CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT STRATEGIES IN THE LANCANG-MEKONG SUB-REGION

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Abstract. The Lancang-Mekong Sub-region (LMSR) is experiencing escalating climate change impacts, including intensified hydrological variability, ecosystem degradation, and threats to food and water security. Given the varying economic development levels and inadequate climate proofing infrastructure, the countries in the LMSR are confronted with the dual challenges of economic growth and environmental protection. This review synthesizes and evaluates existing research on climate governance in the LMSR, with a focus on institutional frameworks, cooperative initiatives, and persistent governance gaps. The LMSR has established a multi-level climate governance framework within environmental governance. Addressing climate change and its adverse effects has become a crucial area of cooperation for the region in implementing the Sustainable Development Goals (SDGs). While climate change cooperation in the LMSR faces challenges, including the lack of binding agreements, fragmented adaptation strategies, and asymmetrical power dynamics, these challenges remain significant. Key stressors, such as hydropower development, biodiversity loss, and transboundary water disputes, are often addressed in isolation rather than through integrated governance approaches.
Keywords: *LMSR, climate change, cooperation, national interests, sustainable development*

Introduction

The Lancang-Mekong Sub-region (LMSR), which includes Cambodia, Vietnam, Laos, Myanmar, Thailand, and China, forms a captivating and diverse region in Southeast Asia (*Fig. 1*). The LMSR hosts abundant natural resources and diverse habitats. As the region's economies grow, environmental problems are worsening. Coupled with climate change impacts like sea-level rise, ocean warming, and acidification, and frequent natural disasters, the LMSR now faces crises in food security, population mobility, water resource utilization, and biodiversity (Li, 2021).

Climate change, a long-term, intangible, and global issue with varying impacts, requires all countries to take responsibility and collaborate beyond borders (Visser and Brundtland, 2009). The international community has made progress in global climate governance, as seen in key treaties like the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, and the Paris Agreement. While regional governance alone cannot alter global climate change, regional sustainable development cooperation is important for global efforts, and thus such cooperation is essential (Warner, 2014). The inherent transboundary nature of climate change necessitates robust and coordinated regional responses. The LMSR countries, characterized by diverse economic development levels and often inadequate climate-proofing infrastructure, face the complex dual imperative of fostering economic growth while simultaneously safeguarding their environmental integrity and enhancing climate resilience. This intricate balance underscores the urgent need for effective climate change cooperation mechanisms.

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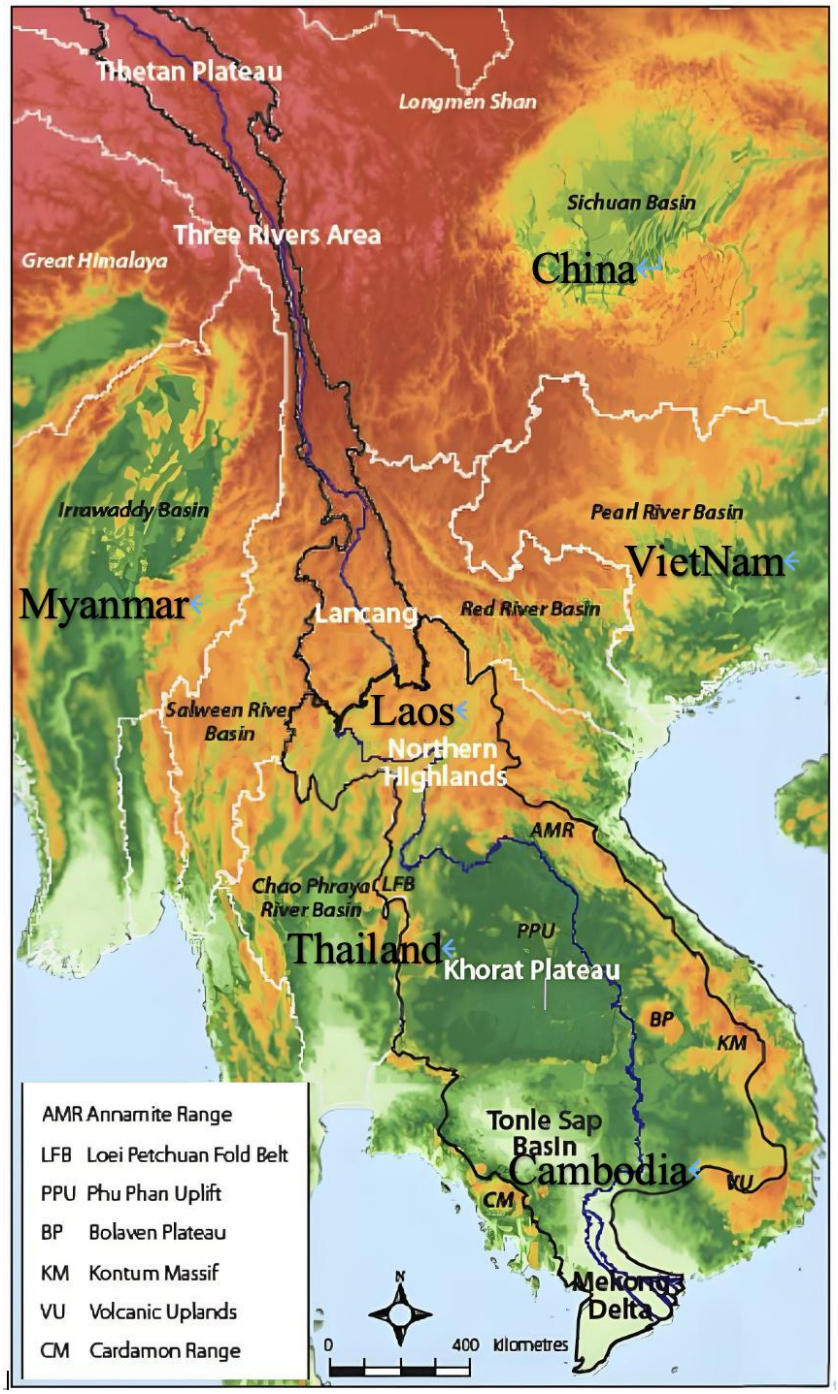

Figure 1. *Geographical location of the Lancang-Mekong River Basin. (Source: Mekong River Commission, available at https://www.mrcmekong.org/geographic-regions/)*

Existing scholarship highlights that the LMSR has incrementally developed a multi-level framework for environmental governance, within which climate change adaptation and mitigation have emerged as important areas for regional collaboration, which align closely with the broader objectives of the Sustainable Development Goals (SDGs) (Zhang et al., 2024). Despite these efforts, the landscape of climate change cooperation in the LMSR remains fraught with significant challenges. These include, but are not limited to,

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the absence of legally binding agreements that could enforce collective action, the prevalence of fragmented adaptation strategies that often lack regional coherence, and the persistent influence of asymmetrical power dynamics among riparian states. Furthermore, critical stressors such as extensive hydropower development, accelerating biodiversity loss, and recurrent transboundary water disputes are frequently addressed in isolation, rather than through the integrated, holistic governance approaches that are essential for effective climate resilience.

The growing academic engagement with climate governance in the LMSR underscores its strategic and environmental significance. A search in the Web of Science core database for topics ("Lancang-Mekong" OR "Mekong River") AND ("climate change" OR "water governance") over the past two decades (2004-2024) reveals a marked increase in publications. Keyword co-occurrence analysis of these publications shows several dominant and emerging clusters: (1) Hydrological modeling and climate impact assessment (e.g., "streamflow", "drought", "sediment"), representing the foundational natural science focus; (2) Governance and policy (e.g., "transboundary water governance", "cooperation", "hydropower"), reflecting the political and institutional research; and (3) Socio-ecological systems and livelihoods (e.g., "ecosystem services", "fisheries", "agriculture"), a growing interdisciplinary area. Notably, while keywords like "Lancang-Mekong Cooperation (LMC)" and "Mekong River Commission (MRC)" frequently appear, their co-occurrence with "effectiveness", "compliance", or "conflict resolution" is less pronounced, indicating a research gap in critically evaluating the outcomes of these mechanisms. Furthermore, there is a relative scarcity of literature quantitatively linking specific governance interventions to measurable socio-ecological resilience outcomes. This review paper aims to systematically synthesize and critically evaluate the existing body of research pertaining to climate change cooperation mechanisms in the LMSR. Drawing upon a diverse range of academic disciplines, including geopolitics, regional cooperation studies, as well as climate change mitigation and adaptation research, this paper seeks to provide a comprehensive overview of the current state of knowledge. The literature review will categorize and analyze the literature based on key research themes, offering a comparative analysis of the strengths and limitations of various studies. By doing so, it intends to illuminate the progress made, identify persistent governance gaps, and suggest directions for future research and policy in LMSR. The overarching goal is to contribute to a deeper understanding of how the LMSR can navigate its complex environmental and geopolitical landscape to foster more effective and equitable climate change cooperation.

Understanding climate change impacts and regional vulnerabilities in the LMSR

The LMSR stands as a critical hotspot for climate change impacts, with profound implications for its environment, economy, and societies. A foundational understanding of these impacts is crucial for appreciating the urgency and complexity of regional cooperation efforts (Wu et al., 2020). Current studies highlight the complex interplay between climate change impacts and regional governance, emphasizing the importance of collaborative approaches to address transboundary issues include: (1) Hydrological Variability and Water Security: Uncoordinated upstream reservoir operations affecting downstream water availability (Yun et al., 2021; Wei et al., 2021); (2) Sediment and Nutrient Flux Disruption: Dam-induced sediment trapping leading to delta erosion and agricultural loss (Shrestha et al., 2013; Li et al., 2024); (3) Compounding Ecological

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Degradation: Combined climate and transboundary habitat threats to migratory fisheries (Meur et al., 2022); (4) Saline Intrusion and Delta Sustainability: Sea-level rise and reduced flow exacerbating saltwater intrusion in Vietnam (Vu et al., 2018; Phuong et al., 2024); (5) Transboundary Pollution and Climate Resilience: Land-use changes affecting regional carbon sinks and watershed functions (Tang et al., 2021; Lang et al., 2024); and (6) Data and Early Warning Gaps: Lack of shared data hindering joint forecasting and planning (Li and Song, 2020). The persistence of these challenges underscores the urgent need for, and the potential benefits of, more effective and institutionalized climate change cooperation mechanisms.

The annual average temperature in the region is projected to rise at rates of 0.219°C/10a and 0.578°C/10a under RCP4.5 and RCP8.5 scenarios, respectively, while annual precipitation is expected to increase by 29.474 mm/10a and 50.733 mm/10a under the same scenarios (Li and Song, 2020). These projections underscore a clear trend towards a warmer and wetter climate, with abrupt shifts in temperature and precipitation patterns anticipated around the mid-21st century. Climate change is altering the Mekong's hydrological cycles, manifesting in shifting streamflow patterns, increased extreme weather events, and sediment yield variability. Research findings indicate that increasing temperatures and variable precipitation patterns in upper basin areas significantly alter hydrological regimes, leading to downstream water scarcity (Fan and He, 2015; Yun et al., 2021). Drought and flood dynamics are particularly concerning. Recent analyses reveal a concerning trend of escalating meteorological and hydrological drought occurrences, characterized by a distinct eastward shift in drought vulnerability that intensifies regional water stress (Yu et al., 2021). In contrast, climate projections indicate a parallel increase in flood hazards resulting from modified precipitation patterns, necessitating the implementation of robust flood management approaches (Wang et al., 2021). The stability of delta systems faces additional challenges from diminishing sediment loads. Empirical evidence from the Nam Ou Basin demonstrates how climatic variations in temperature and precipitation directly contribute to declining sediment yields, with significant implications for fluvial geomorphology and engineered structures (Shrestha et al., 2013).

Beyond these direct impacts, the Mekong's ecological systems face compounding stressors from climate change and human activities. A substantial decline in forest cover coupled with a notable expansion of cultivated land happened in LMSR between 2000 and 2020. This trend is particularly concerning given the vital role of forests as carbon sinks, which are essential for climate change mitigation (Lang et al., 2024). The compounding effects of dam construction and climate change present particular threats to ecological stability in the Lower Mekong region, creating complex challenges that require careful balancing of economic development with environmental protection (Meur et al., 2022; Li et al., 2024). The Mekong Delta faces compounding threats from rising sea levels and saltwater infiltration, with significant consequences for agricultural systems, aquatic resources, and potable water availability (Renaud and Kuenzer, 2012; Vu et al., 2018). Current assessments suggest that while immediate food production capacity appears resilient, the sustainability of agrarian outputs becomes increasingly precarious without substantive adaptation interventions (Phuong et al., 2024). These pressures are amplified by landscape transformations, particularly the widespread conversion of forested areas to commercial plantations--a transition affecting approximately 82% of deforested land--with measurable impacts on both biogeochemical cycles and watershed dynamics (Tang et al., 2021).

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The scientific understanding of climate change characteristics forms the bedrock upon which discussions of cooperation mechanisms must be built. Without a clear grasp of the specific climate threats, i.e., their nature, magnitude, and projected trajectory, any cooperative endeavor risks being misdirected or insufficient. The insights from such climatological research highlight the need for both mitigation efforts, though largely global in scope, and, more critically for the LMSR, robust adaptation strategies that can address the immediate and projected impacts of a changing climate.

Institutional frameworks and regional cooperation mechanisms in LMSR

The LMSR is characterized by a complex web of regional cooperation mechanisms, each with distinct mandates, memberships, and operational approaches. These mechanisms play a crucial role in addressing the transboundary challenges of the Mekong River, including those exacerbated by climate change. However, their effectiveness is often shaped by underlying geopolitical dynamics, national interests, and the inherent competition for influence among external powers.

The Lancang-Mekong Cooperation (LMC) and its role

The LMC mechanism, initiated by China in 2016, stands out as a significant platform for regional engagement. The LMC's focus areas, including water resources, connectivity, industrial capacity, agriculture, and poverty reduction, directly or indirectly touch upon climate change adaptation and sustainable development. For instance, infrastructure projects promoted under the LMC, while offering economic development opportunities, also carry environmental implications that need careful consideration in the context of climate resilience. The LMC's characteristics of being "down-to-earth" and "results-oriented" are increasingly evident. The LMC Special Fund has supported over 800 projects, including flagship projects such as the LMC Bumper Harvest Projects, the Green Lancang-Mekong Initiative and the Lancang-Mekong Sweet Spring Action (China Daily, 2025). These projects span the "three pillars" of political-security, economic, and socio-cultural cooperation, with significant focus on sustainable development and climate-related issues.

The LMC exemplifies "Chinese-style multilateralism," characterized by its informality, issue-centricity, and a distinct preference for scale and inclusivity, aiming to enhance China's resilience and pivotal role in the Asia-Pacific region (Wu and Kim, 2024). Some scholars further analyze the LMC as an institutional balancing strategy, arguing that it serves as a counterweight to other existing mechanisms like the US-Mekong Partnership (UMP) and the Mekong River Commission (MRC) (Po and Primiano, 2021). This perspective suggests that while the LMC promotes cooperation, it is also deeply embedded in a broader geopolitical competition for influence in the sub-region.

The Mekong River Commission (MRC) and its challenges

In contrast to the LMC, the MRC represents an older, more established intergovernmental organization, formed by Cambodia, Laos, Thailand, and Vietnam. While China and Myanmar are dialogue partners, they are not full members, which limits the MRC's comprehensive basin-wide management capabilities, particularly concerning upstream hydropower development. The MRC's mandate focuses on sustainable

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development of the Mekong River, including water resource management, environmental protection, and flood and drought management. In recent years, the MRC has increasingly recognized the impacts of climate change in LMSR. In response to member countries' calls for cooperative regional adaptation measures, the MRC developed the Climate Change and Adaptation Initiative in 2009. This initiative reviews existing monitoring systems and explores ways to protect the Mekong region and its biodiversity from the effects of climate change, thereby assessing the impacts of and vulnerabilities to climate change. To effectively predict the impacts of climate change on the Mekong River Basin, the MRC approved the Mekong Adaptation Strategy and Action Plan (MASAP) in 2017. MASAP provides technical advice, methodologies and tools to strengthen the implementation of national strategies by member countries and informs the development of the Basin Development Strategy (BDS) 2021-2030 and MRC Strategic Plan (SP) 2021-2025.

The MRC actively provides technical advice to member countries to enhance their capacity to implement national strategies related to climate change. However, the main function of the MRC serves as a regional platform for water diplomacy and a knowledge hub of water resources management of the region, actions on climate change have not been carried out adequately. In addition, the MRC acts as a consultative body offers a platform for information exchange and promotes information sharing among member countries, while it does not possess enforcement or regulatory powers. Thus, it has limited influence over the national policies of its members. For example, The MRC's involvement in moderating the effects of river regulation is demonstrated by the procedures for prior consultation and consent on major dam projects. The case of the Xayaburi Dam in Laos is illustrative. While the MRC's prior consultation process facilitated technical discussions and led to design modifications (e.g., adding fish passages), it could not veto the project. The dam's operation has since been linked to documented changes in downstream water levels and sediment transport, impacting communities in Thailand and Cambodia (MRC, 2019).

Competing and complementary initiatives

The LMSR hosts multiple significant cooperative frameworks beyond the LMC, notably including the UMP and Mekong-Japan Cooperation (MJC). Recent scholarship examining strategic competition between major powers in the region reveals divergent approaches to regional engagement. The United States prioritizes principles of transparency and multilateralism through initiatives such as the UMP, framing its involvement within sustainable development paradigms. In contrast, China's engagement through the LMC manifests primarily through infrastructure development, particularly hydropower projects, alongside financial instruments and strategic diplomacy (Tran, 2025).

As the most substantial downstream state, Vietnam exemplifies the complex navigation of this competitive landscape, strategically engaging with both frameworks to advance national priorities while confronting persistent challenges in water governance, institutional alignment, and regional power balancing (Tran, 2025). This strategic environment creates conditions where regional states frequently pursue multi-alignment strategies with external partners to mitigate risks and maximize developmental opportunities. Contemporary analyses further highlight the increasingly multipolar character of Mekong cooperation, with additional actors including Russia contributing to

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– and occasionally complicating – the regional governance architecture through distinct engagement modalities (Burova, 2024).

The proliferation of cooperative mechanisms generates both opportunities and systemic challenges. Institutional competition, particularly centered around China's LMC initiative, frequently results in fragmented governance outcomes (Po and Primiano, 2021). Duplicative programming, divergent strategic priorities, and inconsistent policy coordination undermine the development of cohesive, basin-wide climate adaptation and mitigation strategies. Riparian states may find themselves in a position of choosing between initiatives, or attempting to balance engagement with all, which can strain resources and dilute collective action. Empirical studies of regional water governance reveal that while high-level diplomatic engagements and multilateral projects generate positive momentum in technical cooperation, fundamental tensions persist regarding infrastructure development and asymmetric power relations (Wei et al., 2021). These structural factors continue to constrain the emergence of genuinely integrated climate governance approaches.

In summary, the regional cooperation mechanisms in the LMSR are a dynamic interplay of cooperation and competition. While platforms like the LMC and MRC aim to foster regional development and address shared challenges, their effectiveness is often constrained by geopolitical rivalries, differing national interests, and the contentious issue of transboundary water management, particularly hydropower development (Liu et al., 2020). Understanding these complex dynamics is essential for identifying pathways towards more robust and integrated climate change cooperation in the sub-region.

Challenges and governance gaps in LMSR climate change cooperation

Despite the recognized imperative for cooperation and the existence of various regional mechanisms, climate change cooperation in LMSR faces a multitude of persistent challenges and significant governance gaps. These impediments often stem from a complex interplay of geopolitical dynamics, differing national interests, institutional limitations, and the inherent characteristics of transboundary resource management.

Uncertainty of the cooperation willingness

Climate change cooperation in the LMSR is often linked with traditional security issues and influenced by differences in national interests and norms, leading to uncertainty in countries' willingness to cooperate (Zou and Zhang, 2020). For example, maritime delimitation disputes between China and Vietnam, as well as the historical-based sovereignty disputes between Cambodia and Thailand, etc., result in a lack of political trust and hinder information-sharing and coordinated actions. In addition, differences in economic development levels, resource endowments, and environmental reliance also lead to varying policy priorities and levels of enthusiasm for climate action (*Table 1*) (Zhang and Li, 2020; Sasaki et al., 2021; Lang et al., 2024; Phuong et al., 2024). For instance, Thailand focuses on energy efficiency and carbon fixation technologies, while Cambodia prioritizes agriculture and public health in its climate adaptation efforts. However, one country's solution might become another's problem, e.g., Thailand's water diversion ambitions could directly impact Cambodia's water availability. Sustainable climate adaptation cannot be achieved by national policy alone; instead, integrated, cooperative governance is required.

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Table 1. *National eco-economic policies and their transboundary implications*

Country	Key eco-economic policy/goal	Primary domestic rationale	Potential transboundary challenges for other LMSR countries
China	"Western Development Strategy", "Dual Carbon" goals, Lancang-Mekong hydropower cascade development	Regional balance, energy transition, renewable energy security	Alters natural flow regime (affecting dry-season flows & flood pulses), traps sediment (affecting delta agriculture/fisheries), perceived unilateralism undermining downstream trust
Laos	"Battery of Southeast Asia", extensive conversion of forest to plantations (e.g., rubber, banana)	Poverty alleviation, revenue from electricity & commodity export	Hydropower dams affect fish migration (impacting Cambodian/Vietnamese fisheries), deforestation reduces regional carbon sink and affects watershed hydrology
Thailand	Import of hydropower from Laos/Myanmar, water diversion projects for drought-prone northeast	Energy diversification, domestic water security for agriculture	Increased demand for upstream hydropower incentivizes dam construction in neighboring countries, with associated downstream ecological impacts. Diversion plans can be a source of tension with downstream Cambodia
Cambodia	Reliance on Tonle Sap Lake fisheries and flood-recession agriculture, recent rapid deforestation	Food security, livelihoods, economic growth from timber/agriculture	Deforestation contributes to regional carbon emissions and sedimentation issues. Its vulnerability makes it highly sensitive to upstream flow alterations from China, Laos, and Thailand
Vietnam	"Rice First" policy in the Mekong Delta, coastal resilience projects against saline intrusion	National food security, protection of densely populated delta	Requires stable, sufficient freshwater and sediment flows from the entire basin. Upstream dams and water use directly threaten this, creating a high-stakes dependency and potential for conflict

Fragmented cooperation mechanisms

The fragmentation is a direct consequence of the diverse economic development levels among LMSR states and the asymmetrical power dynamics within the sub-region. Countries with greater economic and technical capacity, often pursue their own development agendas, including large-scale infrastructure projects, which they may view as adaptation measures (e.g., building dams for energy security or flood control). However, dam infrastructure might be a major element of conflict and negative reporting in the basin, indicating that these "adaptation" measures by one state can create significant maladaptation challenges for others, particularly downstream nations reliant on natural flow regimes (Wei et al., 2021). For instance, the cascade of hydropower dams developed on the Lancang (Upper Mekong) in China, often discussed within broader LMC cooperation frameworks on energy and water resources, presents a critical case. While contributing to China's renewable energy goals and framed as a means of regulating flow

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for downstream flood and drought mitigation, empirical studies highlight significant transboundary externalities. Research indicates that these dams have altered the river's natural flow regime, notably reducing the amplitude of the annual flood pulse and trapping an estimated 50-90% of the sediment historically carried by the river (Kondolf et al., 2018; Li et al., 2024). The downstream economic and environmental impacts are substantial: in Cambodia, the Tonle Sap Lake's ecosystem, which relies on the flood pulse to nourish the world's most productive inland fishery, has shown signs of ecological stress, threatening the livelihoods of millions.

Lack of binding agreements and enforcement mechanisms

A primary and overarching challenge is the conspicuous absence of legally binding agreements that could effectively govern climate change cooperation in LMSR. While platforms like the LMC and the MRC facilitate dialogue and project-based collaboration, their mandates often lack the teeth of enforceability. Regarding to the international environmental law, issues such as national sovereignty, the lack of unified implementation, and weak institutional frameworks significantly affect the effectiveness of agreements (Albakjaji and Baroudy, 2024). In LMSR, this translates into a situation where upstream development decisions, particularly regarding hydropower, can proceed without the explicit consent or full consideration of downstream impacts, despite their profound implications for climate resilience. The MRC, for instance, relies on consensus and notification procedures rather than binding veto powers, which limits its ability to halt or significantly alter projects initiated by its members or dialogue partners. This institutional weakness is a critical governance gap, as it allows individual national interests to override collective basin-wide sustainability.

Data gaps and technical capacity limitations

Climate change cooperation in LMSR is also hindered by data gaps and technical capacity limitations. Scholars have documented how insufficient meteorological monitoring across the LMSR states severely limits climate research capabilities and undermines effective decision-making (Li and Song, 2020). This data deficit spans multiple critical domains - from hydrological records to ecological benchmarks and socioeconomic indicators - all essential for reliable climate modeling and adaptation strategies. To implement policies like those under the UNFCCC, countries need to meet several requirements for REDD+ Mechanism: a national REDD+ strategy or action plan (NRS), reference emission levels (FREL/FRL), a robust forest monitoring system (NFMS), and safeguards information systems (Sasaki et al., 2021). However, for countries with limited technical know-how, putting these policies into practice is challenging. For example, Vietnam faces the challenges for REDD+ such as ineffective consultation processes leading to lack of inclusion in decision making (Tien and Panwong, 2023), and gaps in the implementation of numerous safeguards-relevant policies, laws and regulations (Wurtzebach et al., 2019). This, along with a lack of trained personnel and funding, makes LMSR countries, despite their strong desire to cooperate on climate change, still very passive in their response.

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Pathways for enhanced cooperation and sustainable development

Addressing the multifaceted challenges of climate change in LMSR necessitates a concerted effort to enhance cooperation and foster sustainable development, moving beyond fragmented approaches towards integrated governance. The existing literature, while highlighting significant gaps, also implicitly or explicitly points towards several pathways for improvement.

Firstly, a primary pathway involves strengthening the legal and institutional frameworks governing transboundary water resources and environmental protection. While the LMSR currently lacks comprehensive, legally binding agreements, the principles of international environmental law offer a foundation for more robust commitments. A comprehensive overview of these principles, including the precautionary principle, the polluter pays principle, and the principle of common but differentiated responsibilities, which could be more rigorously applied to the Mekong context (Sands et al., 2018). The adoption of a framework convention on planetary boundaries could provide a scientific and legal basis for defining safe operating spaces for human activities in the basin, thereby guiding development decisions, particularly regarding hydropower and land use, to prevent the transgression of critical ecological thresholds (Fernándezc and Malwé, 2018). Such a framework would necessitate a shift towards a more eco-centric rule of law, moving beyond an anthropocentric ontology that has historically prioritized economic development over environmental integrity (Kotzé and French, 2018).

Secondly, addressing the geopolitical dynamics and power asymmetries is another crucial pathway for fostering genuine cooperation. While the strategic competition between the extra-regional powers and China may complicate regional efforts, it also presents opportunities for riparian states to diversify their partnerships and leverage competing interests for their benefit. A pathway forward involves strengthening the collective voice and agency of the downstream Mekong countries, perhaps through enhanced coordination within ASEAN or a revitalized MRC, to advocate for more equitable and sustainable water governance (Po and Primiano, 2021; Tran, 2025).

Thirdly, coordinating the relationships among the existing climate change cooperation mechanisms is needed. The LMSR countries have reached some achievements in climate change mitigation and adaptation by working together. However, this cooperation has also given rise to intense competition among the various mechanisms (Biba, 2014; Renwick, 2016). In response to this situation, the establishment of an information-sharing platform for all cooperative mechanisms within the region is highly recommended. Such a platform will serve as a venue for information exchange, experience sharing, and dispute resolution among the different cooperative mechanisms. This will facilitate more flexible and effective cooperation, reduce cooperation costs and institutional conflicts.

Finally, aligning regional climate cooperation with the broader SDGs offers a holistic framework for integrated development. Some scholars discuss how SDGs can be integrated into integrated coastal zonal management (ICZM) for coastal sustainability, which is highly relevant for the Mekong Delta (Zhang et al., 2024). Extending this integration across the entire basin, linking climate action (SDG 13) with water and sanitation (SDG 6), poverty eradication (SDG 1), food security (SDG 2), and ecosystem protection (SDG 15), would ensure that climate strategies contribute to broader human well-being and ecological health (Zhang et al., 2024). The LMSR's unique position, with its significant agricultural base and reliance on natural resources, makes the achievement of these interconnected goals particularly challenging but also particularly impactful. By

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framing climate cooperation within the comprehensive agenda of the SDGs, the sub-region can attract broader international support and foster more integrated policy-making that transcends narrow sectoral interests.

Research gaps

Despite the growing body of literature, several research gaps persist, offering fertile ground for future inquiry:

(1) *Effectiveness of cooperation mechanisms:* While studies analyze the strategic motivations and institutional competition among various mechanisms, including LMC, MRC, UMP, there is a need for more rigorous, empirical assessments of their actual effectiveness in delivering tangible climate change adaptation and mitigation outcomes on the ground. This includes evaluating the extent to which projects under these mechanisms genuinely enhance climate resilience, rather than merely serving geopolitical or economic objectives. How do these mechanisms translate high-level commitments into practical, measurable improvements in water security, ecosystem health, and community resilience?

(2) *Integrated governance models for transboundary climate risks:* The literature highlights the fragmentation of cooperation mechanisms. Future research should explore and propose concrete, integrated governance models that can effectively bridge these silos. This could involve examining successful cases of integrated river basin management from other regions and assessing their applicability to the Mekong, considering its unique geopolitical and hydrological characteristics. Specifically, how can international legal principles, such as the ecosystem approach, be operationalized within the LMSR's complex institutional landscape to foster genuinely integrated climate governance?

(3) *The role of non-state actors and local communities:* While the current literature focuses heavily on state-led initiatives and intergovernmental organizations, the role of non-state actors, including civil society organizations, local communities, and scientific networks, in climate change cooperation in the LMSR remains underexplored. How do these actors influence policy, implement grassroots adaptation, and contribute to regional resilience? Understanding their agency and potential for collaboration with formal mechanisms is crucial for holistic climate governance.

(4) *Data sharing and scientific cooperation challenges:* The lack of meteorological and hydrological data causes a critical gap in scientific cooperation. Future research could investigate the political economy of data sharing in transboundary river basins, identifying barriers and incentives for greater transparency and collaborative data collection and analysis. This includes exploring the role of international organizations and third-party scientific bodies in facilitating such cooperation.

Future directions

Building on the identified research gaps, future directions for scholarship and policy in the LMSR should focus on: (1) How to Strengthen Legally binding mechanisms for climate change cooperation in LMSR. This might involve incremental steps, such as strengthening the mandates of existing institutions like the MRC, or exploring new legal instruments that address specific contentious issues like cumulative hydropower impacts. The emphasis should be on fostering a "rule of law" that is both effective and equitable,

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potentially moving towards a more eco-centric orientation. (2) Policy efforts should prioritize fostering multi-stakeholder platforms that bring together governments, civil society, the private sector, and local communities in climate change planning and implementation. This also entails strengthening multi-level governance, ensuring that regional strategies are effectively translated into national and sub-national actions, and vice versa. (3) Leveraging Technology for Enhanced Cooperation. Enhancing technical exchange and training among countries, and conducting special research on climate change for LMSR countries can clarify key directions for future cooperation and boost the practical effects (Zhang et al., 2020). Future efforts should focus on developing a unified regional framework for data sharing and technology adoption, coupled with capacity-building initiatives to ensure equitable access and utilization across all riparian states. (4) Exploring other cooperation models. The triangular cooperation, which is a form of international cooperation that has evolved from South-South cooperation, can be actively explored and carried out in LMSR (Alonso and Santander, 2022). Compared with South-South cooperation and North-South cooperation, tripartite cooperation can increase the scale of aid funds and fully utilize the complementary knowledge, resources and technologies of developed country donors and developing country donors. The involvement of multiple parties, including multilateral organizations, is conducive to generating more flexible and innovative solutions. For example, academic institutions can provide intellectual and technical support, while multilateral fund organizations can offer financial support. This ensures the smooth implementation of climate change cooperation in the LMSR region.

Conclusions

The LMSR faces an escalating climate crisis, characterized by intensified hydrological variability, ecosystem degradation, and profound threats to food and water security, etc. This review has systematically synthesized the existing academic literature, revealing a complex landscape of climate governance shaped by a multiplicity of institutional frameworks, intricate geopolitical dynamics, and persistent governance gaps. While various cooperation mechanisms have been established in LMSR, e.g., MRC, LMC, these initiatives operate within a challenging environment marked by varying economic development levels, diverse national interests, and the pervasive influence of major power competition. Existing scholarship underscores that advancing climate cooperation and promoting sustainable development across the LMSR demands a multifaceted strategy. Further research is essential to develop a more refined comprehension of the dynamics of regional climate collaboration, which can in turn support the design of more effective, inclusive, and resilient governance approaches. The necessity for integrated and cooperative responses is evident; the central obstacle remains the mitigation of longstanding geopolitical, institutional, and legal barriers to achieve meaningful action.

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REFERENCES

[1] Albakjaji, M., Baroudy, J. E. (2024): The effectiveness of the international environmental law: the issues of state sovereignty, national interests, and differing levels of commitments. – Journal of Ecohumanism 3: 1348-1354. DOI: 10.62754/joe.v3i7.4297.

[2] Alonso, J. A., Santander, G. (2022): Triangular cooperation: change or continuity? – Regional Environmental Change 34: 248-271. DOI: 10.1057/s41287-021-00370-8.

[3] Biba, S. (2014): De-securitization in China's behavior towards its transboundary rivers: The Mekong River, the Brahmaputra River, and the Irtysh and Ili Rivers. – Journal of Contemporary China 23(85): 21-43. DOI: 10.1080/10670564.2013.809975.

[4] Burova, E. S. (2024): Scholars from Russia and Southeast Asia countries on the present and future of Mekong River. – The Russian Journal of Vietnamese Studies 8: 82-90. DOI: 10.54631/vs.2024.83-636613.

[5] China Daily (2025): A 'Golden Model' of Regional Collaboration. – http://www.lmcchina.org/eng/2025-10/15/content_43249861.html.

[6] Fan, H., He, D. (2015): Temperature and precipitation variability and its effects on streamflow in the upstream regions of the Lancang-Mekong and Nu-Salween Rivers. – Journal of Hydrometeorology 16: 2248-2263. DOI: 10.1175/JHM-D-14-0238.1.

[7] Fernándezc, E. F., Malwé, C. (2018): The emergence of the 'Planetary Boundaries' concept in international environmental law: a proposal for a framework convention. – Review of European, Comparative & International Environmental Law 28: 48-56. DOI: https://doi.org/10.1111/reel.12256.

[8] Kondolf, G. M., Schmitt, R. J. P., Carling, P., et al. (2018): Changing sediment budget of the Mekong: Cumulative threats and management strategies for a large river basin. – Science of the Total Environment 625: 114-134. DOI: https://doi.org/10.1016/j.scitotenv.2017.11.361.

[9] Kotzé, L. J., French, D. (2018): The anthropocentric ontology of international environmental law and the sustainable development goals: towards an ecocentric rule of law in the Anthropocene. – Global Journal of Comparative Law 7: 5-36. DOI: 10.1163/2211906X-00701002.

[10] Lang, F., Liang, Y., Li, S., et al. (2024): Spatio-temporal patterns of land use and cover change in the Lancang–Mekong River basin during 2000-2020. – Land 13: 1-20. DOI: 10.3390/land13030305.

[11] Li, H., Song, W. (2020): Characteristics of climate change in the Lancang-Mekong sub-region. – Climate 8: 1-17. DOI: 10.3390/cli8100115.

[12] Li, X., Fan, H., Yang, T. (2024): Detecting the three-dimensional dynamics of post-dam sandbars from Sentinel-2 time-series images: a case study in the Lower Lancang-Mekong River. – Earth Surface Processes and Landforms 49: 3489-3509. DOI: 10.1002/esp.5918.

[13] Li, Z. (2021): On the non-traditional security governance in the Lancang-Mekong cooperation mechanism. – Journal of International Security Studies 39: 90-119. [in Chinese] DOI: 10.14093/j.cnki.cn10-1132/d.2021.01.004.

[14] Liu, H., Liang, S., Cui, Q. (2020): The nexus between economic complexity and energy consumption under the context of sustainable environment: evidence from the LMC countries. – International Journal of Environmental Research and Public Health 18: 1-14. DOI: 10.3390/ijerph18010124.

[15] Meur, M. L., Phu, V. L., Nicolas, G. (2022): What Is the Future of The Lower Mekong Basin Struggling Against Human Activities? A Review. – In: Manning, A. J. (ed.) River Deltas Research-Recent Advances. IntechOpen, London. DOI: 10.5772/intechopen.95010.

[16] MRC (2019): Review of the design change made for Xayaburi hydropower project: a technical reference paper. – Technical Reference Paper: No. 65. https://www.mrcmekong.org/wp-content/uploads/2024/08/Review-of-the-Design-Change-Made-for-Xayaburi-Hydropower-Project-A-Technical-Reference-Paper-No.65.pdf.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_31773191

[17] Phuong, T. T., Vien, T. D., Son, C. T., et al. (2024): Impact of climate change on agricultural production and food security: a case study in the Mekong River Delta of Vietnam. – Sustainability 16: 1-16. DOI: https://doi.org/10.3390/su16177776.
[18] Po, S., Primiano, C. B. (2021): Explaining China's Lancang-Mekong cooperation as an institutional balancing strategy. – Australian Journal of International Affairs 75: 323-340. DOI: 10.1080/10357718.2021.1893266.
[19] Renaud, F. G., Kuenzer, C. (eds.) (2012): The Mekong Delta System Interdisciplinary Analyses of a River Delta. – Springer, Dordrecht. DOI: 10.1007/978-94-007-3962-8.
[20] Renwick, N. (2016): China as a Development Actor in Southeast Asia, Brighton: Institute of Development Studies. https://opendocs.ids.ac.uk/articles/report/China_as_a_Development_Actor_in_Southeast_Asia/26464957?file=48240376.
[21] Sands, P., Peel, J., Fabra, A., et al. (2018): Principles of International Environmental Law. – Cambridge University Press, Cambridge.
[22] Sasaki, N., Myint, Y. Y., Abe, I., et al. (2021): Predicting carbon emissions, emissions reductions, and carbon removal due to deforestation and plantation forests in Southeast Asia. – Journal of Cleaner Production 312: 127728. DOI: 10.1016/j.jclepro.2021.127728.
[23] Shrestha, B., Babel, M. S., Maskey, S., et al. (2013): Impact of climate change on sediment yield in the Mekong River Basin: a case study of the Nam Ou Basin, Lao PDR. – Hydrology and Earth System Science 17: 1. DOI: 10.5194/hess-17-1-2013.
[24] Tang, X., Woodcock, C. E., Olofsson, P., et al. (2021): Spatiotemporal assessment of land use/land cover change and associated carbon emissions and uptake in the Mekong River Basin. – Remote Sensing of Environment 256: 1-13. DOI: 10.1016/j.rse.2021.112336.
[25] Tien, N. D., Panwong, P. (2023): Overview of REDD+ Implementation in Vietnam, Economic and Political Aspects of EU-Asian Relations. – In: Nguyen, T. L., Nguyen, A. T., Ślęzak-Belowska, E., Salamaga, M. (eds.) Economic and Political Aspects of EU-Asian Relations. VEF 2023. Springer, Singapore, pp. 299-306. https://link.springer.com/chapter/10.1007/978-981-99-8945-4_18.
[26] Tran, S. T. (2025): The impact of U.S.-China strategic competition in the Mekong Sub-Region on Vietnam's national interests. – Journal of International Relations 5(1): 1-11.
[27] Visser, W., Brundtland, G. H. (2009): Our Common Future ("The Brundtland Report"): World Commission on Environment and Development. Top Sustainability Books, No. 4. – http://un-documents.net/our-common-future.pdf.
[28] Vu, D. T., Yamada, T., Ishidaira, H. (2018): Assessing the impact of sea level rise due to climate change on seawater intrusion in Mekong Delta, Vietnam. – Water Science and Technology 77: 1632-1639. DOI: https://doi.org/10.2166/wst.2018.038.
[29] Wang, S., Zhang, L., She, D., et al. (2021): Future projections of flooding characteristics in the Lancang-Mekong River basin under climate change. – Journal of Hydrology 602: 1. DOI: 10.1016/j.jhydrol.2021.126778.
[30] Warner, R. (2014): The Portents of Changing Climate: Maritime Security Implications for the South China Sea. – In: Wu, S., Zou, K. (eds.) Non-Traditional Security Issues and the South China Sea: Shaping a New Framework for Cooperation. Routledge, New York.
[31] Wei, J., Wei, Y., Tian, F., et al. (2021): News media coverage of conflict and cooperation dynamics of water events in the Lancang–Mekong River basin. – Hydrology and Earth System Sciences 25: 1603-1605. DOI: 10.5194/hess-25-1603-2021.
[32] Wu, J., Wang, X., Zhong, B., et al. (2020): Ecological environment assessment for Greater Mekong Subregion based on pressure-state-response framework by remote sensing. – Ecological Indicators 117: 1-14. DOI: 10.1016/j.ecolind.2020.106521.
[33] Wu, X., Kim, D. (2024): China's perception of minilateralism and Chinese-Style multilateralism. – Australian Journal of International Affairs 78: 869-888. DOI: 10.1080/10357718.2024.2409969.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2402_31773191

[34] Wurtzebach, Z., Casse, T., Meilby, H., et al. (2019): REDD+ policy design and policy learning: the emergence of an integrated landscape approach in Vietnam. – Forest Policy and Economics 101: 129-139. DOI: 10.1016/J.FORPOL.2018.10.003.
[35] Yu, L., Jia, X., Chi, Z., et al. (2021): Impact of climate change on the spatio-temporal characteristics of meteorological and hydrological drought over the Lancang-Mekong River basin. – Advances in Water Science 32: 508 (in Chinese). DOI: 10.14042/j.cnki.32.1309.2021.04.003.
[36] Yun, X., Tang, Q., Li, J., et al. (2021): Can reservoir regulation mitigate future climate change induced hydrological extremes in the Lancang-Mekong River basin? – Science of the Total Environment 785: 1-9. DOI: 10.1016/j.scitotenv.2021.147322.
[37] Zhang, H., Li, M. (2020): China's water diplomacy in the Mekong: a paradigm shift and the role of Yunnan Provincial Government. – Water International 45: 347-364. DOI: 10.1080/02508060.2020.1762369.
[38] Zhang, L., Zhou, P., Qiu, Y. Q., et al. (2020): Reassessing the climate change cooperation performance via a non-compensatory composite indicator approach. – Journal of Cleaner Production 252: 1-11. DOI: 10.1016/j.jclepro.2019.119387.
[39] Zhang, S., Wu, Q., Butt, Q. M. J., et al. (2024): Coastal cities governance in the context of integrated coastal zonal management. – Frontiers in Marine Science 11: 1-17. DOI: https://doi.org/10.3389/fmars.2024.1364554.
[40] Zou, K., Zhang, L. (2020): Handing Climate Change for the East and South China Sea. – In: McDonald, J., McGee, J., Barnes, R. (eds.) Research Handbook on Climate Change, Oceans and Coasts. Edward Elgar, Cheltenham.
DOI: https://doi.org/10.4337/9781788112239.00018.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
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