

Hydropower-economic Relationship between Nepal and India

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Abstract

Nepal is an important actor in regional energy strategy because of its enormous water resources and great hydropower potential, which is projected to be over 83,000 megawatts. Nepal is located in the Himalayas, which puts it in a highly advantageous location. Because India's rising energy demands create a major market for Nepal's untapped hydropower potential, the economic relationship between Nepal and India is of the utmost importance. On the other hand, the development of these resources is not without its challenges, which include political instability, finance dependencies, and environmental issues, all of which have traditionally stymied progress.

The study examines the strategic importance of hydropower not only in meeting energy needs but also as a geopolitical lever within the broader regional dynamics, especially considering the influences of neighbouring countries like China. Recent initiatives such as the Power Trade Agreement and cross-border electricity transmission projects underscore a renewed focus on enhancing cooperation, yet the realization of the full potential of this partnership requires addressing both technical and socio-economic challenges.

Through a comprehensive review of governmental reports, policy documents, and academic literature, the study aims to provide a deeper understanding of the mechanisms that can foster sustainable and equitable growth in the hydropower sector, proposing pathways to overcome the current barriers. This analysis highlights the critical need for transparent and fair practices that can transform Nepal-India hydropower resources into a cornerstone for sustainable economic growth and regional stability, ensuring mutual benefits and long-term cooperation between the two nations.

Keywords: *Hydropower-economic relationship, Nepal-India cooperation, Regional energy strategies, Geopolitical dynamics, Sustainable development*

Introduction

Nepal, situated amidst the majestic Himalayas, boasts plentiful water resources, rendering it a prime contender for hydropower development (Kumar & Katoch, 2015). With its rugged topography and abundant rivers, the country holds immense potential for hydropower generation, promising to bolster Nepal's economic progress and energy

self-sufficiency. In recent times, there has been a notable surge in attention towards hydropower project development, indicating a pivotal shift towards sustainable energy initiatives (Agrawala et al., 2003; Bhandari et al., 2018).

Nepal possesses a significant hydropower potential estimated at approximately 83,000 megawatts (MW), ranking among the world's leaders in per

capita hydropower potential (Adhikari, 2006). Originating from the Himalayas, the country's numerous rivers, such as the Koshi, Gandaki, and Karnali, present extensive prospects for the implementation of both large and small-scale hydropower initiatives.

The economic relationship between Nepal and India in the hydropower sector is a vital component of both nations' energy strategies and economic development. Given the rugged terrains and abundant water resources, Nepal holds a significant potential for hydropower generation, which can substantially enhance its economic growth, lower energy costs, and address poverty issues (Gunatilake et al., 2020). On the other side, India's growing energy demand provides a substantial market for Nepal's hydropower potential, presenting a unique opportunity for symbiotic economic benefits through cross-border power trade (Pradhan, 2011).

However, the development and utilization of hydropower resources between these two countries are fraught with complexities. Despite the potential economic advantages, the sector's growth in Nepal has been stymied by several challenges. These include reliance on external funding, which has led to a net power import situation despite abundant resources (Berkoff, 2003) and the need for substantial investment in infrastructure and skills, particularly in remote regions (Pandey, 1996). Moreover, environmental concerns and the socio-economic impact on local communities remain significant issues needing careful management.

The relationship is further complicated by the geopolitical dynamics in the region, particularly the strategic interests of neighboring countries like China and the broader implications for regional stability (Johnny, 2021). The ultimate goal of this research is to foster a deeper understanding of

how hydropower can serve as a cornerstone for sustainable economic growth and regional stability between Nepal and India, propelling both nations towards achieving their energy and economic objectives.

Geographical and Hydrological Context

Nepal, characterized by its mountainous terrain and the presence of part of the Himalayan range, possesses a natural predisposition for hydropower development due to its abundant water resources. The country is home to some of the world's major river systems that originate in the Himalayas, including the Koshi, Gandaki, and Karnali, which are part of the larger Ganges basin. These rivers have significant hydropower potential due to their steep gradients and substantial flow volumes (Shrestha, 2015).

India, with its varied topography and vast geographical spread, also has substantial hydropower potential, particularly in the northern regions which share the Himalayan range. India's energy needs are vast and growing, and hydropower forms a critical component of the country's renewable energy strategy to meet these demands sustainably (Berkoff, 2003).

Historical Cooperation and Challenges

The history of Nepal-India hydropower cooperation dates back several decades, marked by both achievements and controversies. The cooperation has largely been governed by bilateral treaties and agreements, such as the 1954 Koshi Agreement, the 1959 Gandak Agreement, and more recently, the 1996 Mahakali Treaty. These agreements have facilitated various hydropower projects but have also been subjects of disputes over water rights, project benefits, and environmental and social impacts (Gunatilake et al., 2020).

Economic and Strategic Importance

Hydropower is a cornerstone of Nepal's economic strategy. It is seen not only as a solution to the country's own energy needs but also as a significant export opportunity—primarily to energy-hungry India. For India, importing hydropower from Nepal could help meet its energy deficits in a clean and sustainable manner, contributing to its renewable energy targets and reducing reliance on fossil fuels (Pokharel, 2001; Pradhan, 2011).

The strategic importance of Nepal-India hydropower relations extends beyond mere energy economics. It plays a vital role in regional geopolitics, where energy security is increasingly becoming a tool for political stability and diplomatic leverage. Additionally, the involvement of other regional powers, such as China, adds a layer of complexity to the Nepal-India energy dialogue, influencing broader regional energy and security policies (Johnny, 2021)

Recent Developments

In recent years, there has been a renewed focus on enhancing hydropower cooperation between Nepal and India. Initiatives such as the Power Trade Agreement in 2014 and the establishment of cross-border electricity transmission lines have paved the way for increased power exchange. Moreover, projects like the Arun III, Upper Karnali, and Pancheshwar, which are being developed with Indian investment, highlight the potential for mutual benefits through collaborative development (Adhikari, 2006).

The background of Nepal-India hydropower cooperation is marked by significant potential and complex challenges. Understanding this context is essential for framing the current economic interactions and for identifying pathways to

enhance the hydro-economic relationship between the two nations. This sets the stage for a detailed examination of the current state of affairs, the opportunities for growth, and the obstacles that need to be overcome to realize the full potential of Nepal-India hydropower cooperation.

Methodology

In this research paper, data will be gathered from a variety of sources to provide a comprehensive analysis of hydropower development between Nepal and India. The following data sources will be utilized:

1. **Energy Production Reports:** Official energy production reports from governmental and non-governmental organizations will serve as primary sources of data on hydropower generation in Nepal and India. These reports will provide insights into the installed capacity, electricity generation, and operational performance of hydropower projects.
2. **Government Policy Documents:** Policy documents issued by the governments of Nepal and India will be examined to understand the regulatory frameworks, incentives, and strategies governing hydropower development. These documents will include national energy policies, hydropower development plans, and regulatory guidelines issued by relevant ministries and agencies.
3. **International Trade Records:** Trade data related to cross-border electricity trade between Nepal and India will be sourced from international organizations such as the World Trade Organization (WTO),

International Energy Agency (IEA), and regional trade agreements. These records will provide information on electricity exports, imports, tariffs, and trade dynamics between the two countries.

4. **Academic Literature:** Peer-reviewed research articles, conference papers, and academic journals will be consulted to review existing studies, methodologies, and findings related to hydropower development, cross-border electricity trade, and bilateral relations between Nepal and India. This literature review will provide theoretical frameworks, empirical evidence, and comparative analyses to contextualize the research findings.

Results

Nepal-India Hydropower Economic Relationship: Opportunities and Challenges

As Nepal intensifies its hydropower development efforts to meet its energy demands and explore export opportunities, recent studies have unveiled the country's vast potential in this sector. A recent study by the Water and Energy Commission Secretariat indicates that Nepal can harness over 72,000 megawatts (MW) of hydropower across its major river basins and sub-basins (Agrawala et al., 2003; Schulz & Saklani, 2021). Nepal's abundant water resources, comprising approximately 6,000 rivers spanning 45,000 kilometers (Panday, 2006), have long been recognized. According to an Asian Development Bank (ADB) report, these rivers yield an average annual water runoff of about 220 billion cubic meters (Nepal, 2021). Even under the Q40 standards, where hydropower projects operate at full capacity for 40% of the year, these

river basins and their tributaries hold the potential to generate between 72,000 MW to 73,000 MW of hydropower. This estimation aligns with a previous study conducted in 2019 by the commission, which identified Nepal's gross hydropower potential at 72,544 MW, with the Koshi, Gandaki, and Karnali river basins contributing 94% of the total gross potential.

Despite the substantial potential, Nepal's actual hydropower generation capacity remains relatively low. The country's installed capacity of hydropower projects stands at around 2,800 MW, according to the Nepal Electricity Authority (NEA) (Shahi, 2020). This disparity between potential and actual generation can be attributed to various historical and contemporary factors.

Historically, Nepal experienced limited progress in hydropower development due to its state-led economic model during the Panchayat regime and a lack of private sector involvement. The country's first hydropower plant, the 500 kW Pharping Hydropower Plant, was developed in 1911, followed by slow progress until 1960, with only 1.1 MW of power generated by then (Adhikari, 2006). Despite early studies and proposals for large-scale hydropower projects, such as the Karnali-Chisapani Multipurpose Project and the West Seti Hydropower Project, actual development remained minimal.

The liberalization of Nepal's economy following the restoration of democracy in 1990 marked a turning point for private sector involvement in hydropower development (Osmani, 2007). However, political factors, such as the controversy surrounding the World Bank's withdrawal from the Arun III project in 1995, hindered progress. Consequently, Nepal suffered from prolonged power cuts, lasting until 2018.

Following the full operation of the 456MW Upper Tamakoshi Hydropower Project in August 2021, Nepal witnessed an energy surplus during the wet season. This surplus led India to open its power exchange market to Nepal in early November 2021, enabling the sale of electricity generated from projects like the 24MW Trishuli Hydropower Project and the 15MW Devighat Hydropower Project. Over time, India gradually increased the import quota from Nepal, allowing exports of up to 632.6MW. By mid-November of that year, Nepal had already exported power worth Rs14.5 billion, as reported by NEA. This development has instilled confidence in Nepal's ability to export power not only to India but also to other South Asian markets. During Prime Minister Pushpa Kamal Dahal's visit to India in May-June, India pledged to purchase up to 10,000MW over the next decade. Furthermore, Nepal and India have committed to collaborating in the power sector under the BBIN initiative. With the rapid increase in domestic power production in recent years, NEA aims for Nepal to become a net exporter of power by 2026.

Looking ahead, Nepal aims to significantly increase its energy production and exports, with plans to generate over 28,000 MW of electricity by 2035 (Neupane,2022). However, achieving this target will require substantial investments, estimated at \$46.5 billion for generation and infrastructure development. Challenges such as local obstructions, delays in environmental clearance, and corruption must also be addressed to realize Nepal's hydropower potential fully (Poudyal,2019).

Despite these challenges, Nepal sees a growing opportunity to expand its domestic market for electricity and strengthen its bargaining power with India. By maximizing domestic consumption, leveraging regional partnerships, and attracting foreign investment, Nepal aims to become a key player in the regional energy market, contributing to sustainable development and regional stability.

Major river system of Nepal

Nepal possesses significant untapped hydropower potential estimated at 90,000 MW, yet only 650 MW is currently being generated annually (Ojha, 2020). This underutilization can be attributed to various factors, including insufficient investment in the energy sector (Thapa, 2014), limited electricity access, and the seasonal variability of hydropower (Ale & Shrestha, 2008). The country's energy crisis, with only 60% of the demand being met domestically, further underscores the need for increased hydropower production (Kumar & Katoch, 2015). Political obstacles have also hindered the development of energy infrastructure and investment in hydropower projects (Zhou, 2011). Despite these challenges, the potential for hydropower to meet domestic demand, create a surplus for export, and generate employment is significant (Alam et al., 2017).

Table 1: Major rivers of Nepal

River Basin	Area of Drainage (in square kilometers)	Hydropower Potential (in megawatts)	Geographic Coverage
Karnali and Mahakali	Approximately 48,811	Estimated at around 36,180	Spanning across India and Nepal
Gandaki	Covering approximately 36,607	Potential hydropower of about 20,650	Extending through India and Nepal
Koshi	Encompassing an area of 57,700	Estimated hydropower potential of 22,850	Shared boundary with Tibet/China and Nepal
Southern Rivers	Covering an area of approximately 3,070	Hydropower potential estimated at 4,110	

Source:“The Way Forward for Nepal’s Hydropower Development”, *Hydro Review*, 2019”

Although Nepal is the second most abundant country in terms of freshwater resources on Earth, it struggles to harness these waters for electricity generation. Over 30 percent of the population lacks access to electricity, and those who are connected to the grid, whether in urban or rural settings, endure frequent power outages. During the fiscal year 2018-19, the peak demand for electricity reached 1,320 MW, yet the total installed capacity was just 1,182 MW. A significant hindrance to Nepal's progress in this area is the lack of reliable, grid-based electricity supply. Additionally, the country's energy demand is surging at an impressive annual rate of 10 percent due to population growth. Currently, in the absence of ample alternatives, biomass has become a more consistent energy source in Nepal's energy portfolio. (Refer to Table 2) Hydropower meets merely one percent of Nepal's energy requirements. The nation has embarked on an initiative known as 'Vision 2020 Hydropower' to pinpoint economically viable projects that will attract investors to a favorable business environment. These ventures will proceed through public-private partnerships (PPPs), involving the Nepal Electricity Authority (NEA) and independent power producers (IPPs). Nevertheless, various obstacles have impeded progress, including regulatory hurdles, the marginalization of local communities, political instability, [h] the lack of a comprehensive framework and optimal locations, as well as an increasing reliance on international aid. India has been proactive in engaging with Nepal's hydroelectric sector to enhance investment prospects, which, in turn, fortifies its own economic growth and energy security. The two nations have collaborated on multiple projects, the most recent being the Lower Arun Hydropower Project—a USD 1.3-billion collaboration. The Indian Satluj Jal Vidyut Nigam (SJVN) supported a 679-MW venture spanning Sankhuwasabha and Bhojpur districts in eastern Nepal. This project follows India's earlier investment in the USD 1.04 billion, 900 MW Arun III project. (See Tables 3 and 4).

Table 2: Total Energy Supply (TES) of Nepal (Energy Mix), by Source, 1990-2018 (in ktoe)

Year	Coal	Hydro	Biofuels and waste	Oil	Wind, solar, etc.
1990	49	75	5426	244	
1995	74	100	6040	501	
2000	258	140	6989	713	
2005	248	216	7930	724	
2010	303	276	8593	982	
2015	557	297	9528	1180	1
2018	843	421	9940	2582	1

Source: World Energy Balances, 2020

Table 3: India-Nepal projects in the pipeline

Project	Details	Investment in USD (million)
Pancheshwar Multipurpose Project	This endeavor arises from the Mahakali Treaty between India and Nepal, targeting energy production and irrigation enhancement. It's expected to generate 10,055 GWh of energy annually from the Pancheshwar and Rupaligad dam power houses.	Estimated to be around USD 6,715,000
Saptakoshi High Dam Project and SunKoshi Storage cum diversion project	This project generates 3000 MW of electricity. Following the exchange of Letters of Understanding between the two governments in June 2004, a Joint Project Office (JPO) was established in August 2004 to conduct detailed field investigations for the preparation of the Detailed Project Report (DPR) of the Saptakoshi High Dam Project at Barakshetra in Nepal. Additionally, this project aims to mitigate flooding in Bihar's flood-prone regions through the proposed reservoir on the Saptakoshi high dam.	

Arun-3 Hydro-electric Project	This 900 MW project is a run-of-river-type development planned for the Sankhuwasabha district of Nepal. It has been awarded by the government of Nepal to Sutlej Jal Vidyut Nigam Ltd., based in New Delhi, India, which is a joint venture between the Government of India and the Government of Himachal Pradesh. The project's foundation stone was laid in 2018, with completion expected by 2024.	Estimated to be around USD 983 million
Upper Karnali Hydro-electric Project	This 900 MW run-of-the-river project is planned for placement in the Surkhet, Dailekh, and Achham districts of Nepal. It aims to supply electricity to Nepal, India, and Bangladesh. The Nepalese government has awarded the project to GMR Upper Karnali Pvt. Ltd., a venture promoted by the GMR Group of India, under a build-own-operate-transfer arrangement.	975,560,000 million
Rahughat Hydro-electric Project	This Peak Run-of-River (RoR) scheme is situated in the Myagdi District of Gandaki Province, Nepal. It's being developed by Raghuganga Hydropower Limited, a collaboration between NEA and the Government of Nepal (GoN), utilizing a soft loan from the Indian government facilitated through a Line of Credit (LOC) from the Export Import Bank (EXIM Bank) of India. Bharat Heavy Electricals Limited (BHEL) has been contracted by Raghuganga Hydropower (RGHPL) to carry out the electro-mechanical (EM) works for the 40MW Rahughat hydroelectric project in Nepal.	

Projects Supported by Indian Assistance in Nepal

Pokhara: Generating 1 MW

Trisuli: Generating 21 MW

Western Gandak: Generating 15 MW

Devighat: Generating 14.1 MW

Source: Central Electricity Authority, Ministry of Power, Government of India

Despite progress, however, there is great scope for improvement. A crucial obstacle is the absence of mutual trust. The next sections describe the power asymmetries between the two riparians, which result in disharmony in perspectives and strategies.

Nepal and India, integral riparian states of the Ganges basin in South Asia, have a longstanding relationship in water dynamics with discussions tracing back to 1874. Nepal's substantial hydropower potential is seen as a solution to India's escalating energy needs, and could also aid in flood control and water supply during dry seasons. Currently, 89 potential sites in Nepal could yield approximately 30 gigawatts of power. However, the dynamics between an upstream Nepal and a downstream India reflect the common asymmetries in international water relations, with India's larger economy and more stable political structures giving it an edge, despite Nepal's advantageous position as the upper riparian.

While international principles suggest equality among riparian nations, the reality often involves a dominant power. The upper riparian state usually holds significant bargaining strength due to its geographical position, but this advantage does not always translate into actual power, especially if the downstream nation is substantially stronger, as in the case of India. For a balance to be struck, the

weaker state must offer something unique that the stronger counterpart lacks.

The paradox for Nepal is its need for infrastructure to harness its resources effectively. India, 400 times ahead in electricity production, could be a strong partner, but cooperation is hampered by a lack of effort and political will, financial resources, and technological capabilities on Nepal's part, and inadequate support from India. Moreover, a history of unfruitful treaties has fostered mistrust, with Nepal harboring grievances and India citing a lack of trust and willpower in Nepal as the main hindrances to progress. This complex interplay of power, mistrust, and potential underscores the nuanced water relationship between the two nations.

Series of Treaties and Agreements Between Nepal and India

The 2014 Agreement between Nepal and India on Electric Power Trade, Cross-Border Transmission Interconnection, and Grid Connectivity establishes a framework for enhancing cooperation in the power sector. It facilitates the development of transmission interconnections, grid connectivity, and power exchange and trading. The agreement outlines procedures for secure grid operations, promotes non-discriminatory access to interconnections, and encourages investment in power infrastructure through both governmental and private enterprises. Additionally, it aims to harmonize policies to support cross-border electricity trade and establish joint working groups to oversee implementation. Signed on October 21, 2014, the agreement aims to foster a mutually beneficial relationship and is set to remain in effect for 25 years, with provisions for automatic renewal.

Bilateral relations worsened during various periods, notably with a peacetime economic blockade imposed by India in the 1980s and again following

Nepal's 2015 earthquake, which aggravated anti-Indian sentiments amid a humanitarian crisis. These events have underscored the substantial political influence on the bilateral dynamics between the two nations, despite the potential for beneficial hydroelectric cooperation. Domestic politics in Nepal also continue to be volatile, even as the country strives to establish a federal democracy and recover from a decade-long civil conflict.

The hydropower treaties and agreements between Nepal and India present a complex relationship characterized by both potential and challenges. (Bagale, 2020) highlights the prolonged stagnation in the implementation of the Mahakali Treaty, emphasizing the need for mutual trust and fair resource utilization between the two nations. This deadlock illustrates the broader issue of hydro-hegemony, where benefits are not equally shared, underscoring the necessity for a shift towards more equitable cooperation (Bagale, 2020). Additionally, (Pun, 2018) criticizes the protectionist nature of India's 2016 guidelines on cross-border electricity trade, which favor entities with significant Indian ownership, potentially stifling Nepal's hydropower development (Pun, 2018).

However, there are promising avenues for cooperation. (Dhakal & Jenkins, 2013) discusses successful risk and rent-sharing models, such as the Chukha Hydel Project, where India assumed construction risks and costs in exchange for a lower electricity purchase price. This model showcases the potential for mutually beneficial agreements that balance economic and financial risks, thereby enhancing bilateral cooperation (Jenkins & Dhakal, 2008). Maxwell, (2012) further supports this perspective by identifying hydropower as a key driver for bilateral agreements, suggesting that the allure of renewable energy could catalyze further

collaborative efforts between the two countries (Maxwell, 2012).

Expanding the scope beyond bilateral to regional cooperation, Uprety and Salman, (1999) provides an insightful comparative analysis of the Mahakali and Ganges treaties, indicating the potential for collaborative water resource management between Bangladesh, Nepal, and India. This regional approach could serve as a strategic model for future agreements, leveraging geographic proximity and shared interests to foster a more integrated and cooperative management of water resources. The success of such models would depend on overcoming existing challenges through improved legal frameworks and a genuine commitment to equitable and sustainable resource sharing.

Enhancing Cooperation

The potential for enhanced cooperation in the hydropower sector between Nepal and India is significant, particularly given the escalating energy demands within India. According to Sigdel, (2007), this increasing demand presents a unique opportunity for bilateral collaboration which can yield mutual benefits for both countries. Saklani et al., (2020) further supports this notion by illustrating the wide-ranging advantages that such cooperation could offer, extending beyond energy security to encompass economic and developmental synergies.

However, the dynamics of this relationship have been marked by a notable power imbalance. Bagale, (2020) points out that Nepal has often been at a disadvantage in water resource agreements, failing to secure equitable benefits. This criticism highlights the need for fostering mutual trust and ensuring equitable utilization of water resources, which are essential for sustaining long-term cooperation.

The success story of Bhutan in its hydropower cooperation with India serves as an inspiring model

for Nepal. Berkoff, (2003) outlines how Bhutan has managed to leverage its hydropower resources effectively, enhancing its own economic stability while contributing to energy security in India. This case exemplifies how strategic collaboration and fair agreements can lead to mutually beneficial outcomes.

Furthermore, the potential for robust bilateral cooperation on common rivers between Bangladesh and India, as discussed by Huda, (2013) suggests that such collaboration could serve as a foundation for broader multilateral cooperation in South Asia. This approach not only enhances bilateral ties but also fosters regional stability and development.

Huda (2013) also highlights the pivotal role that India can play in initiating and leading multilateral cooperation on water issues within the region. India's central position and its extensive network of rivers shared with neighboring countries place it in a strategic role to spearhead initiatives that promote regional water security and cooperation.

Finally, the importance of a comprehensive economic agreement between India and Nepal that includes multiple sectors such as hydropower development and tourism is emphasized by (Taneja et al., 2011). Such an agreement would not only solidify bilateral relations but also unlock significant economic potential, contributing to poverty alleviation, employment generation, and sustainable development.

Conclusion

The intricate economic relationship between Nepal and India in the hydropower sector is both promising and fraught with challenges. The potential for Nepal to significantly contribute to both nations' energy needs through hydropower

is vast, given its extensive freshwater resources and substantial untapped hydropower capacity. Enhanced cooperation in this sector could not only meet India's growing energy demand but also fuel Nepal's economic growth, thereby fostering a symbiotic relationship between the two countries. However, the realization of this potential is hindered by numerous challenges, including political instability, funding dependencies, and infrastructural inadequacies, which have stymied the rapid development of Nepal's hydropower capabilities.

Furthermore, the geopolitical dynamics of the region, particularly the influence of neighboring countries like China, add another layer of complexity to the Nepal-India hydropower discourse. These dynamics underscore the strategic importance of hydropower not only as an economic asset but also as a geopolitical tool that could influence regional stability. The ongoing efforts to resolve these issues through treaties and collaborative projects, like the recent developments in cross-border electricity transmission and large-scale hydropower projects, indicate a mutual recognition of the benefits that can be derived from increased cooperation.

To harness the full potential of Nepal-India hydropower cooperation, it is crucial for both nations to engage in transparent, equitable, and sustainable practices. This includes addressing the socio-economic impacts on local communities, ensuring fair benefit-sharing, and developing robust legal and regulatory frameworks to support long-term partnership.

By doing so, Nepal and India can transform their hydropower resources into a cornerstone for not only economic growth and energy security but also for fostering long-lasting regional cooperation and stability.

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