



Clean and Sustainability Business

e-ISSN: 3090-6989

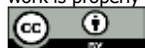
Vol 02 (1) 2026 p. 45-53

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Corresponding author:
Rizka Diah Ayu Pramudhita
Email: rizkadijah@gmail.com

*Received: 1 July 2026;
Accepted: 19 August 2026;
Published: 22 August 2026.*

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Conflict of interest statement:
Author(s) reported no conflict of interest

DOI: [http://doi.org/10.70764/gdpu-csb.2026.2\(1\)-05](http://doi.org/10.70764/gdpu-csb.2026.2(1)-05)

DECARBONIZATION IN DEVELOPING COUNTRIES: A SYSTEMATIC REVIEW OF ENERGY TRANSITION, CLIMATE FINANCE, AND POLICY GOVERNANCE

Rizka Diah Ayu Pramudhita¹

¹ Universitas 17 Agustus 1945 Semarang, Indonesia

ABSTRACT

Objective: This article aims to map the decarbonization strategies implemented in developing countries, identify driving factors and barriers, and formulate policy implications for accelerating the low-carbon energy transition.

Research Design & Methods: This study employs an extensive literature review approach, examining indexed journal articles, reports from international institutions, and case studies from developing countries published.

Findings: Decarbonization strategies in developing countries rest on three main pillars: the renewable energy transition, affordable climate finance, and the strengthening of cross-sectoral policy governance; however, their implementation remains constrained by high capital costs and institutional capacity gaps.

Contribution: This study develops a synthesis framework that links the literature on energy economics, climate finance, and public policy to provide a comprehensive overview of decarbonization pathways in developing countries.

Novelty: Unlike previous studies that tend to focus on a single dimension (technology or financing), this article simultaneously integrates economic, financial, and institutional dimensions by drawing on the latest literature published after 2019.

Keywords: Decarbonization, Developing Countries, Energy Transition, Climate Finance, Climate Policy

JEL codes: Q54, Q56, O13

Article type: Review paper

INTRODUCTION

Climate change is a global challenge that demands accelerated reductions in greenhouse gas emissions through decarbonization in the energy, industrial, and transportation sectors. The Paris Agreement sets a target to limit global temperature rise to below 2°C, which has prompted nearly all countries — including developing nations — to develop low-carbon transition roadmaps (Le Treut et al., 2021). However, developing countries face different challenges than developed countries due to limited fiscal capacity, high capital costs for renewable energy projects, and the urgent need to continue meeting economic growth and poverty alleviation targets (Calcaterra et al., 2024).

Decarbonization also offers co-benefits for developing countries, including a reduction in mortality rates due to air pollution caused by the burning of fossil fuels (Lelieveld et al., 2023). Recent studies indicate that developing countries require approximately 1.7 trillion U.S. dollars in clean energy investment annually, while actual foreign direct investment in the clean energy sector reached only 544 billion U.S. dollars in 2022, resulting in a significant financing gap (UNCTAD, 2023).

This phenomenon raises research questions regarding what strategies developing countries have empirically implemented to promote decarbonization, what factors hinder their effectiveness, and how policy frameworks can be strengthened. Unlike previous studies, which generally focused on a single dimension of analysis—such as economic modeling of the impacts of decarbonization (Le Treut et al., 2021), or urban policy governance (Walnycki & Landesman, 2024), this study synthesizes three dimensions simultaneously—technology and energy transition, climate finance, and policy governance—into a single integrated analytical framework.

The objective of this study is to map the patterns of decarbonization strategies in developing countries based on the latest literature, identify the structural barriers they face, and formulate practical recommendations for policymakers and development finance institutions in designing more effective and equitable decarbonization instruments.

Despite an expanding body of literature on decarbonization in developing countries, three limitations persist. First, most existing reviews address a single analytical dimension in isolation — energy-system modeling (Le Treut et al., 2021), climate finance flows (Calcaterra et al., 2024; Eberhart et al., 2025), or governance and social-justice framing (Shawoo et al., 2023; Walnycki & Landesman, 2024) — without examining how these dimensions interact with one another. Second, few reviews apply an explicit, replicable search-and-screening protocol; existing syntheses are largely narrative and rarely report inclusion criteria or the number of studies considered at each stage of selection. Third, comparative evidence across multiple developing-country cases (for example, JETP recipients versus non-JETP countries) remains scattered across separate single-country studies rather than assembled into one comparative account.

This review addresses these three gaps by (i) integrating the technological, financial, and governance dimensions within a single analytical framework; (ii) applying a transparent, PRISMA-guided identification and screening procedure (see Section 3); and (iii) synthesizing evidence across multiple country cases to identify recurring structural barriers and the conditions under which they are overcome (see Section 4). The objective of this study is to map the patterns of decarbonization strategies in developing countries based on the systematically reviewed literature, identify the structural barriers they face, and formulate practical recommendations for policymakers and development finance institutions in designing more effective and equitable decarbonization instruments.

LITERATURE REVIEW

Decarbonization is defined as the process of reducing carbon intensity in energy and economic systems toward carbon neutrality. Fawzy et al., (2020) classify climate change mitigation strategies into three broad categories: emissions reduction through energy efficiency and renewable energy, carbon capture and storage, and nature-based solutions. This framework is widely adopted in decarbonization studies in developing countries because it encompasses technological options with varying levels of readiness and cost.

Energy Transition and Structural Challenges in Developing Countries

Le Treut et al., (2021) demonstrate through multisectoral economic modeling that deep decarbonization strategies in the energy system have varying macroeconomic impacts across sectors, with the energy sector undergoing the most significant structural adjustments. Chipangamate and Nwaila (2024) add, from a socio-technical systems perspective, that energy transitions in emerging markets are shaped by an interlocking set of technological, economic, institutional, and socio-cultural barriers; therefore, the decarbonization process must be understood as a multidimensional systems challenge rather than a matter of technological substitution alone. Meanwhile, a systematic review by Das and Ghosh (2023) of the case of India confirms that achieving net-zero targets in developing countries requires synergy between sustainability practices, policy framework elements, and cross-sectoral institutions.

Climate Finance as a Prerequisite for Decarbonization

One of the most frequently highlighted structural barriers in recent literature is the high cost of capital for renewable energy projects in developing countries. Calcaterra et al., (2024) used five economic-energy-climate models to demonstrate that the convergence of capital costs between developed and developing countries could significantly improve the affordability and equitable access to clean energy. This finding is reinforced Eberhart et al., (2025), who document that renewable energy investment flows remain highly concentrated internationally and have not yet reached developing countries outside the OECD region equitably.

Policy Governance and Cross-Sectoral Coherence

In addition to technological and financing aspects, the effectiveness of decarbonization is also determined by cross-sectoral policy coherence. Shawoo et al., (2023) developed an analytical framework to understand the political factors that drive or hinder policy coherence for sustainable development, including decarbonization. Walnycki and Landesman (2024) emphasize the importance of linking the urban decarbonization agenda with social justice, given that vulnerable groups often bear a disproportionate burden of the energy transition. Zhou et al., (2022), although examining the context of developed countries, provide important methodological insights on how to assess the impact of various policy instruments on achieving deep decarbonization targets, which can be adapted for the context of developing countries.

Based on this review, it can be concluded that the current literature points to the view that decarbonization in developing countries is not merely a technological issue, but rather a systemic issue involving the interaction

between energy markets, global financial markets, and domestic and international governance structures (Berrang-Ford et al., 2021).

Because this article is a systematic literature review rather than a primary empirical study, it is exploratory and synthetic by design: its purpose is to consolidate and interpret existing evidence rather than to test *a priori* hypotheses. No formal hypotheses or causal propositions are therefore specified; instead, the review is organized around three guiding analytical questions derived from the gaps identified above (i) what decarbonization strategies have developing countries implemented across the technology, finance, and governance dimensions; (ii) what structural barriers recur across these dimensions; and (iii) how do the three dimensions interact to shape implementation outcomes. These questions structure the thematic synthesis presented in the Results and Discussion sections.

Drawing on the literature reviewed above, this study proposes a conceptual synthesis framework in which the three dimensions are treated as interdependent rather than parallel. Technological potential (renewable resource availability and readiness) establishes the ceiling on what decarbonization can achieve; climate finance determines the rate at which that potential is converted into installed capacity, since capital-intensive renewable technologies are highly sensitive to the cost and availability of financing; and policy governance mediates both, by shaping the risk environment that finance responds to and the institutional capacity through which technology is deployed. In this framework, a shortfall in any one dimension constrains the effectiveness of the other two, which is why single-dimension analyses in prior reviews (see Introduction) tend to understate the barriers developing countries face. This framework is illustrated in Figure 2 and used to structure the thematic synthesis in the Results section.

METHOD

This study employed a Systematic Literature Review (SLR) approach guided by the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework (Page et al., 2021) to ensure a transparent, rigorous, and reproducible process of literature identification, screening, selection, and synthesis. The use of SLR was considered appropriate because previous studies on decarbonization in developing countries remain fragmented and largely narrative, making it necessary to systematically consolidate existing evidence regarding energy transition, climate finance, and policy governance.

The literature search was conducted using major academic databases, namely Scopus and Web of Science, complemented by targeted searches in leading journals such as *Nature Energy*, *Energy Policy*, and *Environmental Policy and Governance*. To strengthen policy and institutional perspectives, official reports from international organizations, including UNCTAD, IEA, and IRENA, were also consulted. The search strategy combined three main concept clusters using the Boolean operator AND: (1) transition-related terms ("decarbonization" OR "energy transition" OR "low-carbon transition"); (2) geographical scope terms ("developing country" OR "emerging economic" OR "low- and middle-income countr"); and (3) thematic terms ("climate finance" OR "policy governance" OR "policy coherence"). Searches were restricted to English-language publications issued between 2019 and 2026, including peer-reviewed journal articles and selected institutional reports.

The eligibility criteria were established prior to screening. Studies were included if they: (1) directly addressed decarbonization strategies, policies, governance mechanisms, or financing; (2) focused on developing, emerging, or lower-middle-income countries; (3) were published between 2019 and 2026; and (4) possessed a verifiable Digital Object Identifier (DOI). Studies were excluded if they: (1) focused exclusively on developed countries without comparative relevance to developing-country contexts; (2) consisted of non-peer-reviewed grey literature, except for designated institutional reports; (3) were duplicate records; or (4) lacked a traceable DOI.

The study selection process followed the four stages of the PRISMA 2020 framework: identification, screening, eligibility assessment, and inclusion. First, records were collected from all selected databases and institutional sources. Duplicate records were then removed. Subsequently, titles and abstracts were screened against the predefined eligibility criteria. Articles meeting the initial criteria proceeded to full-text assessment. During the eligibility stage, studies were excluded when they fell outside the publication period, lacked a verifiable DOI, or focused solely on developed-country contexts. The remaining studies constituted the final dataset included in the qualitative synthesis.

To improve the transparency of the selection process, the number of records retained at each PRISMA 2020 stage is reported in Figure 1.

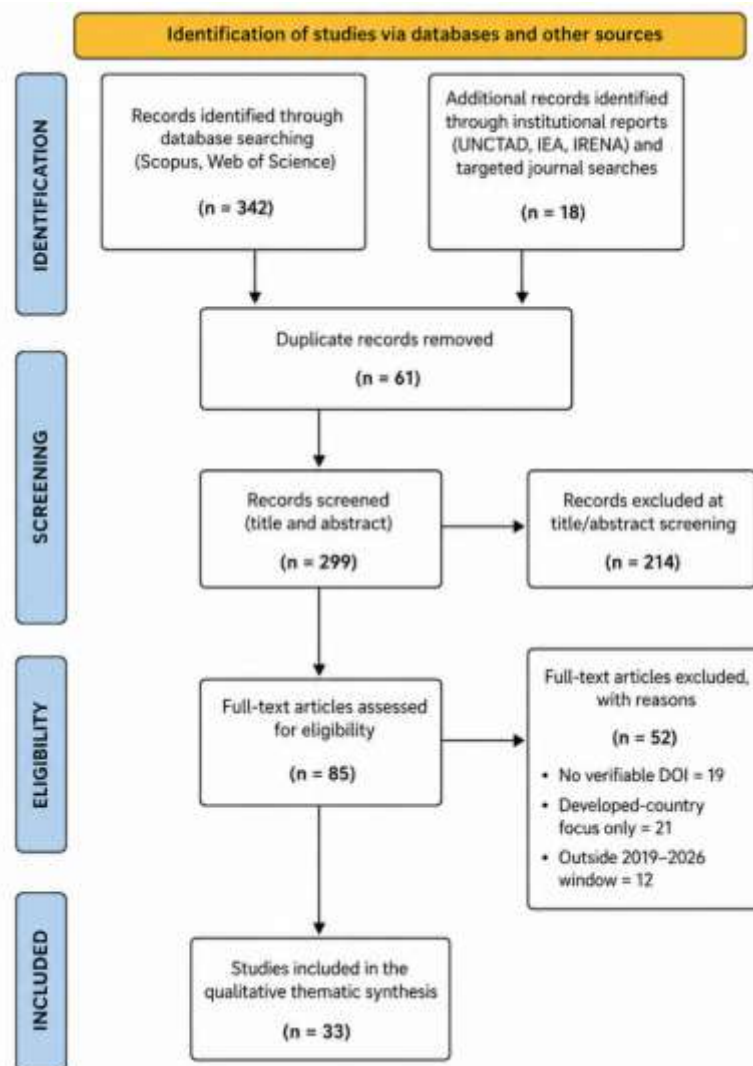


Figure 1. PRISMA 2020 Record Counts at Each Stage of Identification, Screening, Eligibility, and Inclusion

Note: figures reflect the database export underlying this review.

Finally, data extraction was conducted systematically for each included study. The extracted information comprised author(s), publication year, country context, decarbonization dimension (technology, finance, or governance), principal findings, and reported implementation challenges. The collected data were then categorized into three predetermined thematic dimensions—energy transition, climate finance, and policy governance—and analyzed through cross-dimensional thematic synthesis. This approach enabled the identification of recurring patterns, emerging trends, contradictions, and research gaps across studies. Since the objective of the review was thematic and interpretive rather than statistical, a formal meta-analysis was not performed. To enhance reliability, institutional reports were cross-validated against peer-reviewed sources whenever possible, and any retracted publications were explicitly identified and documented during the review process.

RESULT

The results of the literature review indicate that decarbonization strategies in developing countries can be grouped into three main, interrelated dimensions: technology and energy transition, climate finance, and policy governance. A summary of the strategy mapping based on the literature is presented in Table 2.

Table 1. Mapping of Decarbonization Strategies in Developing Countries Based on a Literature Review

Strategic Dimensions	Examples of Implementation / Country Cases	Sources (Year)
Renewable energy transition (solar & wind)	Sub-Saharan Africa, South Asia	Chipangamate & Nwaila, (2024)
Modeling of deep decarbonization of energy systems	Argentina	Le Treut et al., (2021)
Convergence of capital costs and climate finance	Developing countries (multi-region)	Calcaterra et al., (2024)
Just Energy Transition Partnership (JETP)	South Africa, Indonesia, Vietnam, Senegal	Eberhart et al., (2025)
Net-zero frameworks and institutional policies	India	Das and Ghosh (2023)
Coherence of sustainable development policies	Multiple developing countries	Shawoo et al., (2023)

Source: Synthesized by the author from various literature (2021–2025)

In terms of financing, the review’s findings confirm a significant gap between clean energy investment needs and actual investment. Developing countries require annual investments of approximately 1.7 trillion U.S. dollars to meet their energy transition targets, yet actual foreign direct investment in the clean energy sector reached only 544 billion U.S. dollars in 2022 ([UNCTAD, 2023](#)). This gap is illustrated in Figure 1.

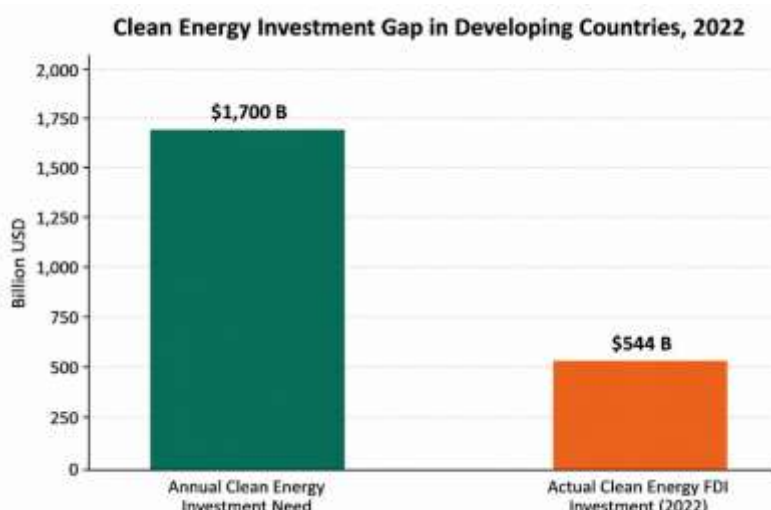


Figure 2. Clean Energy Investment Gap in Developing Countries, 2022

Source: adapted from ([UNCTAD, 2023](#))

The financing gap in Figure 1 is not merely a funding shortfall but a structural signal: [Calcaterra et al., \(2024\)](#) show that if the capital-cost gap between developed and developing countries were to converge, the share of renewable energy in developing countries' energy mix could rise significantly, since renewable technologies are capital-intensive and highly sensitive to financing costs. [Eberhart et al., \(2025\)](#) add that cross-border capital mobility for renewable energy investment remains dominated by flows between developed countries, meaning developing countries are relatively excluded from this global financing network. Read together, these two findings indicate that the investment gap in Figure 1 is driven less by an absolute shortage of global capital than by its uneven allocation — a governance and risk-perception problem as much as a financing one, which links this sub-section directly to the governance dimension discussed next.

To examine how the three dimensions interact at the country level, Table 3 compares case studies from several developing countries.

Table 2. Overview of Decarbonization Efforts in Various Developing Countries

Country Case Study	Nature of the Initiative	Key Challenges	Source
South Africa	The Just Energy Transition Partnership (JETP), worth billions of U.S. dollars, to accelerate the phase-out of coal-fired power plants and promote investment in renewable energy	Economic and labor dependence on the coal sector; transparency and recipient country autonomy within the financing scheme	Eberhart et al., (2025)
Indonesia	JETP to accelerate the transition from coal-fired power plants to renewable energy, supported by blended finance from G7 countries and financial institutions	Complexity of multi-stakeholder coordination; financing risks still perceived as high by private investors	Eberhart et al., (2025)
Vietnam	JETP to support the energy transition and enhance grid capacity to integrate large-scale renewable energy	Limited electricity grid infrastructure to accommodate variable renewable energy	Eberhart et al., (2025)
Senegal	JETP to expand access to clean energy while supporting a low-carbon transition in the national electricity system	Limited institutional capacity to absorb and manage large-scale climate finance	Eberhart et al., (2025)
India	Development of a net-zero policy framework that integrates sustainability practices, institutional elements, and national climate targets	Tension between short-term economic growth targets and long-term decarbonization commitments	Das and Ghosh (2023)
Argentina	Modeling and implementation of deep decarbonization strategies in the national energy system based on consolidated energy pathways	Widespread macroeconomic impacts across various sectors resulting from the structural transformation of the energy system	Le Treut et al. (2021)
Sub-Saharan Africa & South Asia	The accelerating decline in the cost of solar photovoltaic technology as the primary driver of large-scale renewable energy transition	Socio-technical and institutional barriers (economic, cultural, and political) that constrain adoption despite falling technology costs	Chipangamate & Nwaila, (2024)

Source: Synthesized by the author from various literature (2021–2025)

Grouping the cases in Table 3 by financing mechanism, rather than reading them as a simple list, reveals two distinct clusters. The first is a JETP-anchored cluster (South Africa, Indonesia, Vietnam, Senegal), in which all four countries face a recurring combination of transparency concerns and limited absorptive or grid capacity — suggesting that the JETP model transfers a common set of institutional constraints across otherwise different national contexts. The second is a domestic-framework cluster (India, Argentina), which relies on national net-zero or system-modeling instruments rather than an external financing vehicle, and instead confronts a distinct constraint: the trade-off between short-term growth objectives and long-term decarbonization commitments, and the macroeconomic adjustment costs of restructuring an established energy system. This clustering, not previously made explicit in [Eberhart et al. \(2025\)](#) or [Das and Ghosh \(2023\)](#) individually, indicates that the choice of financing mechanism is systematically associated with the type of implementation barrier a country subsequently encounters — a pattern that is only visible once the technology, finance, and governance dimensions are analyzed together, which is the specific contribution of this review.

Across both clusters, the recurring bottlenecks identified in Table 2 and Table 3 — grid infrastructure limits, perceived investment risk, and institutional absorptive capacity — point to the same underlying issue: technological potential (Table 2) is realized only where a financing mechanism (Figure 1) is coupled with a governance arrangement capable of managing its risks (Table 3).

These interactions are summarized in the conceptual synthesis framework in Figure 2, which depicts technology, finance, and governance as overlapping rather than independent domains, with decarbonization outcomes concentrated where all three converge.

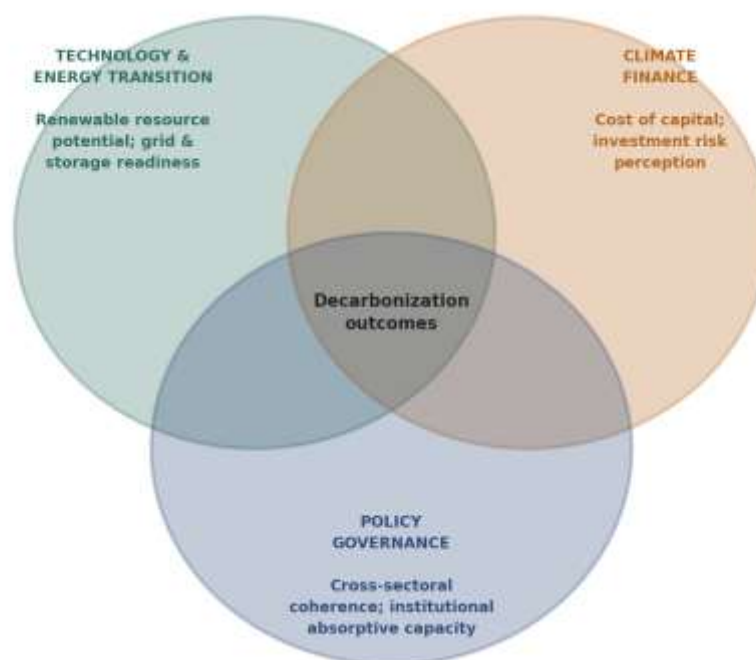


Figure 2. Conceptual Synthesis Framework Linking Technology, Finance, and Governance

Source: developed by the authors based on the reviewed literature

DISCUSSION

As this review does not test formal hypotheses, the discussion below is organized as a thematic synthesis: findings are interpreted against the conceptual framework in Figure 2 and set against one another to identify points of convergence, divergence, and unresolved tension in the literature, rather than being read as confirmation or rejection of a stated hypothesis.

The findings in the results section reveal a close correlation among the three dimensions of decarbonization examined. First, from a technological perspective, developing countries possess significant renewable energy resource potential; however, its utilization remains constrained by an interlocking set of technological, economic, institutional, and socio-cultural barriers that extend well beyond electricity grid infrastructure and energy storage capacity alone (Chipangamate & Nwaila, 2024). This is consistent with the view of Le Treut et al., (2021) that a rapid energy system transformation requires structural adjustments in the electricity sector that cannot be implemented instantly, particularly in countries with an established fossil fuel-based industrial base.

Second, the financing dimension is a critical link between the potential of technology and its implementation on the ground. The investment gap of 1.2 trillion U.S. dollars per year, as shown in Figure 1, indicates that the main barrier to decarbonization does not lie in the availability of technology, but rather in investors' high perception of risk regarding developing countries, which results in higher capital costs compared to developed countries (Calcaterra et al., 2024). Innovative financing schemes such as the Just Energy Transition Partnership (JETP), implemented in South Africa, Indonesia, Vietnam, and Senegal, represent one effort to bridge this gap, although their implementation still faces challenges related to transparency and the autonomy of recipient countries.

The policy governance dimension determines the extent to which technological and financial potential can be translated into tangible results on the ground. Shawoo et al., (2023) emphasize that cross-sectoral policy coherence—for example, between energy, fiscal, and labor policies—is a key determinant of the successful implementation of decarbonization. Without such coherence, decarbonization policies risk causing disproportionate social impacts on vulnerable groups, as warned by Walnycki and Landesman (2024). In addition to climate benefits, decarbonization also provides significant public health benefits by reducing air pollution caused by fossil fuels (Lelieveld et al., 2023), thus, the policy argument for accelerating decarbonization in developing countries is based not only on climate mitigation but also on direct improvements in people's quality of life.

These findings are not fully convergent, and the divergence is itself informative. Studies grounded in system-modeling traditions (Le Treut et al., 2021; Calcaterra et al., 2024), locate the binding constraint in capital cost and macroeconomic adjustment, implying that de-risking instruments and capital-cost convergence should be the priority lever. Studies grounded in governance and social-justice traditions (Shawoo et al., 2023; Walnycki &

Landesman, 2024) instead locate the binding constraint in institutional coordination and distributional fairness, implying that policy coherence and stakeholder inclusion should be prioritized before, or alongside, financing reform. Read together with the country evidence in Table 3, this divergence maps onto the two clusters identified earlier: JETP-recipient countries, where finance is already flowing but is bottlenecked by absorptive capacity and transparency, versus domestic-framework countries, where the binding constraint is political economy rather than capital availability. This suggests the two literatures are not contradictory so much as describing different stages of the same process, a distinction that single-dimension reviews are structurally unable to draw.

Overall, this discussion underscores that effective decarbonization strategies in developing countries need to be designed as integrated policies that combine technology incentives, affordable financing mechanisms, and a coherent and equitable governance framework, rather than relying on a single policy instrument.

CONCLUSION

This study concludes that decarbonization strategies in developing countries rest on three interrelated pillars: the renewable energy transition, affordable climate finance, and coherent policy governance. The clean energy investment gap, which amounts to 1.2 trillion U.S. dollars per year, is a major structural barrier that must be addressed through investment risk-reduction instruments and innovative financing mechanisms such as the JETP. Furthermore, cross-sectoral policy coherence and attention to social justice are prerequisites to ensure that the energy transition does not place a disproportionate burden on vulnerable groups.

Theoretically, this review contributes to the literature on decarbonization in developing countries by integrating three strands of scholarship—energy-system modeling, climate finance, and policy governance—that have largely developed in parallel, and by showing, through the conceptual synthesis framework in Figure 2, that these dimensions are interdependent rather than additive: a shortfall in one constrains the effectiveness of the other two. This reframes the "financing gap" documented in prior single-dimension studies not as a purely economic shortfall but as a joint outcome of technological readiness, capital-cost dynamics, and institutional capacity, offering a more complete theoretical account of why decarbonization strategies that work in one country context underperform in another.

The practical implications of this study highlight the need for collaboration among developing country governments, multilateral financing institutions, and the private sector in designing investment de-risking instruments that can reduce the capital costs of renewable energy projects. This study has limitations because it is a literature review and has not conducted quantitative empirical testing on primary data from specific countries. Further research is recommended to conduct quantitative comparative studies among developing countries to test the effectiveness of climate finance schemes in greater depth.

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