain concentrated in the Global North [6]. This disparity underscores the critical need for developed countries to provide financial, technological, and institutional support to ensure a just and effective transition to low-carbon economies worldwide. Bridging this gap is not merely an ethical imperative but a shared responsibility essential for global climate stability and equitable progress.

State of Indonesia's Climate Commitment

Since the adoption of the Paris Agreement, Indonesia has consistently committed to enhancing its greenhouse gas reduction targets through its NDC, starting in 2016. As of 2024, the NDC has been revised twice to set increasingly ambitious goals. The first NDC set an emission reduction target of 29% unconditionally and 41% conditionally. Indonesia's most recent NDC (2022) aims for a 31.89% reduction against the Business as Usual (BaU) scenario through its own efforts, and up to 43.20% with international support [2, 3, 4].

The majority of the emission reductions are expected to come from the Forestry and Other Land Uses (FOLU) sector [3, 7], which is responsible for approximately 60% of the total reduction target. In 2021, Indonesia also submitted its Long-Term Strategy for Low Carbon and Climate Resilience 2050 (Indonesia LTS-LCCR 2050), which outlines the country's commitment to peaking greenhouse gas emissions and achieving a net carbon sink in forestry and land use by 2030, with the goal of reaching net-zero emissions by 2060 or sooner [8]. The emission trajectory from FOLU highlights key emission sources such as peat fires, peat decomposition, and deforestation, while carbon sinks are projected to come from annual plantations, secondary forest regeneration, afforestation/reforestation, and plantation forests [7]. According to this trajectory, emissions from peat fires are expected to peak in 2030, while emissions from deforestation and peat decomposition will continue to decline until 2050 [7, 9].

The Ministry of Environment and Forestry reports that over the past three decades, Indonesia's net deforestation rate has decreased by 8.4% between 2021 and 2022, with a 14.1% reduction in gross deforestation [9].

State of Financing LCD in Indonesia

According to Indonesia's third Biennial Update Report, the country requires approximately 281 billion USD (equivalent to 4,002.43 trillion IDR) to meet its unconditional NDC target and around 285 billion USD to fulfill its conditional target, as outlined in its climate commitment. However, Indonesia’s financial capacity is estimated to range from 2.3 billion USD to 12.14 billion USD, covering only about 5% of the total funds needed. The energy and transportation sectors account for the largest portion of the financial requirements, with an estimated need of 245 billion USD, followed by the forestry sector, which requires 21.68 billion USD [10].

International assistance plays a critical role in helping Indonesia achieve its climate targets. In this regard, Article 9 of the Paris Agreement [11] acknowledges:

- The specific needs and special circumstances of developing countries, particularly those highly vulnerable to the impacts of climate change.
- The necessity of supporting developing countries to effectively implement the Paris Agreement.
- The longer timeline needed for developing countries to reach peak greenhouse gas emissions.

While Indonesia remains classified as a developing country, it is important to note that it has achieved upper-middle-income status. Over time, this new classification may require the country to contribute more to global emission reductions, given its aspiration to reach high-income status. Furthermore, during the Ministerial Talk, Mr. David Tantow from BMZ emphasized that Germany has acknowledged Indonesia as a 'Global Development Partner,' underscoring the country's expanding role in global climate action.

Role of International Cooperation

Indonesia receives financial support from various international climate funds, managed under specific national authorities. Key sources include the Green Climate Fund (GCF), Adaptation Fund (AF), and Global Environmental Fund (GEF), which play a vital role in supporting sustainable forest management, climate change mitigation, biodiversity conservation, marine protection, and sustainable agricultural practices. Additionally, sector-specific mechanisms such as REDD+ Results-Based Payments (RBPs) provide incentives for verified emission reduction activities in the forestry sector [12].

Beyond climate funds, Indonesia collaborates with international organizations such as UNDP, UNEP, the World Bank, and the Asian Development Bank (ADB) to access technical assistance, facilitate knowledge exchange, and secure funding for climate-related initiatives. Bilateral partnerships also play a crucial role in strengthening Indonesia’s climate resilience. Countries including Norway, Germany, Japan, the United States, and Australia provide direct support for capacity building in climate action. A notable example is the Indonesia-Norway Agreement on REDD+, which contributes to the implementation of Indonesia’s FOLU Net Sink 2030 plan [12].

Between 2021 and 2022, international financial support for Indonesia's climate initiatives totaled 1.78 billion USD, comprising 200.29 million USD from bilateral sources, 1,505.45 million USD from multilateral institutions, and 76.57 million USD from commercial banks. The five largest contributors were the World Bank, ADB, AIIB (Asian Infrastructure Investment Bank), Japan, and Germany. Loans accounted for the majority of financing at 95%, while grants made up only 5% [12].

- ***Bilateral Climate Financing***

Among bilateral contributors, the largest funding came from JICA Japan (156.82 million USD), followed by KfW Germany (43.38 million USD), AFD France (0.09 million USD), and Norway (0.02 million USD). The Ministry of Public Works and Housing received the highest allocation (164.96 million USD) for irrigation, watershed management, and basic infrastructure development. Other allocations included:

- Ministry of Forestry – 19.57 million USD for forest programs
- Ministry of Industry – 3.16 million USD for technical assistance
- Ministry of Transportation – 12.51 million USD
- National Research and Innovation Agency (BRIN) – 0.09 million USD for multipurpose research vessels [12].

- ***Multilateral Climate Financing***

Multilateral support was dominated by contributions from the IBRD (World Bank Group) – 751.92 million USD, ADB – 479.52 million USD, and AIIB – 216.82 million USD. The majority of multilateral financing (1,446.97 million USD) was provided through concessional loans, while 58.46 million USD came in the form of grants.

Loan financing was allocated across key adaptation sectors:

- 529.80 million USD – Adaptation initiatives
- 397.36 million USD – Economic resilience
- 122.89 million USD – Ecosystem and landscape resilience
- 9.55 million USD – Social resilience

Grants were primarily directed towards:

- Forestry – 27.73 million USD
- Energy – 0.21 million USD
- Cross-cutting initiatives – 0.66 million USD
- Adaptation for livelihoods & economic resilience – 2.16 million USD
- Basic health services (Pamsimas project) – 27.70 million USD

Additionally, the World Bank provided 0.66 million USD in technical assistance to support Indonesia’s Environmental Fund Management Agency [12].

This financial landscape underscores the crucial role of international partnerships in supporting Indonesia’s climate agenda, with a predominant reliance on concessional loans rather than grants. While these funds contribute to key climate adaptation and mitigation efforts, continued collaboration and diversified funding sources remain essential for achieving Indonesia’s long-term sustainability goals [12].

Support from German Government

Germany is Indonesia's largest bilateral development partner in Southeast Asia, with German Development Cooperation identifying three key focus areas for collaboration:

- Training and sustainable growth for decent jobs
- Climate and energy
- Protecting natural resources as a basis for livelihoods

Under the climate and energy pillar, Germany is one of Indonesia's most significant development partners, particularly in advancing renewable energy and climate-friendly infrastructure [13, 14]. To support Indonesia's Just Energy Transition Partnership (JETP), the German government has committed approximately 1.5 billion EUR in funding. Launched during the G20 Summit in Bali on November 15, 2022, JETP is a joint initiative between the Indonesian government and the International Partners Group (IPG), co-led by the United States and Japan. The partnership aims to mobilize 20 billion USD in public and private financing to accelerate Indonesia's shift toward a low-carbon energy sector [15]. Key objectives include capping emissions and increasing the share of renewable energy to at least 34% of total power generation by 2030, aligning with the global 1.5°C temperature target [1]. Given Indonesia's growing energy demand and rising greenhouse gas emissions, international cooperation plays a crucial role in achieving these goals.

In the area of natural resource protection, German Development Cooperation actively supports Indonesia's FOLU Net Sink 2030 Strategy, which aims to reduce greenhouse gas emissions and enhance rural livelihoods by preventing deforestation and forest degradation. Through the Forests and Climate Change Programme (FORCLIME), Germany contributes to mangrove and peatland conservation, forest protection and rehabilitation, and climate adaptation measures. The program also promotes sustainable silviculture methods, including the development of non-timber forest products, to support local communities while preserving Indonesia's forests [16].

Enhancing Self-Sufficiency in Climate Action

As discussed earlier, while the principle of Common but Differentiated Responsibilities (CBDR) is widely recognized in global climate policy, Indonesia's ability to achieve its climate targets independently remains crucial. The unpredictability of international politics, shaped by the inherently anarchic nature of global relations, means that developing countries like Indonesia cannot fully depend on sustained international support. During the Ministerial Talk, H.E. Arief Havas Oegroseno addressed that the key element of this self-reliance is establishing sustainable financing mechanisms to reduce dependency on external funds. By leveraging green taxation, public-private partnerships, and sustainable bond programs, Indonesia can secure long-term financial resources for climate initiatives.

Several notable efforts have been undertaken to support this approach:

(1) Climate Budget Tagging

As reported in Indonesia's 5th Biennial Assessment and Overview of Climate Finance Flows, the government has introduced a system for identifying and tracking ministry budgets allocated to climate-related projects aligned with the NDCs.

This initiative has enabled the creation of innovative financing instruments, such as green sukuk and blue bonds, which serve as alternative funding sources for environmentally sustainable projects [17].

(2) Public Funding Instruments

Indonesia has explored various sustainable finance mechanisms, including:

Green Bonds (Frankfurt, EUR-denominated)
Samurai Bonds (Tokyo, JPY-denominated)
Green Sukuk, SDG Bonds, and Blue Bonds

Unlike Green Bonds, which fund general environmental projects, Blue Bonds specifically finance activities related to ocean protection and improved water management [18]. During the plenary session of Green Financing and Sustainable Investments for Low Carbon Development, Indonesia Climate Change Trust Fund (ICCTF) highlights a significant financing gap in sustainable marine management, as the state budget covers only 20-25% of the required funding.

(3) Carbon Trading

In 2023, Indonesia launched the Indonesia Carbon Exchange (IDXCarbon), providing a regulated platform for trading carbon credits. It includes four market types: regular market, negotiated market, auction market, and marketplaces, supporting the Voluntary Carbon Market (VCM) [19]. In January 2025, Indonesia expanded this system to enable international carbon trading, allowing the country to trade carbon credits globally [20].

Additionally, another potential opportunities for climate finance are as following:

(4) Carbon Tax: A Long-Term Potential for Climate Finance

A carbon tax is a levy imposed on greenhouse gas (GHG) emissions, primarily from fossil fuel consumption, to incentivize emission reductions and generate sustainable funding for climate initiatives.

Several countries have successfully adopted carbon taxation as part of their climate strategies:

- Sweden's carbon tax as of 2025 is at 134 EUR per ton of CO_2, for most fuels with 100% fossil content, for example natural gas or coal [21].
- Canada implements a carbon pricing system, with rates starting at 80 CAD per ton of CO_2 in 2024, set to increase over time. A portion of the revenue is redistributed to citizens through rebates [22].
- Singapore introduced its carbon tax in 2019, starting at 5 SGD per ton and set to increase to 50-80 SGD per ton by 2030 to drive industrial decarbonization [23].

Indonesia has acknowledged carbon taxation as part of its environmental policy framework, yet full implementation remains challenging due to concerns over economic competitiveness, industry preparedness, and regulatory infrastructure. However, if effectively designed, a carbon tax could serve as both a crucial tool for emissions reduction and a sustainable revenue source for the country's green transition.

Currently, the legally mandated tax of 30 IDR per Kg-CO_2e under National Law No. 7/2021 is too low to drive meaningful change, especially compared to Singapore's significantly higher rate of 294 IDR per Kg-CO_2e. Without a strong baseline tax, entities lack incentives to cut emissions or engage in carbon trading at effective prices. To address this, Indonesia must urgently implement and progressively increase its carbon tax, ensuring higher rates for larger emitters and an annual increase of at least 10% or double the inflation rate. Moreover, without strict penalties, carbon trading could lead to market distortions, where entities deliberately slow emissions reductions to maximize profits. A well-structured and steadily rising carbon tax is essential to drive genuine, long-term emission cuts and support Indonesia's net-zero ambitions [24].

(5) Leveraging Private Sector Investments from Europe

During the plenary session of Green Financing and Sustainable Investments for Low Carbon Development, Ms. Antje Biber from FERI Group highlighted another promising opportunity to attract private sector financing from European financial institutions. The Corporate Sustainability Reporting Directive (CSRD) and European Union (EU) Taxonomy impose strict regulatory requirements on businesses operating in the EU, mandating them to analyze, report, and disclose their sustainability activities [25, 26]. To comply with these sustainability reporting obligations, European financial institutions are expected to increase investments in biodiversity conservation, sustainable land use, and climate-positive projects in the Global South.

This regulatory shift presents a strategic advantage for Indonesia, offering opportunities to secure international funding through:

- Carbon credit markets
- Reforestation initiatives
- Sustainable agriculture projects

By aligning its climate and sustainability initiatives with EU regulatory priorities, Indonesia can position itself as an attractive destination for green investments, unlocking new financing channels to accelerate its transition to a low-carbon and sustainable economy.

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Plenary Session 2

Carbon Capture, Storage, and Removal: A Pathway to Low Carbon Development

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Introduction

As Indonesia advances toward a sustainable future through its Low Carbon Development Initiative (LCDI) launched by the Ministry of National Development Planning (Bappenas) [1], balancing economic growth with substantial greenhouse gas (GHG) reductions has become increasingly critical. The LCDI framework emphasizes natural carbon storage through the preservation of Indonesia's forests, peatlands, and mangroves, which serve as significant carbon sinks [1]. These nature-based solutions align well with Indonesia's rich environmental resources. However, they may not be sufficient alone to meet Indonesia's ambitious Nationally Determined Contribution (NDC) targets, including a 43% reduction in emissions by 2030 [2].

While Carbon Capture, Storage, and Removal (CCSR) technologies are globally recognized as essential for addressing emissions particularly in hard-to-decarbonize sectors [3] the current LCDI policy summary does not specifically reference these industrial carbon management techniques [1]. Incorporating CCSR into the framework could add a crucial layer of resilience by capturing emissions directly from industrial sources, power plants, and agriculture, thereby complementing renewable energy, efficiency measures, and ecosystem-based approaches.

Understanding CCSR: Definition, Technologies, and Current Approaches

Definition & Scope:

Carbon Capture, Storage, and Removal (CCSR) includes a range of technologies designed to reduce CO_2 emissions [3,4]. These include:

- **Carbon Capture and Storage (CCS):** Capturing CO_2 from sources like power plants and storing it underground [3].
- **Carbon Capture and Utilization (CCU):** Repurposing captured CO_2 for industrial applications [4].
- **Direct Air Capture (DAC):** Removing CO_2 directly from the atmosphere, albeit at higher energy costs [3,4].

State of the Art:

Today's approaches combine both technological solutions and nature-based strategies. Technological CCSR is essential for sectors where emission reductions through conventional measures are challenging, while nature-based solutions such as afforestation, soil carbon sequestration, and wetland restoration, offer accessible and cost-effective means of carbon absorption [7,8,9]. Presenting both options without explicit preference allows for a balanced view that recognizes each method's role in a comprehensive low-carbon strategy.

LCDI Framework and the Role of CCSR

The LCDI outlines several development scenarios that demonstrate how low-carbon pathways can sustain economic growth up to 6% GDP growth, while creating green jobs and preserving natural resources [1]. Integrating CCSR technologies can further strengthen each scenario by addressing emissions from sectors that natural carbon sinks and renewable energy may not fully mitigate. Here's how CCSR could play a role in each scenario:

- **LCDI Moderate Scenario:**

  Aims for a 29% reduction in emissions by 2030 through improved energy efficiency, expanded renewable energy, and land use policies focused on protecting forests and wetlands [1]. CCSR could selectively capture emissions from high-intensity sectors like cement and steel production, where conventional measures face challenges [3]. Introducing pilot CCSR projects may also lay the groundwork for broader implementation as technologies mature [4].

- **LCDI High Scenario:**

  Targets a 43% reduction in emissions by 2030, in line with Indonesia's conditional NDC targets that depend on international support [2]. In this scenario, CCSR technologies can address residual emissions, such as those from petrochemicals and fossil-fuel–reliant power plants, where further reductions via renewable energy or efficiency improvements may not be feasible [3,4]. Expanding CCSR could help Indonesia achieve or even exceed its NDC targets, especially with international funding and technical support [2,5].

- **LCDI Plus Scenario:**

  Envisions systemic policies including carbon pricing, enhanced urban carbon management, and significant investment in climate resilience [1]. In this context, CCSR can play a pivotal role not only by capturing industrial emissions but also by integrating with urban initiatives, for example, incorporating CCSR projects into waste management systems or energy-intensive infrastructures to reduce the carbon footprint of cities [6]. Such multi-level integration could position Indonesia as a leader in innovative low-carbon solutions [1,7].

Key Findings from the ICONIC 2024 Plenary: "Carbon Capture, Storage, and Removal: A Pathway to Low-Carbon Development"

These key points summarize insights from the Plenary Keynote Talks and Discussions held on September 3, 2024, at the University of Göttingen, featuring experts from Energy Academy Indonesia, TREEO, and Germanwatch:

Essential Role of CCSR for Net Zero:

- **CCSR is Indispensable for Achieving Net-Zero Emissions:**

  Critical for hard-to-decarbonize sectors like heavy industry and existing power infrastructure, CCSR supports low-carbon hydrogen production and delivers negative emissions, vital for sectors lacking cleaner alternatives [3,10].

- **Global and Regional Interest in CCSR is Rising:**

  There has been a significant increase in CCSR projects worldwide [3,4]. In the Asia-Pacific region, particularly in Japan, ambitious CCSR targets have been set, and Indonesia is emerging as a potential CCS hub with significant geological storage capacity [4,12]].

Challenges in CCSR Adoption:

- **High Upfront Costs and Limited Immediate Economic Returns:**

  Barriers exist due to the cost-effectiveness of freely emitting CO_2 without a structured carbon valuation system [5,12]. Establishing a comprehensive carbon valuation is essential to make CCSR economically viable [5,13].

- **Need for Subsidies and Incentives:**

  As seen in the UK and US, subsidies are necessary for making CCSR projects feasible given the high initial investments and energy demands [14,15].

Nature-Based and Technological CDR Pathways:

- **Emphasis on Nature-Based Solutions (NbS):**

  Nature-based solutions are among the most accessible and cost-effective in the short term [7]. Approaches like afforestation, soil carbon sequestration, and wetland restoration offer substantial CO_2 absorption potential [8,9].

- **Challenges with Technological Solutions like DAC:**

  While technological solutions are essential for sectors with limited alternatives, they face challenges due to high costs and energy requirements [4].

CCSR as a Complement to Emission Reduction Efforts:

- **Complementary Role of CCSR:**

  CCSR should complement rather than replace direct reduction strategies such as energy conservation and renewable transition [3,8]. A balanced approach that combines both nature-based and technological solutions is key to achieving net-zero [7,8].

- **Challenges of a "Just Transition":**

  Advanced CCSR technologies may be economically inaccessible to the general population and could divert resources from other critical social initiatives [16,17].

The Need for Regulatory Support:

- Current regulations, such as Minister of Energy and Mineral Resources (ESDM) Regulation No. 2/2023, restrict CCUS primarily to the oil and gas industry in Indonesia [11]. Broader regulatory frameworks are needed to support CCSR across diverse industries, making carbon capture more accessible and economically viable [11,18].

Policy Recommendation

- **Strengthen Regulatory and Strategic Frameworks:** Expand regulatory frameworks beyond oil and gas (amending ESDM Regulation No. 2/2023 [11,18]), develop a comprehensive National CCSR Roadmap, and integrate CCSR targets into Indonesia's NDC [2,5]. This unified framework aligns domestic measures with international climate commitments.
- **Implement Robust Economic Instruments:** Establish a carbon valuation system (e.g., carbon pricing mechanisms [5,13]) and provide targeted financial incentives such as subsidies, tax breaks, or grants to lower the initial investment barriers for CCSR projects [14,15]. These measures aim to make CCSR economically attractive and viable.
- **Foster Research, Innovation, and Collaboration:** Increase funding for research into both nature-based and technological carbon removal solutions [4,7] and encourage public–private partnerships to accelerate technology transfer and drive innovation in CCSR [4,15]. This will help ensure that policies are informed by the latest advances and best practices globally.
- **Enhance Coordination and Implementation:** Develop clear operational guidelines and establish coordination mechanisms among government agencies, industry stakeholders, and international partners [6,11] to ensure effective implementation and monitoring of the integrated low-carbon strategy. This coordination is essential for an effective and efficient policy rollout.

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Plenary Session 3

Decarbonizing Indonesia's Industrial and Transportation Sectors: A Pathway to Sustainable and Inclusive Growth

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Introduction

Indonesia's economic growth: achievements and environmental costs

Indonesia's rapid economic growth has significantly reduced the national poverty rate from nearly 20% to below 10% over the past two decades [1,2]. However, this progress has led to substantial environmental degradation, with the industrial and transportation sectors responsible for over half of the nation's greenhouse gas emissions [4,7]. Consequently, Indonesia faces severe climate-related risks, including increased flooding, drought, and air quality deterioration [1,3]. Projections indicate that by 2035–2044, an additional 1.4 million people could be exposed to extreme river floods [3,5], and over 4.2 million may encounter permanent flooding due to sea-level rise by 2070–2100 without effective adaptation measures [3,6]. As the population and economy are projected to grow sharply by 2045, decarbonizing these sectors is essential for sustainable development and reducing vulnerability to climate change impacts.

Unlocking economic potential through sustainable transport and industry transformation

To achieve economic growth while meeting sustainability targets, Indonesia should prioritize decarbonization in transportation and industry through the Low Carbon Development Initiative (LCDI). The transportation sector accounts for 45% of national energy consumption and approximately 28% of greenhouse gas (GHG) emissions [9,10]; thus, transitioning to electric vehicles (EVs) and enhancing public transport networks are crucial steps. Notably, road transport accounts for over 50% of these emissions, driven by an increase in vehicle ownership, particularly motorbikes and cars [7,12,17,18]. Indonesia aims to integrate 15 million electric vehicles by 2030, enhancing energy resilience and driving industrial transformation [13].

In addition, industries contribute over 30% of anthropogenic emissions, with significant challenges in accessing low-emission technologies [21,22]. Decarbonizing priority industries such as cement, metals, and textiles is essential for reducing emissions while supporting economic growth [17]. By implementing energy efficiency measures, Indonesia can sustain 6% annual gross domestic product (GDP) growth until 2045 [1,8]. Conversely, failure to adopt a low-carbon pathway may slow progress in health, education, and economic resilience, with a projected loss of 130 billion USD by 2024 and over one million more people living in poverty relative to the LCDI's high-growth, low-carbon scenario [1].

Key Findings from the ICONIC 2024 Plenary: "Decarbonizing the Industrial and Transport Sectors: A Pathway to Low-Carbon Development"

The plenary session ***"Decarbonizing Industry and Transportation Sectors: A Pathway to LCD"*** at ICONIC 2024, held on September 4, 2024, at the University of Göttingen, convened experts from the Technical University of Hamburg, PT Astra International Tbk, WPD GmbH, and QSI to discuss pivotal challenges in these sectors, aiming to accelerate the transition to a sustainable future. **The key findings are:**

Challenges and Strategies in Emission Reduction:

- **Resource Overconsumption and Energy Constraints**: Current global resource consumption, particularly in high-energy industries, exceeds Earth's regenerative capacity and is projected to increase by 60% by 2060 due to rising demand [19], highlighting the urgent need for a fundamental shift in energy use and resource allocation in the industrial and transport sectors to address these ecological imbalances.
- **Inherent CO_2 Emissions Across Production**: All forms of production, whether oil-based or utilizing green technologies, generate CO_2 emissions. Therefore, systemic innovations and process efficiencies are critical to decarbonizing production methods, particularly in carbon-intensive sectors like iron and steel industry [23].
- **Need for Broader Adoption of Eco-Effectiveness**: Decoupling economic growth from environmental harm through eco-effectiveness is crucial [24]. However, the adoption of eco-effective practices across global industries remains insufficient, making it difficult to achieve significant carbon emission reductions without more aggressive implementation.

Challenges in Renewable Energy Development:

- **Grid and Financial Barriers in Indonesia:** The growth of renewable energy in Indonesia faces significant challenges stemming from technical and contractual issues within the power system, as well as financial constraints [25]. These barriers hinder the efficient integration of renewable sources and pose obstacles to attracting necessary investments.
- **Intermittent Energy and Grid Constraints***:* Indonesia faces significant challenges in integrating large-scale renewable energy sources, particularly from intermittent options like wind and solar, due to its distributed grid structure. While renewable investments in the country have primarily focused on hydro and geothermal, wind and solar energy remain largely underdeveloped [26].

Emerging Solutions and Innovation:

- **Frugal Innovation:** Frugal innovations (FIs) emerge from grassroots initiatives in developing countries, leveraging unique business models to advance sustainable development [27]. Research suggests that these innovations can be significantly more efficient in energy production compared to conventional methods, showcasing their potential to address sustainability challenges effectively [28].

- **Circular Economy Models**: The circular economy is a production and consumption model that emphasizes sharing, leasing, reusing, repairing, refurbishing, and recycling materials and products to extend their life cycles while minimizing waste [29]. It is built on three core principles: eliminating waste and pollution, maximizing the circulation of products and materials to their highest potential, and regenerating natural systems [30]. By adopting these principles, the circular economy is projected to achieve a 70% reduction in emissions from vehicle materials by 2050, translating to a decrease of 285 million tonnes of CO_2 equivalent [30].
- **Sustainable Consumer Behaviour and Durable Goods**: Encouraging a shift in consumer behaviour toward durable, eco-friendly products presents a viable strategy for reducing waste and resource demands [31]. However, the higher cost associated with these goods poses a barrier to widespread adoption, necessitating supportive policies to enhance accessibility [32].
- **Sustainable Aviation Fuel**: Aviation contributes roughly 2% of global greenhouse gas emissions, with CO_2 from the sector projected to grow by 3-4% each year, highlighting the pressing need for solutions like Sustainable Aviation Fuel [33]. SAF, a liquid fuel compatible with current aviation engines, can reduce CO_2 emissions by up to 80% and could contribute up to 65% of the emissions reductions required for the aviation industry to achieve net-zero CO_2 emissions by 2050 [34].

Policy Recommendation

Indonesia's industrial and transportation sectors are pivotal to its economic growth yet are significant contributors to climate change. Despite recent initiatives, such as Presidential Regulation No. 112 of 2022, which aims for a 23% renewable energy share by 2025 and mandates biofuel blending, the results have been mixed, revealing a continued reliance on coal in the electricity sector over the next decade [17].

- **Enhanced Support for Circular Economy**: Policymakers should provide robust support for circular economy models to encourage resource-efficient strategies across industries, ultimately helping to reduce overall emissions from consumption and waste.
- **Improve Regulatory for Waste Management:** To strengthen Indonesia’s waste management policies and promote a circular economy, a regulatory framework should align with the Rencana Pembangunan Jangka Menengah Nasional (RPJMN/ Medium-term National Development Plan) 2020–2024 and Vision 2045. This framework must set clear targets for a 70% reduction in per capita waste and a 100% recycling rate for industrial wastewater by the net-zero target year, while also enhancing incentives for sustainable practices and raising public awareness on waste minimization and recycling [1].

- **Improving Emissions Tracking and Transparency**: Accurate emissions tracking according to the GHG Protocol scopes and enhancing transparency in reporting are crucial for effective emissions management. Improved data quality and standardized measurement methods will enable more accurate emissions reductions across supply chains.
- **Introduction of Carbon Tax**: To effectively mitigate greenhouse gas emissions in Indonesia's mining sector, the government should implement targeted policies aimed at reducing emissions alongside the introduction of a carbon tax. A moderate carbon tax of 25 USD per ton of CO_2 could lead to a 13% reduction in emissions, generate revenues equivalent to 0.7% of GDP, and support compensatory measures to offset economic costs, making it a viable strategy for enhancing environmental and economic outcomes [14].
- **Vehicle Incentive Scheme:** A sliding scale fee-and-rebate system, which charges higher fees for cars with excessive emissions while rewarding lower-emission vehicles with rebates, could facilitate a rise in the adoption of electric vehicles [9].
- **Accelerate Electric Vehicle Adoption Through Infrastructure Development and Incentives:** To facilitate Indonesia's transition to low-emission transportation, the government should enhance the Battery Electric Vehicle (BEV) program by providing targeted support for domestic battery and electric vehicle production, along with expanding charging infrastructure in residential, commercial, and public areas. Additionally, implementing tax incentives and financial support measures for private sector investments in charging stations will help lower installation costs, stimulate job creation, and maximize emissions reductions [17], while also aligning with recent updates in EV policy frameworks and related government mandates (Presidential Regulations No. 55 of 2019 and No. 79).
- **Implement a Gradual Phase-Out of New Combustion Engine Vehicles**: To align with its 2060 net-zero emissions target, Indonesia should implement a phased ban on new combustion engine cars and two-wheelers by 2040. This transition will promote the adoption of EVs, which are expected to offer lower total ownership costs and significantly reduce greenhouse gas emissions in the transportation sector [17,35].
- **Incentivize Sustainable Practices and Diversify Feedstocks in Biodiesel Production:** To enhance Indonesia's biodiesel policy under Decree No. 208.K/EK.05/DJE/2022 while mitigating environmental impacts, the government should incentivize sustainable land use and diversify biodiesel feedstocks [17]. Although the B35 target reflects a commitment to reducing fossil fuel reliance, the reliance on palm oil-based fatty acid methyl ester (FAME) raises significant environmental concerns due to land use changes that increase greenhouse gas emissions [36,37]. By promoting alternative feedstocks that avoid deforestation and peatland conversion, along with sustainable agricultural practices, Indonesia can meet its climate objectives without harming biodiversity or soil health [38,39].

- **Enhancing Public Transportation Usage through Behavioural Strategies**: To enhance public transportation usage and encourage active mobility in Indonesian cities, policymakers should implement awareness campaigns rooted in the Theory of Planned Behaviour [40]. By improving the public image of transit systems as safe, reliable, and convenient.

In conclusion, while Indonesia has made strides in decarbonizing its industry and transportation sectors through innovation and policy initiatives, enhancing public awareness about sustainable and frugal living is crucial for driving behavioural change. Greater emphasis on educating citizens about the benefits of reduced consumption and eco-friendly practices can complement existing strategies, ultimately fostering a more sustainable future for the nation.

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- Indonesia Population Projection 2015-2045 (BPS)
- Visi Indonesia 2045, 2019

Plenary Session 4

Reducing AFOLU-Emission: Balancing Development and Conservation

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Introduction

The ICONIC 2024 Plenary Session, “Reducing Agriculture, Forestry and Other Land Use (AFOLU) Emissions: Balancing Development and Conservation,” brought together leading experts to discuss Indonesia’s ambitious efforts to reduce emissions in the AFOLU sector. The AFOLU sector, which contributes around 60% of Indonesia’s overall greenhouse gas reduction target, is essential to the government’s Low Carbon Development Initiative (LCDI) and its commitment to achieving net-zero emissions by 2060. Through the LCDI, Indonesia aims to integrate sustainable land management practices and reduce deforestation rates to meet its emissions reduction goals. By 2030, the country has pledged to reduce its carbon emissions by 43.20% with international support or by 31.89% independently. However, balancing conservation efforts with development needs poses a dual challenge, especially given Indonesia's economic reliance on natural resources, including extensive agricultural and forestry industries.

To critically discuss this complex issue, the plenary session featured three distinguished speakers with deep expertise in forestry, indigenous rights, and international cooperation. Prof. Dr. Daniela Kleinschmit, President of the International Union of Forest Research Organizations (IUFRO) and a Professor of Forest and Environmental Policy at the University of Freiburg provided insights into global forest governance trends, discussing forest as the dominant solution for climate change. Rukka Sombolinggi, Secretary General of the Indigenous Peoples Alliance of the Archipelago (AMAN), highlighted the critical role of Indigenous communities and the importance of recognising Indigenous rights within climate policy frameworks. Georg Buchholz, Program Director of the Forests and Climate Change Programme (FORCLIME) at Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) shared perspectives on international collaboration and development to support Indonesia's forest policy progression. Together, these speakers provided a comprehensive view of the opportunities and challenges in achieving Indonesia's climate goals while promoting inclusive and sustainable development in the AFOLU sector.

The Role of Forests in Reducing Emissions in Indonesia: A Solution with Key Caveats

This policy brief begins by highlighting the potential of Indonesia's forests, particularly in reducing greenhouse gas emissions. Indonesia is the third-largest tropical forest country, following Brazil and the Democratic Republic of Congo. Approximately half of Indonesia's land area is forested, covering around 96.2 million hectares.

Additionally, the Indonesian government has designated 120.4 million hectares as state forest areas and aims to ensure these areas are fully reforested [2]. Indonesia is also ranked second among the most biodiverse countries in the world, hosting an incredible array of wildlife and plant species. This includes 1,723 bird species, 383 amphibians, 4,813 fish species, 729 mammals, 773 reptile species, and 19,232 vascular plant species [2]. In addition, Indonesia also holds almost a quarter of the world's mangrove - around 3 million hectares and 24.67 million hectares of peatland [1,2]. These huge areas of forest, special ecosystems and tropical climate contribute to a substantial role in climate change mitigation due to their ability to absorb carbon emissions. Acknowledging this potential, Indonesia has set an ambitious climate change target in its Nationally Determined Contribution (NDC). The forest sector accounts for around 60% of the total emission reduction, highlighting its significant role in Indonesia's climate change mitigation objectives.

However, achieving climate change mitigation targets through the forest sector will be faced with several caveats. Indonesia's forests are under significant pressure, primarily due to anthropogenic demands. This is because forests have multifaceted value, which often involves complex trade-offs across environmental, economic, and social dimensions. Forests provide a range of essential ecosystem services, from regulating local and global climates to supporting biodiversity and sustaining the livelihoods of millions of people. For example, there is an unsustainable trend in Indonesia's development that prioritizes economic goals while undermining social and ecological aspects, which has drawn considerable criticism [3,4]. On the other hand, there are also forest fires as recurring issues which are not only detrimental to the environment but also lead to financial losses and escalate into transboundary issues. [7]. Ultimately, forest conservation and restoration efforts often face competing pressures from economic development, land use change, and resource extraction. As a result, achieving the dual objectives of reducing emissions and promoting sustainable development requires navigating complex trade-offs. This brief aims to explore key trends worth noting to ensure forests are managed in a balanced and sustainable manner. During the iconic plenary session, we identified the most relevant trends for consideration.

Key Insights from the ICONIC 2024 Plenary: Reducing AFOLU Emissions: Balancing Development and Conservation

International Collaboration for Sustainable Development (Georg Buchholz)

The role of international cooperation in supporting forest conservation and development. International partnerships have played a crucial role in shaping Indonesia's forest policy, driving the development of climate change strategies and governance structures. Through collaboration, these partnerships enable the exchange of knowledge, resources, and best practices, enhancing Indonesia's capacity for forest conservation. Programs like FORCLIME emphasize capacity building and organizational development, strengthening forest governance and ensuring the effectiveness of environmental policies.

The principle of "Think Global, Act Local" is key, as it ensures that global solutions are tailored to local contexts, making strategies both effective and sustainable.

Lessons learned from FORCLIME and similar programs. Global partnerships, such as those through FORCLIME, have significantly advanced forest development in Indonesia, with Germany playing a key role in strengthening forest governance. Through capacity-building initiatives for the Ministry of Environment, these collaborations have contributed to the establishment of strategic frameworks like the Forest Development Strategy and the Dewan Pengawas Kehutanan (Forest Supervisory Board). Furthermore, Indonesia's pioneering efforts in developing Reducing Emissions from Deforestation and Forest Degradation (REDD+) have been supported by these international partnerships, highlighting the importance of cross-border cooperation in achieving sustainable forest management and climate goals.

Global Forest Governance and Climate Solutions (Prof. Dr. Daniela Kleinschmit)

Growing scope and ambition towards global sustainability targets. There have been growing global concerns regarding the climate change and sustainability issue. This led to increasing international mechanisms and processes to address deforestation, land degradation, and promote sustainable land-use practices. International and bilateral agreements such as the Paris Agreement, European Union Deforestation Free Regulation, and Global Tree Planting Target reflect a growing commitment to integrating forest into global climate action.

Increasing role of forests as a dominant solution for climate change mitigation. Forests are increasingly recognized as a dominant solution for climate change mitigation. The international mechanisms continue to reinforce forest roles as critical carbon sinks. Therefore, affecting policy priorities, funding allocations and international forest governance such as the growing carbon market and proliferation of carbon standards and verification systems. While this focus brings more attention and financial resources to forest conservation, it also risks simplifying forest governance by sidelining other important ecological and social aspects.

Shift of Decision-Making Beyond the Forest Sector. Forest governance is becoming increasingly complex as climate change mitigation, biodiversity conservation, and economic development intersect. While forests are vital carbon sinks, they also support restoration, rewilding, and biodiversity goals. Balancing these priorities requires careful trade-offs, particularly concerning the livelihoods of forest-dependent communities. Forests are also deeply linked to agriculture, infrastructure, and economic policies, making cross-sectoral governance essential. However, decision-making is shifting beyond the forest sector, with climate policies and international actors playing a growing role. Ensuring an integrated and equitable approach demands stronger coordination across sectors while balancing environmental and socio-economic objectives.

Forests are much more than carbon. Beyond their function as carbon sinks, forests support diverse ecosystems, cultural traditions, and food security, particularly for Indigenous communities. Indigenous territories are vital ecosystems, with 72% classified as key areas for biodiversity, water cycles, and climate resilience. Around 70% of their forest cover remains protected, showcasing Indigenous stewardship in maintaining some of the world's most intact forests.

Injustice against indigenous communities in the name of development and conservation. Indigenous peoples, despite being stewards of forests, are often excluded from decision-making processes, leaving them vulnerable to exploitation. In many cases, conservation efforts are used as a pretext to displace them. Protected area designations, reforestation programs, and carbon offset schemes are frequently implemented without their consent, leading to land grabs and forced evictions. In Indonesia, approximately 11.07 million hectares of Indigenous territories have been expropriated for development or conservation purposes. Around 4.5 million hectares of these lands are now designated as state-run conservation areas, further undermining Indigenous land rights and disrupting sustainable practices that have long preserved these ecosystems. Indigenous leaders and activists face severe repression, with 687 conflicts reported, resulting in the criminalization of 925 individuals, many of whom have been injured or killed while defending their land. The state's conservation efforts, often framed as environmental protection, exacerbate tensions by displacing Indigenous communities and restricting access to vital resources, ultimately undermining local governance and sustainable land management.

Current Regulation and Law remains to fail to Recognize Indigenous Rights. The recently adopted Indonesia Law on Natural Resources and Ecosystem Conservation (No. 32/2024) highlights significant shortcomings in its approach to recognizing Indigenous peoples' rights and participation. Key issues include the misallocation of carbon utilization, the wrongful criminalization of Indigenous individuals, and the expansion of conservation areas, which increases the risk of Indigenous communities facing legal persecution. Despite AMAN’s efforts to provide constructive feedback during the law’s revision process, these concerns were not adequately addressed. This disregard for Indigenous input reflects a regulatory framework that continues to prioritize conservation goals over the rights and socio-economic well-being of the communities most directly impacted.

Way Forward and Recommendations

Drawing from the insights and recommendations shared by the panelists, we propose the following actions to navigate development and conservation effectively:

Critically Investigating Forests as a "Win-Win" Narrative for Solving Climate Change. As emphasized by Daniela Kleinschmit, the prevailing narrative that positions forests primarily as carbon sinks oversimplifies their role in climate solutions [5,6]. While forests are crucial for carbon sequestration, this narrow focus risks overshadowing their broader ecological, social, and cultural significance. Moreover, market-driven approaches like carbon trading reinforce an economic-centric perspective, often sidelining traditional knowledge and local governance. Carbon offset schemes, in particular, can displace Indigenous and local communities, prioritizing external actors in global conservation efforts.

A more inclusive approach must recognize diverse values, integrate marginalized voices, and explore alternative pathways beyond carbon-centric solutions.

To foster a more **inclusive and just** approach to forest governance, the following actions should be prioritized:

- **Expand climate financing mechanisms** beyond carbon markets to directly support community-led conservation and non-market-based solutions.
- **Strengthen social safeguards in carbon offset projects** by requiring Free, Prior, and Informed Consent (FPIC) and ensuring equitable benefit-sharing mechanisms.
- **Develop policy mechanisms** or instruments that integrate multiple forest values, including biodiversity, water regulation, and cultural significance, alongside carbon sequestration.
- **Encourage interdisciplinary research and dialogue** to shift from a carbon-centric to a more holistic understanding of forests' role in sustainability.

Rethinking Deforestation Rates and the 'Target Olympics'. As highlighted by Daniela Kleinschmit, the focus on deforestation reduction as a simplified success metric often overlooks the complex social, economic, and ecological dynamics at play. Policies driven by numerical targets risk neglecting deeper issues like land tenure conflicts and unsustainable economic models. A more people-sensitive approach should complement quantitative goals with qualitative indicators, such as secure land rights, social equity in conservation, and long-term livelihood benefits, ensuring that forest policies truly support sustainable and inclusive development.

To shift from simplistic targets to context-sensitive solutions, key actions include:

- **Redefine success metrics** by incorporating social and economic indicators such as land tenure security, income diversification, and governance quality alongside deforestation rates.
- **Adopt participatory monitoring and reporting systems** to ensure that local knowledge and realities are reflected in forest assessments.
- **Address root causes of deforestation** by integrating land reform, poverty reduction, and sustainable agricultural policies into forest governance frameworks.
- **Ensuring meaningful inclusion of local communities in forest governance.** While the importance of integrating local and Indigenous communities in forest governance has been widely acknowledged at the global level, in practice, their voices often remain marginalized. Many conservation and climate initiatives continue to prioritize top-down approaches, sidelining the lived experiences and traditional knowledge of those directly affected. To bridge this gap, international partnerships and development programs that have demonstrated positive impacts can play a key role in fostering more inclusive, deliberative processes. Project-oriented collaborations should move beyond consultation and actively empower communities by ensuring decision-making power, securing land rights, and providing long-term benefits that align with local priorities.

To institutionalize meaningful community participation, the following steps are critical:

- **Legally recognize and secure Indigenous and local land rights** through national policy reforms and enforcement mechanisms.
- **Require international climate and conservation funding** to uphold community-led governance structures as a condition for financial support.
- **Create permanent platforms for local engagement** in decision-making at national and international levels, ensuring their voices shape forest policies.
- **Establish community-managed conservation areas** with direct funding and technical support, ensuring local people are not just stakeholders but rights-holders in governance processes.

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Plenary Session 5

Adaptation and Mitigation of the Built Environment in a Heating Climate

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Introduction

As climate change globally affects the environment in many different ways, Indonesia has developed its national policy and strategy [1] in order to tackle these complex issues. These efforts obviously force Indonesia to set its ambitious targets of Nationally Determined Contribution (NDC) to reduce emissions by 41% in 2030.

To achieve this holistic goal through realistic action, it is crucial to know that these two strategies – adaptation and mitigation – are not mutually exclusive, which means that they must go hand in hand. It is our challenge to find a way to design how we can protect our mother earth from extremely changing climate as well as contribute to stabilizing it through adaptation [2] and mitigation [3] programs. There are four scenarios developed by Low-Carbon Development Indonesia [4] as the commitment of Badan Perencanaan Pembangunan Nasional (Bappenas/ National Development Planning Agency), to measure the impacts of different policies such as 1) the base case that continues the historical trends for the economy, society, climate, and the environment; 2) the Low Carbon Development Indonesia (LCDI) moderate scenario which required additional investments in an average of 14.8 billion USD per year in 2020-2024 (about 1.15% of gross domestic product; GDP), and 40.9 billion USD per year in 2025-2045 (1.39% of GDP); 3) the LCDI high scenario which includes more ambitious measures with total average LCDI High investments per year of 22.0 billion USD (1.7% of GDP) for the period 2020-2024; and 70.3 billion USD (2.34% of GDP) for the period 2025-2045 to be required; 4) the LCDI plus scenario that incorporates an extra level of effort in low carbon policymaking starting at around 2025, so that emissions continue falling through 2045 and beyond.

Key Findings from the ICONIC 2024 Plenary: "Adaptation and Mitigation of the Built Environment in a Heating Climate"

These are the key points summarized from the plenary session "Adaptation and Mitigation of the Built Environment in a Heating Climate" held on September 5, 2024 at the University of Göttingen.

Key Finding 1: Transforming the degraded land of Nusantara into the green heart of the new capital of Indonesia

As climate change is unavoidable and brings threats [5], Indonesia introduced Nusantara as its future national capital located in the East Kalimantan in hoping of supporting more equitable development, reducing disparities between regions, and definitely leading the way towards achieving Indonesia's vision of becoming sovereign, advances, just, and liveable city by 2045.

Within 3 concepts for Nusantara development – forest city, sponge city, and smart city – Nusantara Capital City Authority (OIKN) highlighted several strategies that have been implemented in achieving net zero emissions such as commitment to maintaining the forest and green area up to 65%, the using of 100% renewable sources for electricity in 2030, applying up to 50% supplementary cementitious materials (SCM), 100% reduction of waste from organic waste composting, and sustainable practices in agriculture field from 2045.

Key Finding 2: Navigating climate information services, governmental agency as a frontline in the fight against climate change

Climate information is a vital service needed as it supports the development of national or territorial adaptation plans [6]. Global warming significantly impacts Jakarta, the former capital of Indonesia due to its massive development and also geographical location that is close to the ocean. Indonesian Agency for Meteorology, Climatology, and Geophysics (BMKG) emphasized that throughout the years, the evolution of carbon concentration (CO_2 and CH_4) is continued to increase, air temperature responds to global warming faster compared to sea temperature, over the past 30 years the urban heat island effect has been relatively strong, and the expansion of urban area addicts the increase on temperature. Therefore, it is crucial to develop climate information services for green buildings through climate zoning based on solar radiation, temperature, wind speed, etc. as an effort to mitigate the impact of heating climate.

Key Finding 3: Promoting plantation while supporting the climate change mitigation and adaptation program

Tons of potential as well as ways to mitigate and adapt the climate change which has been done by the private sector [7]. PT. Astra Agro Lestari highlighted how the company focuses and contributes to adopting sustainable utilization, for instance, retrieving to energy (renewable usage more than 92%), peatland restoration, fire prevention using digital technology and hotspot monitoring with unmanned aerial vehicle (UAV), no deforestation commitment, etc. Furthermore, the private sector also collaborates with the local community to support conservation and nature-based solutions while implementing the plantation.

Key Finding 4: Time to adapt to the climate change

Throughout the historical facts and realities of humanity in designing the weather [8], it is not the time to mitigate climate change anymore; instead, it is time to adapt to these undeniable conditions where choices and actions, for now, will affect the future. Started from designing the house building that highly considers thermal management such as the asymmetry (thermal loads), texture (micro-shadows), verticality of space, porosity (ground/façade), as well as the micro or macro scales of climate. Associate Professor at Harvard Graduate School of Design proves that the significance of weather both as space and matter in design and the interdependency of microclimatic conditions has led to the best practices of how people need to adapt to this changing climate.

Key Finding 5: Collaborative actions to develop a climate-friendly urban city

Considering the wind circulation in designing a livable city can be such a tremendous way to how urban and spatial development affect weather and climate conditions [9]. Humboldt

University of Berlin researcher emphasized how important the contribution of the right people in terms of their capabilities and background e.g. the collaboration of climate scientists and urban planners to develop a friendly design city while also considering and implementing climate planning that will meet spatial conflicts. While there will be several conflicts and protests from the citizens, it presents a good sign of climatology being a public science.

Policy Recommendations

Adaptation

- **Bridging the Knowledge Gap:** The complexity of climate change adaptation issues and information highlights challenges in making public and governmental policies [10]. In addition, the lack of knowledge integration and collaborative approach (such as climate data, economic analysis, vulnerability assessment, etc.) also affect the adaptation capability [11]. Therefore to fill these gaps, there is a need to sustain more space for dialogue as well as bridge the relationship between science and policy by increasing the quality of interaction between researchers and policymakers.
- **Adopting Climate-Resilient Infrastructure:** While Government Regulation No. 21 of 2021 on Implementation of Spatial Planning [12] already manages areas designated through space utilization concerning land tenure, resource territory, and issuance of environmental impact, there is an urgency to increase resilience infrastructure sectors (supply and demand of green energy, water services, transportation), where people are better protected when disasters occur, reducing the need for costly repairs.
- **Promoting Microinsurance for Low-Income Communities:** Policymakers should act to provide 'room' for public-private partnerships in ensuring affordability through flexible frameworks [13] and localized insurance products [14] that address climate-specific risks. In fact, microinsurance improves resilience by reducing economic vulnerability to climate impacts. Moreover, local governments also could provide insurance consultation to households with transparency.
- **Integrating Agricultural Adaptation and Food Diversification:** Adopting sustainable production practices is crucial in building resilience for agrifood systems [15]. Therefore, policymakers also should incentivize the implementation of climate-smart agriculture (CSA) while also integrating it with traditional knowledge to improve food security while reducing dependency on climate-vulnerable crops.
- **Financing and Strengthening Coastal Protection:** Proactive investment in coastal development can significantly reduce economic damages associated with sea-level rise and extreme weather events [16]. In addition, prioritizing nature-based solutions, such as restoring wetlands and construction of artificial reefs can effectively help us in adapting to storm surges and erosion [17]. This initiative should be supported by securing diverse funding sources, including public investments and private-sector partnerships.

Mitigation

- **Catalyzing Emission Reduction and Sequestration:** A comprehensive strategy that combines regulatory measures [18], economic incentives [19], support for the research and development of carbon capture and storage (CCS), and investment in technology innovation, as well as integrating these approaches into national and international climate policies will facilitate coordinated efforts toward achieving net-zero emissions.
- **Supporting Transparent Approaches and Anti-corruption in Climate Planning:** Ensuring public access to information and facilitating stakeholder participation can reduce corruption risks in climate finance [20]. Furthermore, implementing anti-corruption measures at the local level is crucial for the success of climate actions. Tools such as effective monitoring by local leaders and robust complaints mechanisms can safeguard climate interventions from corruption.
- **Shifting to Renewable Energy and Low-Carbon Transportation:** The transition of energy used and transportation into more sustainable systems should be expanded by providing financial incentives (tax credits, subsidies) for the development of solar, wind, and geothermal energy [21], and prioritizing the electric as well as public transportation system [22].
- **Prioritizing Mitigation for Climate Justice:** Policymakers should focus on mitigation strategies that ensure fair distribution of benefits and responsibilities across all communities, with particular attention to those that have been historically marginalized [23]. Incorporating justice into climate action plans results in more inclusive and widely supported mitigation efforts. Moreover, perceptions of fairness and equity are strongly tied to public acceptance of climate policies, highlighting the need for equitable approaches.

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Plenary Session 6

Decarbonization and Circularity in the Building Sector

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Introduction

Building sector consumes 34 % of global energy in 2022 [1], emits 21 % of global greenhouse gas (GHG) in 2019 [2] and makes 52 % of European Union's (EU) material consumption [3]. Thus, the sector, which in both EU and Indonesia, contributes respectively 9% and 10% to each gross domestic product (GDP) [4][5], needs to be reckoned with seriously with respect to its decarbonization and circularity in achieving the Nationally Determined Contributions (NDC) target in the face of climate change. The GHG emission from the building sector is produced in the following phases: the energy used for obtainment of raw materials as well as its manufacturing into construction materials (i.e. grey emission), the building process, and the operational phase (i.e. heating or cooling). The aggregate building operation (i.e. air conditioner) in Indonesia makes 36% of the total national energy consumption-related emission in 2021 [6]. In the face of even more heated living environment, the number would predictably surge further [7]. In addition, since the building sector is a material-heavy one and has a relatively short-term life cycle, the problem of material waste becomes inevitable. In Germany alone, construction waste makes half of the national waste, triggering a call for a moratorium of building demolishment by associations of German planers [8]. One of the solutions lies in the common "circular" economic framework of "slowing" material decay, "narrowing" material choice to be more sustainable and circular, as well as "closing" the loop of new and secondary construction material's supply and demand loop. The implementation would not only positively lead to less waste, but also to less grey emission of reduced production of new material, which globally emits around 40% of the building sector-induced GHG [9]. Another solution is to apply low-carbon materials in the forms of bio-based materials, such as solid wood, its products, bamboos, rattan, etc. Those materials are produced by natural process and have the characteristic of carbon storage, in contrast to the "conventional" materials, such as concrete, steel, bricks, glass, etc., which "embodied energies" are significantly higher than bio-based ones.

Key Findings

The case is thus clear, that issues of decarbonization and circularity in building sector are already well formulated. The plenary speakers, Masulin (CEO of BYO Living), Dr. Euring (wood expert and researcher at the University of Göttingen) and Dr. Schiller (resource-efficient management expert in the built environment and researcher at Leibniz-Institute of Ecological Spatial Development) delivering their keynotes on one of ICONIC 2024's plenary sessions, held on September 5, 2024 further showcase that solutions have also been abundantly researched and implemented in business.

However, its implementation is still not able to keep up with the required fast decarbonization process; what slows it, as revealed in the panelists' discussion and further literature review, seems to be the lack of will from political and significant market actors to change.

Key Finding 1: Bio-Based and Recycled Materials as Alternative to Conventional Ones

Dr. Euring puts forth that timber material for building construction material, consisting in the market mainly in forms of solid woods or processed wooden panels, displays significantly lower environmental impacts, including "grey emission" or "embodied energy", then other "conventional" construction materials. Its material economy and supply chain is proven to be regionalized, in contrast to the globalized conventional material and timber-related furniture industry. The long tradition of German wooden construction and its innovation supports the establishment of wood as modern material, as around 20% of Germany's houses, categorized as the Building Class E, is constructed of wood. Although Indonesia is also in possession of a long building tradition with bio-based material, including that which takes the forms of weaving, Masulin claims that the usage of bio-based materials are considered niche at the presence due to the public negative perception as well as legal discrimination against the "traditional" materials. He, however, emphasizes on the high adaptability of the tradition-rich weaving (or other) techniques with new or recycled non-biogenic materials (i.e. plastic bottles, conveyor belts) for both structural or decorative elements in buildings. The CEO of Byo Living points out further that the application of bio-based materials, such as bamboo, rattan, *purun*, hyacinth, and others, supports the productivity of small-holders farmers on the upstream side of the value chain. Thus, technical solutions to build with bio-based and recycled materials have not just only been invented, but practiced by market actors, which, when up-scaled and its market price economized, could collectively reduce the emission of new building material production. However, despite being included in the Indonesian Long-term National Development Planning, that the use and innovation of local bio-based materials are necessary to decarbonize the building sector while rendering building in non-industrialized or even remote areas more practical [10], the Indonesian government keeps opting for subsidized industrial cement, for instance to solve the increasing housing demand in remote area [11].

Key Finding 2: Methodologies to Quantify Regional Aggregate of Building Information

Quantifying materials used for buildings also in terms of its emission is paramount to have scientific data to inform decision making. In Germany, some certification bodies or consultants are active in the market, such as Deutsche Gesellschaft für Nachhaltiges Bauen (DGNB) or Bewertungssystem Nachhaltiges Bauen (BNB) [12], to develop and apply methodologies to measure carbon emission in each "life stages" of certain types of projects of high economic value with a formalized "Life-Cycle Analysis" (LCA). Information on the carbon and material footprint of various building materials are rendered traceable and measurable [13]. On a bigger, regional scale, Dr. Schiller displayed exemplary methodologies to quantify and visualize the material footprints and embodied energy of buildings of a certain region in form of a "Material Cadaster".

Just like what the green building certification does, the methods attempt to read materiality of an entire region to provide information of available secondary resources to reuse or recycle once certain buildings end its life cycle. A "Regional Material Flow" comes in play enabling one to clearly portray the supply and demand of both new or secondary building materials to proceed with the "closing of the loop" for a circular economy. Indonesian government has recently made efforts to catch up on the matter with the Government Regulation 16/2021 [14] to further formalize and legalize building certifications including a Green Building certification issued (GBCI) by independent certification bodies and an integrated building information database collected by local building councils. However, the implementation of the law progresses slowly with only less than 300 units of building scrutinized nation-wide until the end of 2024 [15].

Key Finding 3: The Importance of Market Acceptance

Masulin points out that what finally matters is the decisions taken by market actors with respect to the acceptance of innovative and low-carbon building products. He reports about a significant number of timber factories for building materials which filed bankruptcy in the last years due to low demand. Thus, pragmatic approach is necessary to be adopted by market actors who champion bio-based or circular products by emphasizing not only the positive ecological impact of their products, which urgency of the matter does not receive much market attention as of now, but general aspects, such as the possibility of rapid construction, the earthquake-resistance and the esthetics of the marketed green products. The current trends prove that the demand of sustainable materials are limited to clients of high capital and corporate organization due to its higher cost in comparison to the conventional materials.

Key Finding 4: Policy Framework and Institutions

In contrast to Indonesia, active policy making to push market actors, such as planners, real estates or material producers to innovate on sustainable materials, is undertaken in Germany and the EU. Dr. Schiller refers to the New European Bauhaus, as EU-initiated funding and policy initiative related to the New European Green Deal, which has funded many building projects across European countries which innovate on bio-based materials or apply of circular principles from EU budget or channelled private investments since 2020 [16]. At the national level, Germany has set strategies to support the up-scaling of timber construction products and techniques [17] which are followed by regional policies at the *Bundesland*-level; for instance, the Bavarian *Bundesland* has implemented a subvention scheme for timber buildings with 500 EUR per ton of CO_2 which is stored or embedded in the timber building materials [18]. The existence of research institutions, such in which Dr. Schiller and Dr. Euring work, which develop methodologies (i.e. LCA) and thrive forward technical innovation hand in hand with the German companies, who are in turn supported by enough political will, bureaucratical information provision, and state's subvention, define the institutional landscape of the "collective" efforts to decarbonize and circularize the building sectors in the country.

Having set its own target of emission reduction in the building sector, Indonesia's policy landscape remains confusing on how to achieve decarbonization and circularity, as Masulin emphasizes instead the predominantly more relevant roles of private actors (i.e. companies and planners) in undertaking innovations in building sector of the country. The main issue remains the lack of a coordinated effort across relevant bodies to systematically monitor the compliance of the national aggregate of undertaken building processes to the existing regulations and national standards [19].

Policy Recommendations

Considering and synthesizing panelists' input and discussion as well as scientists' findings presented at the ICONIC 2024 conference, we propose to governmental or private actors in Indonesia the following actions:

- **Endeavor State-Led and Nation-Wide Promotion of Bio-Based and Recycled Materials:** Big and high investment building projects, which consumed much industrial materials and prove of high carbon and material footprint, must comply with the existing Green Building regulation. Its implementation would support the development of various new bureaucratic and certification processes, as well as create new innovations using bio-based and secondary materials by future-minded companies. The companies would in turn have better chance to thrive and widen the public or market acceptance of the sustainable material. On the other hand, for the building agendas in less industrialized and socio-economically more traditional areas, the message must be reframed to encourage people living in the areas to further use, develop and respect the existing local materials and techniques. The recent moratorium of the expansion of conventional cement industry in Indonesia due to national oversupply since 2022 [20] has to cause further reflection on the future of low-carbon building sector as has been promised and formulated in the Indonesian NDC.
- **Develop a systematic tool to track material footprints and incorporate it in the bureaucracy:** Internationally developed and available methodologies to count carbon and material footprints of used in aggregate building process need to be adjusted further for Indonesian case. The tools need to also pass theoretical or experimental levels and be implemented nation-wide as an integral process of building, at the individual building level, as soon as possible. At the regional or aggregate scale, the tools help the local government to determine the supply and demand rate of new or recycled materials to further formulate regulatory, local policies to ensure the closing of the material loops and operate a circular economy. At the national or even global level, the enforced LCA, if honestly and properly complied with timber suppliers, could also help to solve the problems of upstream material provision (i.e. forests' illegal logging).

- **Set Up Clear Agenda for Available Stakeholders and Better Information Flow of Building Sector-Related Regulations:** Indonesian stakeholders, such as construction planner, architecture planner, interior designer, building material manufacturer, researcher, farmer, and others [21], who are aligned with climate political agendas, do not number only a few. Instead, they are well connected, and their works are acclaimed. The Indonesian government must only conduct open dialogues and absorb their aspirations as results of their long-years practical experience. Learning from European or German experience in setting clear policy directionality and funding of pilot projects to produce initial best-practices of various building functions and classes, Indonesian government must attempt to do the same, not only in its future national capital city "IKN" with its mostly, state corporations-supplied gigantic towers of conventional materials [22], but in a distributed manner in the entire archipelago to commence a change.
- **Enforce the "Building Code," Get the Bureaucracy Function Cleanly and Properly:** All of the previous points are of no use, if the Indonesian bureaucratic agencies which administer the building sector remain transactionally compromised [23]. A huge bill for the regulation of the building sector, which was already issued with the Law on Building 28/2002, has never been implemented totally despite of more than 20 years already passing. It shall display the case that solving one sectoral problem requires the revamping of the entire compromised system.

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